Annual Report 2016

Jožef Stefan Institute, Ljubljana, Slovenia

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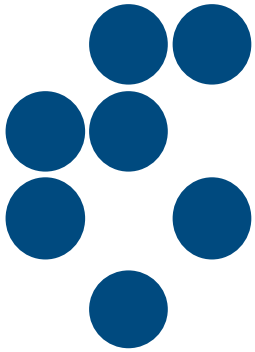
ANNUAL REPORT
JULY 2017

Annual Report 2016



Jožef Stefan Institute, Ljubljana, Slovenia

Annual Report 2016

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Ljubljana, July 2017

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INTRODUCTION

Prof. Jadran Lenarčič,
Director of the Jožef Stefan Institute

If you don't contribute to the world's treasury of knowledge, you cannot benefit from it.

According to the European Commission, there is unquestionable evidence that the route to economic growth and competitiveness is strongly linked to increased investments in research and development. I find it necessary to emphasise this because it has become even clearer in the last years of the economic crisis that in spite of many declarations the differences between European countries are getting larger, with some countries, like Switzerland, Denmark, Germany, Sweden and Austria, investing heavily in research and development, while other countries are reducing investments, due to the wrong policies, or simply a lack of policies. Slovenia is, unfortunately, among those countries that do not recognise the benefits of investing in research and development, nor see them as a major opportunity for economic and social breakthroughs. The result of this indifference and political passivity is a worrying decline of the Slovenian innovation system.

When the public-sector austerity measures began to be introduced in Slovenia, the biggest cut was experienced by the research and development sector. Any thinking person would find it completely unreasonable to reduce the funding for research and development; there is simply no justification for such a measure. Even if Slovenes are not alone in this self-destructive behaviour, the resulting damage is immeasurable, because as a society we are losing a generation of talented people, who either go abroad or become involved in other, non-innovative activities, and are therefore lost forever to research and development. It is absurd that the greatest damage will be done to the economic sector, which is the sector of society that, in order to save on public expenditure, should be able to get the most out of it.

The Institute "Jožef Stefan" strives to remain as a European research centre. Every year, the share of its revenues from abroad increases, and now exceeds a quarter of its funding. Its position in Europe and our long tradition of international cooperation and exchanges are essential for the Institute and therefore we can, like every year, be proud of our excellent achievements, which find their ways into the most important scientific publications, into the sector of the economy, but also into the consciousness of the general public about the meaning of scientific research, technological development and innovations for the greater good. Inevitably our Institute leaves an important mark every year, which anyone who reads the pages of the Annual Report will recognise.

Prof. Jadran Lenarčič
Director of the Jožef Stefan Institute

A BRIEF HISTORY OF THE JOŽEF STEFAN INSTITUTE

1946
~ Decision taken by the Slovenian Academy of Science and Arts to build a Physics Institute

1949
~ Research connected to the peaceful use of atomic energy started, financed by the Federal Government

1952
~ Institute renamed the Jožef Stefan Physics Institute and moved to new laboratories on its present site

1954
~ The betatron and an electron microscope installed as the institute's first major pieces of equipment

1956
~ Van de Graaff accelerator, constructed at the institute, started operation

1958
~ Institute reorganised and new fields of activity defined: nuclear physics, solid-state physics, chemistry, and radiobiology

1959
~ Institute renamed the Jožef Stefan Nuclear Institute. The major source of income was provided by the Yugoslav Atomic Energy Commission

Mass spectrometer at the JSI (about 1960)

1962
~ One of the first compounds of a noble gas, XeF_6, synthesised at the institute
~ The first computer for research, ZUSE Z 23, installed

1966
~ Nuclear research reactor TRIGA starts operation

1968
~ Yugoslav Atomic Energy Commission ceases to operate; The Republic of Slovenia becomes the institute's dominant source of research funding

1969
~ Institute is renamed as the Jožef Stefan Institute

1970
~ University of Ljubljana becomes a co-founder of the Jožef Stefan Institute, together with the Federal Executive Council

1971
~ A new unit, INOVA, established with the aim of applying the institute's expertise and output to productive use in the national economy

Institute buildings after the opening in 1953

1972
~ New computer Cyber 72 purchased, and the Republic Computer Centre established as an independent unit of the Jožef Stefan Institute

1974
~ Collaboration with the international centre CERN in the field of high-energy physics started
~ SEPO group for evaluating environmental interventions is established

1976
~ First Yugoslav 8-bit processor computer DARTA 80

1979
~ Contract defining cooperation between the Jožef Stefan Institute and the Nuclear Power Plant Krško is signed
~ First robot in Slovenia is constructed

1982
~ Ecological Laboratory with Mobile Unit established as a special unit of the Slovenian Civil Protection Organisation

1983
~ Stefin, a cysteine proteinase inhibitor named after Jožef Stefan, isolated and its primary structure determined

The Reactor Centre, Podgorica, built in 1966

1985
~ "2000 New Young Researchers" project established by the Slovenian Research Council
~ Centre for Hard Coatings established by the Jožef Stefan Institute and the firm SMELT

The beginnings of robotics at the JSI, in 1985

1987
~ INEA established by the Jožef Stefan Institute as an independent company to promote technology transfer in the fields of cybernetics and energy management

1989
~ Milan Čopič Nuclear Training Centre established

1990
~ The first Slovenian supercomputer, CONVEX, installed at the Jožef Stefan Institute

1992
~ New technology centres established by the Ministry of Science and Technology
~ Jožef Stefan Institute restructured by the Slovenian Government as a public research institution
~ Jožef Stefan Technology Park founded, later to become the Ljubljana Technology Park

1995
~ Jožef Stefan Institute is a co-founder of the international postgraduate school for environmental sciences, the Nova Gorica Polytechnic
~ Research institutes in Velenje, ERICo and Valdoltra established by the Institute

1997
~ 3.5-MeV electrostatic accelerator, TANDETRON, installed

1999
~ Jožef Stefan Institute celebrates its 50th anniversary

2003
~ Jožef Stefan International Postgraduate School established

2004
~ Jožef Stefan Institute is chosen as the coordinator of four Research Centres of Excellence

2007
~ Nanomanipulation of single atoms using low-temperature scanning tunneling microscope
~ New ERDA/RBS beamline installed at the TANDETRON accelerator at the Microanalytical center

2015
~ New research infrastructure, including new and renovated laboratory and office space with high-tech instrumentation for environmental research

High-tech instrumentation for environmental research at the JSI in 2015

FORMER DIRECTORS

Prof. Anton Peterlin, first Director of the Jožef Stefan Institute

Prof. Anton Peterlin, Founder and first Director of the Jožef Stefan Institute, 1949–1955
Karol Kajfež, 1955–1958
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Prof. Milan Osredkar, 1963–1975
Prof. Boris Frlec, 1975–1984
Prof. Tomaž Kalin, 1984–1992
Prof. Danilo Zavrtanik, 1992–1996
Prof. Vito Turk, 1996–2005

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National Centre for High Resolution NMR Spectroscopy
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Centre for Protein Structure
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Centre for Experimental Particle Physicis in International Laboratories
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Video-conferencing Centre
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Service for Business Informatics (U-5)
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Ljubljana Technology Park Ltd.

University of Nova Gorica

Jožef Stefan International Postgraduate School

Technology Centres

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Technology Centre for Production Automation, Robotics and Informatics (ARI)

Nanotesla Institute Ljubljana

Security Technology Competence Centre (SETTCE)

Development Centre for Hydrogen Technologies

Centres of Excellence

Nanocenter - Center of Excellence in Nanoscience and Nanotechnology

Centre of Excellence for Integrated Approaches in Chemistry and Biology of Proteins (CIPKeBiP)

Centre of Excellence NAMASTE

Centre of Excellence for Polymer Materials and Technologies (PoliMaT)

EN-FIST Centre of Excellence

CEBIC Centre of Excellence for Biosensors, Instrumentation and Process Control

CO NOT: Centre of Excellence for Low-Carbon Technologies

Centre of Excellence for Space Sciences and Technologies SPACE-SI

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Assistant to the Director
Dr. Romana Jordan

Adviser
Marta Slokan, LL. B.

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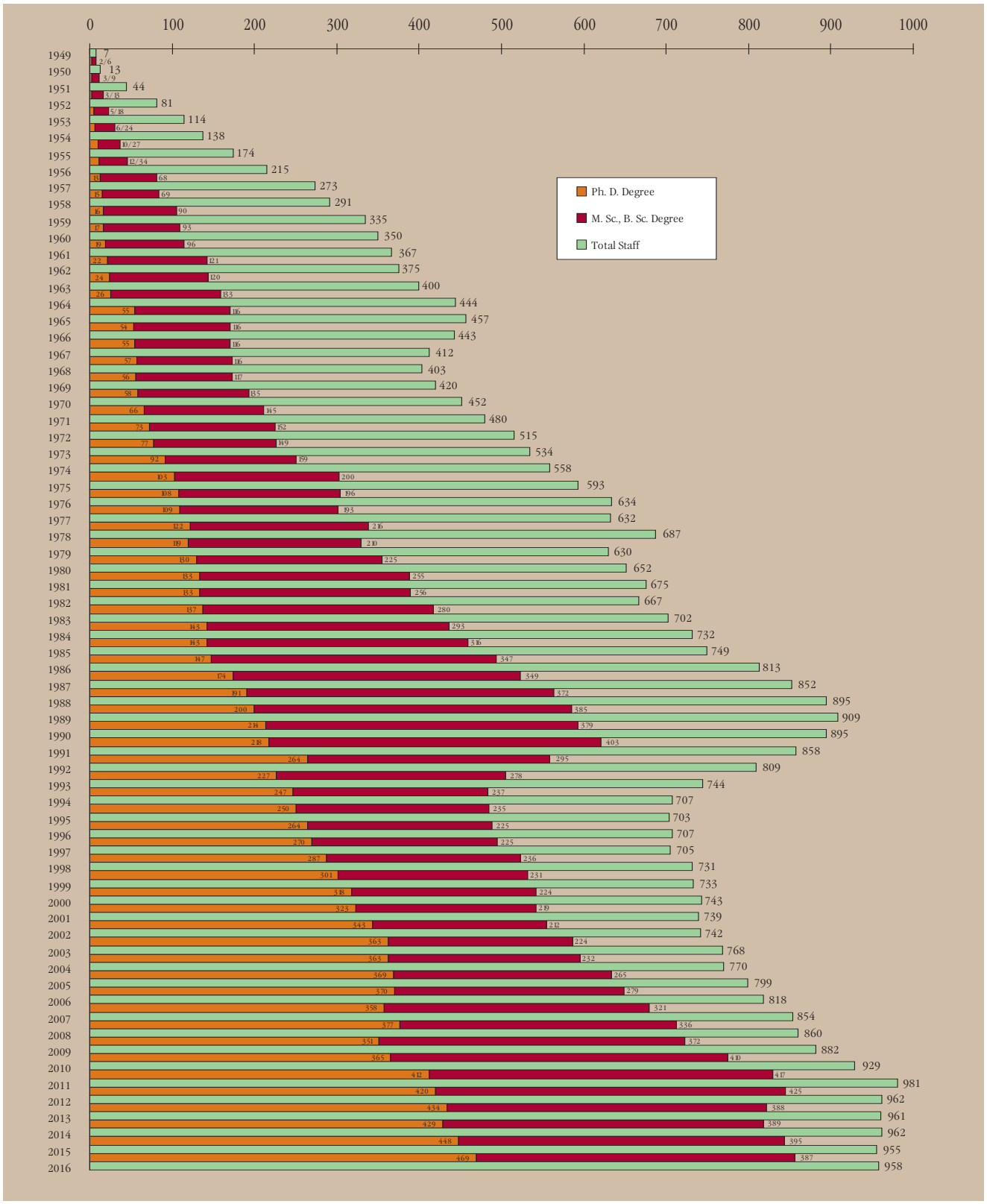
1949-2016



RECIPIENTS OF THE JSI AWARDS AND TITLES

HONORARY MEMBERS

Prof. Robert Blinc†, President of the Scientific Council of the Jožef Stefan Institute from 1992 to 2007 (1933 - 2011)
Prof. Jean-Marie Dubois, Institut Jean Lamour, CNRS - Centre National de la Recherche Scientifique, Paris and Université Lorraine, Nancy, France
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Prof. Robert Huber, Nobel Prize Winner, Max-Planck-Institut für Biochemie, Munich, Germany
Prof. Milan Osredkar†, Director of the Jožef Stefan Institute from 1963 to 1975 (1919 - 2003)
Prof. Anton Peterlin†, Founder and First Director of the Jožef Stefan Institute from 1949 to 1955 (1908 - 1993)

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INTERNATIONAL COOPERATION

Multilateral international cooperation	No. of projects
H2020 (EUROPEAN INSTITUTE OF INNOVATION AND TECHNOLOGY, EXCELLENT SCIENCE, EURATOM, INDUSTRIAL LEADERSHIP, SOCIETAL CHALLENGES, SPREADING EXCELLENCE AND WIDENING PARTICIPATION, SCIENCE WITH AND FOR SOCIETY)	74
7. FP (COOPERATION: HEALTH, FOOD, AGRICULTURE/FISHERIES, BIOTECHNOLOGY, INFORMATION COMMUNICATION TECHNOLOGIES, NANOSCIENCES + NANOTECHNOLOGIES, MATERIALS + NEW PRODUCTION TECHNOLOGIES, ENERGY, ENVIRONMENT AND CLIMATE CHANGE, TRANSPORT (INCLUDING AERONAUTICS), SOCIO-ECONOMIC SCIENCES + THE HUMANITIES, SPACE, SECURITY; IDEAS: FRONTIER RESEARCH (EUROPEAN RESEARCH COUNCIL); PEOPLE: MARIE CURIE FELLOWSHIPS; CAPACITIES: RESEARCH INFRASTRUCTURES, SMEs, REGIONS OF KNOWLEDGE, RESEARCH POTENTIAL, SCIENCE AND SOCIETY, INCO (HORIZONTAL), DEVELOPMENT OF POLICIES) AND 7. FP - EURATOM	64
ESRR	12
OTHERS (COST, IAEA, IEE, JRC, IRMM, ESA, NATO, CIP, MED, EMRP, EMPIR, WHO, LIFE+, SCOPES...)	154
TOTAL	**304**

Bilateral cooperation	No. of projects
Argentine	1
Austria	2
Montenegro	2
France	14
Croatia	8
India	3
Japan	3

Bilateral cooperation	No. of projects
Russia	5
Serbia	10
Turkey	3
USA	27
Bosnia and Herzegovina	2
Others	7
TOTAL	**87**

In 2016, international cooperation agreements were signed between the Jožef Stefan Institute and:

1. UChicago Argonne, LLC, Argonne National Laboratory, Argonne, IL, USA (F2, F7)
2. TUNAP Industrie Chemie GmbH & Co Produktions KG, Wolfratshausen, Germany (F5, CTT)
3. DIC Corporation, Tokyo, Japan (F5)
4. Innovidis AB, Gothenburg, Sweden (F5)
5. CEA - Commissariat a l"Energie Atomique et aux Energies Alternatives, Paris, France (F8)
6. Joint Research Centre of the European Commission, Directorate for Health, Consumers and Reference Centre, Geel, Belgium; Bor Kos, Jesenice, Slovenia (F8)
7. Ulsan National Institute of Science and Technology, School of Mechanical and Nuclear Engineering, Ulsan, Republic of Korea (F8)
8. The International Atomic Energy Agency, Vienna, Austria; The Technische Universitaet Wien - Atominstitut, Vienna, Austria; The Czech Technical University in Prague - Faculty of Nuclear Sciences and Physical Engineering, Prague, Czech Republic; The Budapest University of Technology and Economics - Institute of Nuclear Techniques, Budapest, Hungary (F8)
9. CERN, Geneva, Switzerland (F9)
10. BASF SE, Ludwigshafen am Rhein, Germany (K3, CTT)
11. Nano4Life Europe Co, Agios Dimitrios, Athens, Greece (K3, CTT)
12. BORÇELIK ÇELIK SANAYI VE TIC. A.Ş., Gemlik – Bursa, Turkey (K3, CTT)
13. PRG Ltd Macedonia, Skopje, Macedonia (K1)
14. Duroc N.V., Antwerpen (Wilrijk), Belgium (K3, CTT)
15. EnviroTech Europe Ltd., Hampton, Middlesex, United Kingdom (K3, CTT)
16. Sabanci University, Tuzla/Istanbul, Turkey; Kupfer Ileri Malzeme Teknolojileri Muh. Dan. San. Ltd Sti, Maslak/Istanbul, Turkey (K7)
17. South China University of Technology, Department of Electronic Materials Science and Engineering, Guangzhou, P.R. China (K9)
18. Centro de Desenvolvimento da Tecnologia Nuclear – CDTN, Belo Horizonte – Minas Gerais, Brazil (O2)
19. Masaryk University, Faculty of Science, Research Centre for Toxic Compounds in the Environment (RECETOX), Brno, Czech Republic (O2)
20. Croatian Institute of Public Health, Zagreb, Croatia (O2)
21. University of Helsinki, Laboratory of Radiochemistry, Helsinki, Finland (O2)
22. Blue Ocean Robotics ApS, Odense SO, Denmark; Assist. Prof. Igor Kovač, Radomlje, Slovenia; ELESTRA d.o.o., Ljubljana, Slovenia (E1)
23. ATET S.p.A, Torino, Italy (E2)
24. Bloomberg L.P., New York, NY, USA (E3)
25. Interactive Wear AG, Starnberg, Germany (E6)
26. Sigfox SA, Labege, France (E6)
27. Ghent University, Ghent, Belgium; University of Luxembourg, Luxembourg (E6)
28. Donders Institute for Brain, Cognition and Behaviour, Centre for Cognitive Neuroimaging, Nijmegen, The Netherlands (E7, CTT)
29. Czech Technical University in Prague, Prague 6, Czech Republic (E8)
30. Shinshu University, Global Education Center (GEC), Nagano Ken, Japan (E9)
31. Shanghai Jiao Tong University, School of Nuclear Science and Engineering, ICB for Basic Research on Thermal-Hydraulic of Advanced Nuclear Reactor System, Shanghai, P.R.China (R4)
32. Andaz Limited, Hong Kong, PR China (CTT)
33. Katholieke Universiteit Leuven (KU Leuven), Leuven, Belgium (U1)
34. Euroservis S.r.l, Trieste, Italy (U1)

COOPERATION WITH HIGHER-EDUCATION ESTABLISHMENTS

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3. **Asst. Prof. Rok Bojanc**, University of Primorska, Faculty of Mathematics, Natural Sciences and Information Technologies
4. **Prof. Janez Bonča**, University of Ljubljana, Faculty of Mathematics and Physics
5. **Prof. Ivan Bratko**, Academician, University of Ljubljana, Faculty of Computer and Information Science
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8. **Prof. Mojca Čepič**, University of Ljubljana, Faculty of Education
9. **Prof. Martin Čopič**, University of Ljubljana, Faculty of Mathematics and Physics
10. **Prof. Janez Dolinšek**, University of Ljubljana, Faculty of Mathematics and Physics
11. **Prof. Irena Drevenšek Olenik**, University of Ljubljana, Faculty of Mathematics and Physics
12. **Prof. Svjetlana Fajfer**, University of Ljubljana, Faculty of Mathematics and Physics
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14. **Prof. Boštjan Golob**, University of Ljubljana, Faculty of Mathematics and Physics
15. **Prof. Tomaž Gyergyek**, University of Ljubljana, Faculty of Electrical Engineering
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Assistants and researchers

1. **Asst. Prof. Marko Bračko**, University of Maribor, Faculty of Chemistry and Chemical Engineering
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Assistants and researchers

1. **Dr. Tanja Arh**, IPS, Ljubljana, DOBA Faculty of Applied Business and Social Studies, Maribor
2. **Dr. Zoran Arsov**, University of Ljubljana, Faculty of Mathematics and Physics
3. **Dr. Samir El Shawish**, University of Ljubljana, Faculty of Mathematics and Physics
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Second critical point in supercooled water: Fact or fiction?

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Quantum Teleportation, Entanglement, and Einstein's Question "What is Light?"

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Faculty of Civil Engineering, University of Ljubljana
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Institut Curie, Paris, France, Mechanobiology Institute, National University of Singapore, Singapore
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Jožef Stefan Institute
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Max-Planck Institute for Intelligent Systems, Tübingen, Germany
Exploiting contact interactions for robust manipulation and locomotion skills

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Weizmann Institute of Science, Rehovot, Israel
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University of Ljubljana and Jožef Stefan Institute
BigData processing at present and future LHC experiments

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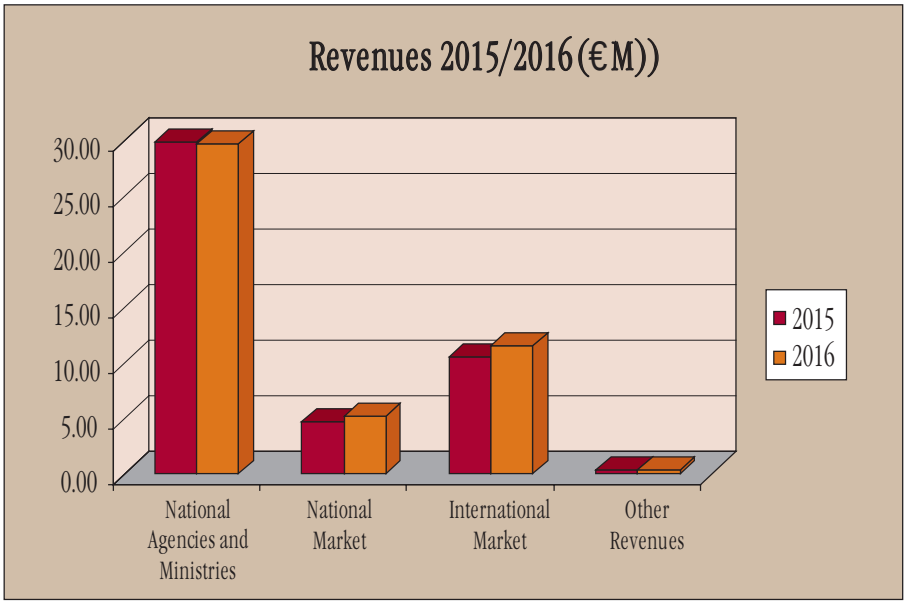
REVENUES JSI (€) AND NUMBER OF PROJECTS

	Contribution 2016		Contribution 2015			No. of Projects in 2016
	2016	2016	2015	2015	Index 2016/2015	
National Agencies and Ministries	29,844,964	63.4 %	29,980,897	65.8 %	99.5	398
National Market	5,244,775	11.1 %	4,703,687	10.3 %	111.5	223
International Market	11,645,413	24.7 %	10,535,749	23.1 %	110.5	328
Other Revenues	340,525	0.7 %	358,872	0.8 %	94.9	
TOTAL	**47,075,677**	**100.0 %**	**45,579,205**	**100.0 %**	**103.3**	**949**



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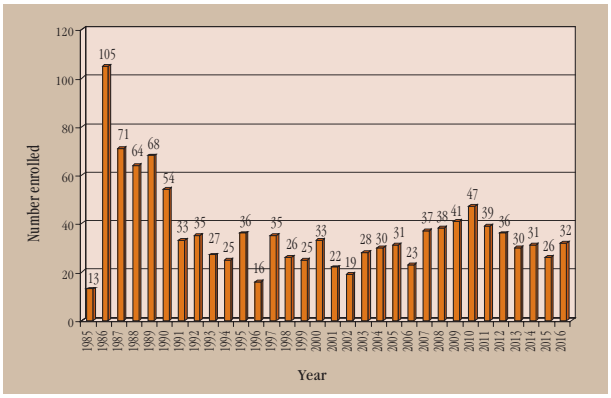
by Slovenian Research Agency



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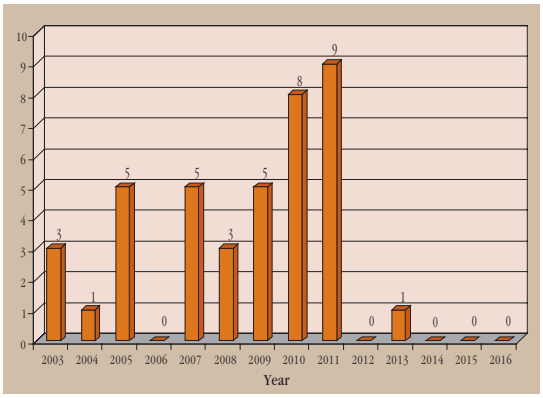

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1977-2016

Year	FMF		FKKT UNI LJ	FKKT UNI MB	NTF	FDV	FA	BF	FE and FRI	Other UNI LJ	FG and FERI	UNG	IPS	Total
	Physics	Mathematics												
... 1982	115	38	100						50	12				315
1983	10	1	5						9		1			26
1984	11	3	7					1	12		1			35
1985	18	4	6					1	19		1			49
1986	16	8	4						22	2				52
1987	20	8	4						23	2				57
1988	26	7	8					1	27	2				71
1989	26	6	10					1	19	3	1			66
1990	26	5	11					2	25		1			70
1991	23	2	9					2	24	2	1			63
1992	22	3	16					3	17	1				62
1993	21	1	15					3	13	1				54
1994	7	1	8					3	6					25
1995	2		9					3	5					19
1996	2		9					3	5					19
1997	2		12					1	4		1			20
1998	1		6					1	7		1			16
1999	2		7					4	7					20
2000	1		5					3	9					18
2001	3		13					3	10					29
2002	4		20					3	10					37
2003	3		18					2	12	1				36
2004	4		17					1	15	1	2	2		42
2005	3		12			1		2	19		2	1		40
2006	2		12			1		1	17		2	2		37
2007	3		14			1		2	18		2	1		41
2008	2	1	13	3		1		2	15		1	1		39
2009	2	1	17	4		1		5	16		1	2		49
2010	2		11	5	2	1	1	3	10		1	2	5	43
2011	2	1	11	5	4	1	1	4	7		1		6	43
2012	2		10	6	3	1		3	6				5	36
2013	3	2	3	2	1		1		2	2			6	22
2014	14	6	3		2		1		3	2			1	32
2015	21	6	4		1				9	1			10	52
2016	16	2	5						7	1			15	46
TOTAL	437	106	434	25	13	8	4	63	479	33	20	11	48	1681

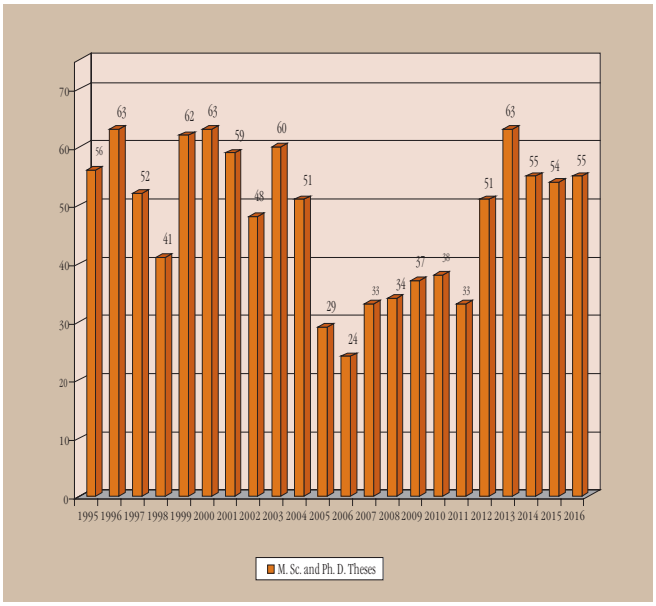
FMF Faculty of Mathematics and Physics, University of Ljubljana
FKKT (Uni-Lj) Faculty of Chemistry and Chemical Technology, University of Ljubljana
FKKT (Uni-Mb) Faculty of Chemistry and Chemical Technology, University of Maribor
NTF Faculty of Natural Sciences and Engineering, University of Ljubljana
FDV Faculty of Social Sciences, University of Ljubljana
FA Faculty of Administration, University of Ljubljana
BF Biotechnical Faculty, University of Ljubljana

FE Faculty of Electrical Engineering, University of Ljubljana
FRI Faculty of Computer and Information Science, University of Ljubljana
FG Faculty of Civil Engineering, University of Maribor
FERI Faculty of Electrical Engineering and Computer Science, University of Maribor
UNG University of Nova Gorica
IPS Jožef Stefan International Postgraduate School
Other UNI LJ Faculty of Pharmacy, Faculty of Mechanical Engineering, Faculty of Economics, Faculty of Medicine, University of Ljubljana

COMPLETED THESES

UNTIL 2016

Year	Ph. D. Theses	M. Sc. Theses	Total
...1962	15	6	21
1963	7		7
1964	7	2	9
1965	16		16
1966	2		2
1967		8	8
1968	4	8	12
1969	3	6	9
1970	2	12	14
1971	7	6	13
1972	11	24	35
1973	8	14	22
1974	21	10	31
1975	10	20	30
1976	6	31	37
1977	5	16	21
1978	10	20	30
1979	7	11	18
1980	13	10	23
1981	12	15	27
1982	13	18	31
1983	5	10	15
1984	14	17	31
1985	6	14	20
1986	8	15	23
1987	18	21	39
1988	12	26	38
1989	15	33	48
1990	16	41	57
1991	22	47	69
1992	19	42	61
1993	28	36	64
1994	27	37	64
1995	34	22	56
1996	38	25	63
1997	29	23	52
1998	21	20	41
1999	33	29	62
2000	36	27	63
2001	31	28	59
2002	29	19	48
2003	41	19	60
2004	31	20	51
2005	22	7	29
2006	22	2	24
2007	26	7	33
2008	29	5	34
2009	30	7	37
2010	33	5	38
2011	31	2	33
2012	47	4	51
2013	56	7	63
2014	51	4	55
2015	44	10	54
2016	42	13	55
TOTAL	1125	881	2006



PATENTS GRANTED

1. Alenka Vesel, Miran Mozetič, Rok Zaplotnik
   Device for high-frequency gas plasma excitation
   DE112012000015 (B4), Deutsches Patent- unt Markenamt, 21. 04. 2016.
2. Matjaž Lukač, Zdenko Vižintin, Boris Cenčič
   Method for lightening or eradicating pigments in human skin
   US9254174 (B2), US Patent Office, 09. 02. 2016.
3. Igor Muševič, Matjaž Humar
   Spherical liquid-crystal laser
   US9263843 (B2), US Patent Office, 16. 02. 2016.
4. P. E. Galavis, Bhudatt R. Paliwal, James E. Holden, Robert Jeraj
   System and method for gradient assisted non-connected automatic region (GANAR) analysis
   US9355447 (B2), US Patent and Trademark Office, 31. 05. 2016.
5. Janko Petrovčič, Damir Vrančić
   Reducing oscillations in a control system
   EP2356522 (B1), European Patent Office, 06. 01. 2016.
6. Rok Zupet, Jernej Iskra, Miloš Ružič, Anica Pečavar, Ivanka Kolenc, Jože Pucelj, Igor Plaper
   A process for a preparation of marbofloxacin and intermediate thereof
   EP2501680 (B1), European Patent Office, 10. 02. 2016.
7. Xinzheng Zhang, Jingjun Xu, Wei Li, Irena Drevenšek Olenik, Wei Cui, Bin Shi, Zhenhua Wang, Qiang Wu, Yongfa Kong
   Micro/nano region liquid crystal alignment method and system thereof based on laser direct writing
   CN103995394 (B), Chinese Patent Office, 17. 08. 2016.
8. Igor Vaskivskyi, Dragan Mihailović, Ian Mihailović
   Switchable macroscopic quantum state devices and methods for their operation
   SI24776 (A), Slovenian Intellectual Property Office, 29. 01. 2016.
9. Gregor Papa, Barbara Koroušić-Seljak, Marko Pavlin
   Device and method for acquisition and transfer of signals
   SI24792 (A), Slovenian Intellectual Property Office, 29. 02. 2016.
10. Matjaž Gams, Hristijan Gjoreski, Mitja Luštrek
    Method and system for detecting a person driving a vehicle while using a mobile computing device
    SI24796 (A), Slovenian Intellectual Property Office, 29. 02. 2016.
11. Luka Suhadolnik, Matic Krivec, Miran Čeh, Kristina Žagar, Goran Dražič
    Photocatalytic reactor
    SI24802 (A), Slovenian Intellectual Property Office, 31. 03. 2016.
12. Matjaž Vencelj, Larisa Hosnar, Klemen Bučar, Janez Burger
    Angle-sensitive gamma camera with a rotary obstruction
    SI24818 (A), Slovenian Intellectual Property Office, 31. 03. 2016.
13. Alenka Vesel, Rok Zaplotnik, Miran Mozetič
    Method for cleaning of with body fluid-contaminated medical implantants and devices with the use of atomic oxygen
    SI24840 (A), Slovenian Intellectual Property Office, 29. 04. 2016.
14. Gregor Filipič, Kristina Eleršič, Darij Kreuh, Janez Kovač, Uroš Cvelbar, Miran Mozetič
    A method of colouring titanium and titanium alloys
    SI24851 (A), Slovenian Intellectual Property Office, 29. 04. 2016.
15. Matjaž Vencelj, Miha Cankar, Andrej Likar
    Process and device for improvement of operation of silicon photomultipliers in the regime of piled-up pulses of light
    SI24863 (A), Slovenian Intellectual Property Office, 29. 04. 2016.
16. Aleš Lapanje
    The impregnation process and attachment of microorganisms in porous materials
    SI24910 (A), Slovenian Intellectual Property Office, 29. 07. 2016.
17. Andrej Kovič, Adolf Jesih, Aleš Mrzel
    Process for the synthesis of the molybdenum carbide in the form of quasi-one-dimensional structures, that is, nano-wires, micro-wires, nano-strips and micro-strips
    SI24925 (A), Slovenian Intellectual Property Office, 31. 08. 2016.
18. Tadej Rejc, Uroš Petrič, Jana Debeljak, Toni Bremec, Polonca Ferk, Mojca Lunder, Irena Roškar, Borut Štrukelj, Samo Kreft
    Mixture of natural polyphenols from white fir wood for reducing postprandial glucose concentration
    SI24984 (A), Slovenian Intellectual Property Office, 30. 11. 2016.
19. Peter Dušak, Marin Berovič, Darko Makovec
    Process for regulation of lactic acid fermentation in wine production by magnetic elimination of bacteria
    SI24998 (A), Slovenian Intellectual Property Office, 30. 11. 2016.

ART EXHIBITIONS AT THE JSI

Suzi Bricelj, 25 January-18 February
Evgenija Jarc and Andrej Mivšek, 22 February-17 March
Andrej Jemec, 21 March-21 April
Janez Kukec Mezek, 25 April-18 May
Teo Spiller, 23 May-15 June
Ištvan Išt Huzjan, 31 May (Forma Viva)
Vesna Drnovšek, 20 June-11 July
Denise Eyer-Oggier, 11 July-1 September
Lucija Stramec, 5 September-6 October
Milan Razboršek, 10 October-3 November
Mito Gegič, 7 November-8 December
Zoran Ogrinc, 12 December-13 January 2017

Acedemician Prof. Andrej Jemec at the opening of his exhibition

AWARDS AND APPOINTMENTS

AWARDS MADE TO JSI RESEARCHERS BY THE REPUBLIC OF SLOVENIA

Zois Certificate of Recognition

Jernej Fesel Kamenik

Presented with the Zois Certificate of Recognition for the search for new physics in the theory of elementary particles

The winner of Zois Certificate of Recognition: Asst. Prof. Jernej Fesel Kamenik

JSI AWARDS AND APPOINTMENTS

The Jožef Stefan Golden Emblem Prize

presented to the following for doctoral theses with high impact :

Ljupka Stojčevska Malbašić

Femtosecond relaxation dynamics in collective-electronic-state materials: cuprate and iron pnictide superconductors and charge-density wave systems

Miha Grilc

Kinetics of the liquefaction process and catalytic deoxygenation of lignocellulosic biomass

Dejan Dovžan

Recursive fuzzy identification in control and process monitoring

The Jožef Stefan Roll of Honour

was awarded for their successful contribution for developing new high-tech products based on scientific and technological achievements of the Jožef Stefan Institute:

Dr. Janez Pirš

Janez Škrlec

OTHER SELECTED AWARDS TO JSI RESEARCHERS

Department of Knowledge Technologies (JSI), Special Recognition for Successful Cooperation with the Committee on Science and Technology of the Chamber of Craft and Small Business of Slovenia and for an interesting presentation of the Department of Knowledge Technologies of the Jožef Stefan Institute at the International Fair of Crafts and Entrepreneurship in Celje.

Energy Efficiency Centre (JSI), Award TARAS – for successfully carrying out the project for the useful exploitation of waste heat in the steel industry in the district heat system in Ravne na Koroškem, which is a recognition for the most successful cooperation of economy and scientific research work

Darko Belavič, Elected to the serving member of Electrotechnical Association Slovenia, MIDEM – Proposer: Society for Microelectronics, Electronic Components and Materials, Ljubljana, Slovenia May, 2016

Blaž Belec, 3rd award for presentation at the 8. Conference of Jožef Stefan International Postgraduate School, Ljubljana, Jožef Stefan International Postgraduate School.

Blaž Belec, Best contribution at the 8. Conference of Jožef Stefan International Postgraduate School, Ljubljana, Jožef Stefan International Postgraduate School.

Janez Bonča, Article in Nature Physics entitled: Snapshots of the retarded interaction of charge carriers with ultrafast fluctuations in cuprates, was selected as one of the most excellent scientific achievements in science in the year 2015.

Andraž Bradeško, Best poster award, Institute of Electrical and Electronics Engineers (IEEE), ISAF/ECAPD/PFM Conference 2016 – IEEE, Darmstadt, Germany, August 21-25, 2016

The winners of the Jožef Stefan Golden Emblem Prize: Dr. Ljupka Stojčevska Malbašić, Dr. Miha Grilc and Dr. Dejan Dovžan

Martin Breskvar, Dragi Kocev, Jurica Levatić, Aljaž Osojnik, Matej Petković, Nikola Simidjievski and Bernard Ženko won the ESA's Mars Express Power Challenge, designing the most accurate solution for predicting a space probe's power consumption.

Primož Cigoj, The Second best Innovation: "MUPOSS" product, 9th International Technology Transfer Conference, Brdo pri Kranju, Slovenia, September 21 2016

Oriol Costa Garrido, Winner prize for the best presentation of relevant research in nuclear fields (ENC 2016 conference, Warsaw, Poland), European Nuclear Education Network, Life-time predictions accuracy of the thermally fatigued pipes under turbulently mixing fluids

Oriol Costa Garrido, Best poster award (ICONE 24 conference, Charlotte, North Carolina, USA), American Society of Mechanical Engineers, Probabilistic prediction of fatigue life of pipes under turbulent fluid mixing

Sašo Džeroski, corresponding member of the Macedonian Academy of Arts and Sciences, was elected for a full member of the European Academy of Sciences (Academia Europaea).

Lovro Fulanovič, SHAPING VI, Student poster award winner, Montpellier, France, July 20, 2016

The winners of the Jožef Stefan Roll of Honour, for their successful contribution to developing new, high-tech products based on the scientific and technological achievements of the Jožef Stefan Institute: Janez Škrlec & Prof. Barbara Malič (left) and Dr. Janez Pirš (right)

Urška Gabor, Award for best oral presentation in young researchers section at the 24th International Conference on Materials and Technology, Portorož, Metals and Technology (IMT), "Different approaches to avoiding lead deficiency in PMN-PT thin films"

Ana Gantar, Nataša Drnovšek, Rok Kocen, Saša Novak, Special prize for Innovations for Economy for "SilkPatch - Innovative Solution for Chronic Skin Wounds", 9th International Technology Transfer Conference & Innovation Day 2016, Brdo pri Kranju, 21 September 2016

Tanja Goršak, Best presentation at the 8. Conference of Jožef Stefan International Postgraduate School, Ljubljana, Jožef Stefan International Postgraduate School.

Tadej Holler, Best paper award (ICONE 24 conference, Charlotte, North Carolina, USA), American Society of Mechanical Engineers, Large-scale homogeneous hydrogen-air-steam deflagration experiment simulated using two turbulent flame speed closure models

Matjaž Humar, 1st Place Poster Prize at prestigious Nobel Laureate Meeting 2016, Lindau, Germany. Matjaž presented a poster about lasers embedded into single live cells for the first time. He has also demonstrated that fat cells already present in human body already contain tiny lasers, which only need to be activated.

Tanja Kaiba, Prešeren Award, Ljubljana, Slovenia, 6. 12. 2016, Faculty of Mathematics and Physics, University of Ljubljana, for the master thesis entitled: Fission and ionization chambers response at the JSI TRIGA reactor

Janez Kokalj, Matjaž Leskovar, Mitja Uršič, Best poster award (NENE 2016 conference, Portorož, Slovenia), Nuclear Society of Slovenia, Modelling of Debris Bed Coollability in Bottom Reflooding Conditions with MC3D

Bor Kos, Young author award. Young author award committee at the international conference NENE 2016, Portorož, 5.-8. 9. 2016, for the contribution entitled "Variance Reduction of Fusion and Fission Neutron Transport Problems using the ADVANTG Hybrid Code" co-authored by Ivan A. Kodeli

Tomaž Kos, The 2016 Prešeren award at the University of Ljubljana, Faculty of Electrical Engineering for his research project entitled Measurement system for automated low-frequency and high-temperature characterization of dielectric materials

Tomaž Kos, Tadej Rojac (co-mentor), Prešeren Award, Faculty of Electrical Engineering, Ljubljana, Slovenia, December 6, 2016

Nina Kostevšek, Best Young Lecturer Award, 2nd International Symposium on Nanoparticles-Nanomaterials and Applications (ISN2A-2016), Lisbon, Portugal, 8-21 January 2016. Title of the awarded contribution: "Multimodal hybrid FePt/SiO2/Au nanoparticles for nanomedical applications: New synthesis approach for improved magnetic and optical properties" (co-authors: Sašo Šturm, Igor Serša, Ana Sepe, Matjaž Spreitzer, Spomenka Kobe, Kristina Žužek Rožman)

Matic Kunšek, Certificate; European master of nuclear engineering (IAEA General Conference, Vienna, Austria), European Nuclear Education Network

Danjela Kuščer, Janez Holc and from ETI d.d.: Ines Bantan, Joži Prašnikar, Helena Razpotnik, Silver Award for innovation: "Neporozni kordieritni material C410 za elektrotehniko", Gospodarska zbornica Slovenije, Zasavje, Slovenia, June 8, 2016

Matej Petković was awarded the Prešeren Prize of the Faculty of Mathematics and Physics of the University of Ljubljana for his Master's thesis titled "Evaluation of the importance of continuous features with the ReliefF method", written under supervision of Sašo Džeroski.

Rudolf Podgornik, "Sackler Scholar", Israel, Mortimer and Raymond Sackler Institute of Advanced Studies, Tel Aviv University in the academic year 2016/2017, selected for "eminence in his field of research".

Vid Podpečan received the Prometheus of Science award for excellence in communication for the year 2016 by the Slovenian Science Foundation for all-round promotion of robotics, especially humanoid robot use among young people.

Luka Snoj, Name of the Month on the Radio Val 202, June 2016, Ljubljana, Slovenia, awarded by RTV Slovenia, Radio Val 202

Stanislav Strmčnik, received the Professor Emeritus of the University of Nova Gorica award for his significant contribution to the development of scientific activities and his remarkable performance as professor and mentor

Luka Suhadolnik, 3rd Best Oral Presentation at the 24th International Conference on Materials and Technology, Portorož, Slovenia, 28-30 September 2016. Title of the awarded contribution: Optimization of Photoelectrocatalytic Activity of TiO_2-based Microreactor (co-authors: Andrej Pohar, Blaž Likozar and Miran Čeh)

Martin Štefanič, Seal of Excellence, Brussels, Belgium, European Commission, project proposal NanoDryCell: Nanoparticle-assisted desiccation of mesenchymal stem cells for the "off-the-shelf" allogeneic cell therapy

Aleš Švigelj, Kemal Alič, Radovan Srnec, the Best Paper Award of the IEEE ComSoc Technical Committee on Communications Systems Integration and Modeling, "Network traffic modeling for load prediction: a user-centric approach", IEEE Network, IEEE Globecom 2016, Washington, USA, December 2016.

REVIEW OF PUBLICATIONS

FOR 2016

Department	Original Articles*	Books	Patent Appl. and Grants	Theses
Department of Theoretical Physics (F-1)	99	1		3
Department of Low and Medium Energy Physics (F-2)	79	2	2	2
Department of Thin Films and Surfaces (F-3)	21			
Department of Surface Engineering and Optoelectronics (F-4)	58		3	
Department of Solid State Physics (F-5)	118	7	3	5
Department for Complex Matter (F-7)	47		4	5
Department of Reactor Physics (F-8)	69	2	1	1
Department of Experimental Particle Physics (F-9)	162			3
Department of Inorganic Chemistry and Technology (K-1)	21		1	1
Department of Physical and Organic Chemistry (K-3)	32		1	3
Electronic Ceramics Department (K-5)	54		4	6
Department for Nanostructured Materials (K-7)	62		3	3
Department for Synthesis of Materials (K-8)	20		1	2
Department for Advanced Materials (K-9)	22			
Department of Biochemistry, Molecular and Structural Biology (B-1)	30			1
Department of Molecular and Biomedical sciences (B-2)	12	1		
Department of Biotechnology (B-3)	27		1	2
Department of Environmental Sciences (O-2)	118		1	2
Department of Automation, Biocybernetics and Robotics (E-1)	54			
Department of Systems and Control (E-2)	35	3	1	2
Artificial Intelligence Laboratory (E-3)	35	1		1
Laboratory for Open Systems and Networks (E-5)	25	2		1
Department of Communication Systems (E-6)	41			
Computer Systems Department (E-7)	19	1	1	
Department of Knowledge Technologies (E-8)	102			4
Department of Intelligent Systems (E-9)	70	2	1	2
Department of Reactor Engineering (R-4)	55	2		4
Reactor Infrastructure Centre (RIC)	8			
Networking Infrastructure Centre (NIC)		2		
Energy Efficiency Centre (EEC)	7			1
Centre for Electron Microscopy and Microanalysis (CEMM)	10			1
Centre for Knowledge Transfer in Information Technologies (CT-3)	3			
Milan Čopič Nuclear Training Centre (ICJT)	6			1
Radiation Protection Unit (SVPIS)	2			
Centre for Technology Transfer and Innovation (CTT)	2	1		
Jožef Stefan Institute	1523	27	28	56

* Articles in Journals and Conference Proceedings, and Chapters in Books

KNOWLEDGE TRANSFER

The JSI pays a lot of attention to furthering its links with industry. In keeping with European aims and the objectives of the Slovenian government, the JSI organized several important meetings on the subject of cooperation with enterprises and industry. In this way the JSI introduced a new method of cooperation, showing industry and the public that it is aware of its leading role, not only in research but also in the transfer of knowledge into practice.

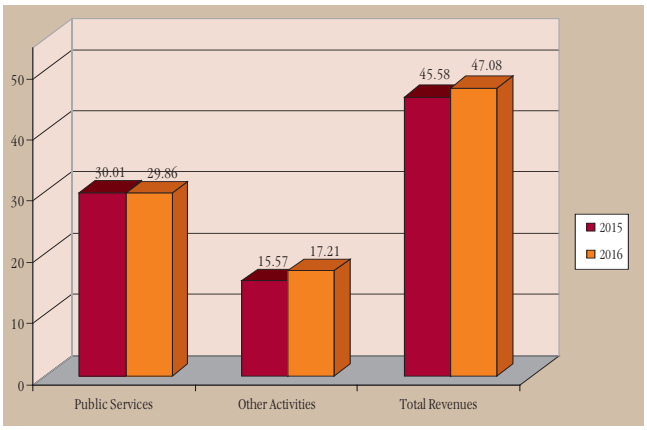
R & D PROJECT PARTNERS

1. Adriaplin, Ltd., Ljubljana
2. Adriatic Slovenica, d. d., Ljubljana
3. Agency for Communication Networks and Services of the Republic of Slovenia, Ljubljana
4. Amebis, Ltd., Kamnik
5. Slovenian Agency for Radioactive Waste Management, Ljubljana
6. Bank of Intesa Sanpaolo d.d., Koper - Capodistria
7. Bioiks, Ltd. - Biomedical production with the finest quality, Ljubljana
8. C & G, Ltd. Ljubljana
9. Idrija Heritage Centre, Idrija
10. Chemass, Ltd., Ljubljana
11. The Centre of the Republic of Slovenia for Mobility and European Educational and Training Programmes (CMEPIUS), Ljubljana
12. Cosylab, d. d., Control System Laboratory, Ljubljana
13. Časnik Finance, Ltd., Ljubljana
14. Domel, Ltd., Železniki
15. DRI upravljanje investicij, Ltd., Ljubljana
16. Transparency International Slovenia, Ljubljana
17. Milan Vidmar Electric Power Research Institute, Ljubljana
18. ELES, Ltd., Electricity Transmission System Operator, Ljubljana
19. Elgoline, Ltd., Cerknica
20. ERICo, Ltd., Velenje
21. Flexatec, Ltd., Ljubljana
22. Fotona, Ltd., Ljubljana
23. GEN Energija, Ltd., Krško
24. Generali, d.d., Ljubljana
25. Goriška Local Energy Agency (GOLEA), Nova Gorica
26. Gorenje, d.d., Velenje
27. Hidria Rotomatika, Ltd., Spodnja Idrija
28. INEA, Ltd., Ljubljana
29. Informa Echo, Ltd., Ljubljana
30. Ecological engineering institute, Ltd., Maribor
31. Institute for Environmental Protection an Sensors (IOS), Ltd., Maribor
32. IPD Med, Ltd., Šentjernej
33. JP CČN Domžale-Kamnik, Ltd., Domžale
34. Kemomed, Ltd., Kranj
35. Agricultural Institute of Slovenia, Ljubljana
36. KMZ - Zalar Miran, s.p., Ljubljana
37. Knauf Insulation, Ltd., Škofja Loka
38. Kolektor Group, Ltd., Idrija
39. Komunala Novo mesto, Ltd., Novo mesto
40. LEK, d.d., Ljubljana
41. LPKF Laser & Electronics, Ltd., Naklo
42. L-TEK, Ltd., Šentjernej
43. Medens, Ltd., Mozirje
44. Merck, Ltd., Ljubljana
45. Metronik, Ltd., Ljubljana
46. Ministry of Finance of the Republic of Slovenia, Ljubljana
47. Ministry of Infrastructure of the Republic of Slovenia, Ljubljana
48. Ministry of the Interior of the Republic of Slovenia, Ljubljana
49. Ministry of Defence of the Republic of Slovenia, Ljubljana
50. Ministry of the Environment and Spatial Planning of the Republic of Slovenia, Ljubljana
51. Ministry of Justice of the Republic of Slovenia, Ljubljana
52. Ministry of Health of the Republic of Slovenia, Ljubljana
53. NELA razvojni center, Ltd., Železniki
54. Krško Nuclear Power Plant, Krško
55. Municipality of Zagorje ob Savi, Zagorje ob Savi
56. Optotek, Ltd., Ljubljana
57. Petrol, d.d., Ljubljana
58. Petrol, Ltd., Ravne na Koroškem
59. Plinovodi, Ltd., Ljubljana
60. Podkrižnik, Ltd., Ljubno ob Savinji
61. Quintelligence, Ltd., Ljubljana
62. Development Centre RC eNeM, Ltd., Zagorje ob Savi
63. Robotina, Ltd., Kozina
64. Sanolabor, d. d., Ljubljana
65. Saving, Ltd., Ljubljana
66. Scan, Ltd. Preddvor
67. Slovenian Biochemical Society, Ljubljana
68. Slovensko društvo ljubiteljev kemije, Ljubljana
69. Republic of Slovenia Statistical office, Ljubljana
70. Studio Moderna, Ltd., Zagorje ob Savi
71. Swatycomet, Ltd., Maribor
72. Špica International, Ltd., Ljubljana
73. TECOS, Celje
74. Unicredit Banka Slovenija, d.d., Ljubljana
75. University of Ljubljana, Ljubljana
76. University of Maribor, Maribor
77. University Rehabilitation Institute, Ljubljana
78. Ustna medicina, Ltd., Ljubljana
79. Vacutech Vakuumske tehnologije in sistemi, Ltd., Ljubljana
80. Xlab, Ltd., Ljubljana
81. Yaskawa Slovenija, Ltd., Ribnica
82. National Education Institute Slovenia, Ljubljana
83. ZEL-EN, Ltd., Krško
84. Zmas Group, Ltd., Ljubljana
85. Institute of Occupational Safety (ZVD), Ltd., Ljubljana

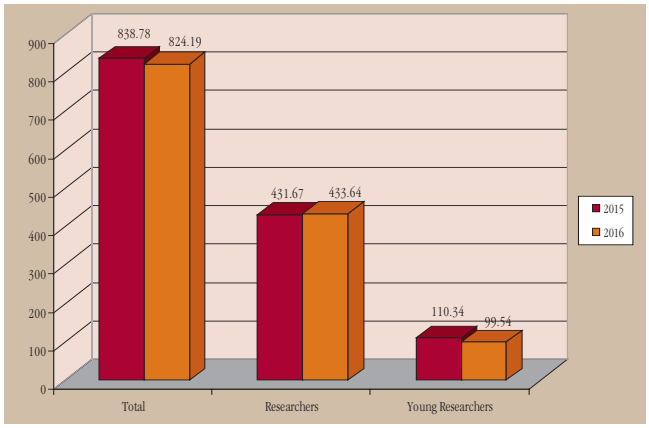
INSTITUTE IN NUMBERS

2015–2016

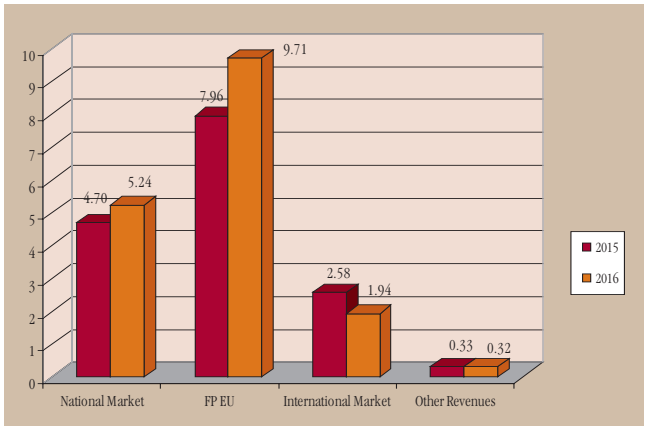
COMPARISON OF REVENUES (€M)



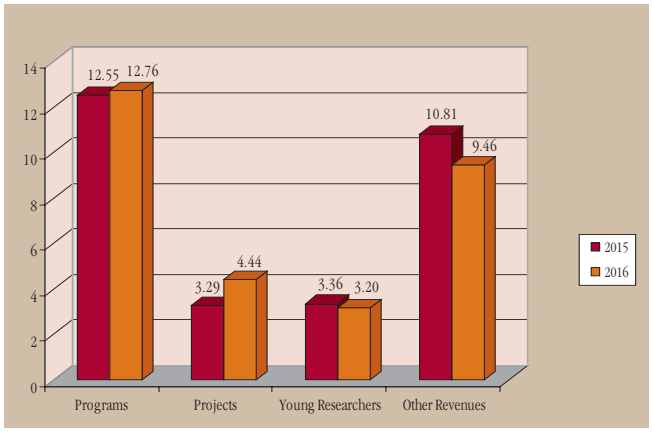
EMPLOYEES (FTE)



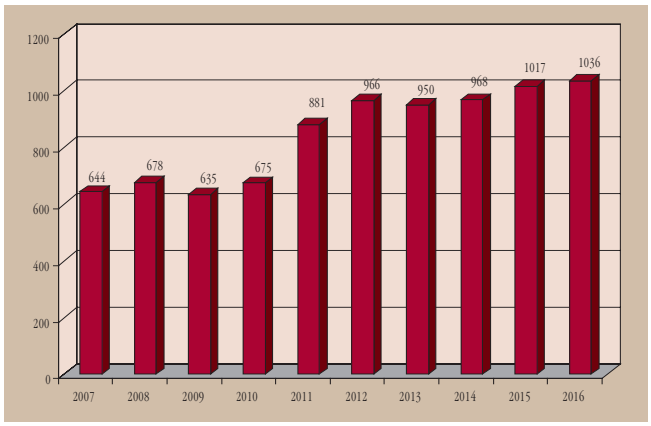
REVENUES FROM OTHER ACTIVITIES (€M)



REVENUES FROM PUBLIC SERVICES (€M)

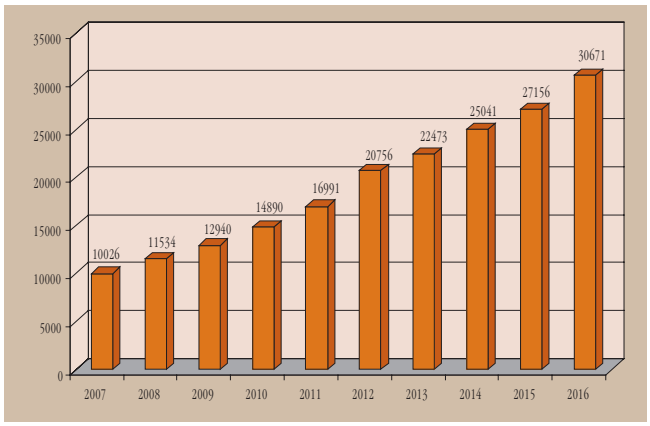


NUMBER OF PUBLICATIONS IN THE WEB OF SCIENCE*



* retrieved 19 July 2017

NUMBER OF CITATIONS IN THE WEB OF SCIENCE*



* retrieved 19 July 2017

RESEARCH DEPARTMENTS

DEPARTMENT OF THEORETICAL PHYSICS F-1

In 2016, members of the programme group THEORY OF NUCLEUS, ELEMENTARY PARTICLES AND FIELDS continued with their research in the area of hadronic physics, quantum chromodynamics, effective field theory of electroweak decays of mrsons, unified theory and precise calculations in the three-body systems

Head:
Prof. Svjetlana Fajfer

We have applied a coupled-channel formalism to calculate pion scattering and meson photo-production in eta N, K Lambda and K Sigma channels using a SU(3) version of the Cloudy Bag Model. With no additional free parameters pertinent to the strange hadrons, our amplitudes in the P11, P13, P33 and S11 partial waves agree well with the most recent partial-wave analyses. We have shown that our model is able to reproduce the free parameters of the Single Quark Transition Model.

A discovery of an intriguing exotic hadron, presumably composed of four quarks with different flavours X(5568), was reported by the D0 experiment in early 2016. We presented the first ab-initio theoretical study of the corresponding scattering channel Bsϖ by means of the lattice QCD simulation. We did not find a candidate for this hadron, in agreement with the high-statistic LHCb experiment, which reported the results after we reached our conclusions.

We analysed the experimental hints of a diphoton resonance in the photon-invariant mass at 750 GeV in terms of a new boson, extracting information on its properties and exploring theoretical interpretations. We then showed how calculability and unitarity considerations severely limit the possible perturbative realizations of such a signal. Within the framework of the effective field theory, we also showed that in general two of the three processes S to ZZ, S to Z gamma, and S to WW must occur with a non-zero rate. We also identified the most useful observables, whose relevance will also remain in model-by-model analyses. Finally, we explored the signal in the context of warped five-dimensional models with the Standard Model fields propagating in the bulk of the extra dimension as well as a bound system of a new QCD-like theory with massive fermions vectorial under the SM. We studied the phenomenology of light spin-0 particles and stressed that they can be efficiently searched for at the LHCb experiment in the form of dimuon resonances.

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We have made an attempt to explain the LHC excess at 750 GeV using the scalar field that is a part of the SU(5) symmetry-breaking sector. Namely, in the adjoint representation of the SU(5) group, which breaks SU(5) down to SU(3) × SU(2) × U(1), there is a Standard Model scalar. We also show that the required production and subsequent decay to two photons of this singlet can be induced by the individual or combined contribution of two scalar multiplets S3 and R2 that transform as (3, 3, −1/3) and (3,2,7/6) under SU(3) × SU(2) × U(1), respectively.

According to the lattice QCD the mass spectrum of Bs mesons seems to follow the pattern of the Ds mass spectrum. As in the case of charmed mesons, the structure of positive parity Bs mesons is very intriguing. To shed more light on this issue, we investigated strong isospin violating decays Bs(0+) → Bs0ϖ0, Bs(1+) → Bs∗0ϖ0 and Bs(1+) → Bs0ϖϖ within the heavy meson chiral perturbation theory.

We showed that a model with a scalar leptoquark of hypercharge Y = 1/6, which includes the light right-handed neutrinos, can successfully describe both of the B-physics anomalies, RKexp < RKSM and RDexp > RDSM. We discussed the corresponding low-energy effective theory and, after using the known experimental data as constraints, we show that the model is viable and that it offers several predictions that can be tested experimentally.

We have shown that the violation of leptonic universality, as observed by the LHCb experiment in the decay B –> Kll, can be explained by the leptoquark with spin 1 and with a mass of around 1 TeV/c2. Furthermore, we also the observed the lepton universality violation in charged-current

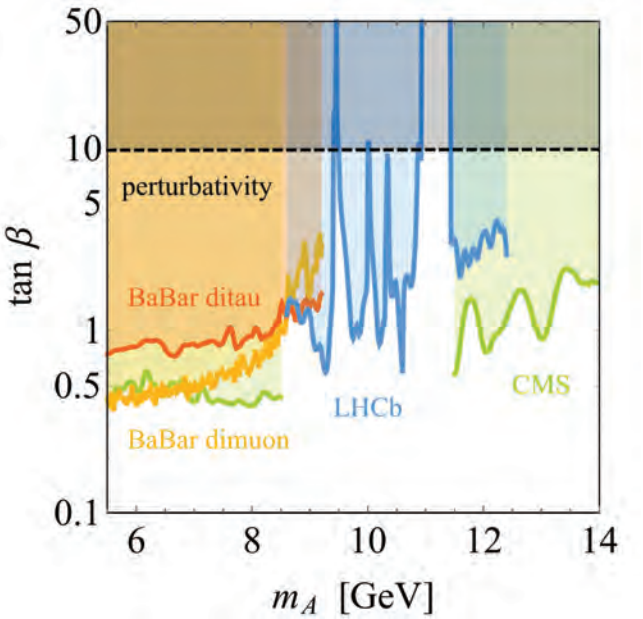


Figure 1: 95% CL bound on tanβ in the THDMII scenario. The blue curve follows from Υ(n) production by LHCb, the green curve arises from a CMS dimuon resonance search, whereas the yellow and orange curves derive from the BaBar 90% CL limit on radiative Υ(1) decays in the dimuon and ditau channel, respectively. The bound on tanβ arising from perturbativity is also shown (black dashed line). All the shaded regions correspond to excluded parameter space.

semitauonic decays B –> D(*)τν compared to semileptonic decays with the light lepton B –> D(*)lν can be explained with the presence of this leptoquark. The minimality of this model allows it to be predictable, and we have predicted the expected rate at which lepton flavour violating processes should be observed. The same leptoquark state has been analysed further in the systematic study of the connection between the lepton universality violation in B –> Kll and the lepton flavour violation.

In the invited review article "Physics of leptoquarks in precision experiments and at particle colliders" we have presented a broad overview of leptoquark physics. We discussed Standard Model extensions that contain leptoquarks and have focused on those leptoquark states that preserve the baryon number. For such states we have presented the most important constraints from precision measurements at low and high energies, the role of leptoquarks in Higgs physics as well as leptoquark searches at hadron colliders.

In an invited review article we presented a broad overview of the physics of leptoquarks, particles which switch between leptons and quarks.

We investigated a spontaneously broken U(1)d gauge symmetry with a muon-specific dark Higgs. Our first goal is to verify how the presence of a new dark Higgs, ϕ, and a dark gauge boson, V , can simultaneously face the anomalies from the muon magnetic moment and the proton charge radius. Secondly, by assuming that V must decay to an electron-positron pair, we explored the corresponding parameter space determined by the low-energy constraints coming from Kaon, and tau physics. We focused on the scenario where the V mass is below ~ 2mμ and the ϕ mass runs from a few MeV to 250 MeV, with V-photon mixing of the order ~ O(10−3).

We restricted the soft terms of the minimal supersymmetric SU(5) to lie typically above 100 TeV with small tan(beta). We found that the threshold corrections in the supersymmetric missing partner SU(5) suppress the D=6 proton decay rate by 60%. We fit fermion masses and mixings with only one Yukawa matrix in a supersymmetric SO(10) with an extra vector-like representation 16. By comparing with data we found an agreement with the hypothesis of hidden residual symmetries in the Yukawa sector of SO(10) theories. We checked the possibility to have an ultraviolet fixed point in supersymmetric SO(10) and found some, not yet realistic, candidates.

The scalar sector of the minimal Left-Right model at the TeV scale is revisited. The stability and perturbativity of the effective potential is discussed and merged with constraints from low-energy processes. Lower limits on the triplet scalars are also derived: the left-handed triplet is bounded by oblique parameters, while the doubly-charged right-handed component is limited by the diphoton and photon-Z decays. Current constraints disfavor triples at the LHC as long as WR is within reach.

We have shown how to describe branes with an action that gives the geodisic equation in an infinite dimensional brane space with a certain metric. In analogy with general relativity we assumed that the metric can be a dynamical variable. Upon quantization of such a theory for the flat metric, we arrived at the quantum field theory of a continuous system of non-interacting scalar fields. The inclusion of a suitable interaction gives in the effective classical theory the equations of motion of a p-brane.

Some outstanding publications in the past three years

1. Doršner, Ilja, Fajfer, Svjetlana, Greljo, Admir, Kamenik, Jernej, Košnik, Nejc. Physics of leptoquarks in precision experiments and at particle colliders. Physics reports, ISSN 0370-1573. [Print ed.], [in press] 2016, 68 str., doi: 10.1016/j.physrep.2016.06.001.

The group of SOLID-STATE THEORY AND STATISTICAL PHYSICS has been investigating the equilibrium and non-equilibrium properties of materials with strongly correlated electrons, nanosystems, as well as the properties of complex networks.

Within the theory of correlated electrons we continued studies of many-body quantum states out of equilibrium. We addressed a long-standing problem concerning the origin of bosonic excitations that strongly interact with charge carriers, and show that the time-resolved pump-probe experiments are capable of distinguishing between phonons and magnons. The ability of phonon degrees of freedom to absorb unlimited amounts of energy renders relaxation dynamics nearly independent of the absorbed energy, while the hard-core effects pose limits on the spin subsystem resulting in a substantial dependence of the relaxation on the fluence. One of recent theoretical challenges is the phenomenon of the many-body localization, which predicts a nonergodic behaviour of disordered systems even in the presence of the interaction between particles. We have investigated several aspects of this problem within the disordered chain of interacting spinless fermions, revealing

It was shown that within a disordered Hubbard model, which simulates the experiments on cold-atom systems, spin degrees reveal an ergodic dynamics even in the presence of a strong disorder, while the charge degrees can localize.

an exponential vanishing of the d.c. conductivity with disorder, as well as universal dynamics in the vicinity of the transition. In the case of identical coupled chains we confirmed the breakdown of localization, consistent with recent experiments on disordered cold-atom systems. The latter were also the motivation for a study of the disordered Hubbard model, which showed that spin degrees of freedom behave ergodic even at strong disorder, while charges can localize, which is the indication of novel partial localization. We also studied the thermalizaion of an electron coupled to optical phonons and confirmed the approach to a thermal Gibbs ensemble.

Within the theory of quantum impurities and nanosystems we studied the sub-gap spectra of magnetic impurities in superconductors at finite temperatures. Experimentally, Shiba states have a finite width that emerges due to a normal-state tunnelling probe with a finite density of states, from experimental noise, but also from the electron-electron interaction, which was the focus of our research. We have explored the Kondo screening of localized moments in the extreme situation where the chemical potential is in the vicinity of a van Hove singularity and found that the resulting potential scattering strongly influences the renormalization of the exchange-coupling constant. We also derived an exact solution for a time-dependent wave function of an initial Kramers-doublet qubit, driven around a quantum ring. It was shown that the initial qubit may be transformed to an arbitrary point on the ring, which might result in an application in quantum computing.

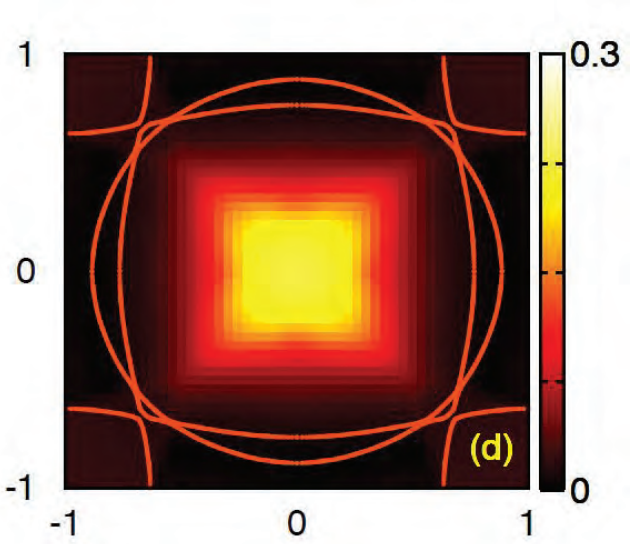


Figure 2: Fermi surface of a layered ruthenate Sr_2RuO_4. The colour encodes the magnitude of the current matrix element in the direction perpendicular to the layer, which leads to an explanation for the enhanced Seebeck coefficient in the c-direction.

We continued studies of the transport properties of materials with correlated electrons and studied the thermoelectric effect and the entropy in Sr_2RuO_4. In collaboration with an experimental group we investigated the THz optical conductivity of pseudocubic ruthenates. We implemented the calculation of optical conductivity in the LDA+DMFT. We investigated the transport properties in doped Mott insulators and explained them within the concept of bad metals. In collaboration with the laboratory for dielectric spectroscopy we also analysed the dielectric response of the ceramic system BZT.

Within the research of statistical physics of complex systems and networks, we have considered the nature of collective fluctuations using the multifractal time series analysis and algebraic topology of graphs, representing the transitions between states in the phase space. We have determined features of fluctuations that lead to an improved conductivity in nanostructured assemblies and the cooperative dynamics of the domain walls depinning. In the empirical data from the portal Mathematics, we have studied the growth of innovation in self-organized processes of knowledge creation through questions and answers. We also analysed multi-brain networks mapping the correlations among EEG signals, which are simultaneously recorded during the communications among the participants and have demonstrated that higher topological structures correlate with an understanding of the communicated contents.

Some outstanding publications in the past three years

1. Mravlje, Jernej, Georges, Antoine. Thermopower and entropy: lessons from Sr[sub]2RuO[sub]4. Physical review letters, ISSN 0031-9007. [Print ed.], 2016, vol. 117, no. 3, str. 036401-1-036401-5, doi: 10.1103/PhysRevLett.117.036401.
2. Kogoj, Jan, Mierzejewski, Marcin, Bonča, Janez. Nature of bosonic excitations revealed by high-energy charge carriers. Physical review letters, ISSN 0031-9007. [Print ed.], 2016, vol. 117, iss. 22, str. 227002-1-227002-5, graf. prikazi, doi: 10.1103/PhysRevLett.117.227002.

The group for THEORETICAL BIOPHYSICS AND SOFT-MATTER PHYSICS investigated polyelectrolytes, liquid crystals, colloids, and phospholipid and biological membranes.

Our efforts in the field of macromolecular interactions and molecular biophysics included a range of problems and the most important ones are dedicated to the role of materials properties in van der Waals interactions, to the determination and analysis of the partitioning of differently sized polymers in membrane nanopores, and to the spectroscopic investigation of the role of magnesium ions on the details of the DNA structure in thin films. We also analysed the charge renormalization in asymmetric electrolytes, van der Waals interactions between layered media and

We have delineated the most recent and comprehensive understanding of the van der Waals interactions in the context including soft matter and biophysics.

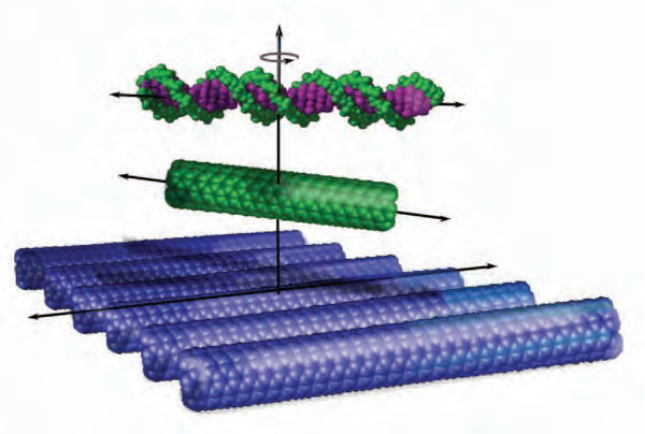


Figure 3: Van der Waals interactions are manifested in forces as well as torques between anisotropic molecules such as DNA and carbon nanotubes and molecular aggregates like the array of cylindrical molecules.

between polymers with sequence-specific polarizabilities, and fluctuation-induced forces in confined fluids and elastomers. In addition, we studied the stability of viral capsids, where we succeeded to relate the influence of long-range interactions with the elastic properties of viral capsids.

We studied the chiral structures and phases of bent-core liquid crystals, showing that the driving force for the formation of the modulated nematic phase are short-range steric interactions. We explained the optical activity of the nanofilament sponge phase, which stems from the layer inhomogeneity. We prepared a set of experiments for the analysis of optically positive and negative birefringent materials in the microwave region. Also developed was a systematic geometric interpretation of the symmetry of the crystals formed by model colloids with a step pair interaction.

We explored both experimentally and theoretically the self-replication of two-component lipid vesicles induced by heating, and we demonstrated that the observed self-replication mode depends on the asymmetric distribution of molecules in the two monolayers. A novel continuum formulation of the elastic behaviour of the red-blood-cell membrane skeleton was proposed and used to analyse cell deformations that occur during its aspiration into a micropipette. We developed a mechanical theory of epithelial tissues, which was then used to interpret the shape of epithelial folds seen in the digestive tract and the airways of certain animals. Using the so-called thermomechanical analogy, we predicted the residual stress in the carotid artery.

Some outstanding publications in the past three years

1. Woods, Lilia M., Dalvit, D. A. R., Tkatchenko, Alexandre, Rodriguez-Lopez, P., Rodriguez, A. W., Podgornik, Rudolf. Materials perspective on Casimir and van der Waals interactions. *Reviews of modern physics*, ISSN 0034-6861, 2016, vol. 88, iss. 4, str. 045003-1-045003-48, ilustr., doi: 10.1103/RevModPhys.88.045003.

Awards and appointments

1. Prof. Dr. Jernej Fesel Kamenik: Zois recognition of achievements for the search for new physics in the theory of elementary particles, Ljubljana, Ministry of Education, Science and Sport.
2. Prof. Dr. Janez Bonča: Article in Nature Physics entitled: Snapshots of the retarded interaction of charge carriers with ultrafast fluctuations in cuprates, was selected as one of the most excellent scientific achievements in science in the year 2015.
3. Prof. Dr. Rudolf Podgornik: "Sackler Scholar", Israel, Mortimer and Raymond Sackler Institute of Advanced Studies, Tel Aviv University in the academic year 2016/2017, selected for "eminence in his field of research".

Organization of conferences, congresses and meetings

1. Nonequilibrium Phenomena in Quantum Systems, Krvavec, 18.-21. 12. 2016

INTERNATIONAL PROJECTS

1. COST CA15108; Connecting Insights in Fundamental Physics (FUNDAMENTALCONNECTIONS)
   Prof. Jernej Fesel Kamenik
   Cost Office
2. COST TD1210; Analysing the Dynamics of Information and Knowledge Landscapes
   Prof. Bosiljka Tadić
   Cost Office
3. H2020 - ITN - COLLDENSE; Hybrid Colloidal Systems with Designed Response
   Prof. Primož Ziherl
   European Commission
4. Search for Composite Higgs Models at the LHC
   Prof. Jernej Fesel Kamenik
   Slovenian Research Agency
5. Relaxation Dynamics and Thermalization of Quantum Many-body Systems
   Prof. Janez Bonča
   Slovenian Research Agency
6. Strong Electronic Correlations and Superconductivity
   Asst. Prof. Rok Žitko
   Slovenian Research Agency
7. From Flavor Anomalies to Signals in High-pT Searches
   Prof. Jernej Fesel Kamenik
   Slovenian Research Agency
8. Dark Side of the Higgs Boson
   Prof. Jernej Fesel Kamenik
   Slovenian Research Agency

RESEARCH PROGRAMS

1. Theory of the condensed matter and statistical physics
   Prof. Janez Bonča
2. Theoretical physics of nuclei, particles and fields
   Prof. Svjetlana Fajfer
3. Biophysics of polymers, membranes, gels, colloids and cells
   Prof. Rudolf Podgornik

R & D GRANTS AND CONTRACTS

1. Integrability and ergodic theory of non-equilibrium quantum many-body systems
   Dr. Jernej Mravlje
2. The many-impurity problem
   Asst. Prof. Rok Žitko
3. Thermodynamics of dissipative nanosystems
   Dr. Jure Kokalj

VISITORS FROM ABROAD

1. Dr. Osor Slaven Barišić, Institut za fiziko, Zagreb, Croatia, 14.-15. 1. 2016
2. Prof. Masayuki Imai, Ochanomizu University, Tokyo, Japan 8. 2.-11. 2. 2016
3. Takuma Kono, Ochanomizu University, Tokyo, Japan, 8. 2.-11. 2. 2016
4. Ryuta Ebihara, Ochanomizu University, Tokyo, Japan, 8. 2.-11. 2. 2016
5. Fagner C. Correia, Institute of Theoretical Physics/UNESP Brazil, São Paulo, Brazil, 5. 2.-30. 7. 2016
6. Dr. Diego Correa, Universidad Nacional de La Plata, La Plata, Argentina, 12. 2. 2016
7. Dr. Sabyasachi Dasgupta, National University of Singapore, Singapore, 4. 3.-6. 4. 2016
8. Dr. Takumi Kuwahara, Nagoya University, Nagoya, Japan, 1.-31. 3. 2016
9. Dr. Robert Triebl, Technical University Graz, Graz, Austria, 29. 2.-3. 3. 2016
10. Dr. Aleksandr Azatov, ICTP, Trieste, Italy, 15. 3. 2016
11. Dr. Fady Bishara, Oxford University, Oxford, Great Britain, 22.-27. 3. 2016
12. Dr. Berislav Buča, Univerza v Splitu, Split, Croatia, 1. 4.-30. 6. 2016
13. Dr. Jacek Herbrych, University of Heraklion, Heraklion, Greece, 4. 4.-12. 4. 2016 in 3.-14. 10. 2016
14. Prof. Dr. John H. Jefferson University of Lancaster, Great Britain, 19.-27. 4. 2016
15. Dr. Luiz Vale Silva, Universite Paris Sud, Orsay, France, 20.-22. 4. 2016
16. Prof. Dr. Sean Tulin, York University, Toronto, Canada, 9.-13. 5. 2016
17. Dr. Oleg Lebedev, University of Helsinki, Helsinki, Finland, 2.-6. 5. 2016
18. Dr. Willem-Victor van Gerven, Institut za fiziko, Belgrade, Serbia, 1.-30. 6. 2016
19. Jan Skolimowski, Institute of Theoretical Physics, University of Warsaw, Warsaw, Poland 16.-18. 5. 2016 in 3. 9. - 31. 10. 2016
20. Dr. Juan Carlos Vasquez Carmona, SISSA, Trieste, Italy, 16.-27. 5. 2016
21. Dr. Aielet Alfrati, Weizmann institute, Rehovot, Israel, 17.-20. 5. 2016
22. Dr. Olcyr Sumensari, Universite Paris Sud, Orsay, France, 23.-27. 5. 2016
23. Prof. Marcin Mierzejewski, University of Katowice, Katowice, Poland, 20.-29. 5. 2016
24. Dr. Ezequiel Alvarez, University of Buenos Aires, Buenos Aires, Argentina, 20.-26. 6. 2016
25. Dr. Darko Tanasković, Institut za fiziko, Belgrade, Serbia, 12.-18. 6. 2016
26. Prof. Dr. Leonid Glozman, University of Graz, Graz, Austria, 26.-27. 5. 2016
27. Dr. Pier Paolo Baruselli, TU Dresden, Germany in SISSA, Trieste, Italy, 31. 5. 2016
28. Dr. Adam Falkowski, Laboratory of Theoretical Physics Orsay, Universite Paris Sud, Paris France, 9.-14. 6. 2016
29. Dr. Mathias Pierre Laboratory of Theoretical Physics Orsay, Universite Paris Sud, Paris France, 9.-14. 6. 2016
30. Dr. Vid Iršič iz ICTP, Trieste, Italy, 23. 6. 2016
31. Dr. Matteo Lotito, University of Cincinnati, Cincinnati, USA, 27. 6. 2016
32. Dr. Josef Pradler, Austrian Academy of Sciences, Vienna, Austria, 7.-8. 7. 2016
33. Dr. Thomas Jacques, SISSA, Trieste, Italy, 14. 7. 2016
34. Miroslav Andjelković, Vinča Institute of Nuclear Science, Belgrade, Serbia, 14.-24. 7. 2016
35. Prof. Ross McKenzie, University of Queensland, Brisbane, Australia, 15.-26. 8. 2016
36. Dr. Admir Greljo, Universität Zürich, Physik-Institut, Zürich, Switzerland, 18.-26. 8. 2016
37. Dr. Banasri Basu, Indian Statistical Institute, Kolkata, India, 23. 8. do 26. 8. 2016
38. Sangeeta Rani Ujjwal, School of Physical Sciences, Jawaharlal Nehru University, New Delhi, India, 11.-18. 9. 2016
39. Dr. Osor Slaven Barišić, Institut za fiziko, Zagreb, Croatia, 28. 9. 2016
40. Dr. Jure Zupan, CERN, Geneva, Switzerland, 18.-23. 10. 2016
41. Dr. Tanja Rindler-Daller, University of Vienna, Vienna, Austria, 13.-16. 10. 2016
42. Dr. Luca Tubiana, University of Vienna, Vienna, Austria, 30. 11. - 2. 12. 2016
43. Dr. Andrea Wulzer, CERN/EPFL, Geneva, Lausanne, Switzerland, 7.-8. 12. 2016
44. Dr. Marija Mitrovič Dankulov, Institut za fiziko, Belgrade, Serbia, 27. 11. - 11. 12. 2016

STAFF

Researchers

1. Prof. Borut Bajc
2. Prof. Janez Bonča*
3. Prof. Milan Brumen*
4. Prof. Mojca Čepič*
5. **Prof. Svjetlana Fajfer*, Head**
6. Prof. Jernej Fesel Kamenik
7. Prof. Bojan Golli
8. Dr. Jure Kokalj*
9. Dr. Nejc Košnik
10. Dr. Rajmund Krivec
11. *Dr. Bing Sui Lu, left 16.08.16*
12. Dr. Jernej Mravlje
13. Asst. Prof. Miha Nemevšek
14. Prof. Rudolf Podgornik*
15. Asst. Prof. Anita Prapotnik Brdnik*
16. Prof. Peter Prelovšek
17. Prof. Saša Prelovšek Komelj
18. Prof. Anton Ramšak*
19. Dr. Tomaž Rejec*
20. Prof. Bosiljka Tadić
21. Prof. Nataša Vaupotič*
22. Prof. Primož Ziherl*
23. Asst. Prof. Rok Žitko

Postdoctoral associates

24. Dr. Nataša Adžić
25. Dr. Tilen Čadež
26. Dr. Jan Kogoj
27. Dr. Anže Lošdorfer Božič
28. *Dr. Tjaša Švelc Kebe, left 01.02.16*
29. Dr. Lev Vidmar

Postgraduates

30. Andreas Kyriakos Doukas, B. Sc.
31. Darius Alexander Faroughy Carias, B. Sc.
32. Jakob Frontini, B. Sc.
33. Victor Francisco Guada Escalona, B. Sc.
34. Alen Horvat, B. Sc.
35. Matej Krajnc, B. Sc.
36. *Dr. Žiga Osolin, left 01.07.16*
37. Urša Skerbiš, B. Sc.
38. Lara Ulčakar, B. Sc.
39. Luiz Henrique Vale Silva, B. Sc.

Technical and administrative staff

40. Nevenka Hauschild

Note:

* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Nataša Adžić, Rudolf Podgornik, "Titratable macroions in multivalent electrolyte solutions: strong coupling dressed ion approach", *J. chem. phys.*, vol. 144, iss. 21, pp. 214901-1-214901-11, 2016.
2. Markus Aichhorn *et al.* (12 authors), "TRIQS/DFTTools: a TRIQS application for ab initio calculations of correlated materials", *Comput. phys. commun.*, vol. 204, pp. 200-208, 2016.
3. M. Alphan Aksoyoglu, Rudolf Podgornik, Sergey M. Bezrukov, Philip A. Gurnev, Murugappan Muthukumar, Vozken Adrian Parsegian, "Size-dependent forced PEG partitioning into channels: VDAC, OmpC, and α-hemolysin", *Proc. Natl. Acad. Sci. U. S. A.*, vol. 113, no. 32, pp. 9003-9008, 2016.
4. Miroslav Andjelković, Bosiljka Tadić, Marija Mitrović, Milan Rajković, Roderick Melnik, "Topology of innovation spaces in the knowledge networks emerging through questions-and-answers", *PloS one*, vol. 11, no. 5, pp. 0154655 -1- 0154655 -17, 2016.
5. K. S. Babu, Borut Bajc, Shaikh Saad, "New class of SO(10) models for flavor", *Phys. rev., D*, vol. 94, no. 1, pp. 015030 -1-015030 -28, 2016.
6. Borut Bajc, Junji Hisano, Takumi Kuwahara, Yuji Omura, "Threshold corrections to dimension-six proton decay operators in non-minimal SUSY SU(5) GUTs", *Nucl. phys, Sect. B*, vol. 910, pp. 1-22, 2016.
7. Borut Bajc, Stéphane Lavignac, Timon Mede, "Resurrecting the minimal renormalizable supersymmetric SU(5) model", *J. high energy phys.*, vol. 2016, no. 1, pp. 044-1-044-54, 2016.
8. Borut Bajc, Francesco Sannino, "Asymptotically safe grand unification", *J. high energy phys.*, vol. 2016, no. 12, pp. 141-1-141-20, 2016.
9. Borut Bajc, Aleyei Yu. Smirnov, "Hidden flavor symmetries of SO(10) GUT", *Nucl. phys, Sect. B*, vol. 909, pp. 954-979, 2016.

10. Osor S. Barišić, Jure Kokalj, Ivan Balog, Peter Prelovšek, "Dynamical conductivity and its fluctuations along the crossover to many-body localization", *Phys. rev., B, Condens. matter mater. phys.*, vol. 94, no. 4, pp. 045126-1-045126-6, 2016.
11. Damir Bečirević, Svjetlana Fajfer, Nejc Košnik, Olcyr Sumensari, "Leptoquark model to explain the B-physics anomalies, R_K and R_D", *Phys. rev., D*, vol. 94, no. 11, pp. 115021-1-115021-7, 2016.
12. Damir Bečirević, Nejc Košnik, O. Sumensari, R. Zukanovich Funchal, "Palatable leptoquark scenarios for lepton flavor violation in exclusive $b \to s\ell_1\ell_2$ modes", *J. high energy phys.*, vol. 2016, no. 11, pp. 035-1–035-30, 2016.
13. José Rafael Bordin, Rudolf Podgornik, Christian Holm, "Static polarizability effects on counterion distributions near charged dielectric surfaces: a coarse-grained molecular dynamics study employing the Drude model", *Eur. phys. j., spec. top.*, vol. 225, iss. 8, pp. 1693-1705, 2016.
14. José M. P. Carmelo, Tilen Čadež, "Pseudofermion dynamical theory for the spin dynamical correlation functions of the half-filled 1D Hubbard model", *Nucl. phys, Sect. B*, vol. 904, pp. 39-85, 2016.
15. Fagner C. Correia, Svjetlana Fajfer, "Restrained dark $U(1)_d$ at low energies", *Phys. rev., D*, vol. 94, iss. 11, pp. 115023-1-115023-10, 2016.
16. Tilen Čadež, Pedro D. Sacramento, "Zero energy modes in a superconductor with ferromagnetic adatom chains and quantum phase transitions", *J. phys., Condens. matter*, vol. 28, no. 49, pp. 1-11, 2016.
17. David S. Dean, Bing-Sui Lu, A. C. Maggs, Rudolf Podgornik, "Nonequilibrium tuning of the thermal Casimir effect", *Phys. rev. lett.*, vol. 116, iss. 24, pp. 240602-1-240602-5, 2016.
18. V. Démery, R. Monsarrat, David S. Dean, Rudolf Podgornik, "Phase diagram of a bulk 1d lattice Coulomb gas", *Europhys. lett.*, vol. 113, no. 1, pp. 18008-p1-18008-p6, 2016.
19. Ilja Doršner, Svjetlana Fajfer, Nejc Košnik, "Is symmetry breaking of SU(5) theory responsible for the diphoton excess?", *Phys. rev., D*, vol. 94, no. 1, pp. 015009-1-015009-8, 2016.
20. D. Drosdoff, Igor V. Bondarev, Allan Widom, Rudolf Podgornik, Lilia M. Woods, "Charge-induced fluctuation forces in graphitic nanostructures", *Phys. rev., X*, vol. 6, iss. 1, pp. 011004-1-011004-7, 2016.
21. Jay Eifler, Rudolf Podgornik, Nicole F. Steinmetz, Roger H. French, Vozken Adrian Parsegian, Wai-Yim Ching, "Charge distribution and hydrogen bonding of a collagen α_2-chain in vacuum, hydrated, neutral, and charged structural models", *Int. j. quant. chem.*, vol. 116, iss. 9, pp. 681-691, 2016.
22. Gonca Erdemci-Tandogan, Jef Wagner, Paul van der Schoot, Rudolf Podgornik, Roya Zandi, "Effects of RNA branching on the electrostatic stabilization of viruses", *Phys. rev., E*, vol. 94, iss. 2, pp. 022408-1-022408-10, 2016.
23. Svjetlana Fajfer, Nejc Košnik, "Vector leptoquark resolution of R_K and $R_{D^{(*)}}$ puzzles", *Phys. lett., Sect. B*, vol. 755, pp. 270-274, 2016.
24. Svjetlana Fajfer, Anita Prapotnik Brdnik, "Isospin violating decays of positive parity B_s mesons in HMχPT", *The European physical journal. C*, vol. 76, art. no. 537, 11 pp., Oct. 2016.
25. Adam Falkowski, Jernej Kamenik, "Diphoton portal to warped gravity", *Phys. rev., D*, vol. 94, no. 1, pp. 015008-1-015008-11, 2016.
26. Roberto Franceschini, Fabio Giudice, Jernej Kamenik, Matthew McCullough, Francesco Riva, Alessandro Strumia, Riccardo Torre, "Digamma, what next?", *J. high energy phys.*, vol. 2016, no. 07, pp. 150-1–150-52, 2016.
27. Roberto Franceschini, Gian F. Giudice, Jernej Kamenik, Matthew McCullough, Alex Pomarol, Riccardo Rattazzi, Michele Redi, Francesco Riva, Alessandro Strumia, Riccardo Torre, "What is the [gamma][gamma] resonance at 750 GeV?", *J. high energy phys.*, vol. 2016, no. 3, pp. 144-1-144-45, 2016.
28. Diana Geiger, Uwe Pracht, Martin Dressel, Jernej Mravlje, Melanie Schneider, Philipp Gegenwart, Marc Scheffler, "Terahertz conductivity of $Sr_{1-x}Ca_xRuO_3$", *Physical review. B*, vol. 93, no. 16, pp. 165131-1-165131-9, 2016.
29. Florian Goertz, Jernej Kamenik, Andrey Katz, Marco Nardecchia, "Indirect constraints on the scalar di-photon resonance at the LHC", *J. high energy phys.*, vol. 2016, no. 5, pp. 187-1-187-34, 2016.
30. Bojan Golli, Simon Širca, "Eta and kaon production in a chiral quark model", *The european physical journal. A, Hadrons and nuclei*, vol. 52, art. no. 279, 14 pp., 2016.
31. Ewa Górecka, Nataša Vaupotič, Anna Zep, Damian Pociecha, "From sponges to nanotubes: a change of nanocrystal morphology for acute-angle bent-core molecules", *Angew. Chem. (Int. ed., Internet)*, vol. 55, no. 40, pp. 12238-12242, 2016.
32. Urlich Haish, Jernej Kamenik, "Searching for new spin-0 resonances at LHCb", *Phys. rev., D*, vol. 93, no. 5, pp. 055047 -1-055047 -12.
33. Alen Horvat, Rok Žitko, Jernej Mravlje, "Low-energy physics of three-orbital impurity model with Kanamori interaction", *Physical review. B*, vol. 94, no. 16, pp. 165140-1-165140-11, 2016.
34. Mutsuo Igarashi, Peter Jeglič, Andraž Krajnc, Rok Žitko, Takehito Nakano, Yasuo Nozue, Denis Arčon, "Metal-to-insulator crossover in alkali doped zeolite", *Scientific reports*, vol. 6, pp. 18682-1-18682-8, Jan. 2016.
35. Takehiro Jimbo, Yuka Sakuma, Naohito Urakami, Primož Ziherl, Masayuki Imai, "Role of inverse-cone-shape lipids in temperature-controlled self-reproduction of binary vesicles", *Biophys. j.*, vol. 110, no. 7, pp. 1551-1562, 2016.
36. Jernej Kamenik, Michele Redi, "Back to 1974: the q-onium", *Phys. lett., Sect. B*, vol. 760, pp. 158-163, 2016.
37. Jernej Kamenik, Benjamin R. Safdi, Yotam Soreq, Jure Zupan, "Comments on the diphoton excess: critical reappraisal of effective field theory interpretations", *J. high energy phys.*, vol. 2016, no. 07, pp. 042-1-042-25, 2016.
38. Jan Kogoj, Marcin Mierzejewski, Janez Bonča, "Nature of bosonic excitations revealed by high-energy charge carriers", *Phys. rev. lett.*, vol. 117, iss. 22, pp. 227002-1-227002-5, 2016.
39. Jan Kogoj, Lev Vidmar, Marcin Mierzejewski, Stuart A. Trugman, Janez Bonča, "Thermalization after photoexcitation from the perspective of optical spectroscopy", *Phys. rev., B, Condens. matter mater. phys.*, vol. 94, no. 1, pp. 014304-1- 014304-10, 2016.
40. Nejc Košnik, Agnieszka Zuzanna Lorbiecka, Boštjan Mavrič, Božidar Šarler, "A multiphysics and multiscale model for low frequency electromagnetic direct-chill casting", *Journal of physics, Conference series*.
41. Maciej Kozarzewski, Peter Prelovšek, Marcin Mierzejewski, "Distinctive response of many-body localized systems to a strong electric field", *Physical review. B*, vol. 93, iss. 23, pp. 235151-1-235151-7, 2016.
42. Ambrož Kregar, J. H. Jefferson, Anton Ramšak, "Arbitrary qubit transformations on tuneable Rashba rings", *Physical review. B*, vol. 93, iss. 7, pp. 075432-1-075432-9, 2016.
43. Ambrož Kregar, Anton Ramšak, "Exact unitary transformation for Rashba Rings in magnetic and electric fields", *Int. j. mod. phys. b*, vol. 30, iss. 13, pp. 1642016-1-1642016-10, 2016.
44. Christian B. Lang, Daniel Mohler, Saša Prelovšek, "$B_s\pi^+$ scattering and search for X(5568) with lattice QCD", *Phys. rev., D*, vol. 94, iss. 7, pp. 074509-1-074509-7, 2016.
45. Bing-Sui Lu, Santosh Prasad Gupta, Michal Belička, Rudolf Podgornik, Georg Pabst, "Modulation of elasticity and interactions in charged lipid multibilayers: monovalent salt solutions", *Langmuir*, 36 pp..
46. Bing-Sui Lu, Ali Naji, Rudolf Podgornik, "Pseudo-Casimir stresses and elasticity of a confined elastomer film", *Soft matter*, vol. 12, iss. 19, pp. 4384-4396, 2016.
47. Bing-Sui Lu, Ali Naji, Rudolf Podgornik, "Van der Waals interactions between polymers with sequence-specific polarizabilities: stiff polymers and Gaussian coils", *Int. j. mod. phys. A*, vol. 31, no. 2/3, pp. 1641035-1-1641035-15, 2016.
48. Bing-Sui Lu, Rudolf Podgornik, "Van der Waals torque and force between dielectrically anisotropic layered media", *J. chem. phys.*, vol. 145, iss. 4, pp. 044707-1-044707-21, 2016.
49. A. C. Maggs, Rudolf Podgornik, "General theory of asymmetric steric interactions in electrostatic double layers", *Soft matter*, vol. 12, iss. 4, pp. 1219-1229, 2016.
50. Alessio Maiezza, Miha Nemevšek, Fabrizio Nesti, "Perturbativity and mass scales in the minimal left-right symmetric model", *Phys. rev., D*, vol. 94, no. 3, pp. 035008-1-035008-11, 2016.
51. Tomer Markovich, David Andelman, Rudolf Podgornik, "Charge regulation: a generalized boundary condition?", *Europhys. lett.*, vol. 113, no. 2, pp. 26004-p1-26004-p6, 2016.
52. Tomer Markovich, David Andelman, Rudolf Podgornik, "Surface tension of acid solutions: fluctuations beyond the non-linear Poisson-Boltzmann theory", *Langmuir*, 14 pp..
53. Joanna Matraszek, Neha Topnani, Nataša Vaupotič, Hideo Takezoe, Jozef Mieczkowski, Damian Pociecha, Ewa Górecka, "Monolayer filaments versus multilayer stacking of bent-core molecules", *Angew. Chem. (Int. ed.)*, vol. 55, iss. 10, pp. 3468-3472, 2016.
54. Zhongtao Mei, Lev Vidmar, F. Heidrich-Meisner, J. C. Bolech, "Unveiling hidden structure of many-body wave functions of integrable systems via sudden-expansion experiments", *Phys. rev., A*, vol. 93, no. 2, pp. 21607-1-21607-7, 2016.
55. Marcin Mierzejewski, Jacek Herbrych, Peter Prelovšek, "Universal dynamics of density correlations at the transition to the many-body

localized state", *Physical review. B*, vol. 94, iss. 22, pp. 224207-1-224207-7, 2016.
56. Christopher Monahan, Ali Naji, Ron R. Horgan, Bing-Sui Lu, Rudolf Podgornik, "Hydrodynamic fluctuation-induced forces in confined fluids", *Soft matter*, vol. 12, iss. 2, pp. 441-459, 2016.
57. Jernej Mravlje, Antoine Georges, "Thermopower and entropy eessons from Sr_2RuO_4", *Phys. rev. lett.*, vol. 117, no. 3, pp. 036401-1-036401-5, 2016.
58. Saeed Najafi, Rudolf Podgornik, Raffaello Potestio, Luca Tubiana, "Role of bending energy and knot chirality in knot distribution and their effective interaction along stretched semiflexible polymers", *Polymers (Basel)*, vol. 8, art. no. 347, 16 pp., Oct. 2016.
59. Saeed Najafi, Luca Tubiana, Rudolf Podgornik, Raffaello Potestio, "Chirality modifies the interaction between knots", *Europhys. lett.*, vol. 114, no. 5, pp. 50007-p1-50007-p6, 2016.
60. Edward Perepelitsky, Andrew Galatas, Jernej Mravlje, Rok Žitko, Ehsan Khatami, B. Sriram Shastry, Antoine Georges, "Transport and optical conductivity in the Hubbard model: a high-temperature expansion perspective", *Physical review. B*, vol. 94, no. 23, pp. 235115-1-235115-26, 2016.
61. Rudolf Podgornik, M. Alphan Aksoyoglu, Selcuk Yasar, Daniel Svenšek, Vozken Adrian Parsegian, "DNA equation of state: In vitro vs in viro", *J. phys. chem., B Condens. mater. surf. interfaces biophys.*, vol. 120, iss. 26, pp. 6051-6060, 2016.
62. Peter Prelovšek, "Decay of density waves in coupled one-dimensional many-body-localized systems", *Physical review. B*, vol. 94, iss. 14, pp. 144204-1-144204-6, 2016.
63. Peter Prelovšek, Osor S. Barišić, Marko Žnidarič, "Absence of full many-body localization in the disordered Hubbard chain", *Physical review. B*, vol. 94, iss. 24, pp. 241104-1-241104-5, 2016.
64. Kristina Serec, Sanja Dolanski Babić, Rudolf Podgornik, Silvija Tomić, "Effect of magnesium ions on the structure of DNA thin films: an infrared spectroscopy study", *Nucleic acids res.*, vol. 44, no. 17, pp. 8456-8464, 2016.
65. Hamid R. Shojaei, Anže Lošdorfer Božič, Murugappan Muthukumar, Rudolf Podgornik, "Effects of long-range interactions on curvature energies of viral shells", *Phys. rev., E*, vol. 93, iss. 5, pp. 052415-1-052415-10, 2016.
66. Daniel Svenšek, Rudolf Podgornik, "Generalized conservation law for main-chain polymer nematics", *Phys. rev., E*, vol. 93, iss. 5, pp. 052703-1-052703-7, 2016.
67. Saša Svetina, Gašper Kokot, Tjaša Švelc, Boštjan Žekš, Richard E. Waugh, "A novel strain energy relationship for red blood cell membrane skeleton based on spectrin stiffness and its application to micropipette deformation", *Biomech. model. mechanobiol.*, vol. 15, iss. 3, pp. 745-758, 2016.
68. Tatjana Škrbić, Artem Badasyan, Trinh Xuan Hoang, Rudolf Podgornik, Achille Giacometti, "From polymers to proteins: the effect of side chains and broken symmetry on the formation of secondary structures within a Wang-Landau approach", *Soft matter*, vol. 12, iss. 21, pp. 4783-4793, 2016.
69. Nick Štorgel, Matej Krajnc, Polona Mrak, Jasna Štrus, Primož Ziherl, "Quantitative morphology of epithelial folds", *Biophys. j.*, vol. 110, pp. 269-277, Jan. 2016.
70. Bosiljka Tadić, "Multifractal analysis of Barkhausen noise reveals the dynamic nature of criticality at hysteresis loop", *J. stat. mech.*, vol. 2016, no. 6, pp. 063305-1-063305-22, 2016.
71. Bosiljka Tadić, Miroslav Andjelković, Biljana Mileva-Boshkoska, Zoran Levnajić, "Algebraic topology of multi-brain connectivity networks reveals dissimilarity in functional patterns during spoken communications", *PloS one*, vol. 11, no. 11, pp. e0166787-1-e0166787-25, 2016.
72. Bosiljka Tadić, Miroslav Andjelković, Milovan Šuvakov, "The influence of architecture of nanoparticle networks on collective charge transport revealed by the fractal time series and topology of phase space manifolds", *J. coupled syst. multiscale dyn.*, vol. 4, no. 1, pp. 30-42, 2016.
73. S. B. Tooski, Anton Ramšak, B. R. Bułka, "Regular and singular Fermi liquid in triple quantum dots: coherent transport studies", *Physica, E, Low-dimens. syst. nanostruct.*, vol. 75, pp. 345-352, 2016.
74. S. B. Tooski, Anton Ramšak, B. R. Bułka, "Reprint of: Regular and singular Fermi liquid in triple quantum dots: coherent transport studies", *Physica, E, Low-dimens. syst. nanostruct.*, vol. 82, pp. 366-373, 2016.
75. Lara Ulčakar, Tomaž Rejec, Anton Ramšak, "Linear conductances of gated graphene structures with selected connectivity", *Acta chim. slov. (Print ed.)*, vol. 63, no. 3, pp. 583-588, 2016.
76. Janez Urevc, Miroslav Halilovič, Milan Brumen, Boris Štok, "An approach to consider the arterial residual stresses in modelling of a patient-specific artery", *Adv. Mech. Eng.*, vol. 8, [nr.] 11, f. 1-19, Nov. 2016.
77. Janez Urevc, Iztok Žun, Milan Brumen, Boris Štok, "Modeling the effect of red blood cells deformability on blood flow conditions in human carotid artery bifurcation", *J. biomech. eng.*, vol. 139, iss. 1, f. [1-11], Nov. 2016.
78. Nataša Vaupotič, Samo Curk, Mikhail Osipov, Mojca Čepič, Hideo Takezoe, Ewa Górecka, "Short-range smectic fluctuations and the flexoelectric model of modulated nematic liquid crystal", *Phys. rev., E Stat. nonlinear soft matter phys.*, vol. 93, no. 2, pp. 022704-1-022704-5, 2016.
79. Lev Vidmar, Marcos Rigol, "Generalized Gibbs ensemble in integrable lattice models", *J. stat. mech.*, vol. 2016, no. 6, pp. 064007-1-064007-48, 2016.
80. Selcuk Yasar, Jacob B. Schimelman, M. Alphan Aksoyoglu, Nicole F. Steinmetz, Roger H. French, Vozken Adrian Parsegian, Rudolf Podgornik, "X-ray characterization of mesophases of human telomeric G-quadruplexes and other DNA analogues", *Scientific reports*, vol. 6, art. no. 27079, 9 pp., 2016.
81. Julija Zavadlav, Rudolf Podgornik, Manuel Nuno Melo, Siewert J. Marrink, Matej Praprotnik, "Adaptive resolution simulation of an atomistic DNA molecule in MARTINI salt solution", *Eur. phys. j., spec. top.*, vol. 225, iss. 8, pp. 1595-1607, 2016.
82. Rok Žitko, "Spectral properties of Shiba subgap states at finite temperatures", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 19, pp. 195125-1-195125-10, 2016.
83. Rok Žitko, Alen Horvat, "Kondo effect at low electron density and high particle-hole asymmetry in 1D, 2D, and 3D", *Physical review. B*, vol. 94, no. 12, pp. 125138-1-125138-8, 2016.

Review Article

1. Ilja Doršner, Svjetlana Fajfer, Admir Greljo, Jernej Kamenik, Nejc Košnik, "Physics of leptoquarks in precision experiments and at particle colliders", *Phys. rep.*, vol. 641, pp. 1-68, 2016.
2. Lilia M. Woods, D. A. R. Dalvit, Alexandre Tkatchenko, P. Rodriguez-Lopez, A. W. Rodriguez, Rudolf Podgornik, "Materials perspective on Casimir and van der Waals interactions", *Rev. mod. phys.*, vol. 88, iss. 4, pp. 045003-1-045003-48, 2016.

Short Article

1. Rajmund Krivec, "Rowing times from Athens to Mytilene: implications of misreading Thucydides for 5th-century Greek trireme speed: note", *Int. j. naut. archaeol.*, vol. 54, no. 1, pp. 199-201, 2016.

Published Conference Contribution (invited lecture)

1. Jernej Kamenik, "Flavour physics and CP violation", In: *Proceedings of the 2014 European School of High-Energy Physics, 18 June -1 July 2014, Garderen, the Netherlands*, (CERN yellow reports, vol. 3), pp. 79-94.
2. Bosiljka Tadić, "Geometrical interpretation of complex signals as a tool to study fluctuations at nanoscale", In: *Proceedings of the 16th International Conference on Computational and Mathematical Methods in Science and Engineering, CMMSE 2016, July 4th - 8th, 2016, Cádis, Spain*, pp. 1193-1196.

Published Conference Contribution

1. Borut Bajc, "Interplay between grand unification and supersymmetry in SU(5) and E6", In: *Proceedings of UNICOS-2014 International Workshop on Unification and Cosmology after Higgs Discovery and BICEP2, 13-15 May 2014, Chandigarh, India*, (Pranama, vol. 86, no. 2, 2016), pp. 231-244.
2. Bojan Golli, Simon Širca, "Puzzles in eta photoproduction: the 1685 MeV narrow peak: B. Golli and S. Širca", In: *Proceedings to the Mini-Workshop Quarks, Hadrons, Matter, Bled, Slovenia, July 3-10, 2016*, (Blejske delavnice iz fizike, vol. 17, no. 1), pp. 44-49.
3. Maša Kenda, Miha Slapničar, Bojan Golli, "Uporaba svetlečih palčk pri pouku kemije in fizike", In: *Sodobni pristopi poučevanja prihajajočih generacij*, pp. 996-1006.
4. Nejc Košnik, "New physics facing LFU and LFV tests in B physics", In: *4th Annual Large Hadron Collider Physics, 13-18 June 2016 Lund, Sweden*, (Proceedings of science, Vol. 2016), pp. 064-1-064-8.

5. Saša Prelovšek, "Hadron spectroscopy and interactions from lattice QCD", In: *QCD@Work 2016*, (EPJ web of conferences, vol. 129, 2016), International Workshop on Quantum Chromodynamics - Theory and Experiment, Martina Franca, Italy, June 27-30, 2016, 8 pp..
6. Saša Prelovšek, Christian B. Lang, Luka Leskovec, Daniel Mohler, "Lattice QCD simulations of the Z_c^+ channel", In: *XIth Conference on Quark Confinement and Hadron Spectrum, 8-12 September 2014, Saint Petersburg, Russia*, (AIP conference proceedings, 1701), pp. 050012-1-050012-6.
7. Saša Prelovšek, Urša Skerbiš, Christian B. Lang, "Operators for scattering of particles with spin", In: *34th annual International Symposium on Lattice Field Theory, LATTICE2016, University of Southampton, UK*, (Proceedings of science), 7 pp..
8. Primož Ziherl, Tomonari Dotera, "A geometric view of structure formation in soft colloids", In: *Soft matter self-assembly: proceedings of the International School of Physics "Enrico Fermi", Course 193, Varenna on Lake Como, 29 June-7 July 2015*, (Proceedings of the International School od Physics "Enrico Fermi", course 193), pp. 307-329.

Independent Component Part or a Chapter in a Monograph

1. Gregor Trefalt, Bosiljka Tadić, Barbara Malič, "Modeling of colloidal suspensions for the synthesis of the ferroelectric oxides with complex chemical composition", In: *Nanoscale ferroelectrics and multiferroics: key processing and characterization issues, and nanoscale effects. Vol. I and II*, Miguel Algueró, J. Marti Gregg, ed., Liliana Mitoseriu, ed., New York, Wiley, 2016, pp. 100-117.

University, Higher Education or Higher Vocational Education Textbook

1. Simon Čopar, Daniel Svenšek, Aleš Mohorič, Saša Prelovšek, *Rešene kolokvijske naloge iz fizike I in II*, (Zbirka izbranih poglavij iz fizike, 50), Ljubljana, DMFA - založništvo, 2016.

Mentoring

1. Ana Gostinčar-Blagotinšek, *Inquiry-based teaching of physics-related topics in primary science:* doctoral dissertation, Ljubljana, 2016 (mentor Mojca Čepič).
2. Janez Urevc, *Characterizing the mechanical response of human carotid artery in physiological state:* doctoral dissertation, Ljubljana, 2016 (mentor Boris Štok; co-mentor Milan Brumen).
3. Nataša Adžić, *Varieties and phenomenology of electrostatic interactions in protein physics:* doctoral dissertation, Ljubljana, 2016 (mentor Rudolf Podgornik).
4. Urška Jelerčič, *Mechanical models of cell organelles:* doctoral dissertation, Ljubljana, 2016 (mentor Primož Ziherl).
5. Jan Kogoj, *Microscopic mechanisms of ultra fast relaxation in correlated electron systems:* doctoral dissertation, Ljubljana, 2016 (mentor Janez Bonča).
6. Ambrož Kregar, *Spin-charge states in the presence of spin-orbit coupling:* doctoral dissertation, Ljubljana, 2016 (mentor Anton Ramšak).
7. Kristina Leskovar, *Ferroelectric smectic-A phase made of bent-core liquid crystals:* doctoral dissertation, Maribor, 2016 (mentor Nataša Vaupotič).
8. Žiga Osolin, *Strong correlations and magnetism in the Kondo lattice model:* doctoral dissertation, Ljubljana, 2016 (mentor Rok Žitko).
9. Maja Pečar, *Konoskopija in poučevanje anizotropnih optičnih lastnosti snovi:* doctoral dissertation, Ljubljana, 2016 (mentor Mojca Čepič).
10. Matej Erjavec, *Bottle model of colour vision:* master's thesis, Maribor, 2016 (mentor Nataša Vaupotič).
11. Neda Gačnik Čebulj, *Primary students' comprehension of density concept:* master's thesis, Ljubljana, 2016 (mentor Mojca Čepič).
12. Damjan Gašparič, *Measurments and Analysis of the Vertical Jump and its Use at the Physics Lessons in Primary School:* master's thesis, Maribor, 2016 (mentor Milan Brumen; co-mentor Robert Repnik).
13. Marko Rožič, *Video clip as a didactic accessory in physics classes:* master's thesis, Ljubljana, 2016 (mentor Bojan Golli).
14. Bernarda Urankar, *Active liquid crystal optical protective filter:* master's thesis, Maribor, 2016 (mentor Mojca Čepič).
15. Monika Hadalin, *Energy flow in a model of the solar collector:* master's thesis, Ljubljana, 2016 (mentor Bojan Golli).
16. Matija Kuclar, *Signali nove fizike v semileptonskih razpadih mezona B v stanja čarobnih mezonov s pozitivno parnostjo:* master's thesis, Ljubljana, 2016 (mentor Svjetlana Fajfer).
17. Črt Lozej, *Časovno odvisen transport naboja in toplote skozi kvantno piko:* master's thesis, Ljubljana, 2016 (mentor Tomaž Rejec).
18. Tadej Mežnaršič, *Laser Cooling of Cesium Atoms:* master's thesis, Ljubljana, 2016 (mentor Rok Žitko; co-mentor Peter Jeglič).
19. Jan Ornik, *Novel concepts for the detection of microplastics:* master's thesis, Maribor, 2016 (mentor Nataša Vaupotič; co-mentor Jan C. Balzer).
20. Klemen Pečnik, *Uporaba NMR spektroskopije in metod strojnega učenja za natančnejše iskanje biomarkerjev tumorskih celic:* master's thesis, Ljubljana, 2016 (mentor Primož Ziherl; co-mentors Janez Plavec, Gregor Serša).
21. Lara Ulčakar, *Stabilnost magičnih razmerij prevodnosti majhnih grafenskih sistemov:* master's thesis, Ljubljana, 2016 (mentor Anton Ramšak; co-mentor Tomaž Rejec).
22. Marion Antonia van Midden, *Reconstruction of the intrinsic spectral function of the magnetic adatoms on superconductor surfaces from the differential conductance:* master's thesis, Ljubljana, 2016 (mentor Rok Žitko).

DEPARTMENT OF LOW AND MEDIUM ENERGY PHYSICS F-2

The Department of Low and Medium Energy Physics is engaged in research in the field of atomic and nuclear physics. The knowledge and expertise acquired in basic research is exploited for numerous applications, including radiological monitoring of the environment, in materials research, fusion, biology, energy storage, medicine, pharmacology, environment and archaeometry. Research is executed with our own instrumentation, consisting of ion accelerator and beamlines, dedicated detectors of ionizing radiation, experimental setups for atomic physics and calibrated radiation fields. In addition, researchers from the department are granted access to large scientific installations worldwide, including accelerators, synchrotrons, free-electron lasers, fusion reactors and plasma guns.

Head:
Prof. Primož Pelicon

In 2016, within the A1 Collaboration at the microtron MAMI (University of Mainz, Germany), we have continued with the measurement of quasi-elastic electron scattering on deuteron and carbon nuclei, in which we have used a polarimeter to detect the recoil proton polarization components. The purpose of both these measurements is to determine whether the nuclear environment (for example, by its increased local density) influences the elastic form factors of the nucleons and whether the polarization transfer to the outgoing proton is driven by some kinematic quantity, for example, the amount of the proton being off its relativistic mass shell.

We continued the innovation work in the field of instrumentation in medical physics. A national patent "Angle-sensitive gamma camera with a rotary obstruction" was obtained in a close collaboration with the Institute of Oncology in Ljubljana. A connected patent is meanwhile undergoing a grant procedure in the United Kingdom.

We have continued our analysis of the method for the initial-state radiation (ISR) experiment and have submitted a paper for publication. The analysis of virtual Compton scattering at low momentum transfer, dedicated to the determination of generalized polarizabilities of the proton, and the analysis of electro-production of neutral pions in the energy region of the Roper resonance are also in their final stages. In addition, we completed the third production beam-time devoted to measurements of parity-violating electron scattering in which transversely polarized electrons are used and which offer a completely different sensitivity to the strange-quark content in the protons and their contribution to the electro-magnetic form-factors.

At the Thomas Jefferson National Accelerator Facility (Jefferson Lab) we have continued our measurement of real Compton scattering on the protons at high momentum transfers in the regime of the large Mandelstam variables s, t, and u, as well as the second part of the experiment, which is aimed at determining the magnetic form-factor of the proton at high momentum transfers (up to 18 GeV^2).

In 2016 we studied electron screening in the nuclear reaction between protons and deuterons at a proton beam energy of 260 keV. This reaction is important in the p-p chain, which dominates the energy production in the Sun and other similar stars. We were checking the hypothesis whether the resulting ^{3}He emits an electron instead of a gamma ray. For this purpose we made an electron detection system for electron energies between one and ten MeV. Connected to our membership in the NUSTAR collaboration at the ESFRI infrastructure FAIR in Darmstadt, we proposed an experiment in which we would study isomeric excited states of heavy lead nuclei Pb-212, 214 and 216. In addition, we applied for a Slovenian-German bilateral cooperation project between JSI and centre FAIR. Within the proposed project, we would improve the active shielding of the DEGAS germanium detector array. Within the engagement at FAIR, we will host the NUSTAR collaboration annual meeting at JSI in 2017.

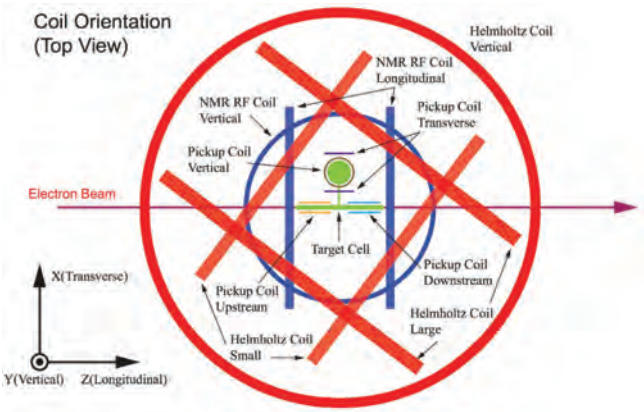


Figure 1: The polarized 3He target setup used in several recent Jefferson Lab experiments dedicated to the study of neutron structure functions and investigations of electromagnetic and spin structure of 3He. The Helmholtz coils provide the holding magnetic field while the RF coils closer to the target cell are used for measurements of the degree of polarization by nuclear magnetic resonance techniques (Flay et al., Phys. Rev. C, 2016, 94, 052003).

We have published several papers in the field of hadronic physics; the most important among them are the results of our study of eta and kaon production in chiral quark models (*Golli in Širca, Eur. Phys. Jour. 2016*), the report on measurements of d2n and A1n in order to probe the neutron spin structure (*Flay et al. Phys. Rev. D 2016*), the paper on the ground-state binding energy of 4ΛH hypernucleus from high-resolution decay-pion

spectroscopy (*Schulz et al., Nucl. Phys. A 2016*), as well as on the electro-excitation of the Δ(1232) resonance (*Blomberg et al., Phys. Lett. B 2016*).

We continued the innovation work at the field of instrumentation in medical physics. A national patent, ""Angle-sensitive gamma camera with a rotary obstruction" *Vencelj et al, SI 24818 A, WO 2016050631 A1,* was granted for the work in a close collaboration with the Institute of Oncology in Ljubljana. Three system houses active in the market of medical instruments have so far inquired regarding the transfer of patent rights. A connected patent is meanwhile undergoing a grant procedure in the United Kingdom. A national patent "Process and a device for improvement of operation of silicon photomultipliers in the regime of piled-up pulses of light", *Vencelj et al., SI 24863 A, WO 2016060622 A1,* was granted for the result of a collaboration with Beyond Semiconductor LLC.

The Division of Ionizing Radiation Measurements was conducting the environmental radioactivity monitoring of the living environment in Slovenia, regular Krško Nuclear Power Plant (KNPP) off-site environmental radioactivity monitoring, independent verification of the regular environmental radioactivity monitoring around KNPP, monitoring of radioactivity in fodder, central radioactive waste repository radiological monitoring, monitoring of the radioactivity in drinking water, proficiency tests, material characterizations, calibrations of the radiation gauges and measurements of the personal and environmental doses by thermoluminescent dosimeters.

At the Free-Electron Laser (FEL) LCLS in Stanford we investigated short-lived transient states during the interaction of photoexcited complexes $Fe(CO)_5$ with an ethanol solution. We submitted an experiament proposal at FEL Flash in Hamburg, based on the open issues arising at the last experimental campaign at FEL Fermi in Trieste.

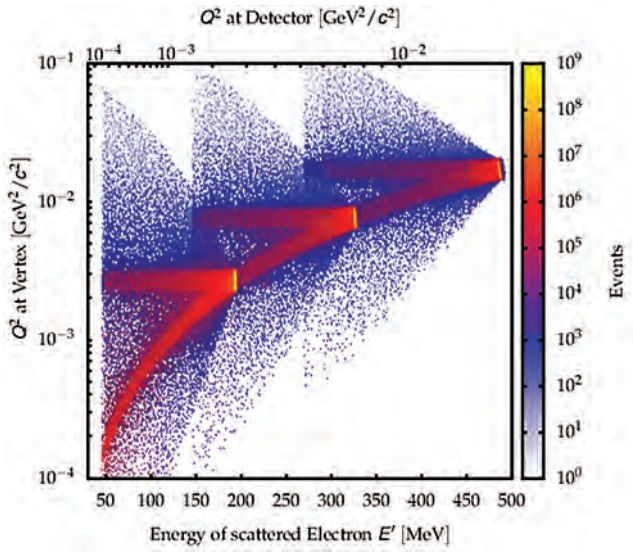


Figure 2: The figure presents the simulation for the Bethe-Heitler initial-state and final-state radiation processes which are being exploited to reach the information on the proton charge form-factors at extremely small four-momentum transfers. Shown is the distribution of events as a function of the momentum of the detected electron (horizontal axis) and the square of the four-momentum transferred from the virtual photon to the proton (vertical axis). In the initial-state radiation (ISR) process the incident electron emits a real photon before interacting with the proton; since the emitted photon carries away part of the incident energy, the momentum transferred to the proton is decreased. Hence, this process opens the possibility to probe the proton structure at extremely small values of Q2 that, using existing apparatus, could not be reached otherwise. (Mihovilović et al., AIP Conf.Proc. 2016, 1701, 040014).

The Laboratory for Dosimetry Standards calibrated a number of measuring devices for radiation dose and ensured measurement traceability in the region. The listed laboratories active in the dosimetry of ionizing radiation are accredited according the standard SIST EN ISO/IEC 17025 and successfully performed at international intercomparisons in 2016. We participated in a number of international programmes and actions, including European Metrology Research Programme (EMRP), EURAMET, MODARIA II and CONCERT. We continued our activities on EMRP projects: "Metro materials with elevated natural radioactivity (MetroNORMprimo)" and "Metrology for radiological early-warning networks in Europe" (ENV57 MetroERM). Our main deliverable was the design and construction of a high-volume flow-rate air-pump with the embedded spectrometric system (Figure 1) for identification of the radionuclides in case of an incidental release. The system was tested in NPL, UK in spring 2016 and at intercomparison measurements at SCK-CEN in Belgium.

Members of the Infrastructure Group took part in regular drills and several special tasks with the radiological mobile unit ELME in Slovenia and participated at international comparison drills in Ronneburg, Germany, at intercomparison measurements at SCK-CEN in Belgium and at international regional drill of fire brigades in Venice.

In the field of theoretical atomic physics we focused our efforts on the development of the model for exact description of resonant decay in two-electron atoms within Exterior complex Scaling approach, as well as with the simulation of the effects of short intense light pulses through a dense gas. This was the foundation for the interpretation and the preparation for the experiments at Free Electron Lasers (FELs), where nonlinear effects need to be taken into account, such as many-photon excitations, and the inverse occupational states as a source of stimulated emission of hard ultraviolet (VUV) and x-ray light. Together with colleagues from the XFEL installation in Hamburg, we prepared an experiment proposal at FEL Flash in Hamburg, based on the open issues arisen at the last experimental campaign at FEL Fermi in Trieste. We want to understand, to what extent the observed stimulated emission in helium is a result of plasma processes, and if their role could be enhanced by excitation via short-lived double excited states. We took part at the experiment at FEL LCLS in Stanford, where we investigated short-lived transient states during the interaction of photo-excited complexes $Fe(CO)_5$ with ethanol solution. At the beamline SuperXAS of the SLS synchrotron in Villigen, Swiss, we executed similar experiment studying the interaction of photo-excited molecules CBr_4 with molecules of methanol solvent. In the time-stamped XANES we observed for the first time the intermediate product HBr, which indicates, that the present understanding of the reaction dynamics

With methods RIXS, XANES and EXAFS, we were probing *in operando* the chemistry of Li-S and Mg-S batteries.

should be redefined. At synchrotron Soleil we participated in the experiment with a magnetic bottle together with colleagues from the University Pierre and Marie Curie, where we studied Auger spectra from the photoionization of SiH_4 and Na. In 2016, we published a study of exotic Auger transition of the Two-Electron-One Electron (TEOE) type, which was executed for the first time with high spectroscopic resolution for the the case of double 2p vacancy in Argon *(Žitnik et al. Phys. Rev. A, 2016)*. With approved beam time at the Galaxies beamline at Soleil, we will extend the research of TEOE to the molecular systems with Cl atoms. In the experiments executed at MaxLab in Lund in collaboration with partners from the University of Oulu, we showed that the decay of CH_3Cl leads to the fragments HCl^+ (figure 3). We described the mechanism of molecular redistribution, which leads to the formation of these fragments (*Kokkonen et al. Phys. Rev. A).*

In the field of high-energy resolution x-ray spectroscopy two experimental runs have been performed at ID26 beamline of the ESRF synchrotron in Grenoble. In collaboration with the group from the Max Planck Institute **for Chemical Physics of Solids from Dresden, we have performed resonant inelastic x-ray scattering (RIXS) measurements** at the Ru-$L_{2,3}$ edges on $RuCl_3$ ($4d^5$) single crystal with a cubic local octahedral symmetry and at the Rh-$L_{2,3}$ edges on Sr_2RhO_4 ($4d^5$) single crystal with a distorted octahedral symmetry. RIXS spectroscopy provides $L_{2,3}$ absorption spectra of 4d transition elements with energy resolution below the 2p core-hole lifetime broadening (HERFD technique), which is crucial to resolve the t_{2g} spectral component. In our experiment we have recorded Ru and Rh $L_{2,3}$ HERFD spectra with energy resolution < 1eV and also their polarization dependence, which will provide a direct information about the purity of J_{eff} =1/2 state of a low-spin (LS) $4d^5$ configuration. In the second experiment performed in collaboration with the group from CEA in Grenoble, *in-operando* RIXS measurements at the sulphur 1s edge were performed on Li-S batteries to characterize the electronic structure of sulphur within the cathode material during the battery cycle. We were studying batteries where the S_8 as the active material in the cathode is replaced by the Li_2S. The main problem in this case is high polarization in the first charge, which is not observed during the following ones. This might be due to differences in the particle size of raw Li_2S material (micron-sized) and the electrochemically produced one in a battery (nano-sized). In addition, we have performed also *ex-situ* RIXS and XAS measurements on magnesium-sulphur (Mg-S) batteries in collaboration with the group from the National Institute of Chemistry in Ljubljana. Among the potential sulphur-based batteries, the combination with Mg represents one of the most promising electrochemical couples. Mg-S batteries are still in the very early stage of research and development. Our experiment will contribute towards better understanding of complex electrochemistry within this novel type of high-energy-density batteries.

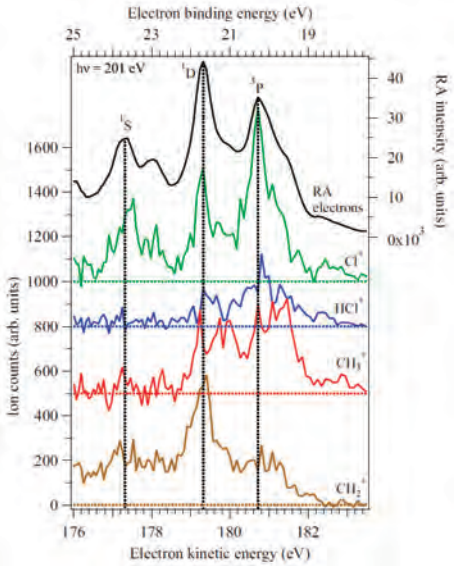


Figure 3: Distribution of the ionic fragments in coincidence with Auger electrons L-V2 after the photo-excitation of 2p electron in LUMO. The HCl+ fragment is formed from the specific final states V-2 only, with the energy of approx. 20 eV (Kokkonen et al., Phys. Rev. A, 2016, 94, 033409).

Chemical shifts of the Kα emission lines in X-ray spectra of P, S and Cl were systematically measured as a function of the chemical environment and reproduced within the numerical calculations using density functional theory.

In 2016 we have published the results of *in-operando* RIXS measurements of sulphur within the Li-S battery, which were performed at ESRF in collaboration with the group from the National Institute of Chemistry in Ljubljana (*Kavčič et al., J. Phys. Chem. C 2016*). By using a selective resonant excitation the sensitivity for the lithium–polysulfide detection was significantly enhanced, while the sulphate signal from the electrolyte was heavily suppressed. This enabled a full quantitative analysis of separate sulphur compounds built up during the battery discharge (Figure 1). The results of our electronic structure study of phosphorus, sulphur, and chlorine in compounds with T_d and C_{3v} local symmetries performed by high-resolution Kβ X-ray emission spectroscopy (XES) were published (*M. Petric et al., Inorg. Chem. 2016)*. Measured spectra were reproduced by the model spectra of isolated XO_4^{n-} and XO_3^{n-} anions (X = P, S, or Cl) calculated within the density functional theory (DFT). The main spectral components were explained by the molecular orbital theory (Figure 2). We have also published the results of our theoretical and experimental studies of the structural and dynamical properties of chlorinated hydrocarbons performed by RIXS at the Cl 1s edge (*Bohinc et al., J. Chem. Phys. 2016*). The energy position, relative intensity, and the width of the Franck-Condon distribution of low-lying σ* and ϖ* resonances were experimentally determined and compared with the theoretical values. In collaboration with the group from University of Helsinki we have published the results of our x-ray emission study of bulk aqueous sulfuric acid (*J. Niskanen et al., Sci. Rep. 2016*). We demonstrated

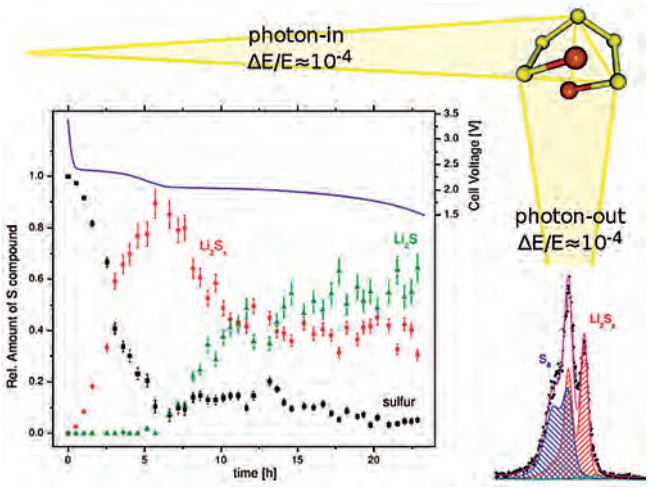


Figure 4: Relative intensity ratios of S8 and Li2Sx compounds within the battery cathode during the discharge process together with the corresponding voltage diagram of the Li–S cell (M. Kavčič et al., J. Phys. Chem. C 2016, 120, 24568–24576).

that the S Kβ emission spectrum is a sensitive probe of the protonation state of the H_2SO_4 molecule and can be used to determine quantitatively the fractions of different protonation states in the system.

In the field of proton-induced x-ray emission spectroscopy performed at the Microanalytical center, we have published the results of systematic experimental and theoretical study of chemical shifts of the characteristic K emission line of phosphorus, sulphur, and chlorine in different compounds covering the full range of oxidation states (*Petric and Kavčič, J. Anal. At. Spectrom. 2016*). The measured shifts reflect directly the effective local charge based on the DFT-calculated valence electron population and can be used to determine the oxidation state of the elements in various chemical environments, spreading the application of PIXE spectroscopy also towards chemical speciation. We have also published the results of the high-energy resolution $K\beta_{1,3}$ x-ray emission measurements of Ar induced in collisions with 0.75–3.0 MeV protons (*Kavčič and Banaś, J. Phys. B: At. Mol. Opt. Phys. 2016*). Measured $K\beta_{1,3}M$ satellite lines were used to extract the M shell single ionization probability for near-central collisions. Experimental values were compared with theoretical predictions. Good agreement was achieved with the values calculated within the semi-classical approximation using DHF wave functions for the description of valence M shell electrons.

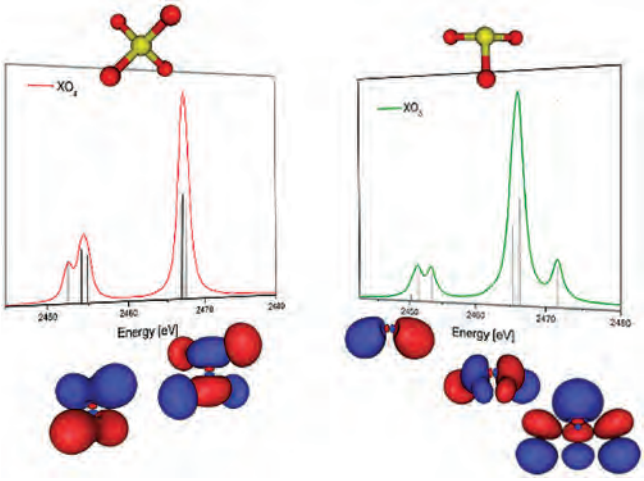


Figure 5: Theoretical Kβ x-ray emission model spectrum of the SO42- in SO32- ions with corresponding molecular orbitals building the main spectral components (M. Petric et al., Inorg. Chem. 2016, 55, 5328–5336).

The research with x-ray absorption spectroscopy was in 2016 performed at three synchrotron facilities: ELETTRA (Trst), PETRA III DESY (Hamburg) and ESRF (Grenoble). In collaboration with the National Institute of Chemistry, Ljubljana, a series of *in-operando* XANES and EXAFS experiments on high-energy-density Li-sulphur and Mg-sulphur batteries with various cathode materials and electrolytes were performed. The XAS spectra were recorded during charging and discharging of the battery. In this way we were able to monitor with high precision the change of valence of sulphur, and the formation of Li- or Mg-polysulphides (Li_2Sx, MgS_x) compounds and finally crystalline Li_2S or MgS during discharge, and reversibility of the process during charging. This key information on the battery dynamics opened the way to an optimization of the synthesis of the material with maximum capacity.

In collaboration with Biotechnical Faculty of University of Ljubljana, Université catholique de Louvain (Belgium), Universitaet Bayreuth, Lehrstuhl Pflanzenphysiologie (Germany), ESRF Grenoble (France), National Agri-Food Biotechnology Institute (India), TU Berlin (Germany), we performed XAS experiments at PETRA III and at ESRF to determine the distribution of pollutant elements (Se, Hg, Cd, Pb) and essential elements (Zn. Cu, Ni, Mn, Fe) in cells to elucidate the molecular and cellular mechanisms which induce the tolerance to the noxious metal cations, or the mechanism of accumulation of essential elements in edible parts of the plants. With micro X-ray spectroscopy analysis at BLIX (TU Berlin) we investigated distribution of toxic elements on a cellular level. We published the results on Fe binding and distribution at the cellular and tissue levels in Tartary buckwheat, which revealed the effects of hydrothermal processing and germination on Fe speciation and Fe bio-accessibility to human intestinal cells *(P.* Pongrac et al., *Food chemistry 2016). In addition we report* on the strategy, how the roots of the metal-resistant plants cope with cadmium and zinc toxicities *(I. Lefevre et al., Plant and soil, 2016*), and on a study of Hg root uptake and ligand environment in fungi. In collaboration with University of Nova Gorica and National Institute of Chemistry, we continued long-term projects involving XANES and EXAFS measurements on the catalytic materials CeO_2 doped with Cu and/or Zr, in operando during catalytic reaction at 400 C, and on TiO_2 and SiO_2 materials doped with Cu and/or Zr or Cr, Mn, Fe, Ni or Zn at room temperature. The valence of dopants and their atomic neighbourhood is determined to elucidate their catalytic properties. The materials aim to commercial applications such as photo catalysis for water cleaning, adsorbents and ion traps, as well as a solid heterogeneous catalysts.

We experimentally demonstrated the synergistic effects of simultaneous structural defect creation and plasma bombardment in tungsten: hydrogen isotopes from plasma inhibit the defect annealing, and thus enhance the structural damage in the tokamak wall.

The collaborative work at the beamlines ALOISA and ANCHOR/HASPES (Laboratory IOM-CNR TASC) at synchrotron Elettra we investigated two-directional charge transfer at organic contacts. Using X-ray resonant photoemission spectroscopy we determined ultrafast charge transfer rates across pyridine/Au(111) interfaces, while also controlling the molecular orientation on the metal. We have shown that a bi-directional charge transfer across the molecule/metal interface is enabled upon creation of a core-exciton with a rate that has a strong dependence on the molecular adsorption angle. These findings give an insight into the charge-transfer dynamics of photo-excited molecules at organometallic interfaces. (Cvetko et al., *Phys.Chem.Chem.Phys.* 2016).

In 2016, we continued with research in fusion, coordinated within EUROfusion Consortium within the Work Package on "Preparation of efficient Plasma-Facing Component (PFC) operation for ITER and DEMO". Major focus

of our research is the study of hydrogen-isotope retention in tungsten material, which is considered to be the most suitable material for plasma-facing components in future fusion reactors such as DEMO. The first important achievement was within the studies of the influence of material displacement damage on fuel retention, where high-energy ion irradiation is used as a surrogate for neutron damaging *(Ogorodnikova et al., J. Appl. Phys. 2016)*. We made one step forward towards more realistic conditions by simultaneous defect creation by 10.8-MeV W-ion implantation and D-atom-beam exposure at five different temperatures between 450 K and 1000 K. Deuterium depth profile was measured by nuclear reaction analysis using $D(^3He,p)\alpha$, which provides a measure of the defect density. The defects can retain hydrogen isotopes with high binding energy. Synergistic effects were observed as predicted by theory, i.e., higher D concentrations were found in the case of simultaneous damaging and D-atom loading as compared to sequential damaging at elevated temperatures and D loading afterwards (figure 5) due to the stabilization of defects by the presence of solute hydrogen in the bulk. Without the presence of hydrogen in the lattice the defects would namely annihilate at higher temperatures. (Markelj et al, Nuclear Materials and Energy 2017). The second achievement was on the subject to study the effect of He on hydrogen-isotope retention and transport, which was new in 2016. Recent experiments studying the interaction of hydrogen isotopes and helium with tungsten using He-seeded deuterium plasmas showed that He addition leads to reduced D retention. On the other hand, theory shows strong attraction between He and hydrogen, indicating preferential trapping of deuterium around implanted He clusters. In order to elucidate the possibility of He acting as a diffusion barrier or inducing preferential binding of hydrogen, we took an alternative experimental approach. He was implanted 1 μm deep into a self-damaged tungsten to concentration of 4 at.%. Deuterium depth profiling was performed in-situ during isothermal annealing in the temperature range from 300 K to 800 K. It is shown for the first time that D accumulated in the He-implanted zone. D retention increased by a factor of two as compared to a non-He implanted tungsten reference. Rate equation modelling can explain the measured D depth profiles quantitatively when keeping the de-trapping parameters unchanged, but only increasing the number of traps in the He zone. This bolsters the confidence in the theoretical calculations predicting that more hydrogen can be stored around the He cluster zone. *(Markelj et al, submitted to Nucl. Fus. Lett.)*. In 2016, an extensive study of the lateral distribution of D, 11B and 15N was performed by the use of focused ion beams on samples exposed in the divertor region of tokamak ASDEX Upgrade in nitrogen-15 seeding and He campaign.

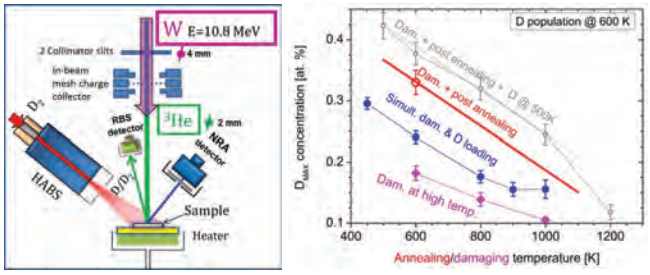


Figure 6: Left: Schematic figure of the INSIBA experimental set-up for simultaneous W-ion irradiation and exposure to atomic deuterium. Right: Maximum deuterium concentration versus annealing/damaging temperatures obtained from deuterium depth profiles on samples damaged at high temperatures and samples simultaneously damaged and deuterium loaded, respectively. The data are compared to results on samples damaged at room temperature and afterwards post-damaging annealed and defect populated by deuterium. (S. Markelj et al., Nucl. Mat. Energ., 2017).

With Mössbauer spectroscopy we studied $FePO_4$ catalysts for the synthesis of methanol from methane with the addition of O_2, N_2O in H_2O as oxidants. We determined the phase changes in fresh, reduced and spent catalysts. The Mössbauer data showed that the $Fe_2P_2O_7$ phase is a dominating phase in the reduced catalyst. Cu-Fe oxide catalysts for partial CO oxidation (POX) in H_2-rich process streams have been studied. The Mössbauer data of the Cu and Fe loaded catalyst showed three well-defined sextets belonging to the tetrahedral and octahedral sites of Fe^{3+} ions.

At the JSI tandem accelerator, we enabled intense research work with high-energy ion beams in 2016. The accelerator delivered over 4000 beam hours to the users at the associated beamlines. In 2016, we initiated an upgrade of the beamline for the in-air beam applications. The insertion of the quadrupole lens and precise slits will allow us the formation of the in-air proton beam with diameter of 50 micrometres. This will enable us to measure the elemental maps with high lateral resolution at the field of archaeometry and biomedicine. With micro-PIXE method, we executed a series of measurements for the users from biomedicine. In collaboration with University Clinical Centre Maribor, we studied the clinical cases of failed hip prostheses. In selected cases, we observed high concentrations of wear metallic particles in the surrounding tissue sampled during the prosthesis replacements *(Fokter et al, Jour. Mech. Beh. Biom. Mat. 2017)*. Within the collaborative work with University in Bayreuth *(Detterback et al., New Phytologist 2016)*, we measured the distribution of nutrients and microelements in the grains of selected barley varieties (figure 7).

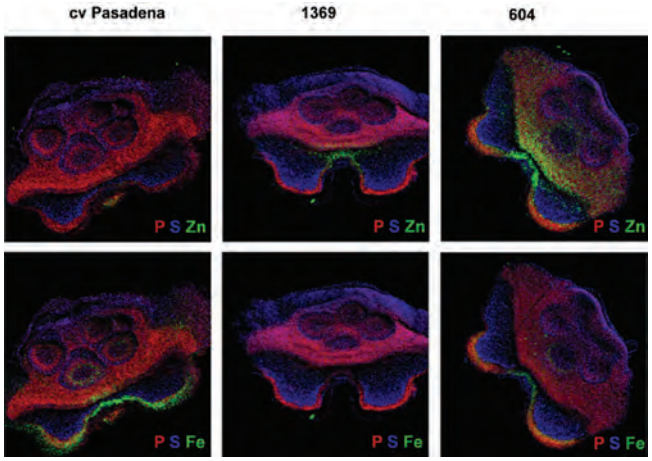


Figure 7: Co-localisation of zinc, iron, phosphorus and sulphur in the cross-section of barley seed, measured by micro-PIXE. From left to right: varieties "cv Pasadena", "1369" with low accumulation ability of zinc, and variety with high accumulation ability of zinc "604" (Detterbeck et al, New Phytologist 211 (2016), 1241).

In the field of archaeometry, most attention was paid to the analysis of archaeological glass. We analysed a series of early medieval glass beads from the sites in Slovenia, which complement our measurements that were

already published in 2012. A detailed report for the magazine "Arheološki vestnik" is under preparation. Further, we measured a series of Late Antique glass from the site Gradina near Jelica in Serbia, which appears as a parallel to the site Tonovcov grad in Slovenia. However, important differences exist between the two sites, as the trace element pattern points to different sources of primary glass. We also contributed to the study of Venetian glass from Dalmatia and medieval Bosnia, which we do in collaboration with archaeologist Nikolina Topić from Dubrovnik and Rudjer Bošković Institute from Zagreb. As part of this work, we analysed a series of glass from medieval Bosnia and pointed out that the glass composition matches the original Venetian glass. Among the work, completed in in previous years but published in 2016, we mention the study of pigments in the hand-painted autobiography of the Austrian diplomat Sigmund Herberstein printed in 1560. We found out that the pigments are based on the iron-gall ink, which has a harmful effect on the paper composition.

We continued the development of the MeV-SIMS method for molecular mapping of biology tissue. The existing method applying a pulsed primary ion beam was upgraded with an approach with a continuum primary beam. Within this upgrade, we install a channeltron that detects each individual arrival of primary ions. This configuration yields excellent lateral resolution of the molecular imaging, as well as better mass resolution due to a better time definition of the start signal. In collaboration with Maastricht University we studied the stigmatic imaging principle with the Time-Of-Flight (TOF) spectrometer for the MeV-SIMS case. For this purpose, we incorporate a TimePIX detector in the spectrometer, which combines both position sensitivity as well as fast timing characteristics required for TOF mass spectroscopy.

Organization of conferences, congresses and meetings

1. MetroNORM Meeting, 23–24 February 2016, Ljubljana

Patents granted

1. Matjaž Vencelj, Larisa Hosnar, Klemen Bučar, Janez Burger, Angle-sensitive gamma camera with a rotary obstruction, SI24818 (A), Slovenian Intellectual Property Office, 31. 03. 2016
2. Matjaž Vencelj, Miha Cankar, Andrej Likar, Process and device for improvement of operation of silicon photomultipliers in the regime of piled-up pulses of light, SI24863 (A), Slovenian Intellectual Property Office, 29. 04. 2016

INTERNATIONAL PROJECTS

1. Calibrations
   Matjaž Mihelič, M. Sc.
2. TLD Dosimetria
   Boštjan Črnič
3. Extraction of Tantalum and Niobium from Ores
   Dr. Marijan Nečemer
   Prg Ltd.
4. FAIR Detectors
   Asst. Prof. Matej Lipoglavšek
   Gsi Helmholtzzentrum
5. 7FP - SPRITE; Supporting Postgraduate Research with Internships in Industry and Training Excellence
   Asst. Prof. Matjaž Kavčič
   European Commission
6. 7FP - PREPARE; Innovative Integrative Tools and Platforms to be Prepared for Radiological
   Emergencies and Post-accident Response in Europe
   Dr. Benjamin Zorko
   European Commission
7. MetroNORM; Metrology for Processing Materials with High Natural Radioactivity
   Branko Vodenik, M. Sc.
   Euramet E.v.
8. MetroERM; Metrology for Radiological Early Warning Networks in Europe
   Denis Glavič Cindro, M. Sc.
   Euramet E.v.
9. COST CM1204: XUV/X-ray Light and Fast Ions for Ultrafast Chemistry (XLIC)
   Prof. Matjaž Žitnik
   Cost Office
10. Hydrogen Retention in Self-damaged and He Irradiated Tungsten Alloys in Fusion Devices; Plasma-Wall Interaction for Irradiated Tungsten and Tungsten Alloys in Fusion Devices
    Asst. Prof. Sabina Markelj
    IAEA - International Atomic Energy Agency
11. RC 18353/R2; Dual Imaging of Biological Samples with MeV SIMS and PIXE Analysis; Development of Molecular Concentration Mapping Techniques using MeV Focussed Ion Beams
    Prof. Primož Pelicon
    IAEA - International Atomic Energy Agency
12. RC 18186/R2; Application of Synchrotron Radiation in Studies of Environmental Impact on Biological Organisms; Experiments with Synchrotron Radiation for Modern Environmental and Industrial Applications
    Prof. Katarina Vogel-Mikuš
    IAEA - International Atomic Energy Agency
13. COST CA16117 - ChETEC; Chemical Elements as Tracers of the Evolution of the Cosmos
    Asst. Prof. Matej Lipoglavšek
    Cost Office
14. H2020 - CONCERT; European Joint Programme for the Integration of Radiation Protection Research
    Dr. Benjamin Zorko
    European Commission
15. Education-ED-FU, EUROFUSION
    Prof. Primož Pelicon
    European Commission
16. Plasma Facing Components-1-IPH-FU, EUROFUSION
    Asst. Prof. Sabina Markelj
    European Commission
17. Electromagnetic Structure of the Proton at High Momentum Transfers
    Prof. Simon Širca
    Slovenian Research Agency

RESEARCH PROGRAMS

1. Archaeological and Archaeometric Research of Portable Archaeological Heritage
   Prof. Žiga Šmit
2. Structure of hadronic systems
   Prof. Simon Širca
3. Studies of atoms, molecules and structures by photons and particles
   Prof. Matjaž Žitnik
4. Object and Prestige; taste, status, power (Researches of the material culture in Slovenia)
   Dr. Marijan Nečemer

R & D GRANTS AND CONTRACTS

1. Nanostructured cathodes for lithium sulphur batteries
   Dr. Darko Hanžel
2. Vegetation and hydrology of Ljubljansko barje in the past, present and future a consequence of succession, human impact or climatic fluctuations?
   Dr. Marijan Nečemer
3. Evaluation of quality and safety parameters of vegetables produced on different systems in Slovenia and abroad with aim to establish national quality scheme for vegetables
   Dr. Marijan Nečemer
4. Evaluation of quality and safety parameters of vegetables produced on different systems in Slovenia and abroad with aim to establish national quality scheme for vegetables
   Dr. Marijan Nečemer
5. Provision of Testing Services for Filter Media used in IMS Radionuclide Stations
   Dr. Benjamin Zorko
   The Preparatory Commission For The Comprehensive
6. Different Analyses
   Dr. Jasmina Kožar Logar

NEW CONTRACTS

1. Ecology laboratory with mobile unit
   Asst. Prof. Matej Lipoglavšek
   Ministry of Defence
2. Annex No. 14 to the contract on performing activities and fulfillment of obligations of holder of national standard in the field of ionising radiation
   Matjaž Mihelič, M. Sc.
   Ministry of Higher Education, Science and Technology
3. Maintenance of radiological emergency preparedness for a period of 5 years (2012-2017)
   Asst. Prof. Matej Lipoglavšek
   Krško Nuclear Power Plant
4. Analyses of atmospheric releases in 2015, 2016 and 2017
   Dr. Benjamin Zorko
   Krško Nuclear Power Plant
5. Environmental radioactivity monitoring of living environment in Slovenia in 2015
   Dr. Benjamin Zorko
   Ministry of the Environment and Spatial Planning
6. Off-site radiological monitoring of the Krško Nuclear Power Plant in2016 and 2017
   Dr. Benjamin Zorko
   Krško Nuclear Power Plant
7. Environmental radioactivity monitoring of living environment in Republic Slovenia in 2016
   Dr. Benjamin Zorko
   Ministry of the Environment and Spatial Planning
8. Measurement of gross alpha and beta activities in drinking waters in Republic of Slovenia
   Dr. Jasmina Kožar Logar
   Ministry of Health
9. Monitoring of radiaoactivity in drinking water in Republic of Slovenia in 2016 and 2017
   Dr. Benjamin Zorko
   Ministry of Health
10. Central radioactive waste repository radiological monitoring
    Dr. Marijan Nečemer
    ARAO – Agency for Radwaste Management, Ljubljana

VISITORS FROM ABROAD

1. Dr. Thomas Schwarz-Selinger, Max Planck Institute (IPP), Garching, Germany, 20–25 March 2016
2. Prof. Dr. Chary Rangacharyuluja, University of Saskatchewan, Saskatoon, SK, Canada, 5. May 2016
3. Branko Petrinc, IMI, Zagreb, Croatia, 19. July 2016
4. Dr. Juegen Gerl, GSI, Darmstadt, Germany, 7–9 August 2016
5. Dr. Jelena Ajtić, The Faculty of Veterinary Medicine and Dr. Dragana Todorović, Vinča Institute, Belgrade, Serbia, 14–16 September 2016
6. Ivica Prlić and Branko Petrinec, IMI, Zagreb, Croatia, 7. December. 2016
7. Dr. Tim Vidmar in Jos Rutten, SCK-CEN, Mol, Belgium, 14.–16. 12. 2016
8. Dr. Luca Marchesi, Concettina Giovani in dr. Stefano Micheletti, ARPA FVG, Palmanova, Italy, 20. 12. 2016

STAFF

Researchers

1. Prof. Iztok Arčon*
2. Asst. Prof. Klemen Bučar
3. Prof. Dean Cvetko*
4. Denis Glavič Cindro, M. Sc.
5. Dr. Darko Hanžel
6. Asst. Prof. Matjaž Kavčič
7. Dr. Jasmina Kožar Logar
8. *Dr. Peter Kump, retired 01.02.16*
9. Asst. Prof. Matej Lipoglavšek
10. Asst. Prof. Sabina Markelj
11. Asst. Prof. Andrej Mihelič
12. Dr. Marijan Nečemer
13. **Prof. Primož Pelicon, Head**
14. Prof. Simon Širca*
15. Prof. Žiga Šmit*
16. Asst. Prof. Matjaž Vencelj
17. Branko Vodenik, M. Sc.
18. Prof. Katarina Vogel-Mikuš*
19. Dr. Benjamin Zorko
20. Prof. Matjaž Žitnik

Postdoctoral associates

21. Dr. Romana Krištof
22. Dr. Miha Mihovilovič
23. Dr. Toni Petrovič
24. Dr. Jelena Vesić
25. Dr. Anže Založnik

Postgraduates

26. Žiga Barba, B. Sc.
27. Tilen Brecelj, B. Sc.
28. Mateja Hrast, B. Sc.
29. Boštjan Jenčič, B. Sc.
30. Tim Kolar, B. Sc.
31. *Nina Ogrinc Potočnik, B. Sc., on leave 01.06.14*
32. *Marko Petric, left 01.09.16*
33. *Samo Štajner, B. Sc., left 29.11.16*
34. **Technical officers**
35. Boštjan Črnič, B. Sc.
36. Mitja Kelemen, B. Sc.
37. Matjaž Mihelič, M. Sc.
38. Primož Vavpetič, B. Sc.

Technical and administrative staff

39. Drago Brodnik
40. Mojca Gantar
41. Sandi Gobec
42. Mirko Ribič, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Karmen Bat, Klemen Eler, Darja Mazej, Branka Mozetič Vodopivec, Ines Mulič, Peter Kump, Nives Ogrinc, "Isotopic and elemental characterisation of Slovenian apple juice according to geographical origin: preliminary results", *Food chem.*, vol. 203, pp. 86-94, 2016.
2. A. Blomberg *et al.* (100 authors), "Electroexcitation of the $\Delta^+(1232)$ at low momentum transfer", *Phys. lett., Sect. B*, vol. 760, pp. 267-272, 2016.
3. Rok Bohinc, Matjaž Žitnik, Klemen Bučar, Matjaž Kavčič, S. Carniato, Loíc Journel, Renaud Guillemin, Tatiana Marchenko, Elie Kawerk, M. Simon, W. Cao, "Structural and dynamical properties of chlorinated hydrocarbons studied with resonant inelastic x-ray scattering", *J. chem. phys.*, vol. 144, no. 13, pp. 134309-1-134309-12, 2016.
4. Dean Cvetko, Guido Fratesi, Gregor Kladnik, Albano Cossaro, Gian Paolo Brivio, Latha Venkataraman, Alberto Morgante, "Ultrafast electron injection to photo-excited organic molecules", *PCCP. Phys. chem. chem. phys.*, vol. 18, iss. 32, pp. 22140-22145, 2016.
5. T. Čižmar, Urška Lavrenčič Štangar, Iztok Arčon, "Correlations between photocatalytic activity and chemical structure of Cu-modified $TiO_2 - SiO_2$ nanoparticle composites", *Catal. today*, pp. 1-6, 2016.
6. Amelie Detterbeck, Paula Pongrac, Stefan Rensch, Stefan Reuscher, Matic Pečovnik, Primož Vavpetič, Primož Pelicon, Stefan Holzheu, Ute Krämer, Stephan Clemens, "Spatially resolved analysis of variation in barley (Hordeum vulgare) grain micronutrient accumulation", *New phytol.*, vol. 211, iss. 4, pp. 1241-1254, 2016.
7. Carlo Dri *et al.* (13 authors), "Chemistry of the methylamine termination at a gold surface: from autorecognition to condensation", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, iss. 11, pp. 6104-6115, 2016.
8. Jefferson Lab Hall A Collaboration, D. Flay *et al.,* "Measurements of d_2^n and A_1^n: probing the neutron spin structure", *Phys. rev., D*, vol. 94, iss. 5, pp. 052003-1-052003-51, 2016.
9. Samo K. Fokter, Andrej Moličnik, Rajko Kavalar, Primož Pelicon, Rebeka Rudolf, Nenad Gubeljak, "Why do some titanium-alloy total hip arthroplasty modular necks fail?", *Journal of the mechanical behavior of biomedical materials*, pp. 1-12, [14] f. pril., Available online 27 December 2016.
10. Emna Fourati, Mariem Wali, Katarina Vogel-Mikuš, Chedly Abdelly, Tahar Ghnaya, "Nickel tolerance, accumulation and subcellular distribution in the halophytes Sesuvium portulacastrum and Cakile maritima", *Plant physiol. biochem. (Paris)*, vol.108, pp. 295-303, 2016.
11. Denis Glavič-Cindro, Matjaž Korun, Marijan Nečemer, Branko Vodenik, Benjamin Zorko, "Evaluation of comparison and proficiency test results of gamma ray spectrometry at Jožef Stefan Institute from 1986 to 2014", *Appl. radiat. isotopes*, vol. 109, pp. 54-60, 2016.
12. Bojan Golli, Simon Širca, "Eta and kaon production in a chiral quark model", *The european physical journal. A, Hadrons and nuclei*, vol. 52, art. no. 279, 14 pp., 2016.
13. Mina Jovanovic, Iztok Arčon, Janez Kovač, Nataša Novak Tušar, Bojana Obradović, Nevenka Rajić, "Removal of manganese in batch and fluidized bed systems using beads of zeolite A as adsorbent", *Microporous and mesoporous materials*, vol. 226, pp. 378-385, 2016.
14. Matjaž Kavčič, D. Banas', "M shell ionization of Ar induced in nearcentral collisions with MeV protons", *J. phys., B At. mol. opt. phys.*, vol. 49, no. 6, pp. 065204-1-065204-8, 2016.
15. Matjaž Kavčič, Klemen Bučar, Marko Petric, Matjaž Žitnik, Iztok Arčon, Robert Dominko, Alen Vižintin, "Operando resonant inelastic X-ray scattering: an appropriate tool to characterize sulfur in Li-S batteries", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, no. 43, pp. 24568-24576, 2016.
16. Gregor Kladnik, Michele Puppin, Marcello Coreno, Monica de Simone, Luca Floreano, Alberto Verdini, Alberto Morgante, Dean Cvetko, Albano Cossaro, "Ultrafast charge transfer pathways through a prototype amino-carboxylic molecular junction", *Nano lett.*, vol. 16, no. 3, pp. 1955-1959, 2016.
17. E. Kokkonen, M. Vapa, Klemen Bučar, K. Jänkälä, W. Cao, Matjaž Žitnik, M. Huttula, "Formation of stable HCl[sup]+ following resonant Auger decay in CH[sub]3Cl", *Phys. rev., A*, vol. 94, 033409, 2016.
18. Matjaž Korun, Branko Vodenik, Benjamin Zorko, "Calculation of the best estimates for measurements of radioactive substances when the presence of the analyte is not assured", *Accredit. qual. assur.*, vol. 21, no. 3, pp. 191-195, 2016.
19. Matjaž Korun, Branko Vodenik, Benjamin Zorko, "Calculation of the decision threshold in gamma-ray spectrometry using sum peaks", *Appl. radiat. isotopes*, vol. 109, pp. 522-525, 2016.
20. Matjaž Korun, Branko Vodenik, Benjamin Zorko, "Calculation of the correlation coefficients between the numbers of counts (peak areas and backgrounds) obtained from gamma-ray spectra", *Appl. radiat. isotopes*, vol. 118, pp. 1-6, 2016. [COBISS.SI-ID 30064935]
21. Matjaž Korun, Branko Vodenik, Benjamin Zorko, "Calculation of the decision thresholds for radionuclides identified in gamma-ray spectra by post-processing peak analysis results", *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 813, pp. 102-110, 2016.
22. Isabelle Lefevre, Katarina Vogel-Mikuš, Iztok Arčon, Stanley Lutts, "How do roots of the metal-resistant perennial bush Zygophyllum fabago cope with cadmium and zinc toxicities?", *Plant soil*, vol. 404, iss. 1, pp. 193-207, 2016.
23. A. Macková, Žiga Šmit, L. Giuntini, "Discovering new information from historical artefacts using electromagnetic radiation and charged particles as a probe", *Europhys. news*, vol. 47, no. 3, pp. 17-21, 2016.
24. Sabina Markelj, Anže Založnik, Thomas Schwarz-Selinger, Olga Ogorodnikova, Primož Vavpetič, Primož Pelicon, Iztok Čadež, "In situ NRA study of hydrogen isotope exchange in self-ion damaged tungsten exposed to fuel atoms", *J. nucl. mater.*, vol. 469, pp. 133-144, 2016.
25. Marijan Nečemer, Marko Gerbec, "Automated preparation of water samples for low-level gamma spectrometry", *Acta chim. slov. (Print ed.)*, vol. 63, no. 1, pp. 204-212, 2016.
26. Marijan Nečemer, Doris Potočnik, Nives Ogrinc, "Discrimination between Slovenian cow, goat and sheep milk and cheese according to geographical origin using a combination of elemental content and stable isotope data", *J. food compos. anal.*, vol. 52, pp. 16-23, 2016.
27. Johannes Niskanen, Christoph J. Sahle, Kari O. Ruotsalainen, Harald Müller, Matjaž Kavčič, Matjaž Žitnik, Klemen Bučar, Marko Petric, Mikko Hakala, Simo Huotari, "Sulphur $K\beta$ emission spectra reveal protonation states of aqueous sulfuric acid", *Scientific reports*, vol. 6, pp. 21012-1-21012-8, 2016.
28. Olga Ogorodnikova, Sabina Markelj, Udo von Toussaint, "Interaction of atomic and low-energy deuterium with tungsten pre-irradiated with self-ions", *J. appl. phys.*, vol. 119, no. 5, pp. 054901-1-054901-9, 2016.
29. Giorgia Olivieri, Alok Goel, Armin Kleibert, Dean Cvetko, Matthew A. Brown, "Quantitative ionization energies and work functions of aqueous solutions", *PCCP. Phys. chem. chem. phys.*, vol. 18, iss. 42, pp. 29506-29515, 2016.
30. Serena Panighello, Anja Kavčič, Katarina Vogel-Mikuš, N. H. Tennent, Arie Wallert, Samo B. Hočevar, Johannes Teun van Elteren, "Investigation of smalt in cross-sections of 17th century paintings using elemental mapping by laser ablation ICP-MS", *Mirochem. j.*, vol. 125, pp. 105-115, 2016.
31. Andraž Pavlišič, Primož Jovanovič, Vid Simon Šelih, Martin Šala, Marjan Bele, Goran Dražić, Iztok Arčon, Samo B. Hočevar, Anton Kokalj, Nejc Hodnik, Miran Gaberšček, "Atomically resolved dealloying of structurally ordered Pt nanoalloy as an oxygen reduction reaction electrocatalyst", *ACS catal.*, vol. 6, iss. 8, pp. 5530-5534, Aug. 2016.
32. Marko Petric, Rok Bohinc, Klemen Bučar, Stanislaw H. Nowak, Matjaž Žitnik, Matjaž Kavčič, "Electronic structure of third-row elements in different local symmetries studied by valence-to-core X-ray emission spectroscopy", *Inorg. chem.*, vol. 55, no. 11, pp. 5328-5336, 2016.
33. Marko Petric, Matjaž Kavčič, "Chemical speciation via X-ray emission spectroscopy in the tender X-ray range", *J. anal. at. spectrom.*, vol. 31, pp. 450-457, 2016.
34. Oleksii Pliekhov, Iztok Arčon, Nataša Novak Tušar, Urška Lavrenčič Štangar, "Photocatalytic activity of zirconium- and manganese-codoped titania in aqueous media: the role of the metal dopant and its incorporation site", *ChemCatChem (Internet)*, vol. 8, iss. 12, pp. 2109-2118, Jun. 2016.
35. Olena Pliekhova, Iztok Arčon, Oleksii Pliekhov, Nataša Novak Tušar, Urška Lavrenčič Štangar, "Cu and Zr surface sites in the photocatalytic activity of TiO_2 nanoparticles", *Environ. sci. pollut. res. int.*, pp. 1-11, 2016.
36. Stefaan Pommé *et al.* (43 authors), "Evidence against solar influence on nuclear decay constants", *Phys. lett., Sect. B*, vol. 761, pp. 281-286, 2016.
37. Paula Pongrac, Mateja Potisek, Anna Fraš, Matevž Likar, Bojan Budič, Kinga Myszka, Danuta Boros, Marijan Nečemer, Mitja Kelemen, Primož Vavpetič, Primož Pelicon, Katarina Vogel-Mikuš, Marjana Regvar, Ivan Kreft, "Composition of mineral elements and bioactive compounds in

tartary buckwheat and wheat sprouts as affected by natural mineral-rich water", *J. cereal sci.*, vol. 69, pp. 9-16, 2016.
38. Paula Pongrac, Nathalie Scheers, Ann-Sofie Sandberg, Mateja Potisek, Iztok Arčon, Ivan Kreft, Peter Kump, Katarina Vogel-Mikuš, "The effects of hydrothermal processing and germination on Fe speciation and Fe bioaccessibility to human intestinal Caco-2 cells in Tartary buckwheat", *Food chem.*, vol. 199, pp. 782-790, 2016.
39. Doris Potočnik, Marijan Nečemer, Darja Mazej, Radojko Jaćimović, Nives Ogrinc, "Multi-elemental-composition of Slovenian milk: analytical approach and geographical origin determination", *Acta IMEKO*, vol. 5, no. 1, pp. 15-21, 2016.
40. A1 Collaboration, F. Schulz *et al.,* "Ground-state binding energy of $^{4}_{\Lambda}$H from high-resolution decay-pion spectroscopy", *Nucl. phys., Sect. A*, vol. 954, pp. 149-160, 2016.
41. Oren Shelef, Paula Pongrac, Primož Pelicon, Primož Vavpetič, Mitja Kelemen, Merav Seifan, Boris Rewald, Shimon Rachmilevitch, "Insights into root structure and function of Bassia indica: water redistribution and element dispersion", *Functional plant biology*, vol. 43, no. 7, pp. 620-631, 2016.
42. Žiga Šmit, "Archery by the Apaches - implications of using the bow and arrow in hunter-gatherer communities", *Doc. Praehistor.*, vol. 43, pp. 515-525, 2016.
43. Faidra Tzika *et al.* (22 authors), "^{60}Co in cast steel matrix: a European interlaboratory comparison for the characterisation of new activity standards for calibration of gamma-ray spectrometers in metallurgy", *Appl. radiat. isotopes*, vol. 114, pp. 167-172.
44. Austin G. Wardrip *et al.* (20 authors), "Length-independent charge transport in chimeric molecular wires", *Angew. Chem. (Int. ed.)*, vol. 55, iss. 46, pp. 14267-14271, 2016.
45. Anže Založnik, Sabina Markelj, Thomas Schwarz-Selinger, Łukasz Ciupiński, Justyna Grzonka, Primož Vavpetič, Primož Pelicon, "The influence of the annealing temperature on deuterium retention in self-damaged tungsten", *Phys. scr., T*, vol. 167, pp. 014031-1-014031-5, 2016.
46. Primož Zidar, Monika Kos, Katarina Vogel-Mikuš, Johannes Teun van Elteren, Marta Debeljak, Suzana Žižek, "Impact of ionophore monensin on performance and Cu uptake in earthworm Eisenia andrei exposed to copper-contaminated soil", *Chemosphere (Oxford)*, vol. 161, pp. 119-126, 2016.
47. Primož Zidar, Špela Kržišnik, Marta Debeljak, Suzana Žižek, Katarina Vogel-Mikuš, "The effect of selenium on mercury transport along the food chain", *Agrofor*, vol. 1, no. 3, pp. 119-126, 2016.
48. Benjamin Zorko, J. Camps, Toni Petrovič, "Lessons learned from a table-top exercise on monitoring a large-scale cross-border contamination in the aftermath of a nuclear accident", *Radioprotection (Paris, 1966)*, vol. 51, hS2, pp. S175-S177, 2016.
49. Benjamin Zorko, Željka Knežević, Boštjan Črnič, Marija Majer, Maria Ranogajec-Komor, "A transnational intercomparison of environmental dosemeters in realistic environmental conditions", *Radiat. prot. dosim.*, 4 pp..
50. Matjaž Žitnik *et al.* (10 authors), "Exercise-induced effects on a gym atmosphere", *Indoor air*, vol. 26, no. 3, pp. 468-477, 2016.
51. Matjaž Žitnik *et al.* (13 authors), "Two-to-one Auger decay of a double L vacancy in argon", *Phys. rev., A*, vol. 93, no. 2, pp. 021401-1-021401-5, 2016.

Review Article

1. Gregor Bavdek, Dean Cvetko, "Helium atom scattering - a versatile technique in studying nanostructures", *Mater. tehnol.*, vol. 50, no. 4, pp. 627-636, 2016.
2. Benjamin Zorko, Matjaž Korun, Juan Carlos Mora Canadas, Valerie Nicoulaud-Gouin, Pavol Chyly, Anna Maria Blixt Buhr, Charlotte Lager, Karin Aquilonius, Pawel Krajewski, "Systematic influences of gamma-ray spectrometry data near the decision threshold for radioactivity measurements in the environment", *J. environ. radioact.*, vol. 158/159, pp. 119-128, 2016.

Short Article

1. Denis Glavič-Cindro, Matjaž Korun, Branko Vodenik, Benjamin Zorko, "On the definition of the decision threshold as stated in the standard ISO 11929", *Accredit. qual. assur.*, vol. 21, no. 6, pp. 433-435, 2016.

Published Conference Contribution (invited lecture)

1. Ivan Kreft, Blanka Vombergar, Paula Pongrac, Cheol Ho Park, Kiyokazu Ikeda, Sayoko Ikeda, Alena Vollmannová, Krzysztof Dziedzic, Gunilla Wieslander, Dan Norbäck, Vida Škrabanja, Igor Pravst, Aleksandra Golob, Lea Lukšič, Giovanni Bonafaccia, Nikhil K. Chrungoo, Meiliang Zhou, Katarina Vogel-Mikuš, Marjana Regvar, Alenka Gaberščik, Mateja Germ, "Coordinated buchwheat research: genetics, environment, structure and function", In: *The 13th international symposium on buckwheat (ISB): 2016. 9. 9. (Fri.) - 9. 11. (Sun.), [Korea]*, pp. 29-37.
2. Ivan Kreft, Blanka Vombergar, Paula Pongrac, Cheol Ho Park, Kiyokazu Ikeda, Sayoko Ikeda, Alena Vollmannová, Krzysztof Dziedzic, Gunilla Wieslander, Dan Norbäck, Vida Škrabanja, Igor Pravst, Aleksandra Golob, Lea Lukšič, Giovanni Bonafaccia, Nikhil K. Chrungoo, Meiliang Zhou, Katarina Vogel-Mikuš, Marjana Regvar, Primož Pelicon, Alenka Gaberščik, Mateja Germ, "Coordinated buchwheat research: genetics, environment, structure and function", In: *Strategies for improving the chronic diseases using buckwheat*, pp. 3-20.
3. Miha Mihovilovič, Harald Merkel, Adrian Weber, "Puzzling out the proton radius puzzle", In: *XIth Conference on Quark Confinement and Hadron Spectrum, 8-12 September 2014, Saint Petersburg, Russia*, (AIP conference proceedings, 1701), pp. 040014-1-040014-7.

Published Conference Contribution

1. Denis Glavič-Cindro, Drago Brodnik, Toni Petrovič, Matjaž Vencelj, Dušan Ponikvar, Steven J. Bell, Lynsey Keightley, Selina Woods, Stefan Neumaier, "MetroERM : Metrology for radiological early warning networks in Europe", V: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, str. 1001-1-1001-10.
2. Bojan Golli, Simon Širca, "Puzzles in eta photoproduction: the 1685 MeV narrow peak: B. Golli and S. Širca", In: *Proceedings to the Mini-Workshop Quarks, Hadrons, Matter, Bled, Slovenia, July 3-10, 2016*, (Blejske delavnice iz fizike, vol. 17, no. 1), pp. 44-49.
3. Boštjan Jenčič, Luka Jeromel, Nina Ogrinc Potočnik, Katarina Vogel-Mikuš, Eva Kovačec, Marjana Regvar, Zdravko Siketić, Primož Vavpetič, Zdravko Rupnik, Klemen Bučar, Mitja Kelemen, Janez Kovač, Primož Pelicon, "Molecular imaging of cannabis leaf tissue with MeV-SIMS method", In: *The 22nd International Conference on Ion Beam Analysis (IBA 2015), June 14 - 19, 2015, Opatija, Croatia*, (Nuclear instruments & methods in physics research, Section B, vol. 371, 2016), pp. 205-210.
4. Matjaž Korun, Branko Vodenik, Benjamin Zorko, "Measurement function for the activities of multi-gamma-ray emitters in gamma-ray spectrometric measurements", In: *Proceedings of the 20th International Conference on Radionuclide Metrology and its Applications, 8-11 June 2015, Vienna, Austria*, (Applied radiation and isotopes, vol. 109, 2016), pp. 518-521.
5. Branko Lukač, Lovro Sinkovič, Aleš Kolmanič, Marijan Nečemer, Vladimir Meglič, "Effect of growth stage on nutritive value and mineral composition of dandelion (Taraxacum officinale web.) at spring cut", In: *Celebrating food: proceedings*, FoodTech Congress, 25-27. 10. 2016, Novi Sad, Serbia [:] XVII International Symposium Feed Technology [and] III International Congress Food Technology, Quality and Safety, pp. 79-84.
6. Anja Mahne Opatić, Marijan Nečemer, Sonja Lojen, "Determination of the geographical origin of Slovenian potato and garlic, based on stabel isotope and elemental analylsis: preliminary results", In: *Proceedings of the 2nd IMEKO FOODS "Metrology Promoting Objective and Measurable Food Quality and Safety", October 2nd - 5th, 2016, Benevento*, pp. 119-122.
7. Marijan Nečemer, Karmen Bat, Nives Ogrinc, "Capabilities of the combination of isotope ratio mass spectrometry and total reflection X-ray fluorescence spectrometry in foodstuffs analysis", In: *Proceedings of the 2nd IMEKO FOODS "Metrology Promoting Objective and Measurable Food Quality and Safety", October 2nd - 5th, 2016, Benevento*, 4 pp.
8. Olga Ogorodnikova, Sabina Markelj, V. S. Efimov, Yu. Gasparyan, "Deuterium removal from radiation damage in tungsten by isotopic exchange with hydrogen atomic beam", In: *XIX. Conference on Plasma Surface Interactions, 28-29 January 2016, Moscow, Russia*, (Journal of physics, vol. 748, no. 1, 2016), 19th International Summer School on Vacuum, Electron and Ion Technologies (VEIT2015), 21-25 September 2015, Sozopol, Bulgaria, pp. 012007-1-012007-5.
9. Marko Petric, Klemen Bučar, Matjaž Žitnik, Matjaž Kavčič, "Chemical speciation of third-row elements via valence-to- core x-ray emission

spectroscopy", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 261-272.
10. Doris Potočnik, Marijan Nečemer, Nives Ogrinc, "Stable isotope composition and elemental profile as a tool for determination of cheese species and geographical origin", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 96-105.
11. Lovro Sinkovič, Aleš Kolmanič, Marijan Nečemer, Branko Lukač, Vladimir Meglič, "Effect of different management systems on yield and multimineral composition of oat grains (Avena sativa L.)", In: *Celebrating food: proceedings*, FoodTech Congress, 25-27. 10. 2016, Novi Sad, Serbia [:] XVII International Symposium Feed Technology [and] III International Congress Food Technology, Quality and Safety, pp. 474-479.
12. Simon Širca, "The perennial Roper puzzle: S: Širca", In: *Proceedings to the Mini-Workshop Quarks, Hadrons, Matter, Bled, Slovenia, July 3-10, 2016*, (Blejske delavnice iz fizike, vol. 17, no. 1), pp. 55-58.
13. Jelena Vesić, Matej Lipoglavšek, Andrej Likar, Toni Petrovič, Primož Pelicon, Alberto Sànchez Ortiz, Aleksandra Cvetinović, "Electron screening in metals", In: *6th Nuclear Physics in Astrophysics, NPA 6, 19-24 May 2013, Lisbon, Portugal*, (Journal of physics, Conference series, vol. 665, 2016), pp. 012037-1-012037-5.
14. Anže Založnik, Primož Pelicon, Zdravko Rupnik, Iztok Čadež, Sabina Markelj, "In situ hydrogen isotope detection by ion beam methods ERDA and NRA", In: *The 22nd International Conference on Ion Beam Analysis (IBA 2015), June 14 - 19, 2015, Opatija, Croatia*, (Nuclear instruments & methods in physics research, Section B, vol. 371, 2016), pp. 167-173.

Independent Component Part or a Chapter in a Monograph

1. L. Costantinescu *et al.* (14 authors), "Ion beam analytical methods", In: *Nuclear physics for cultural heritage*, Anna Machová, ed., [S. l.], Nuclear Physics Division of the European Physical Society, 2016, pp. 5-22.
2. Boštjan Črnič, "Zunanje sevanje", In: *Ovrednotenje izpustov iz NEK in primerjava z meritvami v okolju*, Matjaž Stepišnik, et al, 1. izd., Ljubljana, Institut Jožef Stefan, 2016, pp. 71-85.
3. Jasmina Kožar Logar, "Padavine in suhi used", In: *Ovrednotenje izpustov iz NEK in primerjava z meritvami v okolju*, Matjaž Stepišnik, et al, 1. izd., Ljubljana, Institut Jožef Stefan, 2016, pp. 39-52.
4. Toni Petrovič, "Voda iz črpališč in vrtin", In: *Ovrednotenje izpustov iz NEK in primerjava z meritvami v okolju*, Matjaž Stepišnik, et al, 1. izd., Ljubljana, Institut Jožef Stefan, 2016, pp. 21-37.
5. Paula Pongrac, Katarina Vogel-Mikuš, Mateja Potisek, Eva Kovačec, Bojan Budič, Peter Kump, Marjana Regvar, Ivan Kreft, "Mineral and trace element composition and importance for nutritional value of buckwheat grain, groats, and sprouts", In: *Molecular breeding and nutritional aspects of buckwheat*, Meiliang Zhou, ed., Ivan Kreft, ed., London [etc.], Academic Press is an imprint of Elsevier, cop. 2016, pp. 261-271.
6. Jedert Vodopivec, Žiga Šmit, Helena Fajfar, "Characterisation of colouring agents in determining the causes of damage in the Ptuj Gratae Posteritati", In: *Konserviranje knjig in papirja 2*, Jedert Vodopivec, ed., Ljubljana, Arhiv Republike Slovenije, 2016, pp. 48-57.
7. Katarina Vogel-Mikuš, "Radionuklidi v hrani", In: *Ovrednotenje izpustov iz NEK in primerjava z meritvami v okolju*, Matjaž Stepišnik, et al, 1. izd., Ljubljana, Institut Jožef Stefan, 2016, pp. 87-104.
8. Benjamin Zorko, "Zrak", In: *Ovrednotenje izpustov iz NEK in primerjava z meritvami v okolju*, Matjaž Stepišnik, et al, 1. izd., Ljubljana, Institut Jožef Stefan, 2016, pp. 53-70.

University, Higher Education or Higher Vocational Education Textbook

1. Simon Širca, *Probability for physicists*, (Graduate texts in physics), Switzerland, Springer, cop. 2016.
2. Simon Širca, *Verjetnost v fiziki*, (Matematika-fizika, 53), Ljubljana, DMFA - založništvo, 2016.

Patent

1. Matjaž Vencelj, Larisa Hosnar, Klemen Bučar, Janez Burger, *Angle-sensitive gamma camera with a rotary obstruction,* SI24818 (A), Urad RS za intelektualno lastnino, 31. 03. 2016.
2. Matjaž Vencelj, Miha Cankar, Andrej Likar, *Process and device for improvement of operation of silicon photomultipliers in the regime of piled-up pulses of light,* SI24863 (A), Urad RS za intelektualno lastnino, 29. 04. 2016.

Mentoring

1. Anže Založnik, *Interaction of atomic hydrogen with materials used for plasma-facing wall in fusion devices:* doctoral dissertation, Ljubljana, 2016 (mentor Primož Pelicon; co-mentor Sabina Markelj).
2. Mateja Hrast, *Izračun atomskih fotoionizacijskih presekov z metodo zunanjega kompleksnega raztega:* master's thesis, Ljubljana, 2016 (mentor Andrej Mihelič).
3. Tim Kolar, *Analiza neelastičnega sipanja elektronov na ogljikovih jedrih:* master's thesis, Ljubljana, 2016 (mentor Simon Širca; co-mentor Miha Mihovilovič).
4. Irma Mavrič, *The influence of ferrite nanoparticles on synthesis of photosynthetic pigments, photochemical efficiency and oxidative stress in sunflower:* master's thesis, Ljubljana, 2016 (mentor Katarina Vogel-Mikuš).
5. Nastja Poljanšek, *Estimation of absorbed dose during hyperthyroidism treatment using I-131:* master's thesis, Ljubljana, 2016 (mentor Simon Širca; co-mentors Petra Tomše, Simona Gaberšček).
6. Neva Rozman, *Effects of adding mineral wool (cubes and flakes) in the substrate on growth and mineral composition of chosen plants:* master's thesis, Ljubljana, 2016 (mentor Katarina Vogel-Mikuš).

DEPARTMENT OF THIN FILMS AND SURFACES F-3

The main research field of the department is the development, deposition and characterization of hard protective PVD coatings, while research is also conducted in other fields of thin films and surface physics. The basic research is concentrated on the study of the physical and chemical properties of various multicomponent, multilayer and nanostructured coatings. Among the applied research, different coatings are developed for the protection of tools for various production processes in industry.

Head:
Asst. Prof. Miha Čekada

A few years ago we started to investigate two groups of nanostructured coatings: the nanolayer (AlTiN/TiN) and the nanocomposite (TiAlSiN). The work has always been performed in a parallel way: on the basic level we have been studying the coating growth mechanism and their properties, while on the applied level the emphasis has been on the applicability of these coatings for the protection of tools, used in a given production process. In the previous year, we primarily dedicated our work to the latter, i.e., the applied aspect. In collaboration with research partners from Turkey (University of Bartin), Serbia (University of Novi Sad) and Slovenia (Mechanical Engineering Faculty of the University of Ljubljana), and an industrial partner (EMO Orodjarna) we investigated the lifetime of these coatings for hard milling. We have been looking for an optimized structure substrate-coating in a stepwise fashion; last year a lot of work was dedicated to an improved cutting-edge geometry, specifically on a proper radius of curvature. This kind of research is typically conducted in a comparative way, where the standard TiAlN coating is taken as a reference (it has a homogeneous depth profile).

In addition to the cutting processes, we are also engaged in searching for the optimal protection of selected forming processes. In collaboration with the above-mentioned partners from Serbia, we are investigating the influence of CrN and CrAlN coatings for the protection of cores for the die casting of aluminium alloys. The wear mechanism of the tools protected in this way was the main topic of a PhD thesis by a candidate from that faculty; he performed most of the coating-related work in our lab. Aluminium die casting is a topic of several other informal collaborations with various Slovenian companies; there is work on die cores and knives for post-processing. We were also active on the technologically very challenging topic of the protection of tools for hot forging, where we tested the applicability of a CrVN coating. The idea is based on the superior tribological properties of vanadium oxide at high temperatures. For this purpose we analysed the oxidation mechanism for this coating and found that the principal diffusion paths for vanadium follow the growth defects.

We showed that the addition of MoS_2 nanotubes to polyalphaolefin oil decreases the coefficient of friction in standard nitride coatings.

The growth defects have been a topic of our department's research for several years. Last year the work was carried on in two principle directions. With partners from Croatia (Ruđer Bošković Institute) we compared the defect density and their internal structure in dependence on the type of deposition chamber used. In contrast to the previous experiments, which were performed in industrial chambers only, such kind of experiments was repeated in a laboratory chamber, which enables the deposition in a far cleaner environment. Nevertheless, the results showed that the density of small defects (size in the hundreds of nanometres) does not change substantially; this observation proves that the origin of the small defects is in the physical nature of the process, rather than in the secondary preparation.

The second direction of the last year concerns the question, what is the influence of growth defects on the initial stage of the tribological test? For this purpose we observed selected defects using a scanning electron microscope at different stages of the test. We found that the crushing of the growth defects – it appears after just a few laps of the contact surface – is the major source of abrasive particles. After the defects have been broken, the contact surfaces increase substantially and the system enters a stationary stage.

We concluded the project of testing the MoS_2 nanotubes as additives to classical lubricants. We performed several experiments on tribological systems protected by different hard coatings and evaluated the improvement of tribological properties. Last year we opened up a new direction of tribological research: conducting the experiments at high temperatures. With the installation of a new tribometer which enables measurements up to 1000 °C we will be able to track the coefficient of friction in realistic conditions, such as during hot forging, drilling, etc. As of today we have performed only a few preliminary experiments.

Magnetron sputtering is an established vacuum technique, which has been used for decades for the deposition of thin films. The process is based on plasma, acting as a source of ions to be accelerated towards

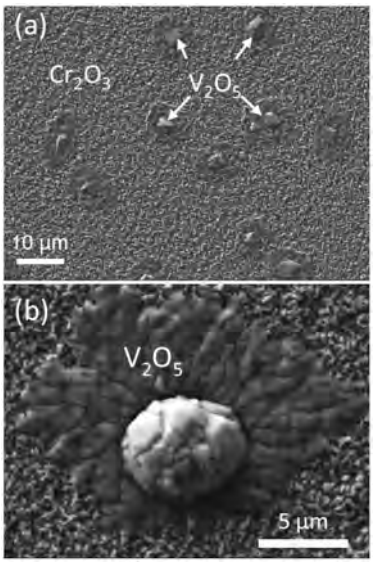


Figure 1: CrVN coating surface after oxidation. The vanadium diffusion takes place at the position of growth defects (a); detail of a single growth defect (b)

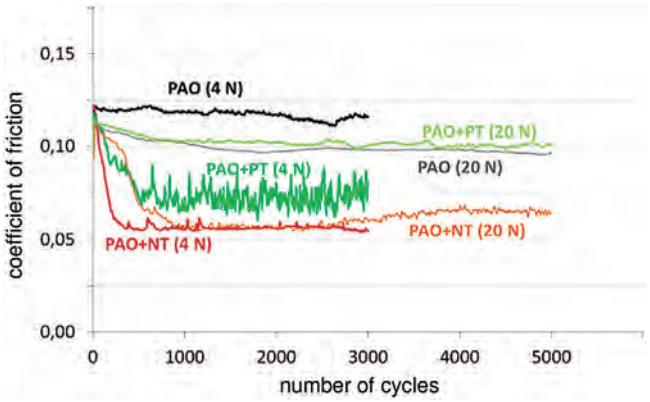


Figure 2: CrN coating coefficient of friction in polyalphaolefin oil (PAO), with MoS_2 powder addition (PT) and with MoS_2 nanotube addition (NT)

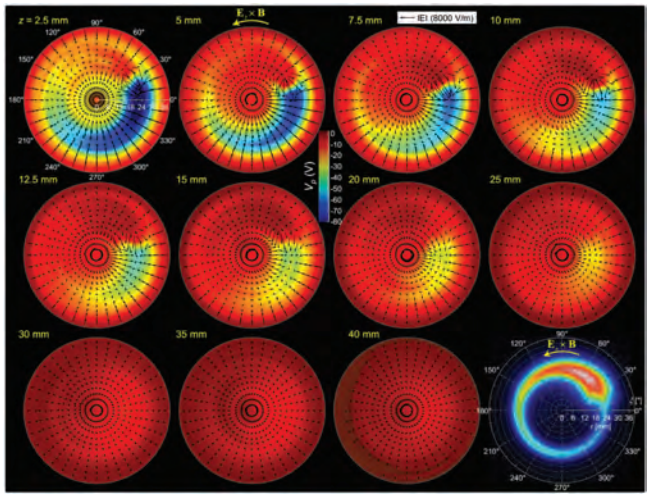


Figure 3: Plasma potential and electric field in magnetron plasma, measured at different axial distances from the cathode surface. The bottom-right image shows the ionization zone recorded by a high-speed camera. The position of the ionization zone approximately corresponds to the plasma potential distribution.

the target, and consequently to sputter the material around the vacuum chamber. The magnetron plasma appears homogeneous with a ring-like shape; however, the high-speed camera imaging showed that the plasma is concentrated in small areas, which were named the ionization zones. The zones have the shape of an elongated arrow, while their number depends on the discharge parameters. In previous years the department's coworker Dr. Matjaž Panjan investigated the properties of ionization zones in DC and pulsed magnetron sputtering. Among other results he showed that the plasma inhomogeneities have an important influence on particle transport in the plasma. In 2016 he measured the plasma potential of the rotating ionization zone using an emission probe. Using these measurements he was able to reconstruct the spatial distribution of the plasma potential, electric field, space charge and electron energy. These distributions enabled a deeper insight into the physics of elementary processes in magnetron sputtering. In collaboration with researchers from the Lawrence Berkeley National Laboratory (Berkeley, USA) he came to a conclusion that the electric field created by the ionization zone accelerates the charged particles and thus influences the ionization process and self-sustains the plasma. This conclusion differs from the commonly accepted hypothesis, that plasma is supported by secondary electrons only.

In addition to our core research topic – the study of hard protective coatings – we have always been at least partly active on some other fields of physics and chemistry of thin films and coatings. The following work should be mentioned:

- collaboration within the European project Eurofusion: deposition of WN thin films for studying ion-beam erosion, similar application with carbon layers, analytics of tungsten surface damages on the inner wall of a fusion reactor
- study of radiation damages during the laser ablation of surfaces, with a special emphasis on multilayer structures
- deposition of multilayer structures of Si/C for studying the diffusion processes
- study of magnetic properties of hematite nanoparticles in the amorphous silica matrix and calcium manganite nanoparticles
- analysis of surface topography for various applications: plasma-treated composites, electrochemically etched composites, optically variable refraction structures, printed oxide structures, etc.

This work was performed in collaboration with the following partners: Max Planck Institute of Plasma Physics, Garching, Germany; Vinča Institut for Nuclear Sciences, Belgrade, Serbia; Hungarian Academy of Sciences, Budapest, Hungary; National Institute of Chemistry, Ljubljana, Slovenia, and some others in a minor contribution.

Besides the above-mentioned research project we performed several analyses for different Slovenia companies: Cetis, EMO Orodjarna, IMP Pumps, Kolektor Sikom, Kovinos, Lama, LTH Castings, Phos in Tosama.

Some outstanding publications in the past year

1. A. Drnovšek, P. Panjan, M. Panjan, M. Čekada, The influence of growth defects in sputter-deposited TiAlN hard coatings on their tribological behavior. *Surface & coatings technology*, 288 (2016), 171–178

INTERNATIONAL PROJECTS

1. Microstructure, Morphology and Magnetism of Natural Hematite Crystallites and its Geological Significance
   Dr. Matjaž Panjan
   Slovenian Research Agency
2. Studies of Fundamental Processes in Magnetron Sputtering
   Dr. Matjaž Panjan
   Slovenian Research Agency
3. JET Campaigns-JET1-FU, EUROFUSION
   Dr. Matjaž Panjan
   European Commission
4. Medium Size Tokamak Campaigns-MST1-FU, EUROFUSION
   Dr. Matjaž Panjan
   European Commission

RESEARCH PROGRAM

1. Thin film structures and plasma surface engineering
   Asst. Prof. Miha Čekada

R & D GRANTS AND CONTRACTS

1. Understanding plasma processes and thin film growth in High Power Impulse Magnetron Sputtering
   Dr. Matjaž Panjan
2. Antibacterial Nanostructured Surfaces for Biological Applications
   Asst. Prof. Miha Čekada
3. Development and production of taylor made milling tools, coatings and corresponding manufacturing technologies in individual tooling industry
   Asst. Prof. Miha Čekada
4. Self-lubricating and wear resistant PVD hard coatings based on (V,Cr,Al,Ti)N for hot-working processes
   Dr. Peter Panjan
5. Building blocks, tools and systems for the Factories of the Future – GOSTOP
   Asst. Prof. Miha Čekada

VISITORS FROM ABROAD

1. Halil Çalışkan, Bartın University, Bartın, Turkey, 29. 2.–4. 3. 2016
2. Dragan Kukuruzović, Aleksandar Miletić, Pal Terek, University of Novi Sad, Novi Sad, Serbia, 20.–21. 6. 2016
3. Aleksandar Miletić, University of Novi Sad, Novi Sad, Serbia, 12.–21. 7. 2016
4. Marin Tadić, Nuklearni institut Vinča, Beograd, Serbia, 21.–31. 8. 2016
5. Saša Kovačić, University of Zagreb, Zagreb, Croatia, 5.–9. 9. 2016
6. Saša Kovačić, University of Zagreb, Zagreb, Croatia, 3.–7. 10. 2016
7. Vesna Damnjanović, University of Belgrade, Belgrade, Serbia, 7.–10. 12. 2016
8. Marin Tadić, Vinča nuclear institute, Belgrade, Serbia, 7.–16. 12. 2016

STAFF

Researchers
1. **Asst. Prof. Miha Čekada, Head**
2. Dr. Darinka Kek Merl
3. Dr. Peter Panjan
4. Dr. Matjaž Panjan

Postdoctoral associates
5. *Dr. Srečko Paskvale, left 01.06.16*

Postgraduates
6. Aljaž Drnovšek, B. Sc.
7. Nastja Poljanšek, B. Sc.

Technical officers
8. Uroš Stele, B. Sc.

Technical and administrative staff
9. Jožko Fišer
10. Damjan Matelič
11. Andrej Mohar
12. Tomaž Sirnik

BIBLIOGRAPHY

Original Article

1. G. Battistiga, Sandor Gurban, G. Sáfrán, Attila Sulyok, A. Németh, Peter Panjan, Z. Zolnai, Miklós Menyhárd, "Wafer-scale SiC rich nano-coating layer by Ar^+ and Xe^+ ion mixing", *Surf. coat. technol.*, vol. 302, pp. 320-326, 2016.
2. G. Battistiga, Z. Zolnai, A. Németh, Peter Panjan, Miklós Menyhárd, "Nanoscale SiC production by ballistic ion beam mixing of C/Si multilayer structures", *J. phys., D, Appl. phys.*, vol. 49, str. 185303-1-185303-8, 2016.
3. Bernhard M. Berger, Reinhard Stadlmayr, Gerd Meisl, Miha Čekada, Christoph Eisenmenger-Sittner, Thomas Schwarz-Selinger, Friedrich Aumayr, "Transient effects during erosion of WN by deuterium ions studied with the quartz crystal microbalance technique", *Nucl. instrum. methods phys. res., B Beam interact. mater. atoms*, vol. 382, pp. 82-85, 2016.
4. Halil Çalişkan, Cagatay Celil Celil, Peter Panjan, "Effect of multilayer nanocomposite TiAlSiN/TiSiN/TiAlN coating on wear behavior of carbide tools in the milling of hardened AISI D2 steel", *J. nano res.*, vol. 38, pp. 9-17, 2016.
5. Aleksander Drenik, Angelos Mourkas, Rok Zaplotnik, Gregor Primc, Miran Mozetič, Peter Panjan, Daniel Alegre, Francisco L. Tabarés, "Erosion of a-C:H in the afterglow of ammonia plasma", *J. nucl. mater.*, vol. 475, pp. 237-242, 2016.
6. Aljaž Drnovšek, Peter Panjan, Matjaž Panjan, Miha Čekada, "The influence of growth defects in sputter-deposited TiAlN hard coatings on their tribological behavior", *Surf. coat. technol.*, vol. 288, pp. 171-178, 2016.
7. Peter Fajfar, Peter Panjan, Milan Terčelj, Goran Kugler, "Analyses of the reasons for the decreased service time of CrN-coated die for aluminy hot extrusion: a case study", *Metalurgija (Sisak)*, vol. 55, no. 3, pp. 369-374, 2016.
8. Višnja Henč-Bartolič, Tonica Bončina, Suzana Jakovljević, Peter Panjan, Franc Zupanič, "Damage caused by a nanosecond UV laser on a heated copper surface", *Appl. surf. sci.*, vol. 378, pp. 357-361, 15 August 2016.
9. Primož Jovanovič, Vid Simon Šelih, Martin Šala, Samo B. Hočevar, Andraž Pavlišič, Matija Gatalo, Marjan Bele, Francisco Ruiz-Zepeda, Miha Čekada, Nejc Hodnik, Miran Gaberšček, "Electrochemical in-situ dissolution study of structurally ordered, disordered and gold doped $PtCu_3$ nanoparticles on carbon composites", *J. power sources*, vol. 327, pp. 675-680, Sep. 2016.
10. Lazar Kopanja, Irena Milošević, Matjaž Panjan, Vesna Damnjanović, Marin Tadić, "Sol-gel combustion synthesis, particle shape analysis and magnetic properties of hematite ($\alpha - Fe_2O_3$) nanoparticles embedded in an amorphous silica matrix", *Appl. surf. sci.*, vol. 362, pp. 380-386, 2016.
11. Aleksander Matavž, Raluca-Camelia Frunză, Aljaž Drnovšek, Vid Bobnar, Barbara Malič, "Inkjet printing of uniform dielectric oxide structures from sol-gel inks by adjusting the solvent composition", *J. mater. chem. C*, vol. 4, no. 24, pp. 5634-5641, 2016.
12. Vladan Mladenovič, Peter Panjan, Srečko Paskvale, Halil Çalişkan, Nastja Poljanšek, Miha Čekada, "Investigation of the laser engraving of AISI 304 stainless steel using a response-surface methodology", *Teh. vjesn. - Stroj. fak.*, vol. 23, no. 1, pp. 265-271, 2016.
13. Srečko Paskvale, Maja Remškar, Miha Čekada, "Tribological performance of TiN, TiAlN and CrN hard coatings lubricated by MoS_2 nanotubes in olyalphaolefin oil", *Wear*, vol. 352-353, pp. 72-78, 2016.
14. Nina Rogelj, Niko Penttinen, Miha Čekada, Marta Klanjšek Gunde, "Goniospectrometric space: identifiable presentation of spectral goniometric data for complex diffractive samples", *Applied optics*, vol. 55, iss. 8, pp. 2049-2058, 10. Mar. 2016.
15. Branislav Salatić, Suzana Petrović, Davor Peruško, Miha Čekada, Peter Panjan, Dejan Pantelić, Branislav Jelenković, "Single- and dual-wavelength laser pulses induced modification in 10×(Al/Ti)/Si multilayer system", *Appl. surf. sci.*, vol. 360, part B, pp. 559-565, 2016.
16. Marin Tadić, Dragana Marković, Matjaž Panjan, Vojislav Spasojević, "Solution combustion synthesis method and magnetic properties of synthesized polycrystalline calcium manganite $CaMnBO_{3-\delta N}$ powder", *Ceram. int.*, vol. 42, no. 16, pp. 19365-19371, 2016.
17. Pal Terek, Lazar Kovačević, Aleksandar Miletić, Peter Panjan, Sebastian Baloš, Branko Škorić, Damir Kakaš, "Effects of die core treatments and surface finishes on the sticking and galling tendency of Al-Si alloy casting during ejection", *Wear*, vol. 356/357, pp. 122-134, 2016.

Published Conference Contribution

1. Aleksander Matavž, Raluca-Camelia Frunză, Aljaž Drnovšek, Barbara Malič, Vid Bobnar, "Inkjet printing of thin metal-oxide structures from sol-gel-precursor inks", In: *2016 Joint IEEE International Symposium on*

the Applications of Ferroelectrics, European Conference on Application of Polar Dielectrics, (ISAF/ECAPD/PFM), 21-25 August 2016 Darmstadt, Germany.

2. Stojana Veskovič Bukudur, Janez Kovač, Peter Panjan, Damjan Klobčar, Milan Bizjak, Blaž Karpe, "Deposition of Al thin film on FeCrAl alloy and continuous electrical resistance measurement", In: *Zbornik radova*, XI naučno-stručni simpozijum sa međunarodnim učešćem Metalni i nemetalni materijali, proizvodnja, osobine, primjena = 11th Scientific - Research Symposium with international participation, Metallic and nonmetallic materials, production, properties, application, Zenica, 21.-22. april 2016, pp. 109-117.

Independent Component Part or a Chapter in a Monograph

1. Halil Çalişkan, Peter Panjan, Cahit Kurbanoğlu, "Hard coatings on cutting tools and surface finish", In: *Reference module in materials science and materials engineering*, M.S.J Hashmi, ed., pp. 230-242.

Mentoring

1. Pal Terek, *Application of surface engineering technologies for improvement of die casting tools quality:* doctoral dissertation, Novi Sad, 2016 (mentor Damir Kakaš; co-mentor Peter Panjan).

DEPARTMENT OF SURFACE ENGINEERING AND OPTOELECTRONICS F-4

The research program is associated with vacuum science, technology and applications. The main activities are focused on plasma science, the modification of advanced biomedical materials and products for improved biocompatibility, the characterization of inorganic, polymer and composite materials with different thin films on the surface, the modification and characterization of fusion-relevant materials, the thermodynamics of trapped gases and methods for sustaining an ultra-high-vacuum environment, vacuum optoelectronics, and basic research in the field of surface and thin-film characterization by electron and ion spectroscopy techniques.

Head:
Prof. Miran Mozetič

The research team has built several plasma reactors in the past decade. The reactors are often made from glass in order to minimize the loss of neutral reactive gaseous species by heterogeneous surface recombination. Namely, the probability of such reactions on a smooth glass surface is low for most reactive particles. Gaseous plasma can be sustained by different discharges, but the team has specialized in electrodeless discharges powered by high-frequency generators. Small reactors are powered with microwaves, but for the sustenance of plasma in large reactors an electromagnetic field in the radiofrequency range performs better. Particularly suitable are both industrial frequencies of 13.56 and 27.12 MHz. A radiofrequency generator is coupled with a metallic coil wrapped on the glass tube. Such a configuration enables very good coupling between plasma electrons and the electromagnetic field in medium-size reactors, but stray effects are observed in large reactors where the plasma is sustained by powerful generators. In such cases stray effects are common and difficult to avoid. The unwanted effects are due to high voltages that appear across the coil at high powers. Such voltages cause stray capacitive coupling of the RF power to grounded metallic components as well as extensive radiation of the electromagnetic waves. Methods for suppressing high voltages, but keeping large powers, have been studied both theoretically and experimentally in the past few years and a patent application has been filed. The patent was granted in 2016 by the German Patent Office in Munich. In it we disclose methods for suppressing stray voltage across the plasma coil by the appropriate coupling of several coils. The invention relates to a device for the excitation of a high-frequency gas plasma, i.e., optimization of the transfer of electromagnetic power from a radio-frequency generator into a gas plasma. The transfer of power is optimized by using two or more parallel overlapping and offset excitation coils that are serially connected into the assembly, consisting of a generator, a high-frequency cable, a matching network and an excitation coil. The measurements on the connections of the excitation coil prove that for equal transfer of power a lower voltage is required on the double excitation coil consisting of overlapping excitation coils connected in parallel than on the ordinary excitation coil. With the same voltage on the connections of the coil, the plasma is also more intensive, if it is generated in two overlapping excitation coils connected in parallel.

The German patent office granted a patent on innovative coupling between an RF generator and gaseous plasma

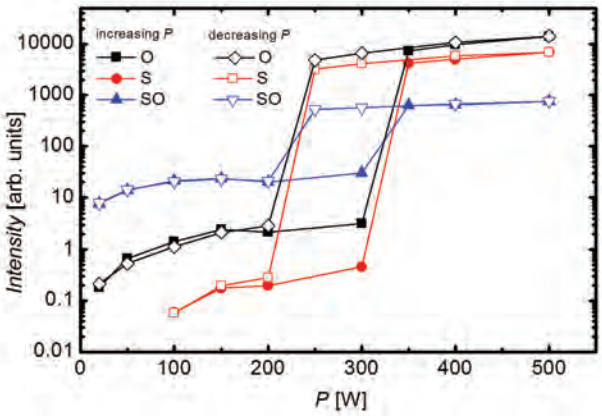


Figure 1: Hysteresis in OES intensities of S, O, and SO versus the forward RF power at a pressure of 30 Pa.

The energy gained by charged gaseous particles oscillating in a high-frequency electric field depends on the mass of the particle. If a RF field is applied, the gaseous ions can hardly follow oscillations in the MHz range, so they gain negligible energy. Electrons are less massive and are accelerating in the field. If they gain enough energy they can multiply during ionization collisions with neutral molecules. The electric field in the coil has at least two components: the capacitive, which develops next to the powered part of the coil; and inductive, which develops inside the coil due to induced electric field. If the predominant component is capacitive, plasma is in the so-called "E-mode". The electric field in this mode is concentrated in a small volume so the density of electrons in gaseous plasma is rather low. In the opposite case the electric field occupies the entire volume inside the coil with a pronounced radial distribution and causes the acceleration of numerous plasma electrons. If the predominant coupling is inductive, the plasma is in "H-mode". The H-mode is characterized by a high electron density and bright luminosity. The appearance of the modes depends on several parameters, with the discharge

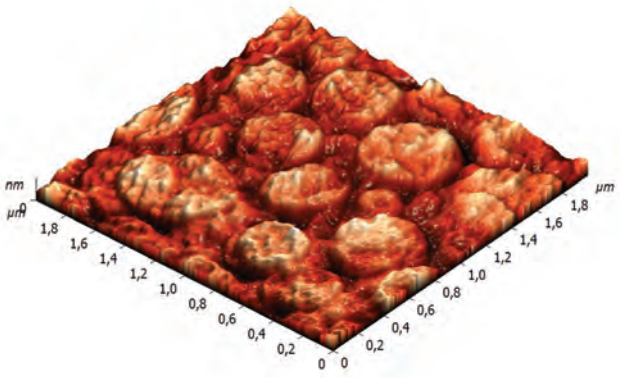


Figure 2: AFM image of originally smooth polymer surface after 80 s of treatment in H_2S plasma in the E-mode.

power and pressure being the most important. The transition between the modes is almost gradual at pressures below about 1 Pa and/or high inductance of the coil, but becomes more abrupt at elevated pressure and lower inductance. The transitions between the modes at a constant pressure and variable power exhibit a pronounced hysteresis. Such effects were studied for the case where plasma was created in sulphur dioxide. SO_2 molecules partially dissociate upon plasma conditions already when the discharge power is low, so that it is in the E-mode. Most intensive radiation arises from the transitions of SO radicals. As the power increases the radiation slightly increases until the transition to the H-mode appears. At this power the plasma luminosity increases abruptly by three orders of magnitude. Simultaneously, the emission from both atomic species (S and O) prevails over the emission of SO radicals, indicating high dissociation of the parent molecules in the H-mode. When decreasing the power, the transition occurs at a lower power, and thus a hysteresis is observed.

Plasma created in sulphur dioxide is used for mimicking sulfurized polymers such as heparin, which is renowned for its anti-thrombogenic properties, and so it is often used as a blood thinner. Heparin binds to the enzyme inhibitor anti-thrombin; therefore, it is a beneficial coating on cardiovascular implants. A brief exposure of polyethylene terephthalate, a polymer commonly used for synthesis of artificial blood vessels, to SO_2 plasma caused mild sulfurization, but atomic oxygen, which abounds in such plasma, causes continuous removal of sulfurized carbon, so the sulphur concentration on the polymer surface was hardly sufficient. Higher concentrations of sulphur on the surface of this polymer were found for the case that the plasma was created in H_2S. Depending on the plasma parameters the sulphur concentration as determined by X-ray photoelectron spectroscopy (XPS) reached almost 40 at.%. A well-pronounced maximum in the sulphur concentration versus the plasma treatment time was observed. A combination of XPS and time-of-flight secondary ion mass spectroscopy (ToF SIMS) techniques revealed the formation of polysulfide on the surface of PET polymer within a limited range of plasma radicals' fluence. The originally smooth polymer surface underwent an interesting change in the surface morphology. Within the limited range of the radicals' fluence, densely distributed circular nanostructures of typical sub-micrometre lateral dimension and a height of several 10 nm were observed by atomic force microscopy (AFM).

The plasma treatment causes changes in both surface morphology and functionality, which in turn influences the adsorption kinetic of proteins upon the incubation of polymeric grafts with human blood. This effect was studied in collaboration with a research team at Soleil synchrotron in France. Thin films of human serum albumin (HSA) were immobilized on polystyrene (PS) substrates previously functionalized either with polar or nonpolar functional groups. The functionalization was performed by treatment with cold gaseous plasma created in pure oxygen and tetrafluoromethane (CF_4) plasmas, respectively. Samples were examined with soft X-rays in the photon energy range of 520 to 710 eV in the ANTARES beam line. Near-edge X-ray absorption fine structure (NEXAFS) was selected for studying the behavior of albumin on the surface of a plasma-treated polymer. NEXAFS spectra of oxygen and fluorine K-edges were collected at different spots on the sample, and measurements at each spot were repeated many times. A strong degradation of the HSA protein upon irradiation with synchrotron light was observed. The weakly irradiated samples exhibited strong absorption at 531.5 eV associated with the O 1s→ϖ^*_{amide} transitions, and a broad non-distinctive peak at 540 eV was attributed to the O 1s→$\sigma^*_{C\text{-}O}$ transitions. Both peaks decreased with increasing irradiation time until they were completely replaced by a broad, non-distinctive peak at around 532 eV, indicating the destruction of the original protein conformation. The shortage of amide groups indicated breakage of the peptide bonds.

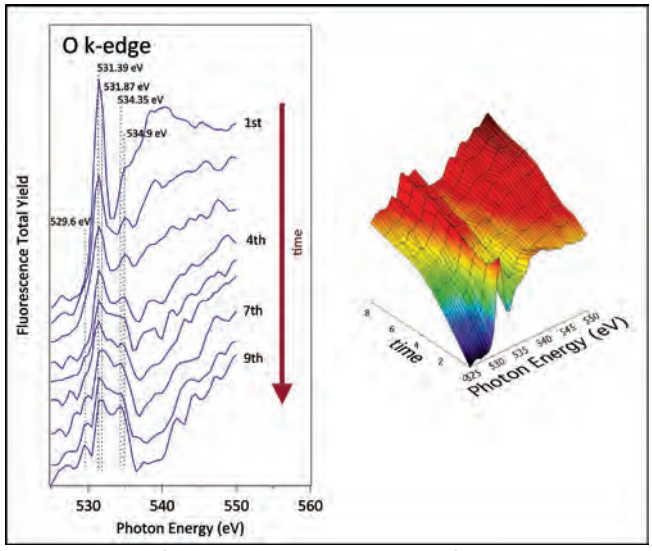


Figure 3: Series of oxygen K-edge NEXAFS spectra of an albumin-incubated sample treated with oxygen plasma and incubated with albumin.

Low-pressure cold plasma is also useful for the treatment of textiles to improve their functional properties. A fruitful collaboration has been established with the Department of Textiles at the Faculty of Natural Sciences and Engineering, University of Ljubljana. Plasma created in various gases was used for both nanostructuring and functionalization of fabrics made from natural fibres. We were following the current trends of using ecologically benign treatments for surface finish as well as dyes extracted

from natural sources. In order to achieve colourful and antibacterial textiles, cotton and bamboo-rayon knitted fabrics were treated using radio-frequency, low-pressure plasma created in water vapour and dyed with the extract of Fallopia japonica (Japanese knotweed) rhizome. Water vapour was used as a natural choice since such fabrics contain a substantial amount of water, which is slowly released upon vacuum conditions. Even a brief plasma treatment induced a weak etching effect on the surface of the cellulose samples, since water molecules in plasma dissociate to produce hydroxyl radicals and oxygen atoms. Both radicals interact chemically with the organic material, thus interacting preferentially with any surface impurities as well as the uppermost layer of cellulose. Plasma-treated samples exhibited a higher dye uptake as well as pronounced antibacterial properties against *S. aureus*.

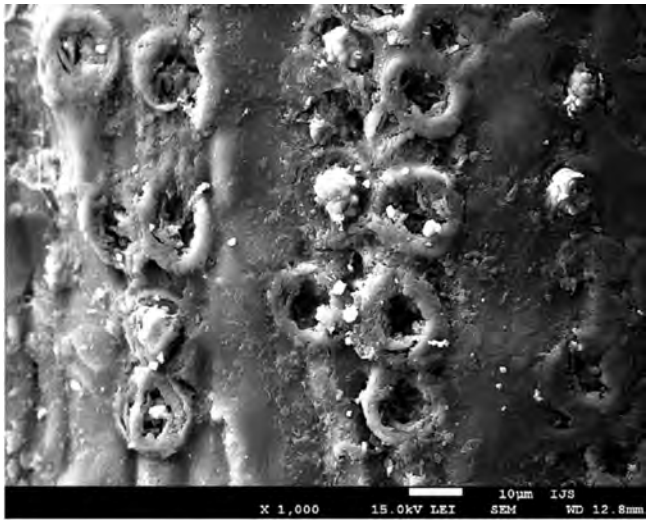


Figure 4: SEM image of a coir fibre after treatment with oxygen plasma reveals an interesting morphology.

Another way to improve the performance of medical textiles is the incorporation of nanoparticles into fabrics or embedment into deposited coatings with antibacterial efficiency using atmospheric pressure plasma process. This research has been performed in the frame of the M-ERA. NET programme and strong collaboration with Ghent University. We developed a direct current plasma jet as a plasma-deposition source. The jet was stabilized by fast nitrogen flow. Three different types of the nanoparticles (silver, copper and zinc oxide) were employed as antimicrobial agents. During the deposition most of these nanoparticles were partially oxidized and embedded into the polymer coating generated by admixing hexamethyldisiloxane (HDMSO). The microbiological testing showed that samples loaded with nanoparticles of Ag and Cu and having a barrier layer of 10 nm, exhibit almost 97% bacterial reduction for *Escherichia coli* and *Staphylococcus aureus*, whereas the samples with ZnO nanoparticles provided only 86% reduction of *Staphylococcus aureus*.

Today, synthetic fibre-reinforced plastics have proven to meet the structural and durability requirements of components for various applications. However, glass-reinforced plastics exhibit shortcomings such as their relatively high fibre density, their difficulty to machine and poor recycling properties. With the growing global energy crisis and ecological risks, natural fibre-reinforced polymer composites have attracted more research interest due to their potential for serving as an alternative for artificial fibre composites. Natural fibres offer benefits such as reductions in weight, cost and CO_2 emission; less reliance on oil resources; and recyclability. To use the natural fibre-reinforced polymers, several major technical issues must be solved to facilitate the insertion of natural fibres in polymer composites. A critical factor in reinforced polymers is the strength of the bond between the fibre and polymer matrix, because the load is transmitted through the fibre–matrix interface. In order to improve it, we used the technology of selective plasma etching. An abundant natural source of fibres are coconuts. The raw coir fibres are not suitable for fibre-enforced plastics due to their hydrophobic nature since they contain lots of lignin and pectin. These components must be removed selectively from the fibres' surface to improve the adhesion of any polymer. Such an effect was achieved using rather aggressive oxygen plasma treatment. The impurities were quickly removed, revealing interesting structure of the coir fibres. Furthermore, the cellulose component was nanostructured so the treated fibres assumed excellent wettability – the water absorbency time decreased by two orders of magnitude.

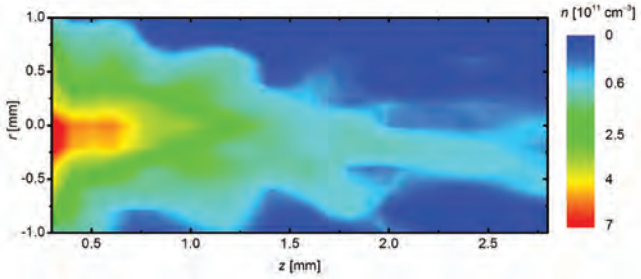


Figure 5: Spatially resolved He metastable density distribution over the effluent of a free atmospheric pressure plasma jet.

Another good example of the selective etching of polymers and polymer-matrix composites is a collaborative work with the industrial partner Kolektor on an improvement of the insulating properties of polyphenolic composites. A composition with suitable fillers is a common strategy to improve the electrical insulation properties of polymeric materials, which is limited by the carbonization of a protruding surface polymer. To resolve this problem, we implemented Ar/O_2 plasma etching of a glass-filled polyphenolic composite to uncover the fillers by selective removal of the surface polymer. The exposure of the glass fillers increased the performance level to 65%, which enabled the material to be used as an insulator for commercial applications. The innovative solution to solving the problem of increasing surface insulation properties without adding expensive fillers to the polymer composite was also protected by a patent application.

Low-pressure, weakly ionized gaseous plasma is also suitable for tailoring the surface properties of inorganic materials. Within a newly granted project we studied the biological response of nanostructured titania that is suitable for the coating of vascular stents. Currently available stents are often made from titanium alloys. Such

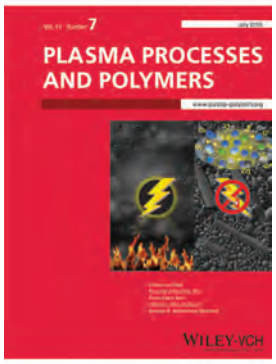


Figure 6: Journal cover page presenting improvement of plasma-etched thermoplastic composites, which become tracking and fire resistant.

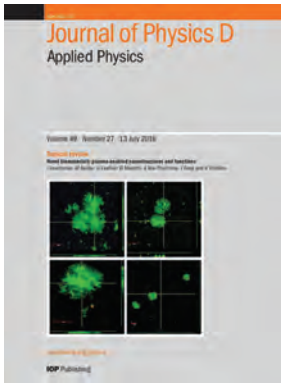
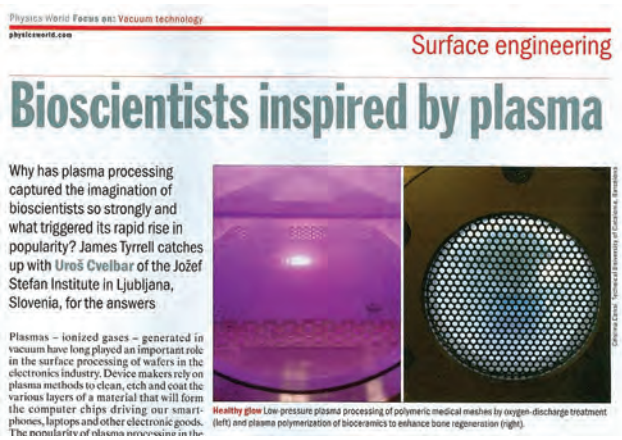


Figure 7: Journal over page presenting reduction of P. aeruginosa biofilm cells after plasma treatment.

stents lack of desired biological response, mostly due to restenosis, which occurs in more than 33% of cases where stents have been implanted. We developed a method for improving the proliferation of endothelial cells and simultaneously reducing adhesion and the activation of blood platelets on the surface of plasma-modified stents. The innovative method was disclosed in a patent application entitled: "Method for coating a medical device, especially a vascular stent" which has been submitted to the German patent office. We managed to achieve appropriate nanostructuring of the surface (biomimetic surface), which, after a treatment with highly reactive oxygen plasma, prevents platelet adhesion and activation, which in turn significantly reduces the possibilities for thrombotic reactions. Moreover, such a surface treatment also improves the endothelial cell proliferation, which is of primary importance, since such cells represent an ideal natural anti-thrombogenic material. In collaboration with the Faculty of Electrical Engineering, University of Ljubljana, we fabricated uniformly distributed dense and mechanically stable TiO_2 nanotubes on stents' surfaces. The plasma treatment enabled the removal of toxic fluorine, which is otherwise present on the surface due to electrochemical anodization process. *In-vitro* studies with whole human blood clearly showed that the platelets did not interact with surfaces prepared by the methods of invention, especially in the case of the 100-nm nanotube diameter. No platelets were detected on the plasma-treated TiO_2 nanotubes of 100 nm in diameter, and only a few on the nanotubes of 50 nm in diameter. Furthermore, *in-vitro* studies conducted with endothelial cells revealed the superior properties of plasma-treated nanostructured surfaces.

The stocks of fossil fuels are limited and their exploitation causes global warming, so we are looking for alternative energy sources for future generations. The cleanest energy arises from solar radiation, but it is difficult and expensive to transform it into useful energy. An alternative is the application of the same process as powers stars - nuclear fusion. Fusion power has the potential to provide sufficient energy to satisfy mounting demand, and to do so sustainably, with a relatively small impact on the environment. Nuclear fusion has many potential advantages over other energy sources. Firstly, its hydrogen isotope fuels are relatively abundant on earth. Furthermore, a fusion reactor would produce virtually no CO_2 or atmospheric pollutants, and its other radioactive waste products would be very short-lived compared to those produced by conventional nuclear reactors. Therefore, experimental fusion reactors have been built in order to solve numerous technological problems that currently prevent the exploitation of fusion energy. We have been involved in fusion-related research within Eurofusion projects for a decade. In 2016 we performed experiments at ASDEX Upgrade and JET reactors, which are currently the largest operating tokamaks. Our interest was mainly focused on ammonia production in fusion reactors. Because the cooling of the fusion plasma is needed near the plasma-facing components, nitrogen is often seeded into the divertor region. The ammonia is formed mainly in this region by surface processes. We investigated the production of ammonia on different materials currently used for manufacturing plasma-facing components in order to estimate the retention of tritiated ammonia in future reactors. This effect may be detrimental, but we discovered that ammonia also has at least one positive effect; it cleans amorphous hydrogenated carbon from the reactor walls.

The gas dynamics, in particular adsorption/desorption from walls of low-pressure reactors, is often studied by mass spectrometry. The precise quantification of extremely small gas amounts requires the applied quadruple mass spectrometer to be *in-situ* calibrated at very small gas-leak rates. A precise calibration of a mass spectrometer was realized by leaking a specific gas through a fixed opening of the leak valve, connected to the analytical chamber. Exponential pressure decay in the upstream volume means that the molecular gas flow rate is also decaying exponentially. The correlation of the ion current of a specific ion mass versus the gas-leak rate expresses the mass spectrometer's sensitivity over a wide range. During the calibration campaign conducted with hydrogen in an ultra-high vacuum (UHV) chamber, a slight deviation from the exponential decay and a drift of the base background pressure were observed. Both effects were attributed to the hydrogen absorption on surfaces. Its importance was then studied intentionally in detail. An UHV chamber is generally supposed to have a constant base background outgassing rate q_0 over very long periods of time. In experiments with ionized or neutral molecular hydrogen, this level might be increased by the absorption of a small fraction of hydrogen. The absorption of molecular hydrogen was monitored in a small, austenitic stainless-steel UHV chamber during 3 h exposures at initial pressures from 0.01 to 1 mbar at room temperature. An absorbed dose of ~10^{13}–10^{14} atom H cm^{-2} was recorded. After gas removal, the desorption period in the closed vacuum system lasted for 20 h, wherein most of the absorbed hydrogen was released. The initial desorption rate was 10–100 times higher than the previous q_0. Calculations based on well-accepted


Physics World Focus on: Vacuum technology

Surface engineering

Bioscientists inspired by plasma

Why has plasma processing captured the imagination of bioscientists so strongly and what triggered its rapid rise in popularity? James Tyrrell catches up with Uroš Cvelbar of the Jožef Stefan Institute in Ljubljana, Slovenia, for the answers

Plasmas – ionized gases – generated in vacuum have long played an important role in the surface processing of wafers in the electronics industry. Device makers rely on plasma methods to clean, etch and coat the various layers of a material that will form the computer chips driving our smartphones, laptops and other electronic goods.

Healthy glow Low-pressure plasma processing of polymeric medical meshes by oxygen-discharge treatment (left) and plasma polymerization of bioceramics to enhance bone regeneration (right).

Figure 8: Promotion of special issue in J. Phys. D: Appl. Phys. on "Plasma-inspired biomaterials" edited by prof. Cvelbar.

models for hydrogen–metal interactions confirm that the observed absorption–desorption processes are related mainly to the native oxide layer. Its reported thickness is between 1 and 3 nm, and our results express its high solubility, which at 1 nm ranges from $K_{sox}(294\ K) = 2.0\times10^{22}$ to 3.8×10^{22} atom H $cm^{-3}\cdot bar^{-0.5}$. The recombination rate coefficient ranges from $K_{Lox}(294K) = 8.9\times10^{-19}$ to 6.45×10^{-18} $cm^4\ s^{-1}$. The properties of the bulk metal were not affected noticeably in 24 h cycles as the oxide-layer–bulk-metal interactions proceed substantially slower.

Apart from low-pressure plasma we are also involved in research on non-equilibrium gaseous plasma created at atmospheric pressure. Although such plasma has several advantages over low-pressure plasma, the inadequate knowledge of its characteristics still prevents mass application on an industrial scale. An investigation of excited species, metastable states, reactive species, etc. is one of the highly desirable goals. Due to its important role in plasma generation and plasma chemistry processes, metastable helium (He) atoms are a great candidate for this kind of an investigation. We studied the properties of atmospheric pressure plasma jet (APPJ) in collaboration with our colleagues from the Institute of Physics in Zagreb, Croatia. Using cavity ring down spectroscopy (CRDS) we measured the density of He atoms in the metastable state (2^3S_1), across the single electrode APPJ during the treatment of various samples. For the first time we managed to obtain the spatially resolved He metastable density distribution over the effluent of the APPJ. We found a correlation between sample conductivities and metastable He densities above the sample surface. The metastable He density can be increased with decreasing sample distance, increasing conductive sample surface area and by increasing He flow,which what is important for the application of such plasma for tailoring the surface properties of materials on a small scale.

Figure 9: An atmospheric pressure plasma reactor was integrated to the production line at Tosama company for the deposition of antimicrobial thin films on wound care products in the frame of the European project IP4Plasma

Atmospheric pressure gaseous plasma is not suitable for the uniform treatment of three-dimensional objects due to strong gradients in reactive particles densities, but performs well for the treatment of planar objects. The best results are obtained with porous two-dimensional products such as textiles. A technology for the treatment of infinite textiles used for wound healing has been developed in the frame of the EU project "IP4Plasma": Industrial Innovations Based on EU Intellectual Property Assets in the Field of Atmospheric Pressure Plasma Technology. The project was completed successfully in the autumn of 2016. The IP4Plasma project was funded by the European Union under the 7th Framework Programme for Research and Innovation. It lasted three years and involved some leading experts in surface engineering by gaseous plasma, equipment manufacturers and users of plasma technologies. Nine European partners from research organizations and industry were involved: Spinverse Ltd (Finland), Fraunhofer Institute for Surface Engineering and Thin Films IST (Germany), IMA (Belgium), Jozef Stefan Institute (Slovenia), LIONEX GmbH (Germany), SOFTAL Corona & Plasma GmbH (Germany), Tosama (Slovenia), VITO - Flemish Institute for Technological Research (Belgium) and 2B (Italy). The result of this project is a new technology for the plasma deposition of coatings on wound dressings, improving the wound-draining behaviour and add anti-inflammatory properties of products made by Tosama company. Our group performed a precise surface characterization of plasma-deposited coatings using the XPS and ToF-SIMS methods. In the frame of the project we also developed a new method for the fast and in-line monitoring of the efficiency of the air plasma surface activation at very high speed of textiles, which has a great potential for global industrial applications.

The European project IP4Plasma involving nine European partners, among them the Jožef Stefan Institute and the Tosama company from Slovenia, was completed successfully

Similarly, the control and regulated release of antibiotic drugs from plasma-treated medical implant surfaces could be achieved using atmospheric plasma sources. Calcium phosphate ceramics are promising bone substitutes, since they have good biocompatibility and bioresorbability. Currently, such ceramics loaded with antibiotics in order to prevent infections are already on the market, but the control of release patterns has to be further improved. Cold plasmas can provide useful means of modifying the surface interactions with drugs through surface modification. For this reason, we explored the possibilities of using atmospheric pressure plasmas as a tool for modifications of calcium phosphate materials with newly

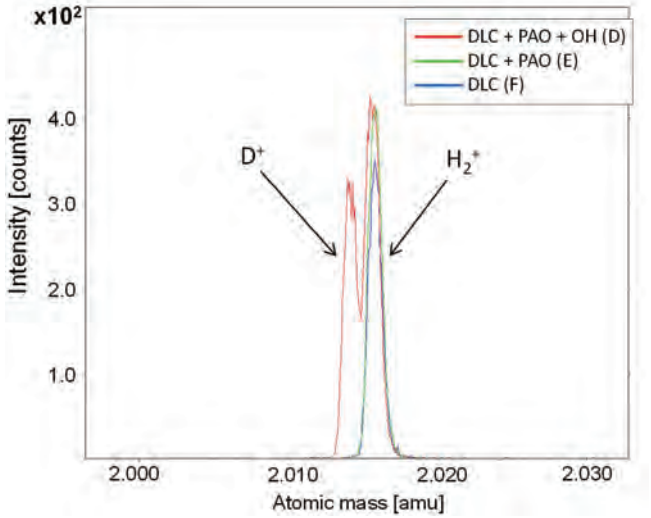


Figure 10: High-resolution mass spectra obtained by the ToF-SIMS method from diamond-like carbon after the desorption of a lubricant containing deuterated hexadecanol molecules.

populated bonds and charges, with the aim of enabling higher loading and controlled drug release. For surface modifications of β-tricalcium phosphate ceramics we implemented APPJ sustained in helium as a tool for tuning the controlled release of the antibiotic doxycycline hyclate, employed as a drug model. The surface chemistry was tailored upon interaction with the APPJ. We managed to obtain an increased oxygen-to-carbon ratio without changes in the topography as well as a build-up of surface charges. This led to slower and steady release kinetics after bonding drugs to the surface. Moreover, we demonstrated that atmospheric pressure plasma might prove to be a promising new tool that will lead to the design of a better controlled drug release from bio-ceramic matrices.

Diamond-like carbon (DLC) films are one of the fastest developing coatings ensuring low friction and protecting the sliding surfaces of various mechanical components. Because of their superior sliding properties, DLC coatings are now being widely used in many applications such as IC engines, slider bearings and hard discs. Despite the good sliding properties, even in the absence of any lubricant, the use of a lubricant seems inevitable for better heat dissipation and thus extended service life. The interaction between lubricants and DLC coatings is still not well understood, despite many studies over the past few years. We used ToF-SIMS and XPS methods to examine the adsorption ability and mechanisms with respect to two oiliness additives, i.e., hexadecanol and hexadecanoic acid, on the surface of weakly oxidized DLC coatings. Additionally, we analysed the resistance of the adsorbed additive films against external influences. Neither of these surface-sensitive techniques is capable of distinguishing between hydrogen from the substrate and the additives. In order to obtain impeccable results, the additives were deuterated. The high resolution of the ToF SIMS instrument allowed for a distinction between deuterium atoms from the additive and hydrogen molecules from the substrate in secondary-ion spectra. Our results show that both molecules adsorb on the surface oxides and hydroxides and shield these structures with their hydrocarbon tails. This makes the surfaces less polar, which was manifested in a smaller polar component of the surface energy. Of the two examined molecules, the hexadecanoic acid showed a greater adsorption ability than the alcohol, which explains the better tribological properties when the acid was used as an additive in a lubrication oil.

Figure 11: The JVC-16 & EVC- 14 conference attracted 181 participants from 25 countries.

The research team organized several international scientific meetings including the 16th Joint Vacuum Conference (JVC-16) and the 14th European Vacuum Conference (EVC-14). The conference took place in Portorož between June 6th and 10th.

Some outstanding publications in the past three years

1. Vesel, A.; Mozetic, M.; Zaplotnik, R., Device for high-frequency gas plasma excitation: DE 112012000015 (B4), 2016-04-21. *Munchen: Deutches Patent Office* 2016.
2. Zaplotnik, R.; Vesel, A.; Mozetič, M., Investigation of reactive plasma species created in SO_2 by an inductively coupled RF discharge in E- and H-mode. *Journal of applied physics,* 2016, *120*, 163302-1-163302-9.
3. Recek, N.; Primc, G.; Vesel, A.; Mozetič, M.; Avila, J.; Razado-Colambo, I.; Asensio, M. C., Degradation of albumin on plasma-treated polystyrene by soft X-ray exposure. *Polymers*, 2016, *8*, 244-1-244-7.
4. Gorjanc, M.; Savić, A.; Topalić-Trivunović, L.; Mozetič, M.; Zaplotnik, R.; Vesel, A.; Grujić, D., Dyeing of plasma treated cotton and bamboo rayon with Fallopia japonica extract. *Cellulose* 2016, *23*, 2221-2228.
5. Drenik, A.; Mourkas, A.; Zaplotnik, R.; Primc, G.; Mozetič, M.; Panjan, P.; Alegre, D.; Tabarés, F.L., Erosion of a-C:H in the afterglow of ammonia plasma. *Journal of Nuclear Materials* 2016, *475*, 237-242.
6. Zaplotnik, R.; Bišćan, M.; Popović, D.; Mozetič, M.; Milošević, S., Metastable helium atom density in a single electrode atmospheric plasma jet during sample treatment. *Plasma Sources Science and Technology* 2016, *25*, 035023.
7. Simič, R.; Kalin, M.; Kovač, J.; Jakša, G., Adsorption of alcohols and fatty acids onto hydrogenated (a-C:H) DLC coatings. *Applied Surface Science* 2016, 363, 466-476.
8. Canal, C.; Modic, M.; Cvelbar, U.; Ginebra, M.P., Regulating th eantibiotic drug release from β-ricalcium phosphate ceramics by atmospheric pressure surface engineering. *Biomaterials science* 2016, 5, 1454-1461.
9. Puliyalil, H.; Slobodian, P.; Sedlacik, M.; Benlikaya, R.; Riha, P.; Ostrikov, K.; Cvelbar, U., Plasma-enabled sensing of urea and related amides on polyaniline. *Frontiers of Chemical Science and Engineering* 2016, 10, 265-272.
10. Nemanič, V.; Žumer, M., Quantification of small gas amounts with an ion trap mass spectrometer, *International Journal of Mass Spectrometry* 2016, 401, 17-21

Patents granted

1. Alenka Vesel, Miran Mozetič, Rok Zaplotnik, Device for high-frequency gas plasma excitation, DE112012000015 (B4), Deutsches Patent- unt Markenamt, 21. 04. 2016
2. Alenka Vesel, Rok Zaplotnik, Miran Mozetič, Method for cleaning of with body fluid-contaminatedmedical implantants and devices with the use of atomic oxygen, SI24840 (A), Slovenian Intellectual Property Office, 29. 04. 2016
3. Gregor Filipič, Kristina Eleršič, Darij Kreuh, Janez Kovač, Uroš Cvelbar, Miran Mozetič, A method of colouring titanium and titanium alloys, SI24851 (A), Slovenian Intellectual Property Office, 29. 04. 2016

INTERNATIONAL PROJECTS

1. 7FP - IP4Plasma; Industrial Innovations Based on EU Intellectual Property Assets in the Field of Atmospheric Plasma Technology
   Asst. Prof. Janez Kovač
   European Commission
2. COST TD1208; Electrical Discharges with Liquids for Future Applications; COST Training School on Liquid Discharges
   Prof. Uroš Cvelbar
   Cost Office
3. NATO Grant; SPS 984555; Atmospheric Pressure Plasma Jet for Neutralisation of CBW
   Prof. Uroš Cvelbar
   Nato - North Atlantic Treaty Organisation
4. COST CA15114; Anti-Microbal Coating Innovations to prevent Infectious Diseases (AMICI)
   Prof. Uroš Cvelbar
   Cost Office
5. Education-ED-FU, EUROFUSION
   Prof. Miran Mozetič
   European Commission
6. Sniffing for Carcinogenic Substances - Research for Toxic Gas Molecule Sensing with Networks of Carbon Nanowalls
   Prof. Uroš Cvelbar
   Slovenian Research Agency
7. Advanced Photo-electrochemical Cells with Nanostructured Iron Oxide Electrodes
   Prof. Miran Mozetič
   Slovenian Research Agency
8. Irradiation of Metal Oxide Nanowires
   Prof. Uroš Cvelbar
   Slovenian Research Agency
9. Biocompatible Nanostructured Tetragonal Zirconium Oxide Thin Films with Alternative Stabilization Dopants
   Prof. Miran Mozetič
   Slovenian Research Agency
10. Innovative Method for Synthesis of Thin Absorption Films for Photovoltaics
    Asst. Prof. Alenka Vesel
    Slovenian Research Agency
11. Sterilization of Heat-sensitive Materials with Innovative Plasma Source of UV Radiation
    Prof. Miran Mozetič
    Slovenian Research Agency
12. Dust in Plasmas (DIP)
    Prof. Miran Mozetič
    Slovenian Research Agency
13. MS-MZDR/16-1-B2-071; ECS Electrochemical Society
    Prof. Uroš Cvelbar
    Slovenian Research Agency
14. Presentations and Invited Talk at the Conference at the University of Liverpool: Plasma Technology as a Tool for the Inactivation of Food-related Microorganisms
    Prof. Miran Mozetič
    Slovenian Research Agency
15. Small Services
    Prof. Uroš Cvelbar

RESEARCH PROGRAMS

1. Vacuum technique and materials for electronics
   Dr. Vincenc Nemanič
2. Thin film structures and plasma surface engineering
   Prof. Miran Mozetič

R & D GRANTS AND CONTRACTS

1. Understanding plasma processes and thin film growth in High Power Impulse Magnetron Sputtering
   Prof. Uroš Cvelbar
2. Nanoscale engineering of the contract interfaces for green lubrication technology
   Asst. Prof. Janez Kovač
3. Multifunctional electrospunned nanofibers development and dynamic interaction studies with pathogen bacteria
   Prof. Miran Mozetič
4. Development of the functional textiles used fot the treatment of diabetic foot (malum perforans)
   Prof. Miran Mozetič
5. New materials for printed sensors and indicators and their integration in smart printed matter
   Asst. Prof. Alenka Vesel
6. Interaction between fully dissociated moderately ionized ammonia plasma and glass-fiber reinforced polymers
   Prof. Miran Mozetič
7. Nanostructures and related composites for detection of hazardous gaseous molecules
   Prof. Uroš Cvelbar
8. Functionalization of polymer cardiovascular implants for optimal hemocompatibility
   Asst. Prof. Alenka Vesel
9. New generation of superior creep resistant steels with nanoparticles modified microstructure
   Prof. Uroš Cvelbar
10. Advanced hydrodesulphurisation with catalyst nanomaterials
    Prof. Uroš Cvelbar
11. Advanced hemocompatible surfaces of vascular stents
    Dr. Ita Junkar
12. Self-lubricating and wear resistant PVD hard coatings based on (V,Cr,Al,Ti)N for hot-working processes
    Asst. Prof. Janez Kovač
13. Building blocks, tools and systems for the Factories of the Future – GOSTOP
    Prof. Miran Mozetič
14. Food for future - F4F
    Asst. Prof. Alenka Vesel
15. Potential of biomass for development of advanced materials and bio-based products
    Dr. Ita Junkar
16. Novel type of antibacterial coatings on textile materials and plastics with controllable release of antibacterial agent
    Prof. Uroš Cvelbar
    Hydrogen Permeation Measurements on PVD-Coated Eurofer
    Dr. Vincenc Nemanič
    Ústav Fyziky Plazmatu Av Čr, V. V. I.

VISITORS FROM ABROAD

1. Prof. Dr Xiao Xia Zhong, Shanghai University, Shanghai, China, 31 January–1 February 2016
2. Prof. Dr Xiao Xia Zhong, Shanghai University, Shanghai, China, 10–12 February 2016
3. Prof. Dr Davide Mariotti, Ulster University, Jordanstown, UK, 2–5 April 2016
4. Prof. Dr Joanna Pawlat, Lublin University of Technology, Lublin, Poland, 16–17 April 2016
5. Prof. Dr Joanna Pawlat, University of Technology, Lublin, Poland, 21–22 April 2016
6. Prof. Stella W. Pang, The University of Hong Kong, Hong Kong, China, 15–17 May 2016
7. Prof. Lin Dai, The University of Hong Kong, Hong Kong, China, 15–17 May 2016
8. Prof. Rosa Chan, The University of Hong Kong, Hong Kong, China, 15–17 May 2016
9. Christian Nöbauer, Vienna University of Technology, Vienna, Austria, 22–26 May 2016
10. Yishan Han, Shanghai University, Shanghai, China, 5–14 June 2016
11. Prof. Jiang Yong Wang, Shanghai University, Shanghai, China, 9–14 July 2016
12. Doc. Ing. Petr Slobodian, Ph.D., Tomas Bata University in Zlín, Zlín, Czech Republic, 20–23 September 2016
13. Jiri Matyas, Tomas Bata University in Zlín, Zlín, Czech Republic, 20–23 September 2016
14. Ondra Grulicha, Tomas Bata University in Zlín, Zlín, Czech Republic, 1 August–30 September 2016

15. Martina Minařík, Tomas Bata University in Zlín, Zlín, Czech Republic, 1 August–30 September 2016
16. Prof. Dr Hyung Jun Cho, Nagoya University, Nagoya, Japan, 12–15 November 2016
17. Christian Nöbauer, Vienna University of Technology, Vienna, Austria, 20–22 October 2016
18. Prof. Dr Christoph Eisenmengger – Sittner, Vienna University of Technology, Vienna, Austria, 20–22 October 2016
19. Masakazu Tomatsu, Nagoya University, Nagoya, Japan, 12–15 November 2016
20. Prof. Dr Makota Sekine, Nagoya University, Nagoya, Japan, 12–15 November 2016
21. Prof. Dr Petr Špatenka, Czech Technical University in Prague, Prague, Czech Republic, 22–24 November 2016

STAFF

Researchers
1. Prof. Uroš Cvelbar
2. *Dr. Aleksander Drenik, on leave 01.03.16*
3. Dr. Ita Junkar
4. Asst. Prof. Janez Kovač
5. **Prof. Miran Mozetič, Head**
6. Dr. Vincenc Nemanič
7. Asst. Prof. Alenka Vesel
8. Dr. Rok Zaplotnik

Postdoctoral associates
9. Dr. Gregor Filipič
10. *Dr. Gregor Jakša, left 01.09.16*
11. Dr. Martina Modic
12. Dr. Gregor Primc
13. Dr. Nina Recek

Postgraduates
14. Nataša Hojnik, B. Sc.
15. Matej Holc, B. Sc.
16. Matic Resnik, B. Sc.
17. Marko Žumer, B. Sc.

Technical officers
18. Tatjana Filipič, B. Sc.

Technical and administrative staff
19. Tinkara Bezovšek, B. Sc.
20. Urška Kisovec, B. Sc.
21. Janez Trtnik

BIBLIOGRAPHY

Original Article

1. Somayeh Akbari, Janez Kovač, Mitjan Kalin, "Effect of ZDDP concentration on the thermal film formation on steel, hydrogenated non-doped and Si-doped DLC", *Appl. surf. sci.*, vol. 383, pp. 191-199, Oct. 2016.
2. Asma Juma Albrbar, Veljko Djokić, Andjelka Bjelajac, Janez Kovač, Jovana Ćirković, Miodrag Mitrić, Đorđe Janaćković, Rade Petrović, "Visible-light active mesoporous, nanocrystalline N,S-doped and co-doped titania photocatalysts synthesized by non-hydrolytic sol-gel route", *Ceram. int.*, vol. 42, no. 15, pp. 16718-16728, 2016.
3. Mojca Božič, Vera Vivod, Robert Vogrinčič, Irena Ban, Gregor Jakša, Silvo Hribernik, Darinka Fakin, Vanja Kokol, "Enhanced catalytic activity of the surface modified TiO_2 −MWCNT nanocomposites under visible light", *J. colloid interface sci.*, vol. 465, pp. 93-105, 2016.
4. Cristina Canal, Martina Modic, Uroš Cvelbar, M. P. Ginebra, "Regulating the antibiotic drug release from β-tricalcium phosphate ceramics by atmospheric plasma surface engineering", *Biomaterials science*, vol. 4, pp. 1454-1461, 2016.
5. A. Dias, N. Bundaleski, E. Tatarova, F. M. Dias, M. Abrashev, Uroš Cvelbar, O. M. N. D. Teodoro, J. Henriques, "Production of N-graphene by microwave N_2-Ar plasma", *J. phys., D, Appl. phys.*, vol. 49, no. 5, pp. 055307-1-055307-9, 2016.
6. Aleksander Drenik, Angelos Mourkas, Rok Zaplotnik, Gregor Primc, Miran Mozetič, Peter Panjan, Daniel Alegre, Francisco L. Tabarés, "Erosion of a-C:H in the afterglow of ammonia plasma", *J. nucl. mater.*, vol. 475, pp. 237-242, 2016.
7. Ajda Flašker, Mukta Vishwanath Kulkarni, Katjuša Mrak Poljšak, Ita Junkar, Saša Čučnik, Polona Žigon, Anca Mazare, Patrik Schmuki, Aleš Iglič, Snežna Sodin-Šemrl, "Binding of human coronary artery endothelial cells to plasma-treated titanium dioxide nanotubes of different diameters", *J. biomed. mater. res., Part A*, vol. 104, no. 5, pp. 1113-1120, May 2016.
8. Marija Gorjanc, Aleksandar Savić, Ljiljana Topalić-Trivunović, Miran Mozetič, Rok Zaplotnik, Alenka Vesel, Dragana Grujić, "Dyeing of plasma treated cotton and bamboo rayon with Fallopia japonica extract", *Cellulose (Lond.)*, vol. 23, no. 3, pp. 2221-2228, 2016.
9. Mina Jovanovic, Iztok Arčon, Janez Kovač, Nataša Novak Tušar, Bojana Obradović, Nevenka Rajić, "Removal of manganese in batch and fluidized bed systems using beads of zeolite A as adsorbent", *Microporous and mesoporous materials*, vol. 226, pp. 378-385, 2016.
10. B. M. Jović, U. Č. Lačnjevac, V. D. Jović, Lj. Gajić-Krstajić, Janez Kovač, Dejan Poleti, Nedeljko Krstajić, "Ni-(Ebonex-supported Ir) composite coatings as electrocatalysts for alkaline water electrolysis. Part II, Oxygen evolution", *Int. j. hydrogen energy*, vol. 41, no. 45, pp. 20502-20514, 2106.
11. Ita Junkar, Mukta Vishwanath Kulkarni, Barbara Drašler, Neža Rugelj, Anca Mazare, Ajda Flašker, Damjana Drobne, Petr Humpolíček, Matic Resnik, Patrik Schmuki, Miran Mozetič, Aleš Iglič, "Influence of various sterilization procedures on TiO_2 nanotubes used for biomedical devices", *Bioelectrochemistry*, vol. 109, pp. 79-86, Jun. 2016.
12. Ita Junkar, Mukta Vishwanath Kulkarni, Barbara Drašler, Neža Rugelj, Nina Recek, Damjana Drobne, Janez Kovač, Petr Humpolíček, Aleš Iglič, Miran Mozetič, "Enhanced biocompatibility of TiO_2 surfaces by highly reactive plasma", *J. phys., D, Appl. phys.*, vol. 49, no. 24, pp. 244002-1-244002-10, 2016.
13. Mohamed Karmaoui, J. S. Amaral, Luc Lajaunie, Harinarayanan Puliyalil, David Maria Tobaldi, Robert C. Pullar, Joao Antonio Labrincha, Raul Arenal, Uroš Cvelbar, "Smallest bimetallic $CoPt_3$ superparamagnetic nanoparticles", *J. phys. chem. lett.*, vol. 7, no. 20, pp. 4039-4046, Oct. 2016.
14. Metod Kolar, Gregor Primc, "Haemostatic response of polyethylene terephthalate treated by oxygen and nitrogen plasma afterglows", *Int. J. Polym. Sci.*, vol. 2016, pp. 1749285-1-1749285-7, 2016.
15. Martina Lorenzetti, Ekaterina Gongadze, Mukta Vishwanath Kulkarni, Ita Junkar, Aleš Iglič, "Electrokinetic properties of TiO[sub]2 nanotubular surfaces", *Nanoscale research letters*, vol. 11, pp. 378-1-378 -13, 2016.
16. Asif Majeed, Xiaoxia Zhong, Shaofeng Xu, Xinhui Wu, Uroš Cvelbar, Zhengming Sheng, "The influence of discharge capillary size, distance, and gas composition on the non-equilibrium state of microplasma", *Plasma processes polym.*, vol. 13, iss. 7, pp. 690-697, 2016.
17. Martina Modic, Miran Mozetič, "In vitro screening procedure for characterization of thrombogenic properties of plasma treated surfaces", *Biointerphases*, vol. 11, no. 2, pp. 029808-1-029808-9, 2016.
18. Aleksandra B. Nastasović, Bojana M. Ekmeršić, Zvjezdana P. Sandić, Danijela V. Ranđelović, Miran Mozetič, Alenka Vesel, Antonije E. Onjia, "Mechanism of Cu(II), Cd(II) and Pb(II) ions sorption from aqueous solutions by macroporous poly(glycidyl methacrylate-co-ethylene glycol dimethacrylate)", *Appl. surf. sci.*, vol. 385, pp. 605-615, 2016.
19. Vincenc Nemanič, Marko Žumer, "Quantification of small gas amounts with an ion trap mass spectrometer", *Int. j. mass spectrom.*, vol. 401, pp. 17-21, 2016.
20. Y, Ni, M. J. Lynch, Martina Modic, R. D. Whalley, J. Walsh, "A solar powered handheld plasma source for microbial decontamination applications", *J. phys., D, Appl. phys.*, vol. 49, no. 35, pp. 355203-1-355203-8, 2016.
21. Željka Nikitović, Jasmina V. Jovanović, Uroš Cvelbar, Miran Mozetič, Vladimir Stojanović, "Modeling of the effect of radicals on plasmas used for etching in microelectronics", *FME Trans.*, vol. 44, pp. 105-108, 2016.
22. K. M. Praveen, Sabu Thomas, Yves Grohens, Miran Mozetič, Ita Junkar, Gregor Primc, Marija Gorjanc, "Investigations of plasma induced effects on the surface properties of lignocellulosic natural coir fibres", *Appl. surf. sci.*, vol. 368, pp. 146-156, 2016.
23. Gregor Primc, Tomaž Gyergyek, Zlatko Kregar, Slobodan Milošević, Alenka Vesel, Miran Mozetič, "Gostota kisikovih atomov v plazemskem

reaktorju s pomičnim rekombinatorjem", *Vakuumist*, vol. 36, no. 3, pp. 4-14, 2016.
24. Gregor Primc, Brigita Tomšič, Alenka Vesel, Miran Mozetič, Sanja Ercegović Ražić, Marija Gorjanc, "Biodegradability of oxygen-plasma treated cellulose textile functionalized with ZnO nanoparticles as antibacterial treatment", *J. phys., D, Appl. phys.*, vol. 49, no. 32, pp. 324002-1-324002-10, 2016.
25. Harinarayanan Puliyalil, Gregor Filipič, Uroš Cvelbar, "Selective plasma etching of polyphenolic composite in O[sub]2/Ar plasma for improvement of material tracking properties", *Plasma processes polym.*, vol. 13, no. 7, pp. 737-743, 2016.
26. Harinarayanan Puliyalil, Gregor Filipič, Janez Kovač, Miran Mozetič, Sabu Thomas, Uroš Cvelbar, "Tackling chemical etching and its mechanisms of polyphenolic composites in various reactive low temperature plasmas", *RSC advances*, vol. 6, iss. 97, pp. 95120-95128, 2016.
27. Harinarayanan Puliyalil, Petr Slobodian, Michal Sedlacik, Ruhan Benlikaya, Pavel Říha, Kostya Ostrikov, Uroš Cvelbar, "Plasma-enabled sensing of urea and related amides on polyaniline", *Front. Chem. Sci. Eng.*, vol. 10, iss. 2, pp. 265-272, 2016.
28. Nina Recek, Sofija Andjelić, Nataša Hojnik, Gregor Filipič, Saša Lazović, Alenka Vesel, Gregor Primc, Miran Mozetič, Marko Hawlina, Goran Petrovski, Uroš Cvelbar, "Microplasma induced cell morphological changes and apoptosis of Ex Vivo cultured human anterior lens epithelial cells relevance to capsular opacification", *PloS one*, vol. 11, no. 11, pp. 0165883-1-0165883-19, 2016.
29. Nina Recek, Gregor Primc, Alenka Vesel, Miran Mozetič, José Avila, Ivy Razado-Colambo, Maria C Asensio, "Degradation of albumin on plasma-treated polystyrene by soft X-ray exposure", *Polymers (Basel)*, vol. 8, no. 7, pp. 244-1-244-7, 2016.
30. Nina Recek, Matic Resnik, Helena Motaln, Tamara Lah Turnšek, Robin Augustine, Nandakumar Kalarikkal, Sabu Thomas, Miran Mozetič, "Cell adhesion on polycaprolactone modified by plasma treatment", *Int. J. Polym. Sci.*, vol. 2016, pp. 7354396-1-7354396-9, 2016.
31. Rok Simič, Mitjan Kalin, Janez Kovač, Gregor Jakša, "Adsorption of alcohols and fatty acids onto hydrogenated (a-C:H) DLC coatings", *Appl. surf. sci.*, vol. 363, pp. 466-476, Feb. 2016.
32. Elena Stoleru *et al.* (11 avtorjev), "Lactoferrin-immobilized surfaces onto functionalized PLA assisted by the gamma-rays and nitrogen plasma to create materials with multifunctional properties", *ACS appl. mater. interfaces*, vol. 8, no. 46, pp. 31902-31915, 2016.
33. Vladimir Švrček, Davide Mariotti, Uroš Cvelbar, Gregor Filipič, M. Lozac'h, C. McDonald, T. Tayagaki, K. Matsubara, "Environmentally friendly processing technology for engineering silicon nanocrystals in water with laser pulses", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, no. 33, pp. 18822-18830, 2016.
34. Peter Topolovšek, Luka Cmok, Christoph Gadermaier, Miloš Borovšak, Janez Kovač, Aleš Mrzel, "Thiol click chemistry on gold-decorated MoS_2: elastomer composites and structural phase transitions", *Nanoscale*, vol. 8, no. 19, pp. 10016-10020, 2016.
35. Jelena Vasiljević, Marija Gorjanc, Ivan Jerman, Brigita Tomšič, Martina Modic, Miran Mozetič, Boris Orel, Barbara Simončič, "Influence of oxygen plasma pre-treatment on the water repellency of cotton fibers coated with perfluoroalkyl-functionalized polysilsesquioxane", *Fiber Polym.*, vol. 17, no. 5, pp. 695-704, 2016.
36. Alenka Vesel, Janez Kovač, Gregor Primc, Ita Junkar, Miran Mozetič, "Effect of H2[sub]S plasma treatment on the surface modification of a polyethylene terephthalate surface", *Materials (Basel)*, vol. 9, no. 2, pp. 95-1-95-14, 2016.
37. Alenka Vesel, Miran Mozetič, Marianne Balat-Pichelin, "Reduction of a thin chromium oxide film on Inconel surface upontreatment with hydrogen plasma", *Appl. surf. sci.*, vol. 387, pp. 1140-1146, 2016.
38. Alenka Vesel, Rok Zaplotnik, Martina Modic, Miran Mozetič, "Hemocompatibility properties of a polymer surface treated in plasma containing sulfur", *Surf. interface anal.*, vol. 48, no. 7, pp. 601-605, 2016.
39. Alenka Vesel, Rok Zaplotnik, Gregor Primc, Liu Xiangyu, Kaitian Xu, Kevin C. Chen, Chiju Wei, Miran Mozetič, "Functionalization of polyurethane/urea copolymers with amide groups by polymer treatment with ammonia plasma", *Plasma chem. plasma process.*, vol. 36, no. 3, pp. 835-848, 2016.
40. Maša Zalaznik, Mitjan Kalin, Saša Novak, Gregor Jakša, "Effect of the type, size and concentration of solid lubricants on the tribological properties of the polymer PEEK", *Wear*, vol. 364-365, pp. 31-39, Oct. 2016.
41. Rok Zaplotnik, Marijan Bišćan, Dean Popović, Miran Mozetič, Slobodan Milošević, "Metastable helium atom density in a single electrode atmospheric plasma jet during sample treatment", *Plasma sources sci. technol.*, vol. 25, no. 3, pp. 035023-1-035023-10, 2016.
42. Rok Zaplotnik, Alenka Vesel, Miran Mozetič, "Investigation of reactive plasma species created in SO_2 by an inductively coupled RF discharge in E- and H-mode", *J. appl. phys.*, vol. 120, no. 16, pp. 163302-1-163302-9, 2016.
43. Rok Zaplotnik, Alenka Vesel, Gregor Primc, Liu Xiangyu, Kevin C. Chen, Chiju Wei, Kaitian Xu, Miran Mozetič, "Rapid hydrophilization of model polyurethane/urea (PURPEG) polymer scaffolds using oxygen plasma treatment", *Polymers (Basel)*, vol. 8, no. 4, pp. 1-18, 2016.

Review Article

1. Igor Levchenko, Michael Keidar, Uroš Cvelbar, Davide Mariotti, Anne Mai-Prochnow, Jinghua Fang, Kostya Ostrikov, "Novel biomaterials: plasma-enabled nanostructures and functions", *J. phys., D, Appl. phys.*, vol. 49, no. 27, pp. 273001-1-273001-16, 2016.
2. Anton Nikiforov, Xiaolong Deng, Qing Xiong, Uroš Cvelbar, N. DeGeyter, Rino Morent, Christophe Leys, "Non-thermal plasma technology for the development of antimicrobial surfaces: a review", *J. phys., D, Appl. phys.*, vol. 49, no. 20, pp. 204002 -1-204002 -8, 2016.
3. Harinarayanan Puliyalil, Uroš Cvelbar, "Selective plasma etching of polymeric substrates for advanced applicationsSelective plasma etching of polymeric substrates for advanced applications", *Nanomaterials (Basel)*, vol. 6, no. 6, pp. 108-1-108-24, 2016.

Short Article

1. Mukta Vishwanath Kulkarni, Ita Junkar, Harinarayanan Puliyalil, Aleš Iglič, "Wettability switch of anodic titanium dioxide nanotubes with various diameters", *Biophys. j.*, vol. 110, iss. 3, sup. 1, pp. 339a, Feb. 2016.

Published Conference Contribution

1. Somayeh Akbari, Janez Kovač, Mitjan Kalin, "Study the chemical structure of the ZDDP thermal film on steel and dlc surfaces at different times and ZDDP concentrations using ATR-FTIR and XPS", In: *Zbornik predavanj posvetovanja o tribologiji, mazivih in tehnični diagnostiki*, SLOTRIB 2016, f. 91-105.
2. Mojca Božič, Vera Vivod, Robert Vogrinčič, Silvo Hribernik, Irena Ban, Gregor Jakša, Darinka Fakin, Vanja Kokol, "New photocatalysts based on the surface modified TiO2-MWCNTs for decolourization of methylene blue dye", In: *Proceedings*, 16th World Textile Conference AUTEX 2016, 8-10 June 2016, Ljubljana, Slovenia, pp. 1-7.
3. Svjetlana Janjić, Ivana Dojčinović, Aleksandar Savić, Miran Mozetič, Gregor Primc, Lidija Černe Hočevar, Marija Gorjanc, "Antibacterial lyocell fibres obtained using plasma treatment and chitosan", In: *Proceedings*, 16th World Textile Conference AUTEX 2016, 8-10 June 2016, Ljubljana, Slovenia, 7 pp.
4. Boštjan Jenčič, Luka Jeromel, Nina Ogrinc Potočnik, Katarina Vogel-Mikuš, Eva Kovačec, Marjana Regvar, Zdravko Siketić, Primož Vavpetič, Zdravko Rupnik, Klemen Bučar, Mitja Kelemen, Janez Kovač, Primož Pelicon, "Molecular imaging of cannabis leaf tissue with MeV-SIMS method", In: *The 22nd International Conference on Ion Beam Analysis (IBA 2015), June 14 - 19, 2015, Opatija, Croatia*, (Nuclear instruments & methods in physics research, Section B, vol. 371, 2016), pp. 205-210.
5. A. G. Nikiforov, Xiaolong Deng, Iulia Onyshchenko, Danijela Vujošević, Vineta Vuksanović, Uroš Cvelbar, Nathalie De Geyter, Rino Morent, Christophe Leys, "Atmospheric pressure plasma deposition of antimicrobial coatings on non-woven textiles", In: *Proceedings of the 6th Central European Symposium on Plasma Chemistry, CESPC-6, September 6-10, 2015, Bressanone, Italy*, (EPJ, Applied physics, Vol. 75, no. 2, 2016), pp. 24710-1- 24710-6.
6. Jelena Vasiljević, Brigita Tomšič, Milena Zorko, Miran Mozetič, Ivan Jerman, Jože Medved, Boris Orel, Barbara Simončič, "Towards the fabrication of "green" flame retardant cotton by the sol-gel processing of hybrid precursors", In: *Proceedings*, 16th World Textile Conference AUTEX 2016, 8-10 June 2016, Ljubljana, Slovenia, 8 pp.
7. Stojana Veskovič Bukudur, Janez Kovač, Peter Panjan, Damjan Klobčar, Milan Bizjak, Blaž Karpe, "Deposition of Al thin film on FeCrAl alloy and continuous electrical resistance measurement", In: *Zbornik radova*, 11th Scientific - Research Symposium with international participation, Metallic and nonmetallic materials, production, properties, application, Zenica, 21.-22. april 2016, pp. 109-117.

Independent Component Part or a Chapter in a Monograph

1. Ita Junkar, "Interaction of cells and platelets with biomaterial surface treated with gaseous plasma", In: *Advances in biomembranes and lipid self-assembly. Volume 23*, Aleš Iglič, ed., Chandrashekhar Kulkarni, ed., Michael Rappolt, ed., Amsterdam [etc.], Elsevier, 2016, pp. 25-59.
2. Alenka Vesel, Miran Mozetič, "Low-pressure plasma-assisted polymer surface modifications", In: *Printing on polymers: fundamentals and applications*, Joanna Izdebska, ed., Sabu Thomas, ed., Amsterdam [etc.], Elsevier, 2016, pp. 101-121.
3. Runcy Wilson, Anil Kumar, Miran Mozetič, Uroš Cvelbar, Sabu Thomas, "Diffusion, transport, and barrier properties of IPNs", In: *Micro- and nano-structured interpenetrating polymer networks: from design to applications*, Sabu Thomas, ed., Uroš Cvelbar, ed., Hoboken, Wiley, 2016, pp. 319-339.

Patent

1. Alenka Vesel, Miran Mozetič, Rok Zaplotnik, *Device for high-frequency gas plasma excitation,* DE112012000015 (B4), Deutsches Patent- unt Markenamt, 21. 04. 2016.
2. Alenka Vesel, Rok Zaplotnik, Miran Mozetič, *Method for cleaning of with body fluid-contaminated medical implantants and devices with the use of atomic oxygen,* SI24840 (A), Urad RS za intelektualno lastnino, 29. 04. 2016.
3. Gregor Filipič, Kristina Eleršič, Darij Kreuh, Janez Kovač, Uroš Cvelbar, Miran Mozetič, *A method of colouring titanium and titanium alloys,* SI24851 (A), Urad RS za intelektualno lastnino, 29. 04. 2016.

Mentoring

1. Harinarayanan Puliyalil, *Selective plasma etching of polymer matrix composites for improvement of their surface properties:* doctoral dissertation, Ljubljana, 2016 (mentor Uroš Cvelbar; co-mentor Miran Mozetič).

DEPARTMENT OF SOLID STATE PHYSICS F-5

Our research program is focused on the study of the structure and dynamics of disordered and partially ordered condensed matter at the atomic and molecular levels, with a special emphasis on phase transitions. The purpose of these investigations is to discover the basic laws of physics governing the behaviour of these systems, which represent the link between perfectly ordered crystals, on one side, and amorphous matter, soft condensed matter and living systems, on the other. Such knowledge provides the key to our understanding of the macroscopic properties of these systems and is an important condition for the discovery and development of new multifunctional materials, nanomaterials and biomaterials for new applications. An important part of the research program is devoted to the development of new experimental methods and techniques in the field of magnetic resonance, magnetic resonance imaging, fluorescence microspectroscopy, scanning tunnelling, electronic and atomic force microscopy, as well as dielectric relaxation spectroscopy and dynamic specific-heat measurements.

Head:
Prof. Igor Muševič

The experimental techniques used are:

- One (1D) and two (2D) dimensional nuclear magnetic resonance (NMR) and relaxation, as well as quadrupole (NQR) resonance and relaxation,
- Multi-frequency NMR in superconducting magnets of 2T, 6T and 9T, as well as the dispersion of the spin–lattice relaxation time T_1 via field cycling,
- Nuclear double resonance and quadrupole double resonance such as ^{17}O–H and ^{14}N-H,
- Fast field cycling NMR relaxometry,
- Frequency-dependent electron paramagnetic resonance (EPR) and 1D and 2D pulsed EPR and relaxation
- MR imaging and micro-imaging
- Measurement of the electronic transport properties
- Magnetic measurements.
- Fluorescence microscopy and microspectroscopy
- Linear and non-linear dielectric spectroscopy in the range 10^{-2} Hz to 10^{9} Hz,
- Electron microscopy and scanning tunnelling microscopy,
- Atomic force microscopy and force spectroscopy,
- Dynamic specific heat measurements.

The research program of the Department of Solid State Physics at "Jozef Stefan Institute" is performed in close collaboration with the Department of Physics at the Faculty of Mathematics and Physics of the University of Ljubljana, Institute of Mathematics, Physics and Mechanics and the J. Stefan International Postgraduate School. In 2016, the research was performed within three research programs:

- Magnetic resonance and dielectric spectroscopy of smart new materials
- Physics of Soft Matter, Surfaces and Nanostructures
- Experimental Biophysics of Complex Systems

The research group has discovered new quantum phenomena in the magnetism of low-dimensional spin systems. It has studied physical properties of a novel type of nanomaterials suitable for gas sensors and has discovered new materials with a giant electrocaloric effect for applications in cooling devices. The group has developed new polymer-dispersed liquid-crystalline elastomers. The Schottky effect has been demonstrated in quasicrystals, which fundamentally changes the interpretation of their low-temperature electronic and magnetic properties. The research has included pharmaceutical and biological substances.

I. Program group "Magnetic resonance and dielectric spectroscopy of smart new materials"

The research of the program group *Magnetic Resonance and Dielectric Spectroscopy of Smart New Materials* was focused on the study of physical phenomena in condensed matter at the atomic and molecular levels. The purpose of the investigations was to discover the basic laws of physics governing the behaviour of the investigated systems. The attained knowledge provides the key to the understanding of the microscopic and macroscopic properties of various types of solids and is an important condi-

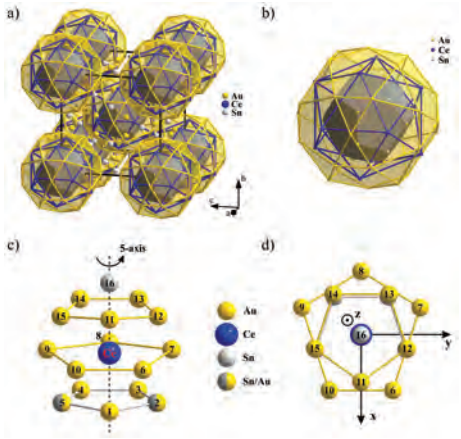


Figure 1: Icosahedral structure and pentagonal distribution of electric charges in Ce-Au-Sn-type quasicrystals for the calculation of the Schottky effect.

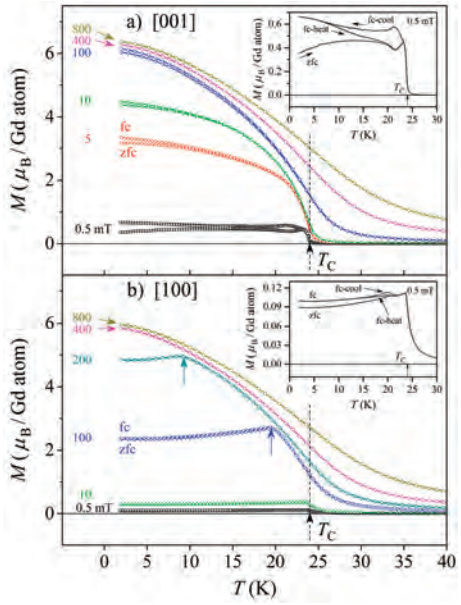


Figure 2: Temperature-dependent magnetization of the Cu-Ca-Gd alloy for a magnetic field directed along the hexagonal axis and in the hexagonal plane.

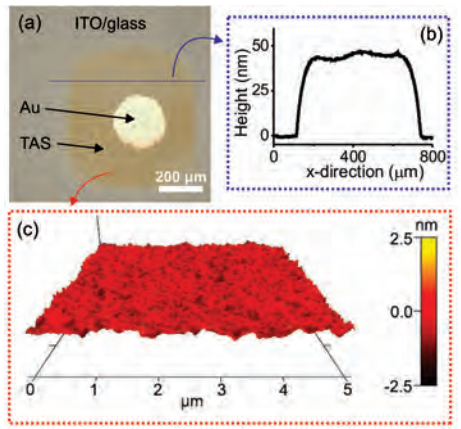


Figure 3: (a) Optical photograph, (b) cross-sectional profile, and (c) 3D AFM topology image of 45-nm-thick printed tantalum-oxide-based (TAS) thin-film capacitor.

tion for the discovery and development of new multifunctional materials and nanomaterials for novel technological applications.

The research program was implemented in close collaboration with the Department of Physics at the Faculty of Mathematics and Physics of the University of Ljubljana, Institute of Mathematics, Physics and Mechanics, and the J. Stefan International Postgraduate School.

In 2016, members of the program group published 47 original scientific papers in international peer-reviewed scientific journals. Among these, one paper was published in Nature Commun. (IF = 11.3), one in Phys. Rev. Lett. (IF = 7.6), one in ACS Applied Mater. & Interfaces (IF = 7.1), two in Sci. Rep. (IF = 5.2), and three in J. Mater. Chem. C (IF = 5.1).

The investigations were focused on the following research fields:

Quasicrystals and complex metallic alloys

In the publication *Schottky effect in the i-Zn-Ag-Sc-Tm icosahedral quasicrystal and its 1/1 Zn-Sc-Tm approximant* (S. Jazbec et al., Phys. Rev. B **93**, 054208 (2016)) we have for the first time experimentally proved the existence of the Schottky effect in quasicrystals. This discovery fundamentally changes the current interpretations of the low-temperature electronic and magnetic effects in quasicrystals and their periodic approximants. We have developed the theory of the Schottky effect for the pentagonal symmetry of the crystal electric fields, applicable to quasicrystals of the structural type Ce-Au-Sn. The icosahedral structure and pentagonal distribution of electric charges in Ce-Au-Sn are shown in Figure 1.

In the publication Random-anisotropy ferromagnetic state in the $Cu_5Gd_{0.54}Ca_{0.42}$ intermetallic compound (M. Krnel et al., Phys. Rev. B **93**, 094202 (2016)) we presented the synthesis of the first ternary compound in the Cu-Ca-Gd system, where the immiscible elements Ca and Gd are chemically bound into a crystal by the third "intervening" element copper, which makes stable binary phases with both elements. We determined physical properties for this new ternary alloy and showed that its magnetic state can be described as a random-anisotropy ferromagnet. Figure 2 shows the temperature-dependent magnetization of the alloy for a magnetic field directed along the hexagonal axis and in the hexagonal plane.

Inkjet printing of uniform dielectric oxide structures

Inkjet printing of high-dielectric-constant metal-oxide layers will enable the low-cost deposition of the essential building blocks in electronics. We have developed an ink formulation suitable for the printing of tantalum-oxide-based dielectric layers. Our goal was to improve the thickness uniformity of dried deposits via optimization of the ink's solvent composition. We have shown that in addition to designing the solvent mixture according to the viscosity and surface-tension criteria, the volatility of solvents has to be considered, as it strongly influences the thickness uniformity. By rigorously adjusting the solvent composition, we were able to tailor the topology of the deposits and print 45-nm-thick, flat and uniform capacitors with functional properties comparable to spin-coated films. We published our discoveries in *Inkjet printing of uniform dielectric oxide structures from sol-gel inks by adjusting the solvent composition* (A. Matavž, R. C. Frunză, A. Drnovšek, V. Bobnar, B. Malič, Journal of Materials Chemistry C 4, 5634 (2016)).

Development of an eco-friendly material for flexible energy-storage devices

Nanocomposite films were fabricated by incorporating ammonia-functionalized graphene oxide (NGO) into the native (CNF) and TEMPO-oxidized (TCNF) cellulose nanofibrils matrices using a solvent-casting method. The structural and morphological analysis revealed good dispersibility of the NGO sheets in the randomly distributed CNF, and the dense and parallel-oriented TCNF nanofibrils. Such a synergistic effect of both components contributed to ultra-strong and stiff films with good mechanical and thermal stability. Due to the Maxwell-Wagner polarization, the dielectric constant strongly increases already at a low NGO content. Thus, this mechanically strong, flexible, and thermally stable composites are suitable, cost-effective, alternative green materials for flexible energy-storage devices. This research was published in the paper *Mechanically strong, flexible and thermally stable graphene oxide/nanocellulosic films with enhanced dielectric properties* (Y. Beeran P. T. et al., RSC Advances 6, 49138 (2016)).

Stable dielectric response of newly developed low-loss polymer thin films

We have investigated the dielectric properties of aromatic polythiourea (ArPTU, polar polymer

containing high dipolar moments with very low defect levels) thin films that were developed on a Pt/SiO_2 substrate. The detected response was compared to the response of commercially available polymers, such as high-density polyethylene (HDPE) and polypropylene (PP), which are at the present both used in foil capacitors. Stable values of the dielectric constant (being two times higher than in HDPE and PP) over broad temperature and frequency ranges and dielectric losses as low as in commercial systems suggest that ArPTU is a promising candidate for future use in a variety of applications. The findings were published in *Stable dielectric response of low-loss aromatic polythiourea thin films on Pt/SiO_2 substrate* (A. Eršte et al., Journal of Advanced Dielectrics 6, 1650003 (2016)).

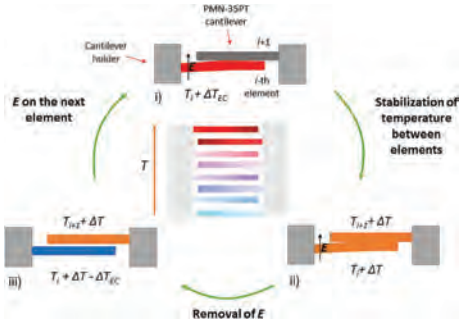


Figure 4: Schematics of the refrigeration cycle of cascade electrocaloric cooling device exploiting in cantilever cooling elements both an electrocaloric and electromechanic response.

Study of nanostructured materials and materials with large electrocaloric effect and its application in a solid-state cooling device:

Using direct measurements, we showed the coexistence of both the electrocaloric and magnetocaloric effect in multiferroic PFN-PMW. We were among the first to demonstrate the existence of a large electrocaloric effect in liquid crystals and of a large elastocaloric effect in liquid-crystal elastomers. In addition, we have analysed the working cycle of a prototype of a cascade electrocaloric device exploiting both the electrocaloric and electromechanic effects. In 2016, the Gorenje d.d. company bought our *Patent application US 2016/0187034 A17700,* 2016, (B. Malič et al.). The above results were published in 11 articles in international scientific journals, among which we must mention *Perovskite ferroelectrics and relaxor-ferroelectric solid solutions with large intrinsic electrocaloric response over broad temperature ranges* (H. Khassaf et al., P. Journal of Materials Chemistry *C,* 4 (2016), 4763), *A multicaloric material as a link between electrocaloric and magnetocaloric refrigeration* (H. Uršič et al., Scientific Reports, 6 (2016), 26629-1-26629-5), *$BaZr_{0.5}Ti_{0.5}O_3$: Lead-free relaxor ferroelectric or dipolar glass* (C. Filipič, Z. Kutnjak, R. Pirc, G. Canu, J. Petzelt, Physical Review B, 93 (2016), 224105-1-224105-8), and *Electrocaloric and elastocaloric effects in soft materials* (M. Trček et al., *Philosophical Transactions A,* 374 (2016), 20150301). Recent publications on electrocalorics and TGB and blue phases have been cited more than 100 times in 2016.

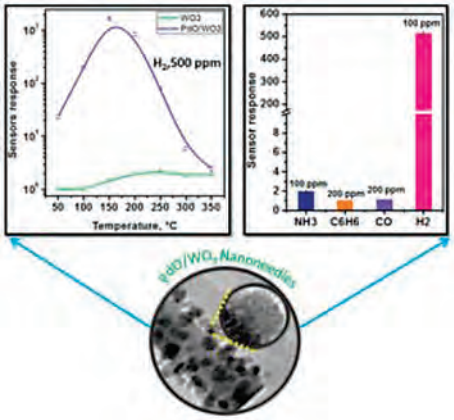


Figure 5: Left: sensor response (WO3 nanoneedles decorated with PdO nanoparticles) on 500 ppm of H_2 between 50 and 350 °C (violet curve) compared with a sensor based on bare WO_3 nanoneedles (green curve). Right: Selectivity diagram of PdO/WO_3 sensor toward NH_3, C_6H_6 and CO interfering gases.

Nanomaterials for gas-sensor applications

Polona Umek collaborated with colleagues from Great Britain, Czech Republic, Belgium, France and Spain in the research of gas sensors based on WO_3 nanoneedles (NN) decorated with PdO nanoparticles (NP). Morphological, structural, and elemental composition analysis revealed that a $Pd(acac)_2$ precursor was very suitable to decorate WO_3 NNs with uniform and well-dispersed PdO NPs. Gas-sensing results revealed that the decoration with PdO NPs led to an ultrasensitive and selective hydrogen (H_2) gas sensor with a low operating temperature (150 °C). The response of the decorated NNs is 755-times higher than that of bare WO_3 NNs. Humidity measurements showed that PdO/WO_3 sensors displayed low-cross-sensitivity towards water vapour, compared to bare WO_3 sensors. The addition of PdO NPs helps to minimize the effect of ambient humidity on the sensor response. The research was published in the article *Aerosol-assisted CVD-grown PdO nanoparticle-decorated tungsten oxide nanoneedles extremely sensitive and selective to hydrogen* (F. E. Annanouch et al., *ACS Applied Materials & Interfaces* 8, 10413 (2016)).

Pharmaceutical substances studied by NQR spectroscopy

^{14}N NQR is a useful tool to characterize pharmaceutical substances and the method of their preparation. In combination with other experimental techniques and quantum chemical calculations, the electronic structure of these molecules and the properties of functional groups can be determined, as shown in the article *Polymorphism and Thermal Stability of Natural Active Ingredients. 3,3'- Diindolylmethane (Chemopreventive and Chemotherapeutic) Studied by a Combined X-Ray, ^1H – ^{14}N NMR NQR, DSC and Solid-State DFT/3D HS/QTAIM/RDS Computational Approach* (J. N. Latosinska, M. Latosinska, M. Szafranski, J. Seliger, V. Žagar, Cryst. Growth Des. 16, 4336-4348 (2016)).

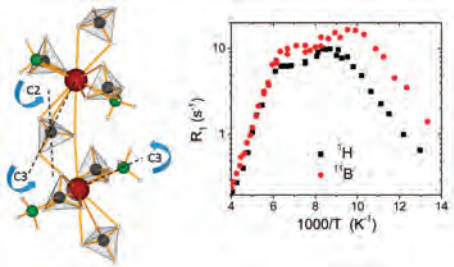


Figure 6: ^1H NMR relaxometric study of molecular dynamics in a "de Vries" liquid crystal.

The compound 3,3′-diindolylmethane (DIM) is a major in-vivo product of the digestion of indole-3-carbinol (I3C) and a main mediator of its chemopreventive and chemotherapeutic effects. In this paper, the co-influence of two factors, polymorphism and temperature, on the topology, nature, and strength of the interaction pattern in DIM are in our area of interest. Upon polymorph screening, it has been found that DIM crystallizes in two polymorphic forms, form I (already known) and form II (newly obtained). Differential scanning calorimetry indicated a slightly lower melting point for form I than for

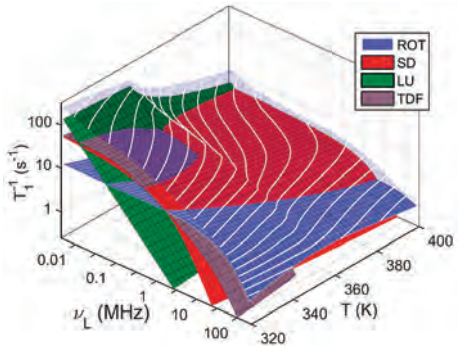


Figure 7: ^{1}H–^{14}N cross-relaxation spectrum analysis in sildenafil and sildenafil citrate.

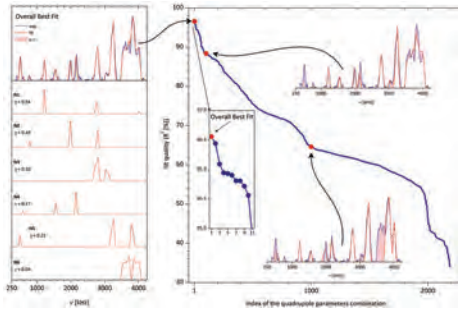


Figure 8. Left: Sildenafil ^{1}H–^{14}N CR spectrum: the experimental data (solid blue line) and the overall best-fit (solid red line). A decomposition of the best fit in contributions from individual nitrogen sites is also shown. Right: The quality of sildenafil CR spectrum fits for all combinations of transition pairing. Here two spectra with poor fits are also shown.

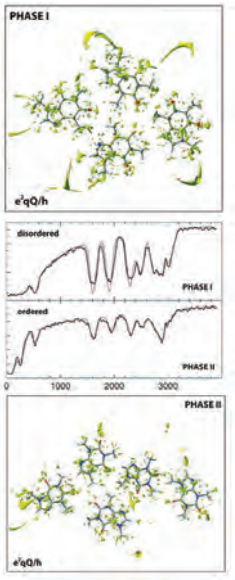


Figure 9: Isosurface plot of EFG asymmetry parameter at each point of the molecular system for phase I (top) and phase II (bottom) of caffeine. Cross-relaxation spectra of caffeine in both phases are shown in the middle.

form II (436 versus 440 K) and the lack of phase transitions in both polymorphs. The crystal and molecular structures of both polymorphs have been determined as a function of temperature from a single-crystal X-ray diffraction. The structure of polymorph I is monoclinic, space group C2/c, while polymorph II is orthorhombic, space group $P2_12_12_1$ The key interaction that determines the crystalline packing in both polymorphs of DIM is the NH···ϖ one. The factor responsible for the locked conformation of DIM in both forms is the electrostatic potential complementarity of the regions of N–H···ϖ, linking neighbouring molecules, which permits easy overcoming of any repulsive interactions that may force the rotation of the molecule. The commercial sample of DIM was found to contain approximately 50% of form I and 50% of form II.

Nuclear magnetic resonance study of molecular dynamics in ammine metal borohydride $Sr(BH_4)_2(NH_3)_2$

Borohydrides are promising hydrogen-storage materials due to their high hydrogen content and relatively low decomposition temperature. In the article *Nuclear magnetic resonance study of molecular dynamics in ammine metal borohydride Sr(BH4)2(NH3)2* (A. Gradišek, L. H. Jepsen, T. R. Jensen, M. S. Conradi, *J. Phys. Chem. C*, 2016, 120, 24646-24654), we investigated $Sr(BH_4)_2(NH_3)_2$, a novel system that contains hydrogen in two molecular groups – BH_4 and NH_3. Molecular dynamics was studied by means of ^{1}H and ^{11}B NMR spectra and spin-lattice relaxation. We identified activation energies for the rotations of BH_4 tetrahedra around two different symmetry axes. Low-temperature measurements unveiled that there are some motions still present around 4 K. In addition, we studied a partially deuterated modification of the compound to further distinguish dynamic processes.

Liquid crystals that exhibit *de Vries* smectic A phases are promising materials for new generations of ferroelectric liquid-crystal displays and other electro-optical devices. We investigated the molecular dynamic properties of a rod-like *de Vries* liquid-crystal compound in the whole mesophasic range by means of fast field-cycling NMR relaxometry. The main molecular motions, i.e., reorientational diffusion, translational self-diffusion, layer undulation, and tilting director fluctuations were fully characterized. The molecular dynamics' behaviour observed across the SmA–SmC* phase transitions of 9HL was consistent with the proposed *cluster diffuse cone* model for the de Vries SmA phase. The findings were published in the article *1H NMR relaxometric study of molecular dynamics in a "de Vries" liquid crystal* (A. Gradišek, V. Domenici, T. Apih, V. Novotná, P. J. Sebastião, *J. Phys. Chem. B*, 2016, 120, 4706-4714).

^{1}H–^{14}N cross-relaxation (CR) spectroscopy is a powerful technique to determine ^{14}N NQR parameters (C_q–), as it requires very small quantities of material. However, the NQR parameters cannot be determined directly from the CR spectrum, but rather through an intermediate step called "peak pairing", that is, finding pairs of ^{14}N transitions belonging to the same nitrogen site. "Peak pairing" is far from straightforward and typically requires good intuition. In order to facilitate CR spectra analysis and make the procedure more robust, we developed an automatic method, which simultaneously fits the lineshapes for all the ^{14}N transitions for all possible combinations of transition pairs, where finally we choose the combination with an overall best fit of the spectrum. For substances with several nitrogen sites, there may be thousands of pairing combinations, but nevertheless, the automatic procedure is still significantly faster than the manual "peak pairing". We have demonstrated the technique on sildenafil (Figure 8) and sildenafil citrate, which both have six nitrogen sites, and published the results in the article *1H–14N cross-relaxation spectrum analysis in sildenafil and sildenafil citrate* (A. Gregorovič, T. Apih, J. Seliger, Solid State Nuc. Mag. 78, 16 (2016)).

Polymorphism of caffeine

The polymorphism of anhydrous caffeine has been studied by ^{1}H–^{14}N NMR–NQR (Nuclear Magnetic Resonance–Nuclear Quadrupole Resonance) double resonance and pure ^{14}N NQR (Nuclear Quadrupole Resonance) and by computational modelling (Density Functional Theory) in the solid state. The assignment of NQR signals detected in stable phase I and in metastable phase II to particular nitrogen sites was verified with the help of DFT. The commercial pharmaceutical sample was found to contain approximately 20–25% of phase I and 75–80% of phase II. The orientational disorder in phase II with a local molecular arrangement mimics that in phase I. Substantial differences in the intermolecular interaction phases I and II of caffeine were analysed using a computational (DFT/QTAIM/RDS) approach and the maps of the principal component of the EFG tensor and its asymmetry parameter at each point of the molecular system were calculated and visualized. The relevant maps calculated for both phases I and II indicate a small variation in electrostatic potential upon phase change. These small differences between packings in phases only slightly disturb the neighbourhood of the N(1) and N(7) nitrogens, and are thus meaningless

from the biological point of view. The composition of the two phases in pharmaceutical material should not be an obstacle, which is relevant from the point of view of the pharmaceutical industry.

The study was published in the article *Polymorphism and disorder in natural active ingredients. Low and high-temperature phases of anhydrous caffeine: Spectroscopic (1H–14N NMR–NQR/14N NQR) and solid-state computational modelling (DFT/QTAIM/RDS) study* (J. Seliger et al., European Journal of Pharmaceutical Sciences, 85 (2016), 18).

Polymer-dispersed liquid-crystal elastomers

We have experimentally investigated the orientational ordering of thermomechanically active liquid-crystal elastomer microparticles dispersed in a PDMS elastomer, using quadrupole-perturbed deuteron NMR. We have also developed a theoretical model of the behaviour of orientational order parameter Q in the external magnetic field B as a function of the microdomain nematic order parameter S and diamagnetic anisotropy $\Delta\mu$, the viscosity of the uncured matrix resin η, and of the curing process kinetic factor k. By comparing theoretical predictions with the experimentally determined values of $Q(B)$, we have demonstrated that the degree of orientational ordering and, consequently, the effective thermomechanical response of the composite material can be tailored by controlling the external magnetic field as well as by properly adjusting the curing time. The research on polymer-dispersed liquid crystal was published in two articles: *Deuteron NMR resolved mesogen vs. crosslinker molecular order and reorientational exchange in liquid single crystal elastomers* (J. Milavec, V. Domenici, B. Zupančič, A. Rešetič, A. Bubnov in B. Zalar, Physical Chemistry Chemical Physics 18, 4071-4077 (2016)) and *Polymer-dispersed liquid crystal elastomers*, (A. Rešetič, J. Milavec, B. Zupančič, V. Domenici in B. Zalar, Nature Communications 7, 13140 (2016)).

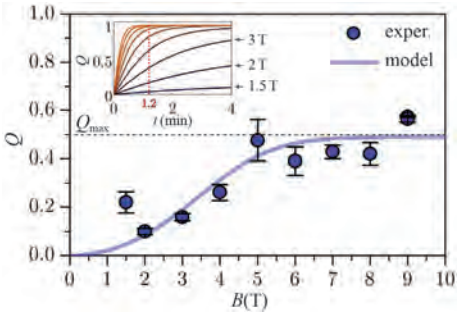


Figure 10: Orientational order parameter Q of liquid-crystal elastomer microparticles dispersed in a PDMS elastomer. Q saturates at $Q_{max} \approx 0.5$ for magnetic fields $B \geq 5$ T. $Q_{max} < 1$ indicates that microparticles are not ideal nematic monodomains. The inset shows theoretically modelled time-dependence of the orientational ordering for different values of magnetic field, corresponding to experimental points Q(B) (blue circles).

Quantum magnetism

Matej Pregelj, Matjaž Gomilšek, Andrej Zorko, and Denis Arčon, in collaboration with partners from Switzerland, Croatia and France, investigated the mechanism responsible for the occurrence of an unusual spin-stripe phase in the β-$TeVO_4$ compound, which represents a model system of the frustrated ferromagnetic spin-1/2 chain. A combination of magnetic-torque, neutron-diffraction, and spherical-neutron-polarimetry measurements was employed to determine all the magnetic structures that the system develops on cooling in the absence of a magnetic field, i.e., in the vector-chiral phase, in the spin-stripe phase and in the collinear amplitude-modulated phase. Based on these results, they developed a phenomenological model that revealed the anisotropy of the exchange interaction as the key ingredient for the spin-stripe formation in frustrated spin systems. Their discovery was published in the article *Exchange anisotropy as mechanism for spin-stripe formation in frustrated spin chains* (M. Pregelj et al., Phys. Rev. B 94, 081114(R) (2016)).

Matjaž Gomilšek, Martin Klanjšek, Matej Pregelj, and Andrej Zorko collaborated with researchers from China, United Kingdom, and Switzerland in an in-depth investigation of magnetic properties of Zn-brochantite. This is a new realization of the quantum kagome antiferromagnet, a paradigm of geometrical frustration in two dimensions, that was synthesized by the Chinese collaborators in 2014. With the use of various experimental techniques, including nuclear magnetic resonance, muon spin relaxation/rotation, and neutron scattering they established that the ground state of this material is magnetically disordered and dynamical. They observed a quantum-critical behaviour at high temperatures and various spin-liquid instabilities that the system goes through with lowering temperature. Their discovery was published in the paper *Instabilities of spin-liquid states in a quantum kagome antiferromagnet* (M. Gomilšek et al., Phys. Rev. B 93, 060405(R) (2016)).

Additionally, they showed that the low-temperature spin-liquid phase behaves like a spinon metal, which is a novel type of behaviour for the kagome lattice. This observation was published in the paper *μSR insight into the impurity problem in quantum kagome antiferromagnets* (M. Gomilšek et al., Phys. Rev. B 94, 024438 (2016)).

Andrej Zorko, Matjaž Gomilšek, and Matej Pregelj, in collaboration with researchers from Germany, USA, Moldova, and Switzerland investigated new functionality of layered metamagnets, with the use of electron spin resonance in high magnetic fields. The properties of the mixed antiferromagnetic/ferromagnetic phase that is stabilized in a finite range of applied fields around 0.8 T at low temperatures and is characterized by enhanced microwave absorption were thoroughly investigated. They showed that thermal fluctuations play an important role in destabilizing the

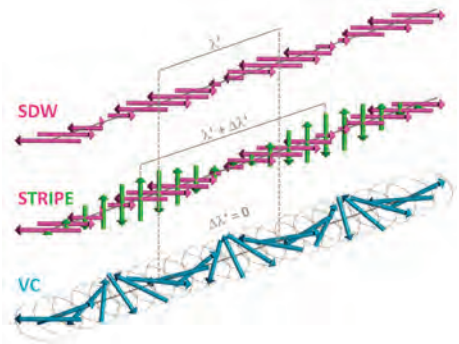


Figure 11: Magnetic order at the V_1 site along the c axis derived for the collinear amplitude-modulated (SDW) phase, for the vector-chiral (VC) phase, and for the spin-stripe (STRIPE) phase. λ' corresponds to the deviation of **k** *from 1/2, i.e., from the antiferromagnetic modulation, while Δλ' corresponds to* Δ**k**. *Published in M. Pregelj et al., Phys. Rev. B 94, 081114(R) (2016).*

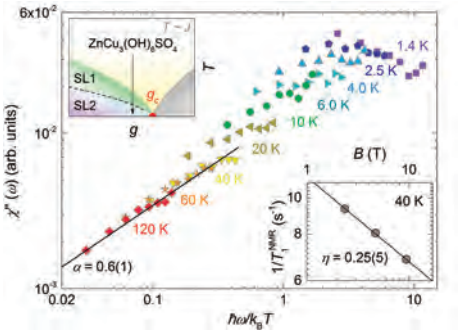


Figure 12: The observation of a quantum-critical scaling of the dynamical susceptibility in Zn-brochantite and the various magnetic states that the system goes through when lowering the temperature (upper inset). Published in M. Gomilšek et al., Phys. Rev. B 93, 060405(R) (2016).

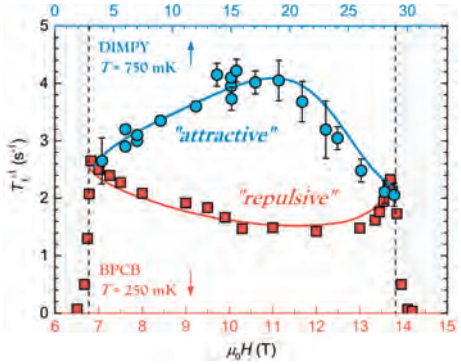


Figure 13: The observed difference of magnetic fluctuations probed by measurements of the spin-lattice relaxation time T_1 in the systems BPCB and DIMPY, containing spin-1/2 ladders with strong rungs and strong legs, respectively.

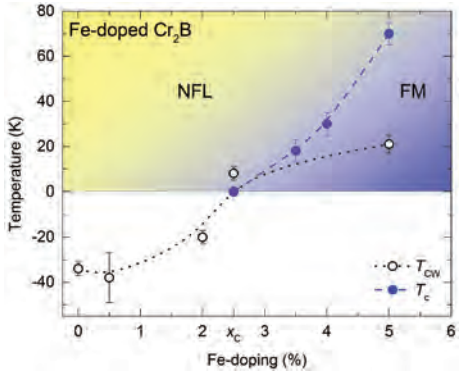


Figure 14: Phase diagram of Fe-doped Cr_2B system obtained from ^{11}B NMR measurements.

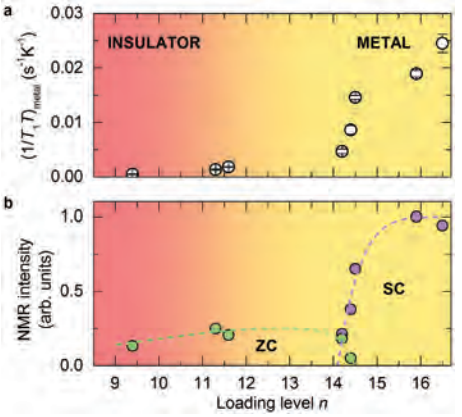


Figure 15: Phase diagram of the sodium-doped LSX zeolite showing the values of (a) metallic contribution to spin-lattice relaxation rate divided by temperature that is proportional to the square of electronic density-of-states, and (b) NMR spectrum intensity for shifted (SC) and unshifted (ZC) components as a function of Na loading level. The colour gradient divides the insulating and metallic regions.

highly absorbing mixed phase. Their discovery was published in the paper *Electron spin resonance insight into broadband absorption of the $Cu_3Bi(SeO_3)_2O_2Br$ metamagnet*, (A. Zorko et al., AIP Advances 6, 056210 (2016)).

Andrej Zorko collaborated with researchers from France, USA and Switzerland in an in-depth neutron scattering investigation of magnetically and structurally chiral Fe langasite, which is a model system of triangle-based frustrated magnets with a strong potential for multiferroicity. They observed bunching of the helical modulation along the *c* axis and the in-plane distortion of the 120° Fe-spin arrangement. These observations enabled a refinement of the spin Hamiltonian, thus providing a link to the magnetically induced electric polarization observed in these systems. The results of this investigation were published in the paper *Helical bunching and symmetry lowering inducing multiferroicity in Fe langasites* (L. Chaix et al., Phys. Rev. B 93, 214419 (2016)).

Martin Klanjšek in collaboration with French and Swiss colleagues studied a difference in the magnetic response of the systems $(C_5H_{12}N)_2CuBr_4$ (BPCB) and $(C_7H_{10}N)_2CuBr_4$ (DIMPY), both containing the spin-1/2 ladders, where the exchange interactions along the rungs are stronger than those along the legs in the first case, and conversely in the second case. They confirmed that the spin ladders in both cases behave as a Tomonaga-Luttinger liquid of spinons. Nevertheless, the systems exhibit markedly different magnetic fluctuations, which can be directly probed by measurements of the spin-lattice relaxation time T_1 in nuclear magnetic resonance. The observed difference emerges from the difference of interactions between the spinons in both cases: these are expectedly repulsive in the first case and surprisingly attractive in the second case. The work is published in *Dichotomy between Attractive and Repulsive Tomonaga-Luttinger Liquids in Spin Ladders* (M. Jeong et al., Phys. Rev. Lett. **117**, 106402 (2016)).

Denis Arčon collaborated with groups from USA (Princeton University, University of Houston) and Israel (The Hebrew University of Jerusalem) on the evolution of magnetic fluctuations in systems, where we induce a transition between the paramagnetic and ferromagnetic metal using some external parameter (e.g., doping or pressure). Theoretical models in such cases predict the closeness of the quantum critical point (QCP) and strong deviations from the Fermi liquid behaviour. The research focused on two model systems, i.e., Fe-doped Cr_2B and $YFe_2(Ge,Si)_2$. In the former case we used ^{11}B nuclear magnetic resonance data to discover the presence of both ferromagnetic and antiferromagnetic fluctuations. The latter are suppressed with Fe doping, before the ferromagnetic ones finally prevail for $x > x_c$. Indications for non-Fermi-liquid behaviour, usually associated with the proximity of a quantum critical point, were found for all samples, including undoped Cr_2B. The sharpness of the ferromagnetic-like transition changes on moving away from x_c, indicating significant changes in the nature of the magnetic transitions in the vicinity of the quantum critical point. Our data provided some important constraints for understanding quantum phase transitions in itinerant ferromagnets in the limit of weak quenched disorder. The results were published in *Evolution of magnetic fluctuations through the Fe-induced paramagnetic to ferromagnetic transition in Cr_2B* (D. Arčon et al., Phys. Rev. B **93**, 104413 (2016)). The research of the $YFe_2(Ge,Si)_2$ system had similar goals. The additional importance of these experiments lies in the fact that these structures are isostructural to some iron-based superconductors. We used ^{89}Y NMR to show the presence of ferromagnetic fluctuations, which may have an impact on our understanding of the formation of Cooper pairs in this and other related compounds. The article was submitted to Phys. Rev. Lett. (J. Srpčič et al., arXiv:1608.01130 (2016)).

Zeolites

Peter Jeglič and Denis Arčon, in collaboration with researchers from Slovenia and Japan, studied Na-type low-silica X (LSX) zeolite loaded with guest Na atoms. They unambiguously confirmed a metallic ground state for higher loading levels. By extracting the density-of-states at the Fermi level as a function of the sodium loading level, they discovered a continuous (crossover-like) evolution across the metal-to-insulator transition. These results reveal a complex loading-level dependence of electronic correlations and disorder due to electron confinement to zeolite cages and were published in the paper, *Metal-to-insulator crossover in alkali doped zeolite* (M. Igarashi et al., Sci. Rep. **6**, 18682 (2016)).

II. Research programme "Physics of Soft Matter, Surfaces, and Nanostructures"

The investigations of the research program "Physics of Soft Matter, Surfaces, and Nanostructures" are focused on novel complex soft-matter systems and surfaces with specific functional properties. We investigated in particular liquid-crystalline elastomers and dendrimers as novel multifunctional materials, nematic colloids, molecular motors, soft-matter photonic crystals and novel synthetic or self-assembled micro- and nano-structures. The aim of the program is to understand structural and dynamical properties of these systems, their interactions, their function at the molecular level, and self-assembly mechanisms in soft matter. The underlying idea is that it is possible to understand complex mechanisms, such as self-assembly, on a macroscopic level, using a simplified physical picture and models. In order to provide a comprehensive approach to the problem, the program combines both experimental and theoretical investigations, supported by modelling and simulations. Special emphasis is given to the possible electro-optic and medical applications.

The group explored topological defects in liquid-crystal droplets and shells, the structure of droplets on biofibres and in defect annihilation in liquid crystals. We developed super-resolution microscopy based on microlaser particles and biodegradable optical waveguides for photomedicine. We explored the working mechanism of the motor protein kinesin-14, new low-friction and low-dimensional nanomaterials.

Topology of liquid crystals: Singular points, skyrmions and torons

Chiral nematic liquid crystals exhibit rich topological phenomena, which were predicted and partially observed in chiral nematic droplets and thin liquid-crystal layers on patterned surfaces. It has been predicted that knots and links are stable in chiral nematic droplets, but this was difficult to observe because of the lack of appropriate experimental methods. We have developed a new method for the reconstruction of the director field, which is based on Fluorescent Confocal Polarisation Microscopy (FCPM) imaging in low birefringent liquid crystals with added fluorescent dyes. A new approach was taken in reconstructing the director field in chiral nematic droplets based on a simulated annealing algorithm. This combined method proved to be very efficient in reconstructing experimental 3D FCMP images. We observed that in chiral nematic droplets, topological singularities always appear in a form of point defects or simple rings, which are never knotted or linked. The complexity of the topological structures in chiral nematic droplets depends on the ratio of the helical pitch of the liquid crystal and the diameter of the droplet. In the case of low chirality, the number of point defects is small and they tend to be expelled to the surface of the droplet. The number of defects is always odd, which is due to the conservation of the total topological charge. We successfully reconstructed droplet structure with three point defects, which showed a cross-section of the Bloch skyrmion, which is similar to skyrmion structures in chiral magnets. When the number of point defects is increased to five for higher chirality, we observed another topological structure, which is akin to the toron structure observed in thin chiral nematic layers. Both skyrmion and toron structures are smoothly embedded in spherical confinement. This work presents the first exact reconstruction of the topology of 3D director in chiral nematic droplets and was published in Scientific Reports (G. Posnjak, S. Čopar and I. Muševič, *Scientific Reports* 6: 26361 (2016)).

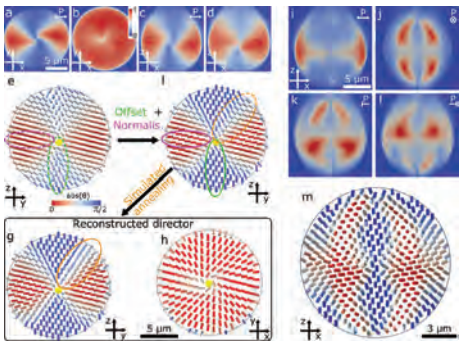


Figure 16: (a-d, i-l) Examples of fluorescent images taken at different polarisations of the fluorescent excitation beam. The panels (e-m) show the reconstructed director structure in a chiral nematic droplet.

Skyrmion structures were also observed in thin nematic LC films on chemically patterned patchy surfaces. When the sample was quenched from the fully aligned state using a strong external electric field, the director on the patterned patches spontaneously relaxed into a vortex-like structure, centred on the patch, as shown in the crossed-polarised image in Figure 17. This work was published in Cattaneo et al., *Soft Matter* **12**, 853 (2016).

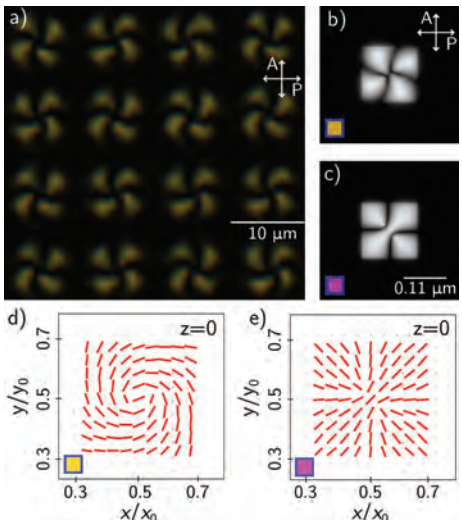


Figure 17: Skyrmions are vortex-like structures, which are clearly observed between crossed polarisers. (a) Experimental optical microscopy image viewed in white light transmission between crossed polarizers after the application of a potential of 30 V. (b and c) Are simulated optical microscopy images for two defect states with the lowest free energy; (d and e) are the corresponding director fields at the patterned surface (z = 0).

Sensing surface morphology of biofibers by decorating spider silk and cellulosic filaments with nematic microdroplets

Liquid-crystal droplets deposited on microthin biofibres – including spider silk and cellulosic fibres – were shown to reveal characteristics of the fibres' surface, performing as simple but sensitive surface sensors. By combining experiments and numerical modelling, different types of fibres are identified through the fibre-to-nematic droplet interactions, including perpendicular and axial or helicoidal planar molecular alignment. The nematic droplets as sensors also directly reveal the chirality of the cellulosic fibres. Different fibre entanglements can be identified by depositing droplets exactly at the fibres' crossings. More generally, the presented method can be used as a simple but powerful approach for probing the surface properties of small-size bio-objects, opening a route to their precise characterization. This work is a collaboration between the soft matter

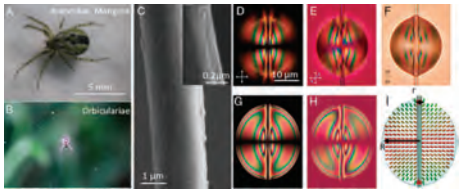


Figure 18: Droplets of a complex nematic fluid were shown to perform as robust sensors for detecting the surface morphology of bio-fibres, such as spider silk and cellulose (PNAS 113, 1174 (2016)).

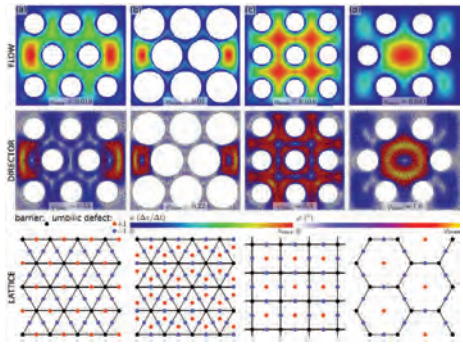


Figure 19: Porous nematic microchannels as generators of umbilic defect lattices (PRF 1, 023303 (2016)).

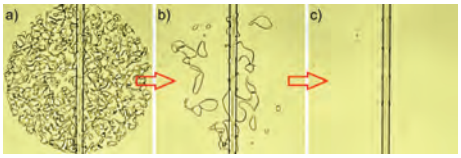


Figure 20: During the fast quenching of a liquid crystal from isotropic to nematic phase tangle of defect lines appear (a) and two pairs of Saturn rings and anti-rings are formed around the glass fibre (c).

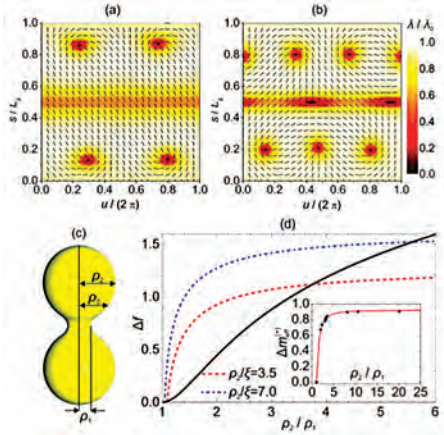


Figure 21: Depinning threshold in dumb-bell configurations. Panels (a,b) show nematic ordering in the (u, s) plane just below and above the threshold. The shape, calculated at the threshold, is presented in panel (c). In panel (d) the free-energy penalties to form a pair defect-antidefect and the effective topological charge are plotted as a function of geometrical parameters.

group in Ljubljana (modelling) and Lisbon (experiments) and was published in L. E. Aguirre et al., *Sensing surface morphology of biofibers by decorating spider silk and cellulosic filaments with nematic microdroplets*, Proc. Natl. Acad. Sci. USA 113, 1174 (2016).

Porous nematic microfluidics for the generation of defect lattices as photonic crystals

Porous nematic microfluidics was demonstrated as a novel route for controlling the microstructure of the nematic order. Specifically, we showed the emergence of regular networks of topological defects, ranging in symmetry from triangular, square, to even kagome. This approach shows interesting possibilities as flow-tunable photonic crystal. The work was published in *Porous nematic microfluidics for generation of umbilic defects and umbilic defect lattices* (J. Aplinc, S. Morris and M. Ravnik, Phys. Rev. Fluids 1, 023303 (2016)).

Annihilation dynamics of topological monopoles on a fibre in a nematic liquid crystal

We studied the dynamics of topological defects on a glass fibre immersed in a nematic liquid crystal. We have used the laser tweezers to create isolated pairs of topological monopoles with the opposite topogical charge and we have observed their annihilation process. When the fibre was set perpendicular to the nematic director, the monopoles were point defects in a form of radial and hyperbolic hedgehog and they attracted at small separations with an elastic force, which is proportional to the inverse square of the separation, following the Coulomb law for electric monopoles. The work was published in M. Nikkhou et al., Phys. Rev. E 93, 062703 (2016). In the case of a parallel fibre to nematic director the monopoles are in the form of Saturn ring and Saturn anti-ring. Here in thick cells we again observe a Coulomb-like attraction, while in thin cells there is an additional string-like force attributed to the formation of defect lines, connecting both monopoles. This force is independent of the separation between monopoles and prevails Coulomb-like attraction at large separations. These findings were published in M. Nikkhou et al., Phys. Rev. E 93, 062703 (2016).

We found that the dynamics of topological monopole annihilation on a fibre is very different for thick and thin nematic layers in thick cells, the two defects show a Coulomb-like pair attraction with no background force, which decays as an inverse square of the defect separation. However, for cell thickness comparable to the glass fibre diameter, there is another dominant type of force which is string-like and independent of the defect separation. It turns out that this constant force of attraction in thin cells is due to the interconnection of topological defects by additional defect lines which are running along the fibre surface. This work was published in M. Nikkhou et al., Eur. Phys. J. E 39: 100 (2016).

Topological defects in thin nematic shells

We studied numerically topological defects (TDs) in effectively two-dimensional closed soft films exhibiting in-plane orientational ordering. We introduced the Effective Topological Charge Cancellation mechanism controlling the localized positional assembling tendency of TDs and the formation of pairs defect-antidefect on curved surfaces and/or the presence of relevant "impurities" (e.g., nanoparticles). For this purpose an effective topological charge m_{eff} is defined consisting of real, virtual and smeared curvature topological charges within a surface patch identified by the characteristic spatially averaged local Gaussian curvature K. We demonstrate a strong tendency enforcing $m_{eff} \to 0$ on surfaces composed of surface patches exhibiting significantly different values of K. For non-zero m_{eff} we estimate a critical depinning threshold to form pairs of defect-antidefect using the electrostatic analogy. The work was presented in two invited lectures and in the publication L. Mesarec et al., Scientific Reports 6, no. 27117, 1-9 (2016).

Biodegradable optical waveguides for use in photomedicine

A new class of optical waveguides for use in deep-tissue photomedicine were demonstrated (S. Nizamoglu, et al., *Nature Communications* 7, 10374, 2016). These waveguides were made out of biocompatible and biodegradable polymer materials, which can be implanted into the body and are naturally degraded over time. The waveguides enable the use of a number of medical laser treatments and diagnostics deep into the body, which were till now only limited to the surface due to limited penetration of light into the tissues. As an example of a possible application, laser wound closure is demonstrated, which could lead to faster healing and less scarring. Biocompatible and biodegradable waveguides can also be directly applied to other light-based diagnostics, surgery and therapeutics.

Optical super-resolution microscopy based on microlaser particles

A novel imaging technique was developed which instead of standard fluorescent molecules, uses small lasers embedded in the sample as probes [S. Cho et al., Phys. Rev. Lett. 117, 193902 (2016)]. The main characteristics of the microlasers are their very nonlinear response to the incoming pump beam intensity. The pump beam is scanned across the sample to form a 2D or 3D image. If the pump beam is set just above the laser threshold, only microlasers exactly in the canter of the beam will emit laser light. This makes it possible to achieve super-resolution as well as to get confocal images with low background without the need for pinholes. Images at a resolution six times higher than that of fluorescence-based microscopes were demonstrated by using a nanowire laser. The new technique was termed *laser particle-based stimulated emission microscopy* (LASE).

Figure 22: A biodegradable optical waveguide through which green laser light is sent into a piece of skin tissue.

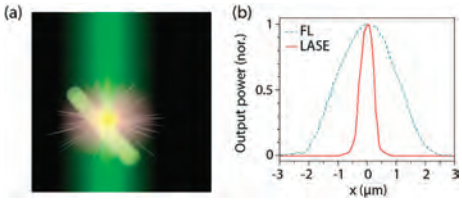


Figure 23: (a) Artistic view of a nanowire microlaser illuminated by an external beam of light. (b) Comparison of resolution between regular fluorescence imaging and the new LASE microscopy.

Liquid-crystal microphotonics

We continued our studies of the possible application of liquid crystals and their structures such as droplets and fibres in photonics. We numerically demonstrated wave guiding of laser beams by birefringent profiles of the escaped topological defect lines. The radially escaped nematic director profiles of a liquid crystal with negative birefringence are able to focus and guide light with radio polarisation, whereas the opposite-azimuthal polarisation passes through unaffected. Lensing by liquid-crystal structure was also demonstrated, which could be controlled by an external electric field. The light attenuation is low and these escaped defect lines have the potential for application in photonic waveguiding. We have also studied the lasing properties of chiral nematic 3D microlasers which were polymerised, as shown in Figure X3. The lasing shows two distinct mechanisms, namely the photonic band edge lasing and lasing from the whispering gallery modes. It was demonstrated that the polarisation of the liquid crystal greatly increases the lasing stability.

We also published an extended review paper on liquid-crystal microphotonics (I. Muševič, Liquid Crystal Reviews 4, 1 (2016)). This work summarises the main aspects of liquid-crystal microphotonics including nematic colloids and liquid-crystal dispersions.

Molecular motors

In collaboration with researchers from Dresden and Warsaw we investigated the working mechanism of the motor protein kinesin-14. Even though the main task of most cytoskeletal motors is longitudinal motion, many of them also exert a torque on their filaments, leading to helical motion. The significance of this torque is still unknown, but it might be involved in the establishment of body chirality in certain organisms. In our motility assay the motors are attached to the surface and move microtubules, whose longitudinal and angular motion is simultaneously observed through attached quantum dots and FLIC microscopy. Unexpectedly, the period of the helical motion strongly depends on the ATP concentration. We developed a minimal mechano-chemical model for kinesin-14, which allows us to explain this dependence and also to reconstruct the motor's working cycle. Our results demonstrate how measurements on large ensembles can be used to infer the properties of individual molecules. The work was published in *Proc. Natl. Acad. Sci. USA* 113, E6582–E6589 (2016).

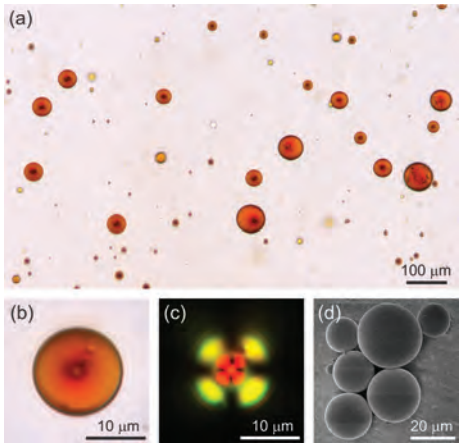


Figure 24: Dispersion of polymerised chiral nematic droplets in glycerol. They are red because the DCM fluorescent dye was added to a liquid crystal. The lower panels show examples of droplets and SEM image of a cluster of polymerised and dried microlasers.

Low-friction nanomaterials

Hard coatings have been used as wear-protection coatings for decades but without optimization of conventional lubrication systems. In the paper "Tribological performance of TiN, TiAlN and CrN hard coatings lubricated by MoS_2 nanotubes in Polyalphaolefin oil". Wear, vol. 352-353, p. 72, by S. Paskvale, M. Remskar, M. Čekada, we reported that the addition of MoS_2 nanotubes in polyalphaolefin (PAO) oils leads to a significant reduction in friction and to a decrease in the wear behaviour of tool steel AISI D2 coated with TiN, TiAlN and CrN hard coatings. Comparative tests using conventional MoS_2 platelets in PAO oil was performed on these hard coatings. In all cases, the MoS_2 nanotubes substantially decreased friction (on CrN for 55%, on TiN for 65%, and on TiAlN for 25%), while the MoS_2 platelets were less efficient or even increased friction.

In the paper *Transitioning to sustainable production – Part III: developments and possibilities for integration of nanotechnology into material processing technologies* (P. Krajnik et al., J. of Cleaner Production 112, 1156 (2016)) we reported on the superior tribological properties of cooling-lubricating fluids based on biodegradable vegetable oils with added functionalized MoS_2 nanotubes, to those of conventional metalworking fluids.

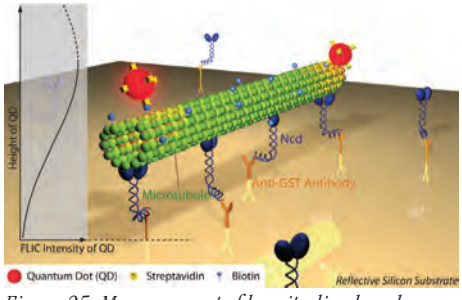


Figure 25: Measurement of longitudinal and rotational motion of microtubules using quantum dots and FLIC microscopy.

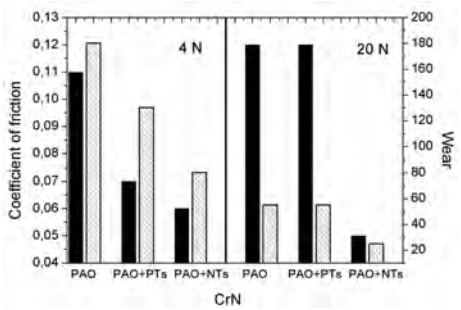


Figure 26: Coefficients of friction and wear at the 4N and 20N loads at the contact between CrN hard coating and steel (100Cr6) ball. We used the following lubricants: pure PAO oil, PAO oil with 2 wt.% of MoS_2 nanotubes (PAO+NTs) or. standard MoS_2 platelets (MoS2+PTs).

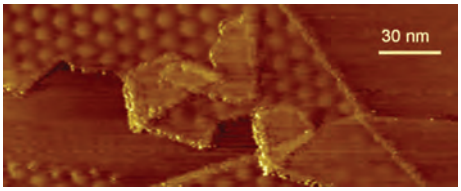


Figure 27: STM picture of a superstructure in graphene lying on graphite substrate.

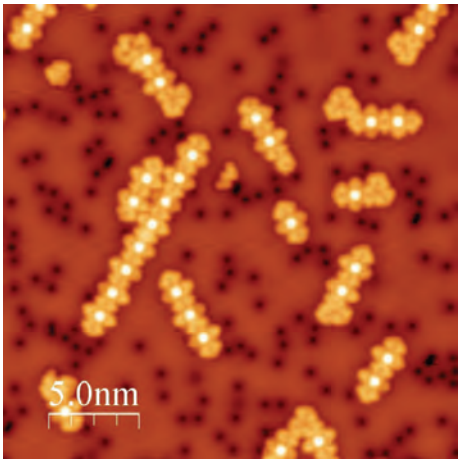


Figure 28: High-resolution STM image showing molecular chains of organic BETS and $GaCl_4$ molecules on Ag(111) surface (25 × 25 nm², T=4.2K)

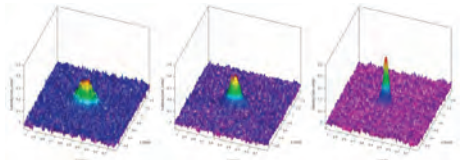


Figure 29: Velocity-distribution images showing about 50,000 caesium atoms being evaporative cooled to temperatures around 1 nK, where the transition to a Bose-Einstein condensate occurs.

Low-dimensional materials

Molybdenum trioxide, MoO_3, belongs to semiconductors with a wide energy band gap. It is used in photovoltaics, as sensors and for energy storage. In the article "Oxygen deficiency in MoO_3 polycrystalline nanowires and nanotubes", Materials Chemistry and Physics 170 (2016) 154, by A. Varlec, D. Arčon, S.D. Škapin and M. Remškar, we reported on the first synthesis route of the orthorhombic MoO_3 nanotubes by oxidation of molybdenum-sulphur-iodine nanowires. Oxygen deficiency was determined by electron-paramagnetic resonance observing paramagnetic defects (Mo_5+) and explained using Raman spectroscopy by appearance of a new resonant band (1004 cm-1).

Superstructures observed by scanning tunnelling microscopy on graphite have been reported several decades ago, but the interest in these superstructures recently intensified due to their occurrence in graphene grown on different substrates. In the article *Influence of surface defects on superlattice patterns in graphene on graphite* (M. Remškar and J. Jelenc, Surface Science 651, 51 (2016)) we reported experimental findings that the orientation of the superstructure is influenced by surface defects and edges of graphene. Superstructures in graphene put on graphite exist even if the graphene is not supported by graphite over its entire area. The modulation of the density of states influences the strength of intra-layer carbon bonds in such a way that the graphene breaks along the superstructure minima.

Nanosafety

In the telecast *When science explodes*, aired on the national television (Slo1) on 17 Dec, 2016 as a part of education program *Bite into science*, and in the telecast *Black market flourishes, fireworks also have a dark side* aired by a commercial TV (POP TV) in broadcast *Inspector* on Dec. 22, 2016, M. Remskar reported on air pollution by nanoparticles released during use of fireworks and sparklers.

Small structures and 1D chains of organic molecules

By carefully controlling the growth conditions, we can fabricate different nanostructures and 1D chains of organic BETS molecules (Fig.) on silver (111) surfaces. We are studying the structure and properties of such formations using low-temperature scanning tunnelling microscopy and spectroscopy. We measured a narrow gap in the density of states, which indicates the chains to be semiconductiing. As previously observed on monolayer islands, grown from same material (single crystals of $(BETS)_2GaCl_4$), the $GaCl_4$ molecules can fill the gaps between pairs of BETS molecules and greatly influence the electronic properties of molecular chains.

Ultra-cold atoms

For the first time in the Laboratory for Cold Atoms at Jožef Stefan Institute caesium atoms were evaporative cooled to temperatures of about 1 nK. Simultaneously, their density was increased, which leads to formation of Bose-Einstein condensate (Figure 29). Currently, we are trying to increase the number of atoms in the condensate and to achieve the condensation at even higher temperatures.

III. Research program "Experimental biophysics of complex systems and imaging in biomedicine«

The program "**Experimental biophysics of complex systems and imaging in biomedicine**" combines the research of the processes and structure of the biological systems with the development of advanced experimental techniques, especially microspectroscopies, super-resolution microscopies, and imaging techniques. Our group is mainly focused on understanding the response of the molecular and supra-molecular structures to the interaction between materials and living cells, and to the interaction between light and living cells. We are interested in mechanisms of this response, time scales and conditions as well as its application in medicine, especially in the field of medical materials and devices, and in healthcare in general. With the development of spectroscopic, microscopic and microspectroscopic techniques, we aim to provide a new understanding of biological systems, which will open up new possibilities in the design of novel medical devices for therapy, diagnostics and regeneration – one of the main health issues among the aging population of the developed world. Our group mastered various spectroscopic techniques, such as the EPR and FTIR, microscopic and microspectroscopic fluorescence techniques such as FMS and many special MRI techniques and we have introduced super-resolution microscopic techniques such as the STED, FCS and STED

FCS, together with the novel two-photon STED and spectral sensitive STED. Among the methods of magnetic resonance imaging, a new method, which enables the monitoring of the electric field in tumours during their treatment by electroporation high-voltage electric pulses, has been developed. In addition, we have developed a method of multiparametric magnetic resonance imaging, which has been found to be very efficient in the characterization of food, drugs and various processes. By using high spatial resolution magnetic resonance imaging, we can monitor the efficiency of the surface treatment, formation and dissolution of gel layers as well as diffusion measurements in samples with restricted geometry.

FMS detection of the lipid wraps around the metal-oxide nanotubes has been confirmed for the first time using STED microscopy, which directly identified the entry of the particles into the cells. FMS has been used to detect the edges of a new blood clot after the laser-induced blood photocoagulation. New methods were developed to monitor food processing and food-quality control based on the multiparametric MR imaging.

Cell-material interaction studies

The cell-material interaction studies, especially from the viewpoint of bioactivity and biocompatibility, are undoubtedly one of the hottest biophysics research topics. We have previously shown that titanium dioxide nanoparticles strongly interact with lipid membranes from either model vesicles or even live cells – they can adsorb to the membrane and wrap themselves by a lipid corona. We have recently indisputably corroborated this idea with additional experiments using original approaches, such as fluorescence (micro)spectroscopy with in-house-designed and synthesized environment sensitive molecular probes, and state-of-the-art biophysical methods, such as fluorescence cross-correlation spectroscopy (FCCS) and super-resolution fluorescence imaging (STED). For the latter two, we teamed with the renowned prof. Christian Eggeling from the University of Oxford (UK) to foster the transfer of knowledge on these advanced techniques, which will also be available in our laboratory.

Many studies on the safety of engineered nanomaterials focused only on finding correlations between nanomaterial properties and adverse health outcomes, without taking into account underlying molecular events. A consortium of research institutions (including our group) and companies teamed up for the SmartNanoTox project with a common goal of identifying molecular initiating events and key events on a cellular level and connecting them to adverse health outcomes after inhalation of the nanomaterial. This approach should therefore yield a mechanistic picture of nanomaterial toxicity, which will lead to the discovery of causal links between molecular initiating events from the in-vitro models and the adverse health outcomes determined with animal models. Using the existing literature, we have identified the most suitable cell-based and cell-free *in-vitro* models of the lung. Some of the molecular initiating events identified are: nanomaterial – lipid interaction including corona formation after exposure of a nanoparticle to lung surfactant, cellular uptake of nanoparticles, and lysosomal destabilization. We have successfully labelled TiO_2 nanotubes with different fluorophores, which are also suitable for high-resolution STED imaging. Our preliminary data show that the nanotubes enter the cells as single nanotubes – an event that cannot be resolved from confocal microscopy (see Figure 30).

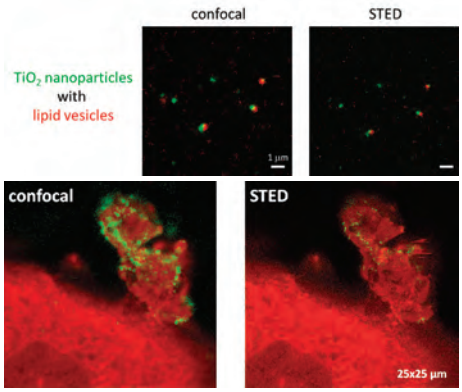


Figure 30: Co-localization of the lipid wraps (red) and nanotubes with STED microscopy (top) of the fluorescently labelled TiO2 nanotubes (green). High resolution STED microscopy of fluorescently labelled TiO_2 nanotubes (green) and a cell (red) enables direct imaging of nanoparticles entering the cell.

Fluorescence microspectroscopy (FMS)

Fluorescence microspectroscopy (FMS) reveals physical properties of molecular environment of fluorescent probes. For example, we have developed probes that are sensitive to the local pH value. They only activate at low pH. In addition, their spectral properties change, if they aggregate. There are a number of mechanisms being exploited with these probes to study molecular vicinity. Widely used is fluorescence resonance energy transfer (FRET). Lately, contact- or aggregation-based mechanisms are also being utilized. In the case of rhodamine probes, aggregate formation leads to non-fluorescent ground-state complexes or spectral shifts. With calibration of concentration and pH dependence, the developed probes will be useful for a quantitative determination of the level of aggregation, i.e., as sensors for the detection of molecular contact.

Multiparametric detection of the impact of the high-intensity light source on biological systems

A new experimental system for multiparametric detection of the impact of the high intensity light source on biological systems was developed. Common fluorescence detection of individual structures of the retina before and after the injury with a strongly focused high-intensity light source was changed and improved with fluorescence micro-spectral detection. The system was developed on an existing fluorescence microspectroscopy (FMS) machine with a newly installed near-IR laser source with a well-defined spatiotemporal resolution. Using this system, we were able to successfully characterize the interaction of the light source with biological matter. In addition, a new method for the localization and dynamics monitoring of blood clotting following the blood vessel injury was introduced, based on the optical tweezers and their mechanical manipulation of individual or multiple erythrocytes.

To mimic the *in vivo* coagulation processes during vessel disruption, we used retinal tissue samples from *ex vivo* porcine eyes. The detection of blood coagulation was performed by the fluorescence microspectroscopy (FMS) system developed in our laboratory. In order to identify the extent of the clot formation after the accurately localized vessel rupture in the intact retina, we measured the auto-fluorescence contrast inside the blood vessel indicating a blood flow. A significant decrease in the negative contrast as detected after one minute is the result of the decreased number of erythrocytes in the volume. The observed blood flow showed the inability of the formed clot to completely seal/close the vessel. Using the negative contrast fluorescence technique, it is difficult to distinguish between the non-coagulated and coagulated region inside the ruptured vessel, but with the FMS blood-clot characterization technique, the differences between the non-coagulated blood (blue colour) and coagulated blood (green colour) in the initial clot localization could be easily observed. The measured red spectral shift of $\Delta\lambda$ = 1-2 nm in the damaged region directly indicates the changed absorption properties of hemoglobin and thus the local physio-chemical changes, which means the onset of the clot formation. We can see that part of the targeted region just below the ruptured vessel wall remains non-coagulated (blue colour).

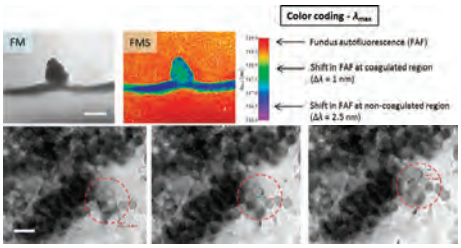


Figure 31: FMS approach to localize a blood clot 5 minutes after laser induced vessel rupture (top, scale bar is 200 μm) and blood clot boundary identification by optical tweezers mechanical manipulation of individual erythrocytes (bottom, scale bar is 10 μm). The concurrent movement of closely packed erythrocytes induced by a laser tweezers (see cross locator) is denoted within the red circle.

In order to confirm the initial clot formation, we used optical tweezers. Strong binding between individual erythrocytes a few tens of μm outside of the ruptured vessel formed on a minute timescale after a vessel injury. Optical tweezers manipulation in a vertical direction (see cross-locator in Figure 31), with trapping force of $F \approx 10$ pN (P = 50 mW), used the concurrent movement of a group of more than 10 closely packed erythrocytes. The optical force was unable to detach single erythrocytes from the bulk, which indicates strong adhesion, i.e., the initial state of the clot formation. For comparison, erythrocytes inside the vessel, a few tens of microns away from the ruptured site, did not aggregate. Our results show that the initial clot formation is in agreement with our hypothesis that the initial clot formation is localized to the site where the plasma calcium concentration is decreased in the region where blood plasma is diluted with released cytoplasm of injured tissue surrounding the blood vessel.

Based on our collaboration with the Smithies' lab from the University of North Carolina and our work published in the Langmuir journal, we were invited to describe and film all the details of our method for the Size Controlled Synthesis of Stable Oligomeric Clusters of Gold Nanoparticles under Ambient Conditions (J. Vis. Exp. 2016 (108):e53388). In this work, we described how reducing dilute aqueous $HAuCl_4$ with sodium thiocyanate (NaSCN) under alkaline conditions produces 2–3-nm-diameter nanoparticles and stable grape-like oligomeric clusters of yellow nanoparticles. The produced yellow oligoclusters range in size from ~3 to ~25 nm. This size range can be further extended by an add-on method utilizing hydroxylated gold chloride ($Na^+[Au(OH_{4-x})Cl_x]^-$) to autocatalytically increase the number of subunits in the as-synthesized oligocluster nanoparticles, providing a total range of 3 nm to 70 nm. We were able to concentrate the oligoclusters more than 300 fold without aggregation and the crude reaction mixtures remained stable for months without further processing.

Diffusion measurement by modulated gradient

We improved our method for diffusion measurement by modulated gradients. In some of our experiments, especially those on bulk liquids, we found that the method gives overestimated results for the diffusion constant with higher frequencies of modulated gradients. In the study, we showed that the origin of the error is in neglecting the off-resonance contributions to the signal of multiple spin echoes in a high magnetic field gradient. Because of these contributions, the total signal was decaying faster than was predicted by our theory, which led to the overestimated calculated diffusion constant. We found a solution to the problem in zero frequency filtering of the spin echo signals, which removed most of the off-resonance signals and therefore made our theoretical model valid again. The results of the study were published in the Journal of Magnetic Resonance, 2016, 270: 77-86.

Dry-curing of different meat products

By using multiparametric magnetic resonance imaging, we studied dry-curing of different meat products. Relaxation time T_1 and T_2 mapping, and the apparent diffusion constant (ADC) mapping were used to find the differences between two different ham muscles (biceps femoris and semimembranosus) at two different stages of salting (low and high). We showed that the maps can be converted into one-dimensional distributions of the parameters T1, T2 and ADC, and in two-dimensional correlations between the parameters ADC-T2, ADC-T1, T1-T2, which show characteristic peaks in the distribution. The location and distribution of these peaks are very sensitive to both the tissue type and the influence of the salting. The characterization was better with the two-dimensional correlation than with one-dimensional distributions. To these three mapping methods, we also added quantitative magnetization transfer imaging, which was found to be efficient for determining the protein content. We concluded that these methods, having greater accessibility to NMR / MRI systems, could serve as an effective tool for monitor-

ing the processing of dry-cured meat products, as well as to control their quality. This research, which was published in the journal Meat Science, 2016, 122: 109, was achieved in cooperation with the researchers from the Agricultural Institute of Slovenia. We also studied the effects of the electroporation on the properties of a potato tuber. We found that with the electric field of more than 400 V/cm, cells start to release substances, which result in an increase of T2 relaxation time. The effect was found to be larger with a higher electric field and was also larger immediately after the electroporation than several hours after it. We found no significant changes associated with electroporation in maps of the apparent diffusion constant or on the maps of T1 relaxation time. During the delivery of the electroporation pulses, we were able to monitor the electric field in the sample using the MREIT method. This enabled us to find relations between the electric field in the sample and its effect on the change of NMR relaxation parameters as well as on the diffusion constant. The findings of this study were published in the Innovative Food Science and Emerging Technologies, 2016, 37: 384.

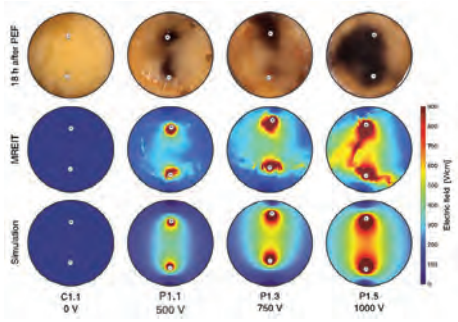


Figure 32: Electric field in the potato tuber sample established during electroporation as measured by the MRTEIT technique (middle row) is in a good agreement with the results of simulation (bottom row) as well as with the release of phenolic compounds that darkened due to an oxidation reaction (optical photographs in the top row). In the study voltages of electroporation pulses were 500, 750 and 1000 V.

Influence of the highly soluble pentoxifylline drug on the dynamics of medium penetration into the tablet and the formation of the gel layer in xanthan tablets

We also investigated the influence of the highly soluble pentoxifylline drug on the dynamics of medium penetration into the tablet and the formation of the gel layer in xanthan tablets. Xanthan is an anionic polymer that exhibits pH- and ionic-strength-dependent swelling. For this reason, the impact of the medium properties on xanthan swelling has also been studied. For hydrophilic polymers, it is generally accepted that, once in contact with a body fluids, they hydrate and swell, forming a gel layer that regulates the penetration of body fluids into the tablet and the dissolution of the incorporated drug. Therefore, the knowledge of the gel layer characteristics is of crucial importance for the use of controlled drug-delivery systems. A combination of different MRI methods enables an accurate determination of the medium penetration into the tablet, as well as hydrogel formation *in situ*. The results of xanthan swelling and pentoxifylline release kinetics were compared to the mathematical model, which combines the polymer swelling kinetics and drug diffusion and solubility to obtain the release mechanism. In water and diluted acid medium (pH >3) with low ionic strength, the main release mechanism is erosion, whereas in acid medium (pH 1.2) and in media with high ionic strength ($\mu \geq 0.2$), the diffusion mechanism dominates, owing to the changes in the polymer structure in media with different pH and ionic strength. The results were published in a paper entitled *The Influence of other high loading and xanthan tablets and media with Different physiological pH and ionic strength on swelling and release* in the Journal of Molecular Pharmaceutics, 2016, 13: 1147. This study was performed in collaboration with our colleagues from the Faculty of Pharmacy, University of Ljubljana.

Penetration of tung oil into various wood species

Furthermore, we studied the penetration of tung oil into various wood species. Tung oil is used as environmentally friendly wood preservatives. However, tung oil does not penetrate deeply into the wood due to its high viscosity. Magnetic resonance imaging was applied to elucidate the influence of the applied impregnation method (immersion in oil or vacuum impregnation with oil) and on the wood species used. It has been shown that the oil penetrated deeply in the wood after the impregnation process than after the immersion process, where the oil remained only on the sample surface. In addition, the depth of penetration of the oil into the wood also depends on the wood species and on the orientation of the sample. Since wood is an anisotropic material, the penetration of the oil is the largest in the axial direction. The results of the research were combined in an article accepted for publication in the Journal Industrial Crops and Products, 2017, 96: 149. The study was performed in collaboration with our colleagues from the Department of Biotechnical Faculty.

Our research has been supported by a number of international projects financed by the European Union. It was also supported within the bilateral Slovenian – USA, Slovenian – German and Slovenian – Greek and other scientific cooperations. In 2016, the Department had cooperation with 108 partners from Slovenia and abroad. Among them:

- The high magnetic field centres in Grenoble, France, and Nijmegen, The Netherlands
- The high magnetic field centre at the University Florida, Tallahassee, Florida, USA
- The ETH, Zürich, Switzerland
- The Ioffe Institute in St. Petersburg, Russia
- The University of Duisburg, the University of Mainz and the University of Saarbrucken in Germany
- The University of California, the University of Utah and the Liquid Crystal Institute, Kent, Ohio, USA,
- National Institute for Research in Inorganic Materials, Tsukuba, Japan
- NCSR Demokritos, Athens, Greece
- Institut für Biophysik und Nanosystemforschung OAW, Graz, Austria

- Bioénergétique et Ingénierie des Protéines, CNRS Marseille, France
- Architecture et Fonction des Macromolécules Biologiques, CNRS Marseille, France
- The Max Delbruck Center for Molecular medicine in Berlin
- The Dartmouth Medical School, Hanover, NH, USA
- The Mayo Clinic, Rochester, USA
- Kyung Hee University, Suwon, Korea
- Technische Universität Ilmenau, Ilmenau, Germany
- Elettra Sincrotrone Trieste, Trieste, Italy
- University if North Carolina at Chapel Hill
- Max-Delbrück-Centrum für Molekulare Medizin (MDC)

made the above studies possible.

Some outstanding publications in 2016

1. A. Rešetič, J. Milavec, B. Zupančič, V. Domenici, B. Zalar. Polymer-dispersed liquid crystal elastomers. *Nature Communications* 7, 13140 (2016).
2. M. Jeong, M. Klanjšek et al. Dichotomy between attractive and repulsive tomonaga-luttinger liquids in spin ladders. *Physical Review Letters* 117, 106402 (2016).
3. F. E. Annanouch, P. Umek et al. Aerosol-assisted CVD-grown PdO nanoparticle-decorated tungsten oxide nanoneedles extremely sensitive and selective to hydrogen. *ACS Applied Materials & Interfaces* 8, 10413 (2016).
4. H. Uršič, V. Bobnar, B. Malič, C. Filipič, M. Vrabelj, S. Drnovšek, Jo Younghun, M. Wencka, Z. Kutnjak. A multicaloric material as a link between electrocaloric and magnetocaloric refrigeration. *Scientific Reports* 6, 26629 (2016).
5. M. Igarashi, P. Jeglič, A. Kranjc, R. Žitko, T. Nakano, Y. Nozue, and D. Arčon. Metal-to-insulator crossover in alkali doped zeolite. *Scientific Reports* 6, 18682 (2016).
6. G. Posnjak, S. Čopar and I. Muševič. Points, skyrmions and torons in chiral nematic droplets. *Scientific Reports* 6, 26361 (2016).
7. L. E. Aguirre, A. de Oliveira, D. Seč, S. Čopar, P. L. Almeida, M. Ravnik, M. H. Godinho, S. Žumer. Sensing surface morphology of biofibers by decorating spider silk and cellulosic filaments with nematic microdroplets. *Proc. Natl. Acad. Sci. USA* 113, 1174 (2016).
8. S. Nizamoglu, M. Humar et al. Bioabsorbable polymer optical waveguides for deep-tissue photomedicine. *Nature Communications* 7, 10374, 2016).
9. S. Cho, M. Humar, N. Martino, S. H. Yun. Laser Particle Stimulated Emission Microscopy. *Phys. Rev. Lett.* 117, 193902 (2016).
10. B. Nitzsche, E. Dudek, L. Hajdo, A. A. Kasprzak, A. Vilfan, S. Diez. Working stroke of the kinesin-14, ncd, comprises two substeps of different direction. *Proc. Natl. Acad. Sci. USA* 113, E6582 (2016).

Some outstanding publications in 2015

1. M. Sluban, P. Umek, Z. Jagličić, J. Buh, P. Šmitek, C. Bittencourt, P. Guttmann, M.-H. Delville, D. Mihailović, D. Arčon. Controlling disorder and superconductivity in titanium oxynitride nanoribbons with anion exchange. *ACS Nano* 9 (2015), 10133.
2. M. Pregelj, A. Zorko, O. Zaharko, H. Nojiri, H. Berger, L. Chapon, D. Arčon. Spin-stripe phase in a frustrated zigzag spin-1/2 chain. *Nature Communications* 6, 7255(2015).
3. M. Klanjšek, D. Arčon, A. Sans, P. Adler, M. Jansen, C. Felser. Phonon-modulated magnetic interactions and spin Tomonaga-Luttinger liquid in the p-orbital antiferromagnet CsO_2. *Physical Review Letters* **115**, 057205(2015).
4. R. H. Zadik, A. Potočnik, P. Jeglič, D. Arčon, et al. Optimized unconventional superconductivity in a molecular Jahn-Teller metal. *Science Advances* **1**, e1500059(2015).
5. M. Pregelj, A. Zorko, M. Gomilšek, et al. Controllable broadband absorption in the mixed phase of metamagnets. *Advanced Functional Materials* **25**, 3634 (2015).
6. M. Nikkhou, M. Škarabot, S. Čopar, M. Ravnik, S. Žumer, I. Muševič. Light-controlled topological charge in a nematic liquid crystal. *Nature Physics* **11**, 183 (2015).
7. S. Čopar, U. Tkalec, I. Muševič, S. Žumer. Knot theory realizations in nematic colloids. *Proc. Natl. Acad. Sci.* **112**, 1675 (2015)).

8. R. Podlipec, J. Štrancar. Cell-scaffold adhesion dynamics measured in first seconds predicts cell growth on days scale - optical tweezers study. *ACS Applied Materials & Interfaces* **7**, 6782(2015).
9. T. Koklič, R. Chattopadhyay, R. Majumder, B. R. Lenz. Factor Xa dimerization competes with prothrombinase complex formation on platelet-like membrane surfaces. *Biochemical Journal* **467**, 37(2015).
10. Z. Arsov, U. Švajger, J. Mravljak, S. Pajk, A. Kotar, I. Urbančič, J. Štrancar, M. Anderluh. Internalization and accumulation in dendritic cells of a small pH-activatable glycomimetic fluorescent probe as revealed by spectral detection. *ChemBioChem* **16**, 2660(2015).

Some outstanding publications in 2014

1. A. Zorko, O. Adamopoulos, M. Komelj, D. Arčon, A. Lappas. Frustration-induced nanometre-scale inhomogeneity in a triangular antiferromagnet. Nature Comms 5, 3222 (2014).
2. P. Koželj, S. Vrtnik, A. Jelen, S. Jazbec, Z. Jagličić, S. Maiti, M. Feuerbacher, W. Steurer, J. Dolinšek, Phys. Rev. Lett. **113**, 107001 (2014).
3. R. Pirc, B. Rožič, J. Koruza, B. Malič, Z. Kutnjak, Negative electrocaloric effect in antiferroelectric $PbZrO_3$. Europhysics Letters 107, 17002-1-5(2014).
4. A. Martinez, M. Ravnik, B. Lucero, R. Visvanathan, S. Žumer, and I.I. Smalyukh Mutually tangled colloidal knots and induced defect loops in nematic fields, Nature Mater. 13, 258-263 (2014).
5. D. Seč, S. Čopar and S. Žumer, Topological zoo of free-standing knots in confined chiral nematic fluids, Nature Comms. 5, 3057 (2014).
6. J. Dontabhaktuni, M. Ravnik and S. Žumer, Quasicrystalline tilings with nematic colloidal platelets, Proceedings of the National Academy of Sciences of the United States of America 111, 2464 (2014).
7. S. Čopar, Topology and geometry of nematic braids, Phys. Rep. 538, 1-37 (2014).
8. A. Vilfan, Myosin directionality results from coupling between ATP hydrolysis, lever motion, and actin binding. Proceedings of the National Academy of Sciences of the United States of America 111, E2076 (2014).
9. Urbančič, I., Ljubetič, A. & Štrancar, J. Resolving Internal Motional Correlations to Complete the Conformational Entropy Meter. J. Phys. Chem. Lett. 5, 3593–3600 (2014).
10. Podlipec, R. et al. Molecular Mobility of Scaffolds' Biopolymers Influences Cell Growth. ACS Appl. Mater. Interfaces 6, 15980–15990 (2014).
11. Mikhaylov, G. et al. Selective targeting of tumor and stromal cells by a nanocarrier system displaying lipidated cathepsin B inhibitor. Angew. Chem. Int. Ed Engl. 53, 10077–10081 (2014).

Awards and appointments

1. Dr. Matjaž Humar: 1st Place Poster Prize at prestigious Nobel Laureate Meeting 2016, Lindau, Germany. Matjaž presented a poster about lasers embedded into single live cells for the first time. He has also demonstrated that fat cells already present in the human body already contain tiny lasers, which only need to be activated.
2. Dr. Matjaž Humar: Bronze Award from community Šempeter-Vrtojba for 2016, Šempeter-Vrtojba. The prize for the high successes in the world scale in recent years and as a stimulation for further scientific work.
3. dr. Janez Pirš, Hononrary distinction of "Jožef Stefan" Institute, Ljubljana, Slovenia, Honorary distinction for his successful contribution for developing new high-tech products based on scientific and technological achievements of the 'Jožef stefan' Institute.

Organization of conferences, congresses and meetings

1. 6th Workshop on Liquid Crystals for Photonics, 14. 9. – 16. 9. 2016, Ljubljana, Slovenia
2. 10. Conference of physicists in basic research, 16. 11. 2016, Otočec, Slovenia

Patent granted

1. Igor Muševič, Matjaž Humar, Spherical liquid-crystal laser, US9263843 (B2), US Patent Office, 16. 02. 2016

INTERNATIONAL PROJECTS

1. 7FP - ESNSTM; Electron Spin Noise Scanning Tunneling Microscopy
   Prof. Janez Dolinšek
   European Commission
2. 7FP - NanoMag; Magnetic Nanoparticles and Thin Films for Spintronic Applications and High Performance Permanent Magnets
   Prof. Janez Dolinšek
   European Commission
3. 7FP - SIMDALEE2; Sources, Interaction with Matter Detection and Analysis of Low Energy Electrons 2
   Prof. Maja Remškar
   European Commission
4. 7FP - LIVINGLASER; A Laser made Entirely of Living Cells and Materials derived from Living Organisms
   Prof. Igor Muševič
   European Commission
5. 7 FP; ERA CHAIR ISO-FOOD - Era Chairs for Isotope Techniques in Food Quality, Safety and Traceability
   Prof. Maja Remškar
   European Commission
6. COST MP1201; Rational Design of Hybrid Organic-Inorganic Interfaces: The Next Step Towards Advanced Functional Materials
   Dr. Polona Umek
   Cost Office
7. COST CA15107; Multi-Functional Nano-Carbon Composite Materials Network
   Dr. Polona Umek
   Cost Office
8. COST CA15209; European Network on NMR Relaxometry
   Prof. Tomaž Apih
   Cost Office
9. COST CA16109;Chemical On-Line cOmpoSition and Source Apportionment of fine aerosoL
   Dr. Griša Močnik
   Cost Office
10. H2020 - SmartNanoTox; Smart Tools for Gauging Nano Hazards
    Prof. Janez Štrancar
    European Commission
11. Solar Cell Application of Rf Rotating Plasma Modified Inorganic Nanotubes
    Prof. Maja Remškar
    Slovenian Research Agency
12. Spin-liquid Ground State of Quantum Kagome Antiferromagnets from a Local-probe Perspective
    Asst. Prof. Andrej Zorko
    Slovenian Research Agency
13. Controlled Nanoparticle Assemblies in Complex Soft Matrices
    Prof. Samo Kralj
    Slovenian Research Agency
14. Investigating Catalytic and Physical Properties of CuGdCa Alloys
    Prof. Tomaž Apih
    Slovenian Research Agency
15. Aromatic Polymers with Ultrahigh Breakdown Field Strength, Low Dielectric Loss, and High Electric Energy Density
    Prof. Zdravko Kutnjak
    Slovenian Research Agency
16. Investigation of Complex Materials for Hydrogen Storage
    Prof. Janez Dolinšek
    Slovenian Research Agency
17. Lipid Wrapped Gold Nanoparticles and Activity of Factor Xa
    Prof. Janez Štrancar
    Slovenian Research Agency
18. Crystal and Electronic Structure of NbS3 Phases
    Dr. Erik Zupanič
    Slovenian Research Agency
19. Radiative forcing of desert mineral dust and PM10 concentrations over Southern Europe
    Prof. Maja Remškar
    Slovenian Research Agency
20. Lead-free (Ba0.8Ca0.2)1-xLa2x/3TiO3 based electrocaloric materials for new dielectric cooling technologies
    Prof. Zdravko Kutnjak
    Slovenian Research Agency
21. Stabilisation of lattices of topological defects
    Prof. Samo Kralj
    Slovenian Research Agency

RESEARCH PROGRAMS

1. Physics of Soft Matter, Surfaces and Nanostructures
   Prof. Slobodan Žumer
2. Experimental Biophysics of Complex Systems
   Prof. Janez Štrancar
3. Magnetic resonance and dielectric spectroscopy of „smart“ new materials
   Prof. Janez Dolinšek

R & D GRANTS AND CONTRACTS

1. Topology and Photonics of Liquid Crystal Colloids and Dispersions
   Prof. Igor Muševič
2. Thermophoretic guidance, accumulation and sorting of biomolecules in microfluidic devices
   Asst. Prof. Andrej Vilfan
3. Intra-pocket-targeted nanomedicines for treatment of periodontal disease
   Prof. Maja Remškar
4. New advanced electrocaloric materials for novel environmentally-friendly dielectric refrigeration technology
   Prof. Zdravko Kutnjak
5. The textural analysis of spatiotemporal changes for breast lesions diagnosis on ultrafastbreast MRIs
   Prof. Igor Serša
6. Role of Calcium and lipid membranes in survival of critically ill patients
   Dr. Tilen Koklič
7. Multifunctional materials for actuator and cooling devices
   Prof. Zdravko Kutnjak
8. High-Entropy Alloys
   Dr. Stanislav Vrtnik
9. Metamaterials from liquid crystal colloids
   Asst. Prof. Miha Ravnik
10. Optimization strategies in biological and artificial microfluidic systems
    Asst. Prof. Andrej Vilfan
11. Selective and hipersensitive microcapacitive sensor system for targetted molecular detection in the atmosphere
    Prof. Igor Muševič
12. Correlated electrons in cnofined molecular systems
    Prof. Denis Arčon
13. Water exclusion efficacy, measure for prediction of wood performance against wood decay fungi
    Prof. Igor Serša
14. Micro-electromechanical and electrocaloric layer elements
    Prof. Zdravko Kutnjak
15. Performance of wood and lignocelolosic composites in outdoor applications
    Prof. Igor Serša
16. Advanced electrocaloric energij conversion
    Prof. Zdravko Kutnjak
17. Microspectroscopy-based optimization of the effects of laser pulses on the retina
    Prof. Janez Štrancar
18. SCOPES; Spin-liquid and Spin-ice States in Frustrated Rare-earth and Transition Metal Spinels
    Dr. Matej Pregelj
    Snf- Swiss National Science Foundation
19. Irradiation and Analysis of Nano SiC Samples
    Prof. Vid Bobnar
    National Nuclear Research Center
20. Building blocks, tools and systems for the Factories of the Future – GOSTOP
    Prof. Janez Štrancar

NEW CONTRACTS

1. MRI scanning of samples
   Prof. Igor Serša
   KRKA, TOVARNA ZDRAVIL, D.D.
2. Analyzes with nuclear quadrupole resonance (NQR
   Prof. Tomaž Apih
   LEK d.d.
3. Measurement of optical transmissivity
   Prof. Igor Muševič
   RLS Merilna tehnika d.o.o.
4. Microspectroscopy-based optimization of the effects of laser pulses on the retina
   Prof. Janez Štrancar
   OPTOTEK d.o.o.

VISITORS FROM ABROAD

1. dr. Mutsuo Igarashi, Gunma National College of Technology, Maebashi, Japan, 16. 1. 2016 – 24. 1. 2016, 21. 8. 2016 – 2. 9. 2016
2. mag. Kushtrim Podrimqaku, University of Pristina, Pristina, Kosovo, 21. 1. 2016 – 27. 1. 2016
3. mag. Valon Veliu, University of Pristina, Pristina, Kosovo, 21. 1. 2016 – 27. 1. 2016
4. dr. Uliana Ognysta, Institute of Physics, National Academy of Science of Ukraine, Kiev, Ukraine, 31. 1. 2016 – 10. 3. 2016
5. dr. Vaida Lunkuviene, Faculty of Natural Sciences of Vilnius University, Vilnius, Litva, 1. 2. 2016 – 31. 3. 2016
6. dr. Alicja Filipek, Institute of Physics, Polish Academy of Sciences, Warsaw, Poland, 20. 2. 2016 – 5. 3. 2016
7. dr. Alan Soper, ISIS Facility STFC Rutherford Appleton Laboratory, Harwell, Oxford, Great Britain, 1. 3. 2016 – 5. 3. 2016
8. dr. Randall Kamien, University of Pennsylvania, Philadelphia, USA, 6. 3. 2016 – 9. 3. 2016
9. dr. Tina Pavlin, University of Bergen, Bergen, Norway, 4. 4. 2016 – 10. 4. 2016
10. dr. Surajit Dhara, School of Physics University of Hyderabad, Talangana, India, 7. 5. 2016 – 11. 6. 2016
11. doc. dr. Michael Grbic, Faculty of Science, University of Zagreb, Zagreb, Croatia, 16. 5. 2016
12. dr. Katarina Butalović, Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia, 1. 6. 2016 – 3. 6. 2016
13. dr. Milijana Savić, Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia, 1. 6. 2016 – 3. 6. 2016
14. dr. Manel Rodriguez Ripoll, AC2T research GmbH, Wiener Neustadt, Austria, 7. 6. 2016
15. dr. Bouchra Asbani, Universite de Picardie Jules Verne, Laboratoire de la Mateiere Condense (LPMC), Amiens, France, 11. 7. 2016 – 8. 8. 2016
16. dr. Mutsuo Igarashi, Gunma National College of Technology, Maebashi, Japan, 21. 8. 2016 – 2. 9. 2016, 27. 10. 2016 – 8. 11. 2016
17. prof. dr. Christian Eggeling, Weatherall Institute of Molecular Medicine, Radcliffe Department of Medicine – Investinative Medicine, University of Oxford, Great Britain, 24. 8. 2016 – 27. 8. 2016
18. dr. Carla Bittencourt, University of Mons, Mons, Belgium, 7. 9. 2016 – 31. 10. 2016
19. dr. Jun-ichi Fukuda, Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, 11. 9. 2016 – 6. 10. 2016
20. dr. Sergey Lushnikov, AF Ioffe Physicotechnical Institute, RAS, St. Petersburg, Russia, 3. 10. 2016 – 31. 10. 2016
21. dr. Magdalena Wencka, Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland, 19. 10. 2016 – 28. 10. 2016
22. prof. dr. Francesco Sagues, University of Barcelona, Barcelona, Spain, 26. 10. 2016 – 28. 10. 2016
23. prof. Eung Je Woo, Kyung Hee University, Seoul, Korea, 13. 11. 2016 – 19. 11. 2016
24. dr. Ana Varlec, APE Research, Area Science Park, Basovizza, Italy, 20. 11. 2016 – 2. 12. 2016

STAFF

Researchers

1. Prof. Tomaž Apih
2. Prof. Denis Arčon*
3. Asst. Prof. Zoran Arsov
4. Prof. Vid Bobnar
5. Prof. Janez Dolinšek*
6. Dr. Cene Filipič
7. Dr. Anton Gradišek
8. Dr. Alan Gregorovič
9. Abdelrahim Ibrahim Hassanien, B. Sc.
10. Dr. Peter Jeglič
11. Dr. Martin Klanjšek
12. Dr. Tilen Koklič
13. *Dr. Georgios Kordogiannis, left 01.10.16*
14. Prof. Samo Kralj*
15. Prof. Zdravko Kutnjak
16. Dr. Mojca Urška Mikac
17. Asst. Prof. Griša Močnik*
18. Asst. Prof. Aleš Mohorič*
19. **Prof. Igor Muševič*, Head**
20. Dr. Andriy Nych
21. Dr. Matej Pregelj
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23. Prof. Maja Remškar
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25. Asst. Prof. Miha Škarabot
26. Prof. Janez Štrancar
27. Asst. Prof. Uroš Tkalec*
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29. Dr. Herman Josef Petrus Van Midden
30. Asst. Prof. Andrej Vilfan
31. Prof. Boštjan Zalar
32. Prof. Aleksander Zidanšek
33. Asst. Prof. Andrej Zorko
34. Prof. Slobodan Žumer

Postdoctoral associates

35. Dr. Franci Bajd
36. Dr. Jerneja Milavec
37. Dr. Giorgio Mirri*
38. *Dr. Maryam Nikkhou, left 01.07.16*
39. Dr. Stane Pajk*
40. Dr. Rok Podlipec
41. Dr. Brigita Rožič
42. Dr. Anna Ryzhkova
43. Dr. Iztok Urbančič
44. Dr. Jernej Vidmar*
45. Dr. Stanislav Vrtnik
46. Dr. Erik Zupanič

Postgraduates

47. Matjaž Gomilšek, B. Sc.
48. Urška Gradišar Centa, B. Sc.
49. Saša Harkai, B. Sc.
50. Dr. Matjaž Humar
51. Uroš Jagodič, B. Sc.
52. Nejc Janša, B. Sc.
53. Tilen Knaflič, B. Sc.
54. Primož Koželj, B. Sc.
55. Mitja Krnel, B. Sc.
56. Marta Lavrič, B. Sc.
57. Janez Lužnik, B. Sc.
58. Bojan Marin*, M. Sc.
59. Aleksander Matavž, B. Sc.
60. Tadej Mežnaršič, B. Sc.
61. Maruša Mur, B. Sc.
62. Luka Pirker, B. Sc.
63. Gregor Posnjak, B. Sc.
64. Andraž Rešetič, B. Sc.
65. Muhammad Saqib, B. Sc.
66. Melita Sluban, B. Sc.
67. *Jan Šömen, B. Sc., left 15.02.16*
68. Maja Trček, B. Sc.
69. Marion Antonia Van Midden, B. Sc.
70. *Dr. Ana Varlec, left 01.03.16*

Technical officers

71. Dr. Luka Drinovec*
72. Dr. Maja Garvas
73. Dr. Andreja Jelen
74. Dr. Andraž Kocjan
75. Boštjan Kokot, B. Sc.
76. Ivan Kvasić, B. Sc.
77. Jože Luzar, B. Sc.
78. Hana Majaron, B. Sc.
79. Jaka Močivnik, B. Sc.

Technical and administrative staff

80. Dražen Ivanov
81. Janez Jelenc, B. Sc.
82. Maša Kavčič
83. Davorin Kotnik
84. Sabina Krhlikar, B. Sc.
85. Silvano Mendizza
86. Janja Milivojević
87. *Iztok Ograjenšek, retired 15.01.16*
88. Ana Sepe, B. Sc.
89. Marjetka Tršinar

Note:
* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLE

1. Andreja Abina, Uroš Puc, Anton Jeglič, Aleksander Zidanšek, "Structural characterization of thermal building insulation materials using terahertz spectroscopy and terahertz pulsed imaging", *NDT E int.*, vol. 77, pp. 11-18, 2016.
2. Anže Abram, Andreja Eršte, Goran Dražić, Vid Bobnar, "Structural and dielectric properties of hydrothermally prepared boehmite coatings on an aluminium foil", *J. mater. sci., Mater. electron.*, vol. 27, no. 10, pp. 10221-10225, 2016.
3. Luis E. Aguirre, Alexandre de Oliveira, David Seč, Simon Čopar, Pedro L. Almeida, Miha Ravnik, Maria H. Godinho, Slobodan Žumer, "Sensing surface morphology of biofibers by decorating spider silk and cellulosic filaments with nematic microdroplets", *Proc. Natl. Acad. Sci. U. S. A.*, vol. 113, no. 5, pp. 1174-1179, 2016.
4. M. Yusuf Ali, Andrej Vilfan, Kathleen M. Trybus, David M. Warshaw, "Cargo transport by two coupled myosin Va motors on actin filaments and bundles", *Biophys. j.*, vol. 111, no. 10, pp. 2228-2240, 2016.
5. Sofija Andjelić, Kazimir Drašlar, Anastazija Hvala, Nina Lokar, Janez Štrancar, Marko Hawlina, "Anterior lens epithelial cells attachment to the basal lamina", *Acta ophthalmol. (2008)*, vol. 94, iss. 3, pp. e183-e188, May 2016.
6. Fatima Ezahra Annanouch *et al.* (12 avtorjev), "Aerosol-assisted CVD-grown PdO nanoparticle-decorated tungsten oxide nanoneedles extremely sensitive and selective to hydrogen", *ACS appl. mater. interfaces*, vol. 8, iss. 16, pp. 10413-10421, 2016.
7. Fatima Ezahra Annanouch, Sergio Roso, Zouhair Haddi, Stella Vallejos, Polona Umek, Carla Bittencourt, Christopher Blackman, T. Vilic, Eduard Llobet, "*p*-Type PdO nanoparticles supported on *n*-type WO_3 nanoneedles for hydrogen sensing", *Thin solid films*, vol. 618, part B, pp. 238-245, 2016.
8. Tomaž Apih, Alan Gregorovič, Veselko Žagar, Janez Seliger, "Nuclear quadrupole resonance study of proton and deuteron migration in short strong hydrogen bonds formed in molecular complex 3, 5-dinitrobenzoic acid-nicotinic acid and in deuterated 3, 5-pyridinedicarboxylic A", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, issue 18, pp. 9992-10000, 2016.
9. Tomaž Apih, Alan Gregorovič, Veselko Žagar, Janez Seliger, "Strong hydrogen bonds formed in molecular complex 3, 5-dinitrobenzoic acid - nicotinic acid and in deuterated 3, 5-pyridinedicarboxylic acid", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, iss. 18, pp. 9992-10000, 2016.
10. Tomaž Apih, Veselko Žagar, Janez Seliger, "NMR and NQR study of above-room-temperature molecular ferroelectrics diisopropylammonium chloride and diisopropylammonium perchlorate", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, no. 11, pp. 6180-6189, 2016.
11. Jure Aplinc, Stephen Morris, Miha Ravnik, "Porous nematic microfluidics for generation of umbilic defects and umbilic defect lattices", *Physical review fluids*, vol. 1, iss. 2, pp. 023303-1-023303-12, 2016.
12. Jure Aplinc, Mitja Štimulak, Simon Čopar, Miha Ravnik, "Nematic liquid crystal gyroids as photonic crystals", *Liq. cryst.*, vol. 43, iss. 13/15, pp. 2320-2331, 2016.
13. Denis Arčon, L. M. Schoop, R. J. Cava, Claudia Felser, "Evolution of magnetic fluctuations through the Fe-induced paramagnetic to ferromagnetic transition in Cr_2", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 10, pp. 104413-1-104413-8, 2016.
14. B. Asbani, Y. Gagou, J. -L. Dellis, A. Lahmar, M. Amjoud, D. Mezzane, Zdravko Kutnjak, M. El Marssi, "Structural, dielectric and electrocaloric properties in lead-free Zr-doped $Ba_{0.8}Ca_{0.2}TiO_3$ solid solution", *Solid state commun.*, vol. 237/238, pp. 49-54, 2016.
15. Franci Bajd, Anton Gradišek, Tomaž Apih, Igor Serša, "Dry-cured ham tissue characterization by fast field cycling NMR relaxometry and quantitative magnetization transfer", *Magn. reson. chem.*, vol. 54, no. 10, pp. 827-834, 2016.
16. Franci Bajd, Carlos Mattea, Siegfried Stapf, Igor Serša, "Diffusion tensor MR microscopy of tissues with low diffusional anisotropy", *Radiol. oncol. (Ljubl.)*, vol. 50, no. 2, pp. 175-187, IV, 2016.
17. Franci Bajd, Martin Škrlep, Marjeta Čandek-Potokar, Jernej Vidmar, Igor Serša, "Application of quantitative magnetization transfer magnetic resonance imaging for characterization of dry-cured hams", *Meat sci.*, vol. 122, pp. 109-118, 2016.
18. Franci Bajd, Martin Škrlep, Marjeta Čandek-Potokar, Jernej Vidmar, Igor Serša, "Use of multiparametric magnetic resonance microscopy for discrimination among different processing protocols and anatomical positions of Slovenian dry-cured hams", *Food chem.*, vol. 197, part B, pp. 1093-1101, 2016.
19. Hyun-Woo Bang, Woosuk Yoo, Joungha Choi, Chun-Yeol You, Jung-Il Hong, Janez Dolinšek, Myung-Hwa Jung, "Perpendicular magnetic anisotropy properties of tetragonal Mn[sub]3Ga films under various deposition conditions", *Current applied physics*, vol. 16, no. 1, pp. 63-67, 2016.
20. Andraž Bradeško, Đani Juričić, Marina Santo-Zarnik, Barbara Malič, Zdravko Kutnjak, Tadej Rojac, "Coupling of the electrocaloric and electromechanical effects for solid-state refrigeration", *Appl. phys. lett.*, vol. 109, no. 14, pp. 143508-1-143508-7, 2016.
21. Laura Cattaneo, Žiga Kos, Matteo Savoini, Paul H. J. Kouwer, Alan Rowan, Miha Ravnik, Igor Muševič, Theo Rasing, "Electric field generation of Skyrmion-like structures in a nematic liquid crystal", *Soft matter*, vol. 12, iss. 3, pp. 853-858, 2016.
22. Sangyeon Cho, Matjaž Humar, Nicola Martino, Seok Hyun Andy Yun, "Laser particle stimulated emission microscopy", *Phys. rev. lett.*, vol. 117, no. 19, pp. 193902-1-193902-5, 2016.
23. George Cordoyiannis, Sašo Gyergyek, Brigita Rožič, Samo Kralj, Zdravko Kutnjak, George Nounesis, "The effect of magnetic nanoparticles upon the smectic-A to smectic-C* phase transition", *Liq. cryst.*, vol. 43, no. 3, pp. 314-319, 2016.
24. Božidara Cvetković, Hristijan Gjoreski, Vito Janko, Boštjan Kaluža, Anton Gradišek, Mitja Luštrek, Igor Jurinčič, Anton Gosar, Simon Kerma, Gregor Balažič, "E-turist: an intelligent personalised trip guide", *Informatica (Ljubl.)*, vol. 40, no. 4, pp. 447-455, 2016.
25. Miha Čančula, Miha Ravnik, Igor Muševič, Slobodan Žumer, "Liquid microlenses and waveguides from bulk nematic birefringent profiles", *Opt. express*, vol. 24, no. 19, pp. 22177-22188, 2016.
26. Simon Čopar, David Seč, Luis E. Aguirre, Pedro L. Almeida, Mallory Dazza, Miha Ravnik, Maria H. Godinho, Pawel Pieranski, Slobodan Žumer, "Sensing and tuning microfiber chirality with nematic chirogyral effect", *Phys. rev., E*, vol. 93, iss. 3, pp. 032703-1-032703-7, 2016.
27. Martin Dobeic, Stanka Grebenc, Zlatka Bajc, Polona Umek, Štefan Pintarič, Irena Uranjek, Ksenija Šinigoj-Gačnik, "Antibacterial properties of non-thermal, atmospheric, Openair(R), plasma jet in surface decontamination of eggs in shell", *Slov. vet. res. (Eng. print ed.)*, vol. 53, no. 1, pp. 29-41, 2016.
28. Valentina Domenici, Anton Gradišek, Tomaž Apih, Věra Hamplová, Vladimíra Novotná, Pedro José Sebastião, " ^{1}H NMR relaxometry in the TGBA* and TGBC* phases", *Ferroelectrics*, vol. 495, iss. 1, pp. 17-27, 2016.
29. Luka Drinovec, Asta Gregorič, Peter Zotter, Robert Wolf, Emily Anne Bruns, Andre S. H. Prevot, Jean-Eudes Petit, Olivier Favez, Jean Sciare, Ian J. Arnold, Rajan K. Chakrabarty, Hans Moosmüller, Filep Ágnes, Griša Močnik, "The filter loading effect by ambient aerosols in filter absorption photometers depends on the mixing state of the sampled particles", *Atmos. meas. tech., Pap. open discuss.*, pp. 1-30, Oct. 2016.
30. J. Enroth *et al.* (11 authors), "Chemical and physical characterization of traffic particles in four different highway environments in the Helsinki metropolitan area", *Atmos. chem. phys.*, vol. 16, iss. 9, pp. 5497-5512, 2016.
31. Andreja Eršte, Lovro Fulanović, Lucija Čoga, M. Lin, Y. Thakur, Qiming M. Zhang, Vid Bobnar, "Stable dielectric response of low-loss aromatic polythiourea thin films on Pt/SiO_2 substrate", *Journal of advanced dielectrics*, vol. 6, no. 1, pp. 1650003-1-1650003-4, 2016.
32. Luca Ferrero *et al.* (20 authors), "Vertical profiles of aerosol and black carbon in the Arctic: a seasonal phenomenology along 2 years (2011-2012) of field campaigns", *Atmos. chem. phys.*, vol. 16, no. 219, pp. 12601-12629, 2016.
33. Cene Filipič, Zdravko Kutnjak, Raša Pirc, Giovanna Canu, Jan Petzelt, "$BaZr_{0.5}Ti_{0.5}O_3$: lead-free relaxor ferroelectric or dipolar glass", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 22, pp. 224105-1-224105-8, 2016.
34. Cene Filipič, Ivana Levstik, Adrijan Levstik, Dušan Hadži, "Polaron conductivity mechanism in potassium acid phthalate crystal: AC-conductivity investigation", *Jpn. j. appl. phys.*, vol. 55, no. 8, pp. 081203-1-081203-5, 2016.

35. Matjaž Gomilšek, Martin Klanjšek, Matej Pregelj, F. C. Coomer, H. Luetkens, Oksana Zaharko, T. Fennell, Y. Li, Qingming Zhang, Andrej Zorko, "Instabilities of spin-liquid states in a quantum kagome antiferromagnet", *Physical review. B*, vol. 93, no. 6, pp. 060405-1-060405-6, 2016.
36. Matjaž Gomilšek, Martin Klanjšek, Matej Pregelj, H. Luetkens, Y. Li, Qiming M. Zhang, Andrej Zorko, "μSR insight into the impurity problem in quantum kagome antiferromagnets", *Physical review. B*, vol. 94, no. 2, pp. 024438-1-024438-6, 2016.
37. Anton Gradišek, Valentina Domenici, Tomaž Apih, Vladimíra Novotná, Pedro José Sebastião, "^{1}H NMR relaxometric study of molecular dynamics in a "de vries" liquid crystal", *J. phys. chem., B Condens. mater. surf. interfaces biophys.*, vol. 120, iss. 20, pp. 4706-4714, 2016.
38. Anton Gradišek, Lars Haahr Jepsen, Torben R. Jensen, Mark S. Conradi, "Nuclear magnetic resonance study of molecular dynamics in ammine metal borohydride $Sr(BH_4)_2(NH_3)_2$", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, no. 43, pp. 24646-24654, 2016.
39. Alan Gregorovič, Tomaž Apih, Janez Seliger, "^{1}H-^{14}N cross-relaxation spectrum analysis in sildenafil and sildenafil citrate", *Solid state nucl. magn. reson.*, vol. 78, pp. 16-23, 2016.
40. Matjaž Humar, "Liquid-crystal-droplet optical microcavities: [invited article]", *Liq. cryst.*, vol. 43, no. 13/15, pp. 1937-1950, 2016.
41. Matjaž Humar, Fumito Araoka, Hideo Takezoe, Igor Muševič, "Lasing properties of polymerized chiral nematic Bragg onion microlasers", *Opt. express*, vol. 24, no. 17, pp. 19237-1-19237-8, 2016.
42. Mutsuo Igarashi, Peter Jeglič, Andraž Krajnc, Rok Žitko, Takehito Nakano, Yasuo Nozue, Denis Arčon, "Metal-to-insulator crossover in alkali doped zeolite", *Scientific reports*, vol. 6, pp. 18682-1-18682-8, Jan. 2016.
43. Simon Jazbec, Shiro Kashimoto, Primož Koželj, Stanislav Vrtnik, Marko Jagodič, Zvonko Jagličić, Janez Dolinšek, "Schottky effect in the i-Zn-Ag-Sc-Tm icosahedral quasicrystal and its 1/1 Zn-Sc-Tm approximant", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 5, pp. 054208-1-054208-14, 2016.
44. M. Jeong *et al.* (11 authors), "Dichotomy between attractive and repulsive tomonaga-luttinger liquids in spin ladders", *Phys. rev. lett.*, vol. 117, no. 10, pp. 106402-1-106402-6, 2016.
45. H. Kaddoussi, A. Lahmar, Y. Gagou, B. Asbani, J. -L. Dellis, George Cordoyiannis, B. Allouche, H. Khemakhem, Zdravko Kutnjak, M. El Marssi, "Indirect and direct electrocaloric measurements of $(Ba_{1-x}Ca_x)(Zr_{0.1}Ti_{0.9})O_3$ ceramics (x = 0.05, x = 0.20)", *J. alloys compd.*, vol. 667, pp. 198-203, 2016.
46. Maja Kaisersberger Vincek, Janez Štrancar, Vanja Kokol, "Antibacterial activity of chemically versus enzymatic functionalized wool with ξ-poly-L-lysine", *Tex. res. j.*, pp. 1-16, Published online before print July 5, 2016.
47. H. Khassaf, J. V. Mantese, N. Bassiri-Gharb, Zdravko Kutnjak, S. P. Alpay, "Perovskite ferroelectrics and relaxor-ferroelectric solid solutions with large intrinsic electrocaloric response over broad temperature ranges", *J. mater. chem. C*, 22 pp..
48. Moonseok Kim, Jeesoo An, Ki Su Kim, Myunghwan Choi, Matjaž Humar, Sheldon J. J. Kwok, Tianhong Dai, Seok Hyun Andy Yun, "Optical lens-microneedle array for percutaneous light delivery", *Biomed. opt. express*, vol. 7, no. 10, pp. 4220-4227, 2016.
49. Gregor Koder, Igor Serša, "Magnetic resonance Imaging of mechanical deformations", *Magn. reson. imag.*, vol. 34, iss. 2, pp. 137-143, 2016.
50. Žiga Kos, Miha Ravnik, "Relevance of saddle-splay elasticity in complex nematic geometries", *Soft matter*, vol. 12, iss. 4, pp. 1313-1323, 2016.
51. Peter Krajnik, Amir Rashid, Franci Pušavec, Maja Remškar, Akinori Yui, Nader Nikkam, Muhammet Toprak, "Transitioning to sustainable production. Pt. 3, Developments and possibilities for integration of nanotechnology into material processing technologies", *J. clean. prod.*, vol. 112, pt. 1, pp. 1156-1164, Jan. 2016.
52. Matej Kranjc, Franci Bajd, Igor Serša, Mark de Boevere, Damijan Miklavčič, "Electric field distribution in relation to cell membrane electroporation in potato tuber tissue studied by magnetic resonance techniques", *Innovative food science & emerging technologies*, vol., no., pp. 1-31, 2016.
53. Mitja Krnel, Stanislav Vrtnik, Primož Koželj, Andraž Kocjan, Zvonko Jagličić, Pascal Boulet, Marie-Cecile De Weerd, Jean-Marie Dubois, Janez Dolinšek, "Random-anisotropy ferromagnetic state in the $Cu_5Gd_{0.54}Ca_{0.42}$ intermetallic compound", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 9, pp. 094202-1-094202-14, 2016.
54. Oh In Kwon, Saurav Z. K. Sajib, Igor Serša, Tong In Oh, Woo Chul Jeong, Hyung Joong Kim, Eung Je Woo, "Current density imaging during transcranial Direct Current Stimulation (tDCS) using DT-MRI and MREIT: algorithm development and numerical simulations", *IEEE trans. biomed. eng.*, vol. 63, iss. 1, pp. 168-175, 2016.
55. Marlon Lawrence, Anže Testen, Tilen Koklič, Oliver Smithies, "A simple method for the size controlled synthesis of stable oligomeric clusters of gold nanoparticles under ambient conditions", *J. vis. exp.*, no. 108, pp. e53388 -1-e53388 -8, feb. 2016.
56. Florian Johannes Maier, Thomas Lachner, Andrej Vilfan, T. Onur Tasci, Keith B. Neeves, David W. M. Marr, Thomas M. Fischer, "Non reciprocal skewed rolling of a colloidal wheel due to induced chirality", *Soft matter*, vol. 12, no. 46, pp. 9314–9320, 2016.
57. Katja Makovšek, Irena Ramšak, Barbara Malič, Vid Bobnar, Danjela Kuščer, "Processing of steatite ceramic with a low dielectric constant and low dielectric losses", *Inf. MIDEM*, vol. 46, no. 2, pp. 100-105, 2016.
58. Gennady I. Maksimochkin, Dina V. Shmeliova, Sergey V. Pasechnik, Alexander Dubtsov, O. A. Semina, Samo Kralj, "Orientational fluctuations and phase transitions in 8CB confined by cylindrical pores of the PET film", *Phase transit.*, vol. 89, no. 7/8, pp. 846-855, 2016.
59. Aleksander Matavž, Raluca-Camelia Frunză, Aljaž Drnovšek, Vid Bobnar, Barbara Malič, "Inkjet printing of uniform dielectric oxide structures from sol-gel inks by adjusting the solvent composition", *J. mater. chem. C*, vol. 4, no. 24, pp. 5634-5641, 2016.
60. Luka Mesarec, Wojciech Góźdź, Aleš Iglič, Samo Kralj, "Effective topological charge cancelation mechanism", *Scientific reports*, vol. 6, art. no. 27117, pp. 1-9, 2016.
61. Luka Mesarec, Wojciech Góźdź, Veronika Kralj-Iglič, Samo Kralj, Aleš Iglič, "Closed membrane shapes with attached BAR domains subject to external force of actin filaments", *Colloids surf., B Biointerfaces*, vol. 141, pp. 132-140, May 2016.
62. Urška Mikac, Ana Sepe, Saša Baumgartner, Julijana Kristl, "The influence of high drug loading in xanthan tablets and media with different physiological pH and ionic strength on swelling and release", *Mol. pharm.*, vol. 13, iss. 3, pp. 1147-1157, 2016.
63. Jerneja Milavec, Valentina Domenici, Blaž Zupančič, Andraž Rešetič, Alexej Bubnov, Boštjan Zalar, "Deuteron NMR resolved mesogen vs. crosslinker molecular order and reorientational exchange in liquid single crystal elastomers", *PCCP. Phys. chem. chem. phys.*, vol. 18, no. 5, pp. 4071-4077, 2016.
64. Giorgio Mirri, Daniël C. Schoenmakers, Paul H. J. Kouwer, Peter Veranič, Igor Muševič, Bogdan Štefane, "Synthesis of functional fluorescent BODIPY-based dyes through electrophilic aromatic substitution: straightforward approach towards customized fluorescent probes", *ChemistryOpen (Weinh.)*, vol. 5, iss. 5, pp. 450-454, 2016.
65. Tomaž Mohorič, Gašper Kokot, Natan Osterman, Alexey Snezhko, Andrej Vilfan, Dušan Babič, Jure Dobnikar, "Dynamic assembly of magnetic colloidal vortices", *Langmuir*, vol. 32, no. 20, pp. 5094-5101, 2016.
66. Urban Mur, Simon Čopar, Gregor Posnjak, Igor Muševič, Miha Ravnik, Slobodan Žumer, "Ray optics simulations of polarised microscopy textures in chiral nematic droplets", *Liq. cryst.*, 9 pp., 2016.
67. Maryam Nikkhou, Miha Škarabot, Simon Čopar, Igor Muševič, "Dynamics of topological monopoles annihilation on a fibre in a thick and thin nematic layer", *The European physical journal. E, Soft matter*, vol. 39, pp. 100-1-100-7, 2016.
68. Maryam Nikkhou, Miha Škarabot, Igor Muševič, "Annihilation dynamics of topological monopoles on a fiber in nematic liquid crystals", *Phys. rev., E*, vol. 93, no. 6, pp. 062703-1-062703-9, 2016.
69. Bert Nitzsche, E. Dudek, L. Hajdo, Andrzej A. Kasprzak, Andrej Vilfan, Stefan Diez, "Working stroke of the kinesin-14, ncd, comprises two substeps of different direction", *Proc. Natl. Acad. Sci. U. S. A.*, vol. 113, no. 43, pp. E6582-E6589, 2016.
70. Sedat Nizamoglu *et al.* (11 authors), "Bioabsorbable polymer optical waveguides for deep-tissue photomedicine", *Nature communications*, vol. 7, pp. 10374-1-10374 -7, 2016.
71. Stane Pajk, Matej Živec, Roman Šink, Izidor Sosič, Margarete Neu, Chun-wa Chung, María Martínez-Hoyos, Esther Pérez-Herrán, Daniel Álvarez-Gómez, Emilio Álvarez-Ruíz, Alfonso Mendoza-Losana, Julia Castro-Pichel, David Barros, Lluís Ballell-Pages, Robert J. Young, Maire A. Convery, Lourdes Encinas, Stanislav Gobec, "New direct inhibitors of InhA with antimycobacterial activity based on a tetrahydropyran scaffold", *Eur. j. med. chem.*, vol. 112, pp. 252-257, April 2016.
72. Srečko Paskvale, Maja Remškar, Miha Čekada, "Tribological performance of TiN, TiAlN and CrN hard coatings lubricated by MoS_2 nanotubes in olyalphaolefin oil", *Wear*, vol. 352-353, pp. 72-78, 2016.
73. Tanja Pečnik, Andreja Eršte, Aleksander Matavž, Vid Bobnar, Maksim Ivanov, Juras Banys, Feng Xiang, Hong Wang, Barbara Malič, Sebastjan Glinšek, "Dielectric dynamics of the polycrystalline $Ba_{0.5}Sr_{0.5}TiO_3$ thin films", *Europhys. lett.*, vol. 114, no. 4, pp. 47009-1-47009-5, 2016.

74. Gregor Posnjak, Simon Čopar, Igor Muševič, "Points, skyrmions and torons in chiral nematic droplets", *Scientific reports*, vol. 6, art. no. 26361, 10 pp., 2016.
75. Yasir-Beeran Potta Thara, Vid Bobnar, Selestina Gorgieva, Yves Grohens, Sabu Thomas, Matjaž Finšgar, Vanja Kokol, "Mechanically strong, flexible and thermally stable graphene oxide/nanocellulosic films with enhanced dielectric properties", *RSC advances*, vol. 6, iss. 54, pp. 49138-49149, 2016.
76. Matej Pregelj, Oksana Zaharko, Mirta Herak, Matjaž Gomilšek, Andrej Zorko, L. C. Chapon, F. Bourdarot, Helmuth Berger, Denis Arčon, "Exchange anisotropy as mechanism for spin-stripe formation in frustrated spin chains", *Phys. rev., B, Condens. matter mater. phys.*, vol. 94, no. 8, pp. 081114-1- 081114-5, 2016.
77. Eva Pušavec Kirar, Uroš Grošelj, Giorgio Mirri, Franc Požgan, Gregor Strle, Bogdan Štefane, Vasko Jovanovski, Jurij Svete, ""Click" chemistry: application of copper metal in Cu-catalyzed azomethine imine-alkyne cycloadditions", *J. org. chem.*, vol. 81, iss. 14, pp. 5988-5997, Jul. 2016.
78. Maja Remškar, Janez Jelenc, "Influence of surface defects on superlattice patterns in graphene on graphite", *Surf. sci.*, vol. 651, pp. 51-56.
79. Andraž Rešetič, Jerneja Milavec, Blaž Zupančič, Valentina Domenici, Boštjan Zalar, "Polymer-dispersed liquid crystal elastomers", *Nature communications*, vol. 7, pp. 13140-1-13140-10.
80. Sergio Roso, Carla Bittencourt, Polona Umek, Oriol González, Frank Güell, Atsushi Urakawa, Eduard Llobet, "Synthesis of single crystalline In_2O_3 octahedra for the selective detection of NO_2 and H_2 at trace levels", *J. mater. chem. C*, vol. 4, iss. 40, pp. 9418-9427, 2016.
81. Gerhard Schauer, Anne Kasper Giebl, Griša Močnik, "Increased PM concentrations during a combined wildfire and saharan dust event observed at high-altitude Sonnblick Observatory, Austria", *Aerosol air qual. res.*, vol. 16, no. 3, pp. 542-554, 2016.
82. Ivan Sedmak, Iztok Urbančič, Rok Podlipec, Janez Štrancar, Michel Mortier, Iztok Golobič, "Submicron thermal imaging of a nucleate boiling process using fluorescence microscopy", *Energy (Oxford)*, vol. 109, pp. 436-445, Aug. 2016.
83. Janez Seliger, Veselko Žagar, Tomaž Apih, Alan Gregorovič, Magdalena Latosińska, Grzegorz A. Olejniczak, Jolanta N. Latosińska, "Polymorphism and disorder in natural active ingredients, Low and high-temperature phases of anhydrous caffeine: spectroscopic ($^1H-^{14}N$ NMR-NQR/ ^{14}N NQR) and solid-state computational modelling (DFT/QTAIM/RDS) study", *Eur. j. pharm. sci.*, vol. 85, pp. 18-30.
84. Igor Serša, Franci Bajd, Aleš Mohorič, "Effects of off-resonance spins on the performance of the modulated gradient spin echo sequence", *J. magn. reson. (San Diego, Calif., 1997)*, vol. 270, pp. 77-86, 2016.
85. Maja Trček, George Cordoyiannis, Zdravko Kutnjak, George Nounesis, Ioannis Lelidis, "Twist-grain-boundary-A* phase stabilisation in confined geometry by the interfaces", *Liq. cryst.*, vol. 43, iss. 10, pp. 1437-1447, 2016.
86. Hana Uršič, Vid Bobnar, Barbara Malič, Cene Filipič, Marko Vrabelj, Silvo Drnovšek, Jo. Younghun, Magdalena Wencka, Zdravko Kutnjak, "A multicaloric material as a link between electrocaloric and magnetocaloric refrigeration", *Scientific reports*, vol. 6, pp. 26629-1-26629-5, 2016.
87. Hana Uršič, Lovro Fulanović, Marko Vrabelj, Zdravko Kutnjak, Brigita Rožič, Silvo Drnovšek, Barbara Malič, "Electrocaloric properties of $0.7Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.3PbTiO_3$ ceramics with different grain sizes", *Advances in applied ceramics*, vol. 115, no. 2, pp. 77-80, 2016.
88. Ana Varlec, Denis Arčon, Srečo D. Škapin, Maja Remškar, "Oxygen deficiency in MoO[sub]3 polycrystalline nanowires and nanotubes", *Mater. chem. phys.*, vol. 170, pp. 154-161, 2016.
89. Ana Varlec, Andreja Eršte, Vid Bobnar, Maja Remškar, "Influence of preparation conditions on structural and dielectric properties of PVDF-MoS_2 nanotubes composite films", *J. polym. res.*, vol. 23, no. 2, pp. 34-1-34-7, 2016.
90. Jernej Vidmar, Mirko Omejc, Rok Dežman, Peter Popović, "Thrombosis of pancreatic arteriovenous malformation induced by diagnostic angiography: case report", *BMC Gastroenterol*, vol. 16, pp. 68-1-68-7, 2016.
91. Marko Vrabelj, Hana Uršič, Zdravko Kutnjak, Brigita Rožič, Silvo Drnovšek, Andreja Benčan, Vid Bobnar, Lovro Fulanović, Barbara Malič, "Large electrocaloric effect in grain-size-engineered $0.9Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.1PbTiO_3$", *J. Eur. Ceram. Soc.*, vol. 36, iss. 1, pp. 75-80, 2016.
92. Ali K. Yetisen, Haider Butt, Tatsiana Mikulchyk, Rajib Ahmed, Yunuen Montelongo, Matjaž Humar, Nan Jiang, Suzanne Martin, Izabela Naydenova, Seok Hyun Andy Yun, "Color-selective 2.5D holograms on large-area flexible substrates for sensing and multilevel security", *Adv. opt. mater.*, vol. 4, no. 10, pp. 1589-1600, 2016.
93. Ali K. Yetisen *et al.* (12 authors), "Photonic hydrogel sensors", *Biotechnol. adv.*, vol. 34, no. 3, pp. 250-271, 2016.
94. Andrej Zorko, Matjaž Gomilšek, Matej Pregelj, M. Ozerov, S. A. Zvyagin, Andrzej Ozarowski, V. Tsurkan, A. Loidl, Oksana Zaharko, "Electron spin resonance insight into broadband absorption of the $Cu_3Bi(SeO_3)_2O_2Br$ metamagnet", *AIP advances*, vol. 6, iss. 5, pp. 056210-1- 056210-7, 2016.
95. P. Zotter, Hanna Herich, Martin Gysel, Imad El-Haddad, Yanling Zhang, Griša Močnik, Christoph Hüglin, Urs Baltensperger, Sönke Szidat, Andre S. H. Prevot, "Evaluation of the absorption Ångström exponents for traffic and wood burning in the Aethalometer based source apportionment using radiocarbon measurements of ambient aerosol", *Atmos. chem. phys.*, 29 pp., [in] press 2016.
96. Kristina Žagar, Andraž Kocjan, Spomenka Kobe, "Magnetic and microstructural investigation of high-coercivity net-shape Nd-Fe-B-type magnets produced from spark-plasma-sintered melt-spun ribbons blended with DyF_3", *J. magn. magn. mater.*, vol. 403, pp. 90-96, 2016.

Review Article

1. Matjaž Humar, Sheldon J. J. Kwok, Myunghwan Choi, Ali K. Yetisen, Sangyeon Cho, Seok Hyun Andy Yun, "Toward biomaterial-based implantable photonic devices", *Nanophotonics (Berl.)*, vol. 5, no. 1, pp. 60-80, 2016.
2. Urška Mikac, Ana Sepe, Julijana Kristl, "Pomen magnetnoresonančnih metod pri raziskavah ogrodnih tablet s podaljšanim sproščanjem", *Farm. vestn. (Tisk. izd.)*, vol. 67, no. 4, pp. 249-256, 2016.
3. Igor Muševič, "Liquid-crystal micro-photonics", *Liq. cryst. rev.*, vol. 4, no. 1, pp. 1-34, 2016.

Published Conference Contribution (invited lecture)

1. Urban Mur, Simon Čopar, Miha Ravnik, Miha Čančula, Slobodan Žumer, "Unveiling details of defect structures in chiral and achiral nematic droplets by improving simulations of optical images", In: *Liquid crystals XX, San Diego, California, United States, August 28-30, 2016*, (Proceedings of SPIE, the International Society for Optical Engineering, vol. 9940), 9 pp..
2. Miha Ravnik, Mitja Štimulak, Urban Mur, Miha Čančula, Simon Čopar, Slobodan Žumer, "Photonic crystals, light manipulation, and imaging in complex nematic structures", In: *Emerging Liquid Crystal Technologies XI, Tuesday-Wednesday 16-17 February 2016, San Francisco, California, United States*, (Proceedings of SPIE, the International Society for Optical Engineering, vol. 9769), pp. 97690B-1-97690B-10.

Published Conference Contribution

1. Božidara Cvetković, Vito Janko, Anton Gradišek, Mitja Luštrek, Tanja Kajtna, Boro Štrumbelj, "Mobile application to stimulate physical activity in schoolchildren", In: *IE 2016*, The 12th International Conference on Intelligent Environments, 14-16 September 2016, London, United Kingdom, pp. 206-209.
2. Božidara Cvetković, Urška Pangerc, Anton Gradišek, Mitja Luštrek, "Monitoring patients with diabetes using wearable sensors: predicting glycaemias using ECG and respiration rate", In: *Proceedings*, 1st ECAI Workshop on Artificial Intelligence for Diabetes, AID, at the 22nd European Conference on Artificial Intelligence (ECAI 2016), 30 August 2016, The Hague, Holland, pp. 18-21.
3. Martin Frešer, Božidara Cvetković, Anton Gradišek, Mitja Luštrek, "Anticipatory system for T-H-C dynamics in room with real and virtual sensors", In: *UbiComp 2016: The 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, September 12-16, 2016, Heildeberg, Gemany*, pp. 1267-1274.
4. Martin Frešer, Božidara Cvetković, Anton Gradišek, Mitja Luštrek, "An intelligent system to improve T-H-C parameters at the workplace", In: *UbiComp 2016: The 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, September 12-16, 2016, Heildeberg, Gemany*, pp. 61-64.
5. Janez Grad, Anton Gradišek, Matjaž Gams, "Čmrlji: pašna dejavnost in zvok brenčanja: daily foraging behavior and buzzing sounds", In: *Zbornik referatov*, 2. znanstveno posvetovanje o čebelah in čebelarstvu [tudi] Poklukarjevi dnevi, Ljubljana, 25. oktober 2016, str 18-23.

6. Anton Gradišek, Jani Bizjak, Matjaž Gams, "Platforma za prepoznavanje in klasifikacijo različnih tipov zvokov", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 46-48.
7. Anton Gradišek, Andraž Kocjan, Miha Mlakar, "Ali nam metode strojnega učenja lahko pomagajo pri načrtovanju novih visokoentropijskih zlitin?", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 25-27.
8. Matej Kranjc, Igor Serša, Damijan Miklavčič, "Magnetic resonance electrical impedance tomography for monitoring electrical conductivity during delivery of electric pulses in irreversible electroporation", In: *1st World Congress on Electroporation and Pulsed Electric Fields in Biology, Medicine and Food & Environmental Technologies (WC 2015): Portorož, Slovenia, September 6-10, 2015*, (IFMBE proceedings, vol. 53), pp. 91-94.
9. Aleksander Matavž, Raluca-Camelia Frunză, Aljaž Drnovšek, Barbara Malič, Vid Bobnar, "Inkjet printing of thin metal-oxide structures from sol-gel-precursor inks", In: *2016 Joint IEEE International Symposium on the Applications of Ferroelectrics, European Conference on Application of Polar Dielectrics, (ISAF/ECAPD/PFM), 21-25 August 2016 Darmstadt, Germany*.
10. Aleš Mohorič, "Raziskava praks študija fizike na evropskih univerzah - projekt HOPE (Obzorja v poučevanju fizike)", In: *Izboljševanje procesov učenja in poučevanja v visokošolskem izobraževanju: zbornik konference*, pp. 184-188.
11. Maruška Mole, Longlong Wang, Asta Gregorič, Klemen Bergant, Luka Drinovec, Griša Močnik, Samo Stanič, Janja Vaupotič, Marko Vučković, "Študij atmosferskih procesov v Vipavski dolini na podlagi razširjanja aerosolov", In: *Raziskave s področja geodezije in geofizike 2015: zbornik del*, 21. srečanje Slovenskega združenja za geodezijo in geofiziko, Ljubljana, 28. januar 2016, pp. 35-49.
12. Igor Serša, Franci Bajd, Matej Kranjc, H. Busse, N. Garnov, R. Trampel, Damijan Miklavčič, "Comparison of single-shot rapid acquisition with relaxation enhancement and echo planar current density MRI sequences for monitoring of electric pulse delivery in irreversible electroporation", In: *1st World Congress on Electroporation and Pulsed Electric Fields in Biology, Medicine and Food & Environmental Technologies (WC 2015): Portorož, Slovenia, September 6-10, 2015*, (IFMBE proceedings, vol. 53), pp. 83-86.
13. Drago Strle, Mario Trifković, Bogdan Štefane, Igor Muševič, "Multi-channel vapor trace detection system", In: *Conference proceedings 2016*, 52nd International Conference on Microelectronics, Devices and Materials and the Workshop on Biosensors and Microfluidics, September 28 - 30 2016, Ankaran, Slovenia, pp. 101-105.
14. Mojca Žlahtič, Urška Mikac, Igor Serša, Maks Merela, Miha Humar, "Distribution and penetration of the tung oil in wood studied by high-resolution magnetic resonance imaging", In: *Papers prepared for the 47th Annual meeting, 15-19 May 2016, Lisbon, Portugal*, pp. 1-17.

Independent Component Part or a Chapter in a Monograph

1. Igor Serša, Franci Bajd, "Current density imaging as means to follow tissue electroporation", In: *Handbook of electroporation: living reference work*, Damijan Miklavčič, ed., Gregor Serša, ed., Continuously updated ed., Switzerland, Springer International Publishing, cop. 2016, pp. 1-21.

Scientific Monograph

1. Matej Ogrin, Katja Vintar Mally, Anton Planinšek, Asta Gregorič, Luka Drinovec, Griša Močnik, Darko Ogrin (urednik), *Nitrogen dioxide and black carbon concentrations in Ljubljana*, (GeograFF, 18), 1. izd., Ljubljana, Znanstvena založba Filozofske fakultete, 2016.

University, Higher Education or Higher Vocational Education Textbook

1. Ksenija Cankar, Andrej Fabjan, Borut Kirn, Helena Lenasi, Živa Melik, Nejka Potočnik, Jernej Vidmar, Žarko Finderle (urednik), *Izbrana poglavja iz fiziologije: z navodili za eksperimentalno delo za študente EMŠ farmacija*, 1. izd., Ljubljana, Medicinska fakulteta, Inštitut za fiziologijo, 2016.
2. Simon Čopar, Daniel Svenšek, Aleš Mohorič, Saša Prelovšek, *Rešene kolokvijske naloge iz fizike I in II*, (Zbirka izbranih poglavij iz fizike, 50), Ljubljana, DMFA - založništvo, 2016.

Secondary and Primary School Textbook or Other Textbook

1. Aleš Mohorič, Vito Babič, *Moja fizika v srednji šoli: zbirka nalog, povzetkov snovi in rešenih zgledov za fiziko v srednji šoli*, 1. natis, Ljubljana, Mladinska knjiga, 2016.
2. Aleš Mohorič, Vito Babič, *Fizika 1: učbenik za fiziko v 1. letniku gimnazij in štiriletnih strokovnih šol*, 1. izd., Ljubljana, Mladinska knjiga, 2016.
3. Aleš Mohorič, Vito Babič, *Fizika 2: učbenik za fiziko v 2. letniku gimnazij in štiriletnih strokovnih šol*, 3. ponatis, Ljubljana, Mladinska knjiga, 2016.
4. Milan Ambrožič, Gorazd Planinšič, Erik Karič, Samo Kralj, Mitja Slavinec, Aleksander Zidanšek, *Fizika, narava, življenje, Učbenik za pouk fizike v 8. razredu devetletne osnovne šole*, (Raziskovalec 8), 1. izd., Ljubljana, DZS, 2000.

Patent Application

1. Barbara Malič, Hana Uršič, Marija Kosec, Silvo Drnovšek, Jena Cilenšek, Zdravko Kutnjak, Brigita Rožič, Uroš Flisar, Andrej Kitanovski, Marko Ožbolt, Uroš Plaznik, Alojz Poredoš, Urban Tomc, Jaka Tušek, *Method for electrocaloric energy conversion,* US2016187034 (A1), US Patent Office, 30. 06. 2016.
2. Denis Arčon, Anton Potočnik, *Method and device for mineral melt stream manipulation,* WO2016076802 (A1), WIPO International Bureau, 19. 05. 2016.

Patent

1. Igor Muševič, Matjaž Humar, *Spherical liquid-crystal laser,* US9263843 (B2), US Patent Office, 16. 02. 2016.

Mentoring

1. Sergej Faletič, *Study of molecular dynamics with oscillating spatial discord of spin phase:* doctoral dissertation, Ljubljana, 2016 (mentor Aleš Mohorič).
2. Andraž Rešetič, *Polymer-dispersed liquid crystal elastomers:* doctoral dissertation, Ljubljana, 2016 (mentor Boštjan Zalar).
3. Ana Varlec, *Electrical, optical and structural properties of molybdenum based nanostructures and their polymer composites:* doctoral dissertation, Ljubljana, 2016 (mentor Maja Remškar).
4. Petra Dolšak, *Source specific fog deposition of black carbon from the atmosphere:* master's thesis, Halmstad, 2016 (mentor Marie Mattsson; co-mentor Griša Močnik).
5. Jože Luzar, *Physical properties of high-entropy alloys Cu-Co-Cr-Fe-Ni-Zr-Al:* master's thesis, Ljubljana, 2016 (mentor Janez Dolinšek).
6. Matic Bergant, *Determination of meglumine by derivatization with sodium naphthoquinone sulfonate and high performance liquid chromatography:* master's thesis, Ljubljana, 2016 (mentor Stane Pajk; co-mentor Jožko Cesar).
7. Jakob Frontini, *Nematic-nematic surface anchoring:* master's thesis, Ljubljana, 2016 (mentor Miha Ravnik).
8. Saša Harkai, *Finite-size effects in soft matter under an electric field stimulus:* master's thesis, Maribor, 2016 (mentor Samo Kralj; co-mentor Victor Teboul).
9. Boštjan Kokot, *Identification of contact between nanoparticles and lipid bilayer:* master's thesis, Ljubljana, 2016 (mentor Janez Štrancar; co-mentor Iztok Urbančič).
10. Nina Lokar, *Contrast optimization of fluorescence confocal microscopy of human lens epithelical cells:* master's thesis, Ljubljana, 2016 (mentor Janez Štrancar; co-mentor Marko Hawlina).
11. Tadej Mežnaršič, *Laser Cooling of Cesium Atoms:* master's thesis, Ljubljana, 2016 (mentor Rok Žitko; co-mentor Peter Jeglič).
12. Manca Podvratnik, *The influence of magnetic field strength on the quality of magnetic resonance images:* master's thesis, Ljubljana, 2016 (mentor Igor Serša).
13. Tanja Seničar, *Synthesis and evaluation of aggregation inhibitors and probes of ß-amiloid fibrils:* master's thesis, Ljubljana, 2016 (mentor Stane Pajk; co-mentor Boris Brus).
14. Eva Shannon Schiffrer, *Design and synthesis of pyrrolo [1,2-a]pyrazin-1(2H)-one derivatives with potential inhibition of gyrase B:* master's thesis, Ljubljana, 2016 (mentor Stane Pajk; co-mentor Rok Frlan).

15. Mateja Skok, *Uvedba elementov dobre kontrolne laboratorijske prakse v analizne laboratorije Fakultete za farmacijo:* master's thesis, Ljubljana, 2016 (mentor Stane Pajk; co-mentor Jožko Cesar).
16. Jan Srpčič, *States close to the ferromagnetic instability in YFe_2 (Ge, Si)$_2$ compounds:* master's thesis, Ljubljana, 2016 (mentor Denis Arčon).
17. Marion Antonia van Midden, *Reconstruction of the intrinsic spectral function of the magnetic adatoms on superconductor surfaces from the differential conductance:* master's thesis, Ljubljana, 2016 (mentor Rok Žitko).
18. Mitja Zidar, *Characterisation of monoclonal antibody aggregation mechanisms in biopharmaceuticals:* master's thesis, Ljubljana, 2016 (mentor Miha Ravnik; co-mentor Drago Kuzman).

DEPARTMENT FOR COMPLEX MATTER F-7

The research within the Department for Complex Matter encompasses a variety of research fields, ranging from the synthesis of new materials to fundamental investigations of elementary excitations in complex systems. These include anything from nano-biosystems to exotic magnetic systems and superconductors. The experimental methods used are suitably diverse, from synthetic chemistry to femtosecond laser spectroscopy. Last year's research achievements are thus quite diverse, but we are able to report on important discoveries in a number of areas.

Head:
Prof. Dragan D. Mihailović

The activities in the department can be grouped together into a number of thematically inter-related research areas. Nanomaterials science research is focused on investigations into the fundamental properties and applications of semiconducting transition-metal dichalcogenides and molecular nanowires, crossing into the physics and nanoscience of macromolecular biological systems venturing also into fields of quantum molecular electronics and nano-electronics. These and other materials, such as strongly correlated systems, electronically ordered systems and superconductors were investigated using advanced femtosecond spectroscopy techniques. In a number of areas we have introduced new materials, technologies and techniques.

Particular emphasis is placed on investigations of phase transitions in time, and most recently into the creation of new states of matter created under non-equilibrium conditions.

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Ultrafast studies of electron dynamics in correlated systems

In the past two decades non-equilibrium spectroscopies have evolved from avant-garde studies to crucial tools for expanding our understanding of the physics of strongly correlated materials. The possibility of obtaining simultaneously spectroscopic and temporal information has led to insights that are complementary to (and in several cases beyond) those attainable by studying the matter at equilibrium. From this perspective, multiple phase transitions and new orders arising from competing interactions are benchmark examples where the interplay among electrons, lattice and spin dynamics can be disentangled because of the different timescales that characterize the recovery of the initial ground state. For example, the nature of the broken-symmetry phases and of the bosonic excitations that mediate the electronic interactions, eventually leading to superconductivity or other exotic states, can be revealed by observing the sub-picosecond dynamics of impulsively excited states. Furthermore, recent experimental and theoretical developments have made it possible to monitor the time-evolution of both the single-particle and collective excitations under extreme conditions, such as those arising from strong and selective photo-stimulation. These developments are opening the way for new, non-equilibrium phenomena that can eventually be induced and manipulated by short laser pulses.

As the field of ultrafast spectroscopy has moved from the avant-garde to the mainstream, and has become an important tool for the study of many body and single-particle relaxation phenomena, as well as material science in general, we have completed an extensive review of the subject. The most recent achievements in the experimental and theoretical studies of the non-equilibrium electronic, optical, structural and magnetic properties of correlated materials are published in **Advances in Physics 65, 58-238 (2016).** The paper, of more than 180 pages, presents different viewpoints, from phenomenology to non-equilibrium quantum dynamics.

Systems that rapidly evolve through symmetry-breaking transitions on timescales comparable to the fluctuation timescale of single-particle excitations may behave very differently than under controlled near-ergodic conditions. A real-time investigation with high temporal resolution can reveal new insights into the ordering through the transitions that are not available in static experiments. We investigated the system trajectory through a normal-to-superconductor transition in a prototype high-temperature superconducting cuprate in which such a situation occurs. Using a multiple pulse femtosecond spectroscopy technique we measured the system trajectory and time-evolution of the single-particle excitations through the transition in $La_{1.9}Sr_{0.1}CuO_4$ and compared the data to a simulation based on time-dependent Ginzburg-Landau theory, using laser excitation fluence as an adjustable parameter controlling the quench conditions in both experiment and theory. The comparison revealed the presence of

The ultrafast non-equilibrium phenomena of superconductors have become a widely used method for the investigation of such materials. The culmination of research on ultrafast phenomena in superconductors starting in the early 1990s by our group is the publication of a 180-page review article in Advances in Physics and a news and views article in Nature Materials 15, 930-931 (2016).

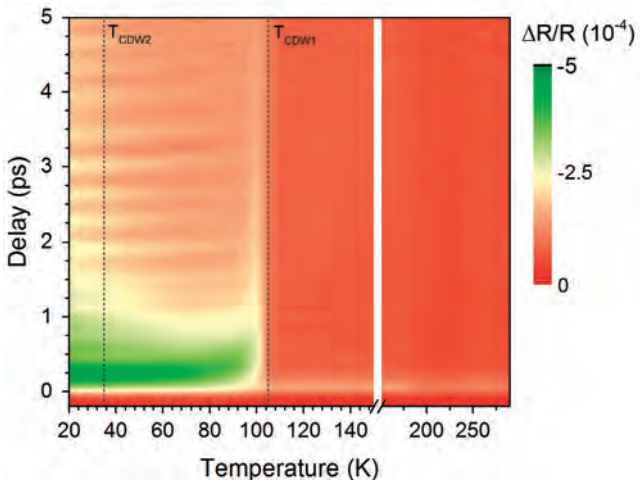


Figure 1: Temperature dependence of the transient reflectivity in Mo_4O_{11}. The vertical dashed lines indicate the CDW transition temperatures: T_{CDW1} = 105 K and T_{CDW2} = 35 K. The appearance of collective oscillatory modes is observed below T_{CDW1}.

significant superconducting fluctuations which precede the transition on short timescales. By including superconducting fluctuations as a seed for the growth of superconducting order we can obtain a satisfactory agreement of the theory with the experiment. Remarkably, the pseudogap excitations apparently play no role in this process, as described in **Phys. Rev. B 93, 224520 (2016)**.

We investigated the temperature- and fluence-dependent dynamics of the time-resolved optical reflectivity in undoped spin-density-wave (SDW) and doped superconducting (SC) $EuFe_2(As,P)_2$ with an emphasis on the ordered Eu^{2+}-spin temperature region. The data indicate that in $EuFe_2(As,P)_2$ the SDW order coexists at low temperature with the SC and Eu^{2+}-ferromagnetic order. Increasing the excitation fluence leads to a slow thermal suppression of the Eu^{2+}-spin order due to the crystal-lattice heating on a nanosecond timescale, while the SDW order is suppressed non-thermally on a sub-picosecond timescale at a higher fluence, as described in **Phys. Rev. B 94, 144519 (2016)**.

We conducted a systematic study of the single-particle and collective excitations by femtosecond transient reflectivity measurements in the single crystals η-Mo_4O_{11}, investigating the dynamics as a function of temperature with two different pump photon energies (3.1 eV and 1.55 eV). A remarkable slowing down of the relaxation dynamics was observed at the first charge density wave (CDW) transition at TCDW1 = 105 K associated with a hidden one-dimensional Fermi surface (FS) nesting. In contrast, the appearance of the second transition at T_{CDW2} associated with further CDW ordering is barely perceptible. The coherent response can be described well by the displacive coherent excitation model of Zeiger et al. assuming a coupling of phonons to the photo-excited quasiparticles. The coupling of the collective modes to the electronic order parameter was found to be weak. The exponential relaxation was discussed in terms of single-particle relaxation and an overdamped collective mode. The manuscript has been submitted to **Phys. Rev. B 93, 125123 (2016)**.

Ultrafast memory materials

An important new area of research is related to the search for new metastable states that have both fundamental and practical importance. The functionality of computer memory elements is currently based on multi-stability, driven either by locally manipulating the density of electrons in transistors or by switching magnetic or ferroelectric order. Another possibility is switching between metallic and insulating phases by the motion of ions, but their speed is limited by slow nucleation and inhomogeneous percolative growth. Here we demonstrate fast resistance switching in a charge density wave system caused by pulsed current injection. As a charge pulse travels through the material, it converts a commensurately ordered polaronic Mott insulating state in 1*T*-TaS_2 to a metastable electronic state with textured domain walls, accompanied by a conversion of polarons to band states, and concurrent rapid switching from an insulator to a metal. The large resistance change, high switching speed (30 ps) and ultralow energy per bit opens the way to new concepts in non-volatile memory devices manipulating all-electronic states as reported in **Nature Communications 7, 11442 (2016)**. An introductory article by Mihailovic in **Nature Materials** describes a new way of tailoring phase diagrams to produce metastable phases with the help of substrate strain. The method was previously reported by Svetin et al in **Appl. Phys. Express**.

The search for a metastable state switched by ultrafast laser pulses or electrical pulses has led to the patenting and publication in Nat. Comm. of a new type of ultrafast memory element with a world-record speed and ultra-low switching energy.

Theoretical studies on the nanoscale

We develop a theory of the upper critical field in a BCS superconductor with a non-local interaction between electrons. We have shown that the non-local interaction is characterized by the universal dimensionless parameter k_{FP0}, where k_F is the Fermi momentum and ρ_0 is the radius of electron-electron interaction. The presence of the external magnetic field leads to the generation of additional components of the order parameter with different angular momenta. This effect leads to the enhancement of the upper critical field above the orbital limiting field. In addition, the upward curvature in the temperature dependence of the upper critical field in the clean limit is predicted. The impurity scattering suppresses the effect in the dirty limit. (**Physical Review B 94, 174506 (2016)**).

We have developed a theoretical model in order to describe the polaron ordering on a triangular lattice. The model takes into account the short range attraction between polarons due to lattice deformation and long-range

Coulomb repulsion. In addition to that we introduce the modulation due to charge density wave ordering. Monte Carlo simulations show that the resulting patterns are similar to that observed in the STM experiments on TaS_2.

Nanomaterials

We investigate the optical and electronic properties of transition-metal dichalcogenides (TMDs) and chalcohalides as well as oxides and carbides synthesized from them, in various low-dimensional forms, in particular atomically thin films, nanoflakes, and nanowires. Moreover, we study organic nanowires and thin-film coatings.

While liquid-phase exfoliation can be used to produce nanosheets stabilized in polymer solutions, very little is known about the resultant nanosheet size, thickness, or monolayer content. The present study uses semi-quantitative spectroscopic metrics based on extinction, Raman, and photoluminescence (PL) spectroscopy to investigate these parameters for WS_2 nanosheets exfoliated in aqueous poly(vinyl alcohol) (PVA) solutions. By measuring Raman and PL simultaneously, the monolayer content can be tracked via the PL/Raman intensity ratio, while varying the processing conditions. The PL is found to be maximized for a stabilizing polymer concentration of 2 g/L. In addition, the monolayer content can be controlled via the centrifugation conditions, exceeding 5% by mass in some cases. These techniques have allowed us to track the ratio of PL/Raman in a droplet of polymer-stabilized WS_2 nanosheets as the water evaporates during composite formation. No evidence of nanosheet aggregation is found under these conditions although the PL becomes dominated by trion emission as drying proceeds and the balance of doping from PVA/water changes. Finally, bulk PVA/WS_2 composites are produced by freeze drying where >50% of the monolayers remain unaggregated, even at WS_2 volume fractions as high as 10%. This work has been published in Adv. Funct. Mater. **26, 1028–1039 (2016)** and is listed as highly cited (i.e., in the top 1% papers in materials science).

We produced fluorescent polymer/WS_2 composites by direct exfoliation in an aqueous polymer solution.

Semiconducting TMDs have been applied as the active layer in photodetectors and solar cells, displaying substantial charge photogeneration yields. However, their large exciton binding energy, which increases with decreasing thickness (number of layers), as well as the strong resonance peaks in the absorption spectra suggest that excitons are the primary photoexcited states. Detailed time-domain studies of the photoexcitation dynamics in TMDs exist mostly for MoS_2. We used femtosecond optical spectroscopy to study the exciton and charge dynamics following impulsive photoexcitation in few-layer WS_2. We confirm excitons as the primary photoexcitation species and found that they dissociate into charge pairs with a time constant of about 1.3 ps. The better separation of the spectral features compared to MoS_2 allowed us to resolve a previously undetected process: these charges diffuse through the samples and become trapped at defects, such as flake edges or grain boundaries, causing an appreciable change of their transient absorption spectra. This finding opens the way to further studies of traps in TMD samples with different defect contents. The work has been published in Nanoscale **8, 5428–5434 (2016)**.

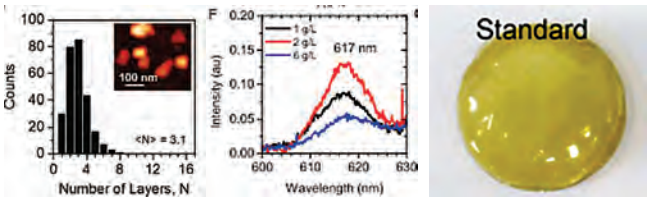


Figure 2: Fluorescent polymer/WS_2 composites. Left: Thickness histogram of exfoliated WS_2 after centrifugation (inset: AFM image of typical flakes). Centre: Fluorescent spectra of WS_2 dispersions. Right: Photograph of a polymer/WS_2 composite film.

The electronic and photophysical properties of a material depend crucially the electron relaxation behavior. Ionic surfactants, which are widely used to stabilize nanomaterials in dispersions, can drastically alter the nanomaterial's photophysical properties. Here, we used femtosecond optical spectroscopy to study the dynamics of excitons and charges in few-layer flakes of the two-dimensional semiconductor MoS_2. We compare samples obtained via exfoliation in water with different amounts of adsorbed sodium cholate, obtained by repeated washing of the dried flakes. We find that the femtosecond dynamics is remarkably robust against the surfactant adsorption, with a slight increase of the initial exciton quenching occurring during the first few picoseconds as the only appreciable effect. The work has been published in the Journal of Nanophotonics **10, 012508-1–8 (2016)** and was among the top ten downloads of that journal throughout 2016.

We show that gold-decorated MoS_2 flakes are amenable to thiol chemistry by blending them with a cross-linkable thiolated polysiloxane (PMMS). MoS_2 flakes from chemical exfoliation are mostly in the metallic 1T rather than the semiconducting 2H phase. One typically recovers the semiconducting phase by thermally transforming 1T into 2H. Blending MoS_2 into the viscous PMMS has many interesting consequences: PMMS acts as a surfactant and makes MoS_2 dispersible in additional solvents such as chloroform, it makes the 1T and 2H flakes dispersible in the same solvent, enabling transformation in a single step by heating the dispersion, and it prevents the MoS_2 flakes from restacking upon drying, which is a great advantage for all forms of deposition from liquid, including printing. Upon cross-linking, PMMS forms an elastomer of good optical quality, which contains individual, mostly single-layer MoS_2 flakes. These are suitable for saturable absorbers, optical limiters, or strain-tuning of the optical resonances, due to the superior anchoring of the elastomer on the flakes through the gold nanoparticles. Besides the new material combination with good biocompatibility, our findings show that the driving force is the interac-

tion between the thiol groups and the gold nanoparticles. This opens up applications based the anchoring on the gold nanoparticles of thiolated antibodies/antigens for biosensing and electron donor or acceptor molecules for light harvesting. These results, which have been obtained in collaboration with the Laboratory for surface and thin film analysis (F4), have been published in Nanoscale **8, 10016–10020 (2016)**.

We produced highly monolayer-enriched dispersions of liquid-exfoliated nanosheets by liquid-cascade centrifugation.

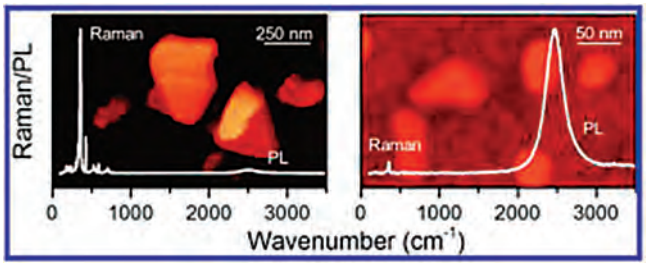


Figure 3: Monolayer-enriched dispersions of WS2 nanosheets by liquid cascade centrifugation. Left: Raman and PL spectra and AFM image of larger flakes after centrifugation. Right: Raman and PL spectra and AFM image of mostly monolayer flakes after centrifugation.

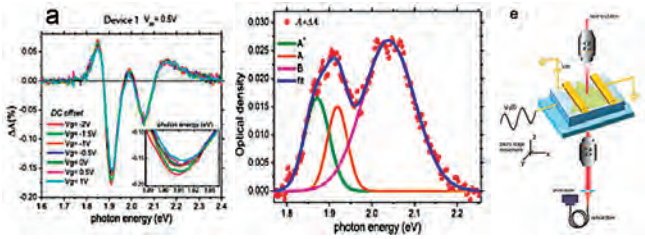


Figure 4: Electro-absorption of monolayer MoS_2. Left: Scheme of the measurement apparatus consisting of a confocal microscope, tunable laser, and transparent MoS_2 transistor. Centre: Electro-absorption spectra for different DC bias voltages. Right: decomposition of the absorption spectrum in the presence of the electric field into the two excitonic resonances A and B and the trion resonance A^-.

Monolayer MoS2 shows an unprecedentedly strong electro-absorption effect with an unusual field dependence.

While liquid exfoliation is a powerful technique to produce defect-free nanosheets in large quantities, its usefulness is limited by broad nanosheet thickness distributions and low monolayer contents. We demonstrated liquid processing techniques, based on iterative centrifugation cascades, which can be designed to achieve either highly efficient nanosheet size-selection and/or monolayer enrichment. We used the resultant size-selected dispersions to establish quantitative metrics to determine monolayer volume fraction, as well as mean nanosheet size and thickness, from standard spectroscopic measurements. Such metrics allowed us to design and optimize centrifugation cascades to enrich liquid exfoliated WS_2 dispersions up to monolayer contents of 75%. Monolayer-rich dispersions show relatively bright photoluminescence with narrow line widths (<35 meV) indicating the high quality of the nanosheets. The enriched dispersions display extinction spectra with distinct features, which also allow the direct estimation of monolayer contents. This work was published in **ACS Nano, 10, 1589–1601 (2016)** and is listed as highly cited (i.e., in the top 1% of papers in Chemistry).

Signal modulation in optoelectronics is obtained by modulation of either the refractive index or the absorbance by an electric field. However, electromodulators have not kept up with the miniaturization of other electronic and optical components. Here we show a strong transverse electro-absorption signal in a monolayer of the two-dimensional semiconductor MoS_2. The electro-absorption spectrum is dominated by an apparent linewidth broadening of around 15% at a modulated voltage of only $V_{pp} = 0.5$ V. Contrary to known variants of the Stark effect, the broadening increases linearly with the applied field strength and arises from a linear variation of the distance between the strongly overlapping exciton and trion resonances. The achievable modulation depths exceeding 0.1 dB nm^{-1} bear the scope for extremely compact, ultrafast, energy-efficient electro-absorption modulators for integrated photonics, including on-chip optical communication. This work has been published in the journal 2D Materials, **4, 021005 (2017)**. Moreover, we filed a UK patent application for the proposed electromodulator device: **GB 1600549.8**.

We have achieved a remarkable 52% relative increase in power conversion efficiency (PCE) of solar cells embedded with small amounts of MoSI nanowires dispersed in a P3HT:PCBM matrix. We have presented a detailed and systematic investigation of the numerous factors influencing this breakthrough increase. Raman spectroscopy and photocurrent imaging are used to investigate the spatial inhomogeneity of solar cell parameters and correlate them with the device's performance. The effect is strongly correlated to the regioregularity of P3HT with highly regioregular P3HT having the largest effect. Our work was published in Synthetic Metals **212, 105–112 (2016)**.

We have shown that we can control the electric-field-induced local domain growth with a magnetic field. Local bias application by a conducting atomic force microscope tip induced local charged states at the surface of lanthanum strontium manganite single crystals. The piezoelectric contrast observed in these states points to the existence of a local polar state. The induced charged states relax with a characteristic time constant of about 50–100 hours at room temperature. The charge and size of the created structures increase significantly if the induction occurs in a magnetic field. This finding indicates the tendency of manganites towards charge segregation stimulated by the magnetic ordering. These results have been published in Ferroelectrics **499, 143–149 (2016)**.

Several synthetic routes exist for the production of bulk molybdenum carbides whereas the production of larger quantities of different molybdenum carbide phases in the form of nanowires and nanowire networks is still challenging. Here we report a novel route for the synthesis of molybdenum carbide nanowires by carburisation of $Mo_6S_2I_8$ nanowire bundles. Gram quantities of molybdenum carbide nanowires composed of mainly MoC and Mo_2C phases were obtained and further reduced to single-phase Mo_2C nanowires. By controlling the reaction conditions during the transformation, we can modify the ratio between MoC and Mo_2C phases in nanowires and produce a novel

hybrid inorganic/organic nanomaterial that we identified as molybdenum carbide nanowires densely covered with carbon nanofibres. We used the same approach on nanowire networks and demonstrate a new use of molybdenum carbide in the form of nanowire networks as transparent electrodes. The sheet resistance of such robust and air-stable electrodes is around 1050 Ωsq^{-1} at room temperature and their transmittance between 93% and 95% in the range of 200–900 nm. The electrodes are thus suitable for electro-optic applications, especially where high transparency in the UV region is required. These results have been published in RSC Advances **6, 90806–90812 (2016)**.

We developed a novel and efficient method used to improve the carrier mobilities of poly(3-hexylthiophene) (P3HT)-based organic field-effect transistors by means of nanowire formation. The treatment, termed solvation, consists of depositing a small quantity of a solvent directly on top of a previously deposited semiconducting film, and allowing the solvent to evaporate slowly. Such treatment results in an increase of the saturation mobility by more than one order of magnitude, from 1.3×10^{-3} up to 3.4×10^{-2} cm^2/Vs, while devices preserve their high ON/OFF ratio of similar to 10^4. The atomic force and scanning electron microscopy studies show that solvated P3HT layers develop a network of nanowires, which exhibit an increased degree of structural order, as demonstrated by micro Raman spectroscopy. The time-of-flight photoconductivity studies suggest that higher hole mobility stems from a reduced energy disorder of the transporting states in these structures. These results have been published in Organic Electronics **30, 92–98 (2016)**.

We investigated the local electronic structure of purified $Mo_6S_{9-x}I_x$ (x = 6, 4.5) nanowires by X-ray absorption and fluorescence spectroscopies. The nanowires are found to be metallic with the density of states altered in both the conduction and the valence band depending on the stoichiometry. First-principle theoretical calculations suggest that the changes can be mainly attributed to the effect of strong Mo-S hybridization in the nanowires. The atomic chain structure of the nanowires is confirmed and the effect of increasing sulphur content is investigated. The results have been published in the Journal of Electron Spectroscopy and Related Phenomena **207, 29–33 (2016)**.

We investigated the role of zirconium tetrapropoxide (ZTP) and methacrylic acid (MAA), following their combination with sol synthesized from tetraethyl orthosilicate (TEOS) and 3-methacryloxypropyl trimethoxysilane (MAPTMS). The molar content of ZTP was varied between 0.06 and 0.96 and that of MAA between 0.12 and 1.92. The synthesized sols were deposited as coatings on aluminium substrates. The effects of the ageing of sols and the curing of the coatings were examined. The composition of the sol, ageing process and size distribution of the particles, the thermal stability of the sols and coatings, the phase composition and microstructure of the coatings and contact angle of the water drop at the coating surface were all investigated. Comparison of sols, using Fourier transform infrared spectroscopy, confirmed important differences in terms of the presence of Si-O-Zr and chelated ZTP-MAA bonds. The three sols studied differ significantly in their ageing behaviour, as shown by dynamic light scattering. Thermogravimetric analysis and analysis of the vapour side products during the curing process confirmed the effect of sol composition on the mass loss at elevated temperatures. Morphology, phase composition and structure of the coating were analysed with scanning and transmission electron microscopy, atomic force microscopy and X-ray diffraction analysis. The coatings possess a homogeneous and amorphous structure, without the formation of nanoparticles. Synthesized coatings offer high corrosion protection of aluminium under simulated aircraft conditions. This work has been published in Surface and Coatings Technology **286, 388–396 (2016)**.

Nanowires and nanotubes decorated with platinum nanoparticles are known for their excellent sensing and catalytic properties. However, the decoration of transition-metal dichalcogenide nanotubes can be very complex. We have discovered a simple procedure that enables efficient production and purification of thin bundles of MoSI nanowires decorated with platinum nanoparticles and a simple procedure for direct decoration of MoS_2 nanotubes. First, we isolated several hundred milligrams of nanowire bundles that were several microns long with average diameters of around 40 nm, and formed a stable dispersion in water without added surfactants. Platinum nanoparticles were directly deposited on the nanowire bundles in a solution at room temperature in a single-step reaction without any additional reducing reagents. A stable and uniform decoration is observed with average particle diameters of around 2 nm and a controllable surface density, covering up to 80% of the nanowire surface. Similar decoration takes place also on MoS_2 nanotubes dispersed in water. Sulfurization of decorated nanowires was performed, during which platinum nanoparticles aggregated into larger formations, and partial encapsulation of elongated platinum nanorods in the obtained multi-wall MoS_2 nanotubes is observed. These results are reported in Materials Letters **159 (2015) 333–336**.

Soft Matter

In cooperation with Nankai University in China we investigated liquid-crystal alignment at interfaces with thin polymeric walls that are oriented in a direction perpendicular to the glass substrates. The walls are fabricated by a direct laser writing process based on two-photon polymerization. This method provides micro-structured liquid-crystal alignment in practically oblique configurations, which opens up several possibilities for applications in liquid-crystalline optical modulators and spatial light filters, microfluidic units based on liquid crystals, etc. The

results of this work were reported in Optics Letters 41, 336 (2016). The described alignment approach is also the main topic of the granted Chinese patent (CN103995394(B), 2016-08-17).

In cooperation with the University of Luxembourg we continued with investigations of the optical properties of 2D arrangements of droplets and shells made of cholesteric liquid crystals. We found that the shells exhibit optical reflection patterns with much better quality than the droplets. We also demonstrated that the addition of a photopolymerizable moiety to such structures results in optical materials exhibiting reversibly changing optical properties even at relatively large mechanical deformations. This makes them very promising for application in authentication tags for the protection of products against imitation. The results were published in Scientif Reports 6, 26840 (2016). We also started collaborative investigations of structural and optical properties of cellulose nanocrystalline films (CNCs). We found that films prepared with and without the presence of a shear flow exhibit very different structural quality, while their optical reflective properties are quite similar. The results of this work were reported in Cellulose 23, 3601 (2016).

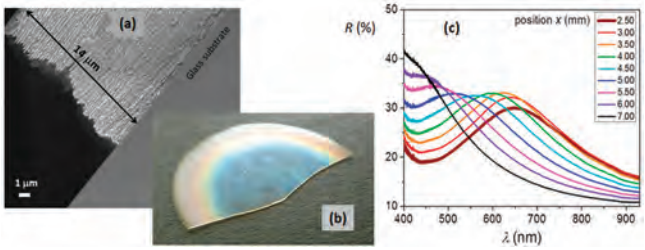


Figure 5: (a) SEM image of cross-sectional plane of cellulose nanocrystalline (CNC) film revealing its periodic microstructure. (b) Photograph of the film showing its iridescent coloration. (c) Diffuse reflectance spectra of the film measured at different distances from the peripheral border.

We performed systematic analyses of the self-assembly of DNA oligonucleotides in drop-cast thin films deposited onto solid substrates. Using AFM imaging, we analyzed a set of guanosine (G)-rich oligonucleotides with GC-termini for their ability to form long G-wires through G:C pairing. We investigated the effects of increasing sequence length, the type of nucleotide in the side loops, and removal of the CG-3′terminus. We found that sequences with adenine in the side loopsmost readily form G-wires. The role of magnesium as an efficient surface-anchoring ion was also confirmed. These observations were published in Langmuir 32, 7056 (2016). We concluded an investigation of the molecular recognition of lipophilic guanosine derivatives in Lagmuir films at air-water interfaces. The investigation took place via film balance experiments and Brewster Angle Microscopy (BAM). The results showed that guanosine, despite strong tendency towards self-assembly, interacts with both complementary and noncomplementary liponucleosides. This indicates that ϖ–stacking interactions between the aromatic planes of liponucleoside derivatives probably dominate over hydrogen-bonding interactions. The work is reported in Biochimica et Biophysica Acta (BBA) - General Subjects, available on line (2016).

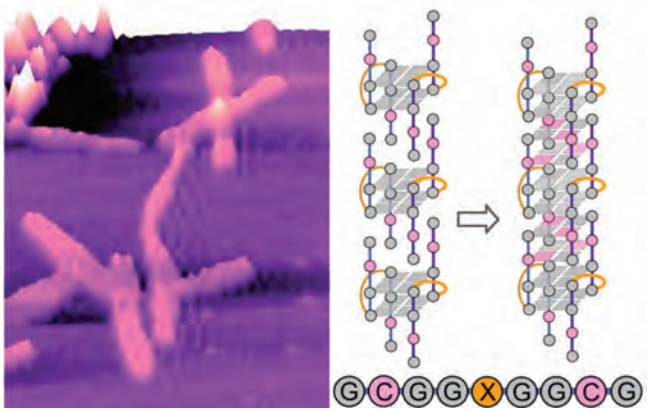


Figure 6: AFM image of G-wires formed on mica surface and bonding scheme of base sequences containing both 5′ and 3′ GC-ends

Formation of G4-nanowires from G-rich DNA oligonucleotides on surface of solid substrates was systematically investigated.

In cooperation with the University of Vienna we continued investigations of holographic micro-patterning in light-sensitive liquid-crystalline elastomers. We examined an unusual effect of destructive interference observed in optical polarization gratings and found that it originates from the strong anisotropy of optical absorbance of the material for recording optical radiation. The results were published in Optical Materials Express 6, 961 (2016).

We have extended our studies of the properties of a ferromagnetic phase to the suspensions of magnetic platelets in chiral nematic liquid crystals, called also cholesteric liquid crystals (CLCs). CLCs form a rich variety of configurations and defect structures when confined in layers or droplets. In confined CLCs surface anchoring usually promotes a uniform configuration, which competes with the helical ground state of bulk CLCs. These frustrated structures can be further manipulated by electric and large magnetic fields. In suspensions of magnetic nanoplatelets in CLCs, similarly as in the suspension in nematic liquid crystals, ferromagnetic ordering of the platelets appears, which makes the suspensions sensitive also to small magnetic fields. These ferromagnetic CLCs can be described macroscopically by two coupled order parameters: the director and the magnetization. The coupling is such that a parallel orientation of the order parameters is the most favorable. The director is sensitive to the electric field and its configuration is preferably helical, while the magnetization is sensitive to small magnetic fields and it prefers a homogenous state, so the frustration is inherent already in the bulk. We have studied the field-induced structures of such ferromagnetic CLC confined to a layer with homeotropic (perpendicular) surface anchoring and a thickness of approximately two cholesteric pitches. We used

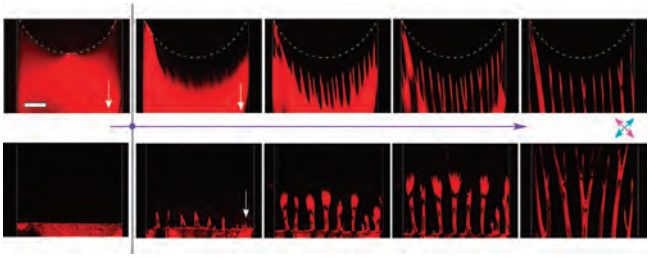


Figure 7: Ferromagnetic nematic spikes at the BF/BuOH isotropic/nematic interface From Nature Communications 7, 10394 (2016)

We have studied field-induced structures in ferromagnetic chiral nematic liquid crystals.

different combinations of electric and magnetic fields to manipulate the structures. The results of our studies were presented at the International Liquid Crystal Conference (ILCC 2016), Kent, OH, USA, and at the 6th Workshop on Liquid Crystals for Photonics, Ljubljana, Slovenia.

In collaboration with the University of Boulder, Colorado, USA we discovered that the suspension of magnetic nanoplatelets in butanol exhibit ferromagnetic ordering. This is the first experimental realization of a ferromagnetic ferrofluid. Its zero-field magnetization produces distinctive magnetic self-interaction effects, including liquid crystal textures of fluid block domains arranged in closed flux loops, and makes this phase highly sensitive, with it dramatically changing shape even in the Earth's magnetic field (*Nature Communications* 7, 10394 (2016)).

Ferromagnetic ferrofluid has been realized in the dense suspension of magnetic nanoplatelets in 1-butanol.

Nonlinear optics

In the Nonlinear Optics Laboratory we study new materials and their interaction with laser light. In cooperation with North Carolina State University, Raleigh, USA, we study new concepts of compact light sources on the basis of nonlinear optical conversion of existing lasers into the short wavelengths spectral regions where lasers are not yet available. AlGaN grown by metalorganic chemical vapor deposition (MOCVD) has a great potential for optoelectronic devices emitting and detecting light in the ultraviolet spectrum. It is also transparent for THz frequencies, making it interesting for new THz applications.

We study AlGaN waveguides in various geometries that allow for phase-matched second-harmonic generation and therefore give high efficiency. We study modal dispersion in multimode waveguides and specially prepared waveguides with alternating sign of the nonlinear coefficient that allows quasi phase matching.

AlGaN waveguides in various geometries that allow for phase-matched second-harmonic generation into the UV spectral region are produced and investigated. Other nonlinear optical applications of AlN are also studied.

Biomedical optics

We have continued with the development of novel biomedical applications based on pulsed photo-thermal radiometry (PPTR). By combining such non-contact measurements of laser-induced radiometric transients with diffuse reflectance spectroscopy and inverse analysis utilizing a numerical model of light transport in strongly scattering biological tissue, we have developed a unique approach for the noninvasive assessment of structure and composition of human skin in vivo.

The same experimental and analysis approach (multi-dimensional nonlinear optimization) in conjunction with an analytical model of bruising in human skin was also adapted for an assessment of the hemoglobin mass diffusion coefficient and biochemical decomposition rate in incidental traumatic bruises (hematomas). The improved understanding of bruise dynamics and the developed methodology could enable a significantly more accurate and reliable determination of the time of injury in forensic science in the near future.

Both studies are supported by an equipment loan from Fotona, d.o.o., Ljubljana.

We have participated in the development of novel co-doped inorganic nanoparticles which exhibit so-called up-conversion fluorescence (e.g., Yb^{3+},Tm^{3+}:$NaYF_4$). By optimization of their size and fluorescence quantum yield, such nanoparticles would exhibit great potential for diagnostic imaging in medicine and enable new approaches to cell-specific therapy, especially for cancer. We have studied their optical properties in relation to synthesis approach, and dissolution kinetics in aqueous media under varying conditions, which is critically important from the point of view of biocompatibility and suitability for biomedical applications. (Collaboration with Department for Materials Synthesis, IJS; Department for Inorganic Chemistry and Technology, IJS; and Medical University of Graz, Austria)

By combining pulsed photothermal radiometry and diffuse reflectance spectroscopy with inverse analysis based on a numerical model of light transport in biological tissue, we have developed a unique approach for the quantitative assessment of structure and composition of human skin *in vivo*.

In a detailed simulation study, employing our custom three-dimensional model of light transport in spatially heterogeneous biological organs (Monte Carlo), we have analyzed the influence of the assumed scattering phase function (e.g., Henyey-Greenstein, modified Henyey-Greenstein, or Mie) on the assessment of tissue properties and morphology in hyperspectral imaging using customary protocols.

The same light-transport model was also applied to simulations of the interactions between intense laser pulses and cutaneous blood vessels containing particular nanostructures of different sizes. These nanostructures were successfully engineered from animal erythrocytes and contained FDA-approved infrared-absorbing dye (indocyanine green). The aim of the project is to derive biocompatible and safe nanoprobes for diagnostic imaging in small

animals and possibly also human patients. (Collaboration with University of California at Riverside and Beckman Laser Institute and Medical Clinic, University of California at Irvine, USA).

Colloidal systems

Microfluidic research of colloidal systems was conducted in close collaboration with Laboratory of Experimental Soft Matter at Faculty of Mathematics and Physics, University of Ljubljana and Department of Condensed Matter Physics (F5). The experiments were performed on magneto-optical tweezers and other laboratory equipment that was developed and produced specifically for our research. The microfluidic research of soft matter included the production of hybrid colloidal particles with laser direct imaging (LDI), an investigation of magnetic colloidal vortices, flow vortices in microfluidic channels, opto-thermal microfluidic pump and investigations of anomalous diffusion in anisotropic fluids.

Laser direct imaging is a maskless lithographic method that enables the fast and precise production of hybrid microstructures. We have shown the advantages of this method by manufacturing microparticles of arbitrary shapes, sizes, and thicknesses functionalised with a variety of materials, for example, fluorescent microbeads or superparamagnetic spheres. The variety of particles gives rise to different colloidal phenomena, the particles are suitable for studying interparticle interactions and can be used in microfluidic devices. We concluded the research on interaction of superparamagnetic beads in a precessing external magnetic field. Within a range of field frequencies, we observed dynamic large-scale structures such as ordered phases composed of precessing chains, ribbons, and rotating fluidic vortices. The results were published in *Applied Physics Express* and *Langmuir.*

In collaboration with the Institute of Biophysics, Medical Faculty, University of Ljubljana, and Group of Soft and Partially Ordered Matter, Faculty of Mathematics and Physics, we investigated fluid flows in elongated side-channels of microfluidic devices. Detailed experimental observations, combined with theoretical analysis and numerical simulations have shown the existence of vortices that appear at large channel aspect ratios. The position of the first vortex depends exponentially with the increasing aspect ratio, whereas below the critical values, the flow decreases exponentially from the cavity entrance. The results of the research were published in *Microfluidics and Nanofluidics.*

We demonstrated a working microfluidic micropump that was based on thermo-viscous fluid pumping. Due to local changes in viscosity and local thermal expansion, a rapidly moving heated area can lead to relatively large fluid flows. We manufactured a series of microheaters, developed the steering electronics and tested its efficiency by following the included tracer particles. Rapidly varying thermal gradients were also used for the manipulation of individual microparticles in so-called opto-thermal tweezers. The high-temperature areas were created by absorbing IR laser light and the sucessfull particle manipulation was shown on micron- and submicron-sized particles. The experiments were made as a part of Jošt Stergar's bachelor thesis.

We also investigated the motion of microparticles in anisotropic fluids, which included liquid crystals. Due to the anisotropic nature of the matter, diffusion of the particles depends on the direction of motion giving two distinct diffusion coefficients: parallel and perpendicular to the director. We studied diffusion in recently discovered ferromagnetic liquid crystals, where the diffusion is influenced by the fluctuations, which in turn can be influenced by external magnetic fields. The diffusion coefficients were thus measured as a function of the magnetic field and we have shown that a reduction of diffusion appears along with subdiffusion. We conclude that the observed subdiffusion is a result of local heterogeneities in the sample. The research was a part of a bachelor thesis, which was successfully defended by Hana Majaron.

Some outstanding publications in the past year

1. Vaskivskyi, Igor, Mihailović, Ian, Brazovskii, Serguei, Gospodarič, Jan, Mertelj, Tomaž, Svetin, Damjan, Šutar, Petra, Mihailović, Dragan. Fast electronic resistance switching involving hidden charge density wave states. Nature communications, ISSN 2041-1723, 2016, vol. 7, str. 11442 -1-11442 -5, doi: 10.1038/ncomms11442. [COBISS.SI-ID 29594919]
2. Madan, Ivan, Kušar, Primož, Baranov, Vladimir V., Lu-Dac, Mathieu, Kabanov, Viktor V., Mertelj, Tomaž, Mihailović, Dragan. Real-time measurement of the emergence of superconducting order in a high-temperature superconductor. Physical review. B, Condensed matter and materials physics, ISSN 1098-0121, 2016, vol. 93, no. 22, str. 224520-1-224520-8, doi: 10.1103/PhysRevB.93.224520. [COBISS.SI-ID 29645351]
3. Ličen, Matjaž, Majaron, Boris, Noh, Junghyun, Schütz, C., Bergström, Lennart, Lagerwall, Jan P. F., Drevenšek Olenik, Irena. Correlation between structural properties and iridescent colors of cellulose nanocrystalline films. *Cellulose*, ISSN 0969-0239, 2016, vol. 23, iss. 6, str. 3601-3609, ilustr., doi: 10.1007/s10570-016-1066-z.

4. Troha, Tinkara, Drevenšek Olenik, Irena, Webba Da Silva, Mateus, Spindler, Lea. Surface-adsorbed long G-quadruplex nanowires formed by G:C linkages. *Langmuir*, ISSN 0743-7463, 2016, vol. 32, iss. 28, str. 7056-7063, ilustr., doi: 10.1021/acs.langmuir.6b01222
5. Ji, Zhichao, Zhang, Xinzheng, Shi, Bin, Li, Wei, Luo, Weiwei, Drevenšek Olenik, Irena, Wu, Qiang, Xu, Jingjun. Compartmentalized liquid crystal alignment induced by sparse polymer ribbons with surface relief gratings. *Optics letters*, ISSN 0146-9592, 2016, vol. 41, iss. 2, str. 336-339, ilustr., doi: 10.1364/OL.41.000336
6. Geng, Yong, Noh, Junghyun, Drevenšek Olenik, Irena, Rupp, Romano A., Lenzini, Gabriele, Lagerwall, Jan P. F. High-fidelity spherical cholesteric liquid crystal Bragg reflectors generating unclonable patterns for secure authentication. *Scientific reports*, ISSN 2045-2322, 2016, vol. 6, art. no. 26840, 9 str., ilustr., doi: 10.1038/srep26840.
7. Lisjak, Darja, Plohl, Olivija, Vidmar, Janja, Majaron, Boris, Ponikvar-Svet, Maja. Dissolution mechanism of upconverting AYF_4:Yb,Tm (A = Na or K) nanoparticles in aqueous media. *Langmuir*, ISSN 0743-7463, 2016, vol. 32, no. 32, str. 8222-8229, doi: 10.1021/acs.langmuir.6b02675. [COBISS.SI-ID 29679655]
8. Shuai, M., Mertelj, Alenka, Lisjak, Darja, Čopič, Martin, et al. Spontaneous liquid crystal and ferromagnetic ordering of colloidal magnetic nanoplate. *Nature communications*, ISSN 2041-1723, 2016, vol. 7, str. 10394-1- 10394-8, doi: 10.1038/ncomms10394. [COBISS.SI-ID 29253927]

Some outstanding publications in the year 2015

1. Madan, Ivan, Kurosawa, T., Toda, Y., Oda, Migaku, Mertelj, Tomaž, Mihailović, Dragan. Evidence for carrier localization in the pseudogap state of cuprate superconductors from coherent quench experiments. *Nature communications*, ISSN 2041-1723, 2015, vol. 6, str. 6958-1- 6958-6, doi: 10.1038/ncomms7958. [COBISS.SI-ID 28758311]
2. Buh, Jože, Kabanov, Viktor V., Baranov, Vladimir V., Mrzel, Aleš, Kovič, Andrej, Mihailović, Dragan. Control of switching between metastable superconducting states in [delta]-MoN nanowires. *Nature communications*, ISSN 2041-1723, 2015, vol. 6, str. 10250-1-10250-6, doi: 10.1038/ncomms10250. [COBISS.SI-ID 29119015]
3. Shumilin, A. V., Kabanov, Viktor V.. Kinetic equations for hopping transport and spin relaxation in a random magnetic field. *Physical review. B, Condensed matter and materials physics*, ISSN 1098-0121, 2015, vol. 92, no. 1, str. 041206-1- 041206-15, doi: 10.1103/PhysRevB.92.014206. [COBISS.SI-ID 28747047]
4. Medle Rupnik, Peter, Lisjak, Darja, Čopič, Martin, Mertelj, Alenka. Ferromagnetic liquid crystals for magnetic field visualisation. *Liquid crystals*, ISSN 0267-8292, 2015, vol. 42, no. 12, str. 1684-1688, doi: 10.1080/02678292.2015.1049570. [COBISS.SI-ID 28701223]
5. Vaskivskyi, Igor, Gospodarič, Jan, Brazovskii, Serguei, Svetin, Damjan, Šutar, Petra, Goreshnik, Evgeny A., Mihailović, Ian, Mertelj, Tomaž, Mihailović, Dragan. Controlling the metal-to-insulator relaxation of the metastable hidden quantum state in 1T-TaS[sub]2. *Science advances*, ISSN 2375-2548, 2015, vol. 1, no. 6, str. e1500168-1-e1500168-6, doi: 10.1126/sciadv.1500168. [COBISS.SI-ID 28753959]
6. Pogrebna, Anna, Mertelj, Tomaž, Vujičić, Nataša, Cao, Guozhong, Xu, Z. A., Mihailović, Dragan. Coexistence of ferromagnetism and superconductivity in iron based pnictides : a time resolved magnetooptical study. *Scientific reports*, ISSN 2045-2322, 2015, vol. 5, str. 7754-1-7754-7, doi: 10.1038/srep07754. [COBISS.SI-ID 28287783]
7. Vidovič, Luka, Milanič, Matija, Majaron, Boris. Objective characteriza-tion of bruise evolution using photothermal depth profiling and Monte Carlo modeling. *Journal of biomedical optics*, ISSN 1083-3668, 2015, vol. 20, no. 1, pp. 017001-1-12, doi: 10.1117/1.JBO.20.1.017001. [COBISS.SI-ID 28243495]
8. Lisjak, Darja, Plohl, Olivija, Ponikvar-Svet, Maja, Majaron, Boris. Dissolution of upconverting fluoride nanoparticles in aqueous suspensions. *RSC advances*, ISSN 2046-2069, 2015, vol. 5, no. 35, str. 27393-27397, doi: 10.1039/c5ra00902b. [COBISS.SI-ID 28445735]

Some outstanding publications in the year 2014

1. 1. Stojchevska, Ljupka, Vaskivskyi, Igor, Mertelj, Tomaž, Kušar, Primož, Svetin, Damjan, Brazovskii, Serguei, Mihailović, Dragan. Ultrafast switching to a stable hidden quantum state in an electronic crystal. *Science*, ISSN 0036-8075, 2014, vol. 344, no. 6180, str. 177-180, doi: 10.1126/science.1241591. [COBISS.SI-ID 27627303]
2. 2. Madan, Ivan, Kurosawa, T., Toda, Y., Oda, Migaku, Mertelj, Tomaž, Kušar, Primož, Mihailović, Dragan. Separating pairing from quantum phase coherence dynamics above the superconducting transition

by femtosecond spectroscopy. *Scientific reports*, ISSN 2045-2322, 2014, vol. 4, str. 05656-1-05656-5, doi: 10.1038/srep05656. [COBISS.SI-ID 27876647]

3. 3. Majkić, Aleksej, Gadermaier, Christoph, Ćelić, Nevena, Topolovšek, Peter, Bratina, Gvido, Mihailović, Dragan. Mo[sub]6S[sub](9-x)I[sub]x nanowires as additives for enhanced organic solar cell performance. *Solar energy materials and solar cells*, ISSN 0927-0248. [Print ed.], 2014, vol. 127, str. 63-66. [COBISS.SI-ID 3306491]
4. 4. Tašič, Blaž, Mrzel, Aleš, Huskić, Miroslav, Zhang, Xinzheng, Drevenšek Olenik, Irena. Alignment of MoS[sub]2 nanotubes in a photopolymerizable liquid- crystalline material. *The journal of physical chemistry. C, Nanomaterials and interfaces*, ISSN 1932-7447, 2014, vol. 118, iss. 45, str. 26396-26401, ilustr. http://pubs.acs.org/doi/abs/10.1021/jp508412w, doi: 10.1021/jp508412w. [COBISS.SI-ID 2746468]
5. 4. Čoga, Lucija, Masiero, Stefano, Drevenšek Olenik, Irena. Lamellar versus compact self-assembly of lipoguanosine derivatives in thin surface films. *Colloids and surfaces. B, Biointerfaces*, ISSN 0927-7765. [Print ed.], 2014, vol. 121, str. 114-121, ilustr. http://www.sciencedirect.com/science/article/pii/S0927776514002732#, doi: 10.1016/j.colsurfb.2014.05.038. [COBISS.SI-ID 2686564]
6. 5. Mertelj, Alenka, Osterman, Natan, Lisjak, Darja, Čopič, Martin. Magneto-optic and converse magnetoelectric effects in a ferromagnetic liquid crystal. *Soft matter*, ISSN 1744-683X, 2014, vol. 10, no. 45, str. 9065-9072, doi:10.1039/C4SM01625D. [COBISS.SI-ID 28078119]
7. 6. Hessari, Nason Ma'ani, Spindler, Lea, Troha, Tinkara, Lam, Wan-Chi, Drevenšek Olenik, Irena, Webba Da Silva, Mateus. Programmed self-assembly of a quadruplex DNA nanowire. *Chemistry*, ISSN 0947-6539. [Print ed.], 2014, vol. 20, issue 13, str. 3626-3630, ilustr. http://onlinelibrary.wiley.com/doi/10.1002/chem.201300692/full, doi: 10.1002/chem.201300692. [COBISS.SI-ID 2644580]
8. 7. Buh, Jože, Kovič, Andrej, Mrzel, Aleš, Jagličić, Zvonko, Jesih, Adolf, Mihailović, Dragan. Template synthesis of single-phase [delta][sub]3-MoN superconducting nanowires. *Nanotechnology*, ISSN 0957-4484, 2014, vol. 25, no. 2, str. 025601-1 025601-6, doi: 10.1088/0957-4484/25/2/025601. [COBISS.SI-ID 27331623]
9. 8. Pogrebna, Anna, Vujičić, Nataša, Mertelj, Tomaž, Borzda, Tetiana, Cao, Guozhong, Xu, Z. A., Chu, Jiun-Haw, Fisher, Ian R., Mihailović, Dragan. Spectrally resolved femtosecond reflectivity relaxation dynamics in undoped spin-density wave 122-structure iron-based pnictides. *Physical review. B, Condensed matter and materials physics*, ISSN 1098-0121, 2014, vol. 89, no. 16, str. 165131-1-165131-9, doi: 10.1103/PhysRevB.89.165131. [COBISS.SI-ID 27689767]

Organization of conferences, congresses and meetings

1. Nonequilibrium Phenomena in Quantum Systems, Ambrož pod Krvavcem, Slovenia, organizers, 17.12.-21.12.2016
2. Flatlands beyond Graphene 2016, Bled, Slovenia, organizers, 4.7.-8.7.2016

Patents granted

1. Xinzheng Zhang, Jingjun Xu, Wei Li, Irena Drevenšek Olenik, Wei Cui, Bin Shi, Zhenhua Wang, Qiang Wu, Yongfa Kong, Micro/nano region liquid crystal alignment method and system thereof based on laser direct writing, CN103995394 (B), Chinese Patent Office, 17. 08. 2016.
2. Andrej Kovič, Adolf Jesih, Aleš Mrzel, Process for the synthesis of the molybdenum carbide in the form of quasi-one-dimensional structures, that is, nano-wires, micro-wires, nano-strips and micro-strips, SI24925 (A), Slovenian Intellectual Property Office , 31. 08. 2016.
3. Igor Vaskivskyi, Dragan Mihailović, Ian Mihailović, Switchable macroscopic quantum state devices and methods for their operation, SI24776 (A), Slovenian Intellectual Property Office , 29. 01. 2016.
4. Matjaž Lukač, Zdenko Vižintin, Boris Cenčič, Method for lightening or eradicating pigments in human skin, US9254174 (B2), US Patent Office, 09. 02. 2016.

INTERNATIONAL PROJECTS

1. Kimberly-Clark - Development of LCD Shutter in the Year 2016
   Prof. Martin Čopič
   Kimberly-clark
2. Spectra Measurements XANES/EXAFS; Extend Existing Work and Include Completing the Data Analysis and Writing s Paper for Submission to a Referred Journal
   Dr. Steven Daniel Conradson
   Areva Mining And Front-end Bg
3. 7FP - MoWSeS; Nanoelectronics based on Two-dimensional Dichalcogenides
   Prof. Christoph Gadermaier
   European Commission
4. 7FP - TRAJECTORY, Coherent Trajectories through Symmetry Breaking Transitions
   Prof. Dragan Dragoljub Mihailović
   European Commission
5. COST MP1205; Advances in Optofluidics: Integration of Optical Control and Photonics with Microfluidics
   Dr. Natan Osterman
   Cost Office
6. COST MP1302; NanoSpectroscopy

Prof. Christoph Gadermaier
Cost Office

7. MPNS COST MP1201: Nanoscale Superconductivity: Novel Functionalities through Optimized Confinement of Condensate and Fields - NanoSC – COST
Prof. Viktor Kabanov
Cost Office
8. COST BM 1205: Biomedicine and Molecular Biosciences
Prof. Boris Majaron
Cost Office
9. H2020 - MagNem; Hydrodynamics of Ferromagnetic Nematic Liquid Crystals
Asst. Prof. Alenka Mertelj
European Commission
10. JET Campaigns-JET1-FU, EUROFUSION
Dr. Natan Osterman
European Commission
11. Medium Size Tokamak Campaigns-MST1-FU,
Dr. Natan Osterman
European Commission
12. Neutron Polarizers based on Polymer-nanoparticle Composites
Prof. Martin Čopič
Slovenian Research Agency
13. Evaluation of Tissue Depth Characterization in Vivo Using Photothermal Radiometry by Co-registration with Alternative Novel Approaches
Prof. Boris Majaron
Slovenian Research Agency
14. Growth and Characterization of Functional 2D Materials based on Graphene and Dichalcogenides
Asst. Prof. Tomaž Mertelj
Slovenian Research Agency
15. Photo-Stimulated Phenomena and Dynamical States in the Vicinity of the Phase Transition
Prof. Viktor Kabanov
Slovenian Research Agency

RESEARCH PROGRAMS

1. Theory of the condensed matter and statistical physics
Prof. Janez Bonča
2. Theoretical physics of nuclei, particles and fields
Prof. Svjetlana Fajfer
3. Light and Matter
Prof. Martin Čopič
4. Medical physics
Dr. Matija Milanič
5. Dynamics of complex nano-systems
Prof. Dragan Dragoljub Mihailović

R & D GRANTS AND CONTRACTS

1. Thermophoretic guidance, accumulation and sorting of biomolecules in microfluidic devices
Dr. Natan Osterman
2. Ultrafast memory devices by molecular beam epitaxy
Prof. Dragan Dragoljub Mihailović
3. Optimization strategies in biological and artificial microfluidic systems
Dr. Mojca Vilfan
4. Symmetry breaking in real time
Prof. Dragan Dragoljub Mihailović
5. Irradiation and Analysis of Nano SiC Samples
Miloš Borovšak, B. Sc.
National Nuclear Research Center

VISITORS FROM ABROAD

1. Dr. Silvia Marchesan, Università degli Studi di Trieste, Trieste Italy, 18.1.-22.1.2016
2. Dr. Venera F. Nasretdinova, Institute of Radioengenieering and Electronics of the Russian Academy of Science, Moscow, Russia, 1.1.-21.1.2016
3. Dr. Yaroslav Gerasimenko, Lebedev Physical Institute of the Russian Academy of Science, Moscow, Russia, 1.1.-21.1.2016
4. Prof. dr. Steven Daniel Conradson, Institut "Jožef Stefan", Ljubljana, Slovenia, 27.5.-31.5.2016
5. Dr. Nataša Vujičić, Institut za Fiziku, Zagreb, Croatia, 31.5.2016
6. Dr. Péter Salamon, Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Budapest, Hungary, 12.6.-8.7.2016
7. Maksim Litskevich, Maxim Bryzgalov, Alexei Shupletcov, P. N. Lebedev Physical Institute of the Russian Academy of Sciences in Moscow Institute of Physics and Technology, Moscow, Russia, 15.7.-20.8.2017
8. Dr. Anna Pogrebna, Spectroscopy of Solids and Interfaces, Institute of Molecules and Materials (IMM) Radboud University Nijmegen, Netherlands, 16.9.-1.10.2016
9. Dr. Fabio Miletto Granozio, CNR-SPIN, Naples, Italy, 27.9.2016
10. Prof. dr. Juergen Klepp, University of Vienna, Vienna, Austria, 7.10.-11.10.2016
11. Dr. Yoshiaki Uchida, Department of Materials Engineering Science, Graduate School of Engineering Science Osaka University, Osaka, Japan, 2.11.-8.11.2016
12. Dr. Sunil Kumar, Department of Physics, Indian Institute of Technology (IIT), Delhi, India, 11.12.-15.12.2016
13. Sanje Fenkart, University of Vienna, Vienna, Austria, 19.12.-20.12.2016

STAFF

Researchers

1. Dr. Steven Daniel Conradson
2. Prof. Martin Čopič*
3. Prof. Irena Drevenšek Olenik*
4. Prof. Christoph Gadermaier
5. Prof. Viktor Kabanov
6. Dr. Matjaž Lukač*
7. Prof. Boris Majaron
8. *Dr. Marko Marinček*, left 01.02.16*
9. Asst. Prof. Alenka Mertelj
10. Asst. Prof. Tomaž Mertelj
11. **Prof. Dragan Dragoljub Mihailović, Head**
12. Dr. Matija Milanič
13. Dr. Aleš Mrzel
14. Dr. Natan Osterman*
15. Dr. Nerea Sebastián Ugarteche
16. Asst. Prof. Lea Spindler*
17. Dr. Mojca Vilfan
18. Prof. Marko Zgonik*

Postdoctoral associates

19. *Dr. Jože Buh, left 01.09.16*
20. Dr. Luka Cmok
21. *Dr. Iaroslav Gerasimenko, left 01.09.16*
22. *Dr. Ivan Madan, left 01.10.16*
23. *Dr. Venera Nasretdinova, left 01.09.16*
24. Dr. Andrej Petelin
25. Dr. Peter Rodič
26. Dr. Anastasia Samodurova
27. Dr. Ljupka Stojčevska Malbašić
28. Dr. Jure Strle
29. *Dr. Igor Vaskivskyi, left 01.09.16*

Postgraduates

30. *Miloš Borovšak, B. Sc., left 01.08.16*
31. Tetiana Borzda
32. Andrej Kranjec, B. Sc.
33. Matjaž Ličen, B. Sc.
34. Luca Moretti, B. Sc.
35. Matej Prijatelj, B. Sc.
36. Jan Ravnik, B. Sc.
37. *Victor Vega Mayoral, B. Sc., left 01.10.16*
38. Dr. Daniele Vella
39. Nina Verdel, B. Sc.
40. Dr. Luka Vidovič*

Technical officers

41. Damjan Svetin, B. Sc.
42. Petra Šutar, B. Sc.

Technical and administrative staff

43. Sabina Cintauer, B. Sc.
44. Martina Knavs, B. Sc.
45. Janja Milivojević

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Mohamed Alaasar, Marko Prehm, Tamba Maria-Gabriela, Nerea Sebastián Ugarteche, Alexey Eremin, Carsten Tschierske, "Development of polar order in the liquid crystal phases of a 4-cyanoresorcinol-based bent-core mesogen with fluorinated azobenzene wings", *ChemPhysChem (Internet)*, vol. 17, no. 2, pp. 278-287, 2016.
2. D. Alden *et al.* (16 authors), "Fabrication and structural properties of AlN submicron periodic lateral polar structures and waveguides for UV-C applications", *Appl. phys. lett.*, vol. 108, no. 26, pp. 261106-1-261106-5, 2016.
3. Claudia Backes *et al.* (13 authors), et al., "Production of highly monolayer enriched dispersions of liquid-exfoliated nanosheets by liquid cascade centrifugation", *ACS nano*, vol. 10, no. 1, pp. 1589-1601, 2016.
4. Robles-Hernández Beatriz, Nerea Sebastián Ugarteche, Josep Salud, Sergio Diez-Berart, David A. Dunmur, Geoffrey R. Luckhurst, David O. López, Fuente M. Rosario de la, "Molecular dynamics of a binary mixture of twist-bend nematic liquid crystal dimers studied by dielectric spectroscopy", *Phys. rev., E*, vol. 93, no. 6, pp. 062705-1-062705-7, 2016.
5. Miloš Borovšak, Ljupka Stojchevska, Petra Šutar, Tomaž Mertelj, Dragan Mihailović, "Critical femtosecond relaxation dynamics of collective and single-particle excitations through the phase transitions in single crystals of $\eta - Mo_4O_{11}$", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 12, pp. 125123-1-125123-7, 2016.
6. Lucija Čoga, Lea Spindler, Stefano Masiero, Irena Drevenšek Olenik, "Molecular recognition of a lipophilic guanosine derivative in Langmuir films at the air-water interface", *Biochim. biophys. acta (G)*, 22 pp..
7. Nevena Ćelić, Egon Pavlica, Miloš Borovšak, Jure Strle, Jože Buh, Janez Zavašnik, Gvido Bratina, Patrick Denk, Markus Scharber, Niyazi Serdar Sariciftcic, Dragan Mihailović, "Factors determining large observed increases in power conversion efficiency of P3HT:PCBM solar cells embedded with $Mo_6S_{9-x}I_x$ nanowire", *Synth. met.*, vol. 212, pp. 105-112, 2016.
8. Nikola Fistonić, Ivan Fistonić, Štefica Findri-Guštek, Iva Sorta Bilajac Turina, Ingrid Marton, Zdenko Vižintin, Marko Kazič, Irena Hreljac, Tadej Perhavec, Matjaž Lukač, "Minimally invasive, non-ablative Er:YAG laser treatment of stress urinary incontinence in women - a pilot study", *Lasers med. sci.*, vol. 31, no. 4, pp. 635-643, 2016.
9. Yong Geng, JungHyun Noh, Irena Drevenšek Olenik, Romano A. Rupp, Gabriele Lenzini, Jan P. F. Lagerwall, "High-fidelity spherical cholesteric liquid crystal Bragg reflectors generating unclonable patterns for secure authentication", *Scientific reports*, vol. 6, art. no. 26840, 9 pp., 2016.
10. Zhichao Ji, Xinzheng Zhang, Bin Shi, Wei Li, Weiwei Luo, Irena Drevenšek Olenik, Qiang Wu, Jingjun Xu, "Compartmentalized liquid crystal alignment induced by sparse polymer ribbons with surface relief gratings", *Opt. lett.*, vol. 41, iss. 2, pp. 336-339, 2016.
11. Blaž Kavčič, Gašper Kokot, Igor Poberaj, Dušan Babič, Natan Osterman, "One-pass manufacturing of multimaterial colloidal particles using optical recognition-enhanced laser direct imaging lithography", *Appl. phys. express*, vol. 9, pp. 026501 -1-026501 -4, 2016.
12. Ł. Kłopotowski, Claudia Backes, A. Mitioglu, Victor Vega Mayoral, Damien Hanlon, Jonathan N. Coleman, V. Y. Ivanov, D. K. Maude, P. Płochocka, "Revealing the nature of excitons in liquid exfoliated monolayer tungsten disulphide", *Nanotechnology (Bristol)*, vol. 27, no. 42, pp. 425707-1-425701-9, 2016.
13. Matjaž Ličen, Boris Majaron, JungHyun Noh, C. Schütz, Lennart Bergström, Jan P. F. Lagerwall, Irena Drevenšek Olenik, "Correlation between structural properties and iridescent colors of cellulose nanocrystalline films", *Cellulose (Lond.)*, vol. 23, iss. 6, pp. 3601-3609, 2016.
14. Darja Lisjak, Olivija Plohl, Janja Vidmar, Boris Majaron, Maja Ponikvar-Svet, "Dissolution mechanism of upconverting AYF_4: Yb, Tm (A = Na or K) nanoparticles in aqueous media", *Langmuir*, vol. 32, no. 32, pp. 8222-8229, 2016.
15. David O. López, Robles-Hernández Beatriz, Josep Salud, Fuente M. Rosario de la, Nerea Sebastián Ugarteche, Sergio Diez-Berart, X. Jaen, David A. Dunmur, Geoffrey R. Luckhurst, "Miscibility studies of two twist-bend nematic liquid crystal dimers with different average molecular curvatures, A comparison between experimental data and predictions of a Landau mean-field theory for the N_TB^N phase transition", *PCCP. Phys. chem. chem. phys.*, vol. 18, no. 6, pp. 4394-4404, 2016.
16. Nejc Lukač, Matjaž Lukač, Matija Jezeršek, "QSP mode characteristics of 3rd generation ASP powered Er:YAG dental lasers", *LAHA*, vol. 2016, no. 1, pp. 1-5, 2016.
17. Nejc Lukač, Tomaž Suhovršnik, Matjaž Lukač, Matija Jezeršek, "Ablation characteristics of quantum square pulse mode dental erbium laser", *J. biomed. opt.*, vol. 21, iss. 1, pp. 1-10, Jan. 2016.
18. Nejc Lukač, Jure Zadravec, Peter Gregorčič, Matjaž Lukač, Matija Jezeršek, "Wavelength dependence of photon-induced photoacoustic streaming technique for root canal irrigation", *J. biomed. opt.*, vol. 21, nr. 7, pp. 1-10, Jul. 2016.
19. Ivan Madan, Primož Kušar, Vladimir V. Baranov, Mathieu Lu-Dac, Viktor V. Kabanov, Tomaž Mertelj, Dragan Mihailović, "Real-time measurement of the emergence of superconducting order in a high-temperature superconductor", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 22, pp. 224520-1-224520-8, 2016.
20. Ingrid Milošev, Peter Rodič, "Cerium chloride and acetate salts as corrosion inhibitors for aluminium alloy AA7075-T6 in sodium chloride solution", *Corrosion (Houst., Tex.)*, vol. 72, no. 8, pp. 1021-1034, 2016.
21. Tomaž Mohorič, Gašper Kokot, Natan Osterman, Alexey Snezhko, Andrej Vilfan, Dušan Babič, Jure Dobnikar, "Dynamic assembly of magnetic colloidal vortices", *Langmuir*, vol. 32, no. 20, pp. 5094-5101, 2016.
22. Robert A. Nawrocki, Egon Pavlica, Nevena Ćelić, Dmitry Orlov, Matjaž Valant, Dragan Mihailović, Gvido Bratina, "Fabrication of poly(3-hexylthiophene) nanowires for high-mobility transistors", *Organic electronics*, vol. 30, pp. 92-98, 2016.
23. Aleš Omerzu, Miloš Borovšak, "Long-range correlated electron transport in M-DNA", *Chem. phys.*, vol. 478, pp. 45-47, 2016.
24. Natan Osterman, Jure Derganc, Daniel Svenšek, "Formation of vortices in long microcavities at low Reynolds number", *Microfluid. nanofluid.*, vol. 20, issue 2, art. no. 33, pp. 1-10, 2016.
25. Anna Pogrebna, Tomaž Mertelj, Guozhong Cao, Z. A. Xu, Dragan Mihailović, "Fluence-dependent femtosecond quasiparticle and Eu^{2+} spin relaxation dynamics in $EuFe_2(As,P)_2$", *Physical review. B*, vol. 94, no. 14, pp. 144519-1- 144519-7, 2016.
26. Matej Prijatelj, Mostafa A. Ellabban, Martin Fally, Valentina Domenici, Martin Čopič, Irena Drevenšek Olenik, "Peculiar behaviour of optical polarization gratings in light-sensitive liquid crystalline elastomers", *Opt. mater. express*, vol. 6, iss. 3, pp. 961-970, 2016.
27. Klementina Pušnik, Mojca Peterlin, Irena Kralj Cigić, Gregor Marolt, Ksenija Kogej, Alenka Mertelj, Sašo Gyergyek, Darko Makovec, "Adsorption of amino acids, aspartic acid, and lysine onto iron-oxide nanoparticles", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, iss. 26, pp. 14372-14381, 2016.
28. Peter Rodič, Alenka Mertelj, Miloš Borovšak, Andreja Benčan, Dragan Mihailović, Barbara Malič, Ingrid Milošev, "Composition, structure and morphology of hybrid acrylate-based sol-gel coatings containing Si and Zr composed for protective applications", *Surf. coat. technol.*, vol. 286, pp. 388-396, 2016.
29. Peter Rodič, Ingrid Milošev, "Corrosion inhibition of pure aluminium and alloys AA2024-T3 and AA7075-T6 by cerium(III) and eerium(IV) salts", *J. Electrochem. Soc.*, vol. 163, no. 3, pp. C85-C93, 2016.
30. Josep Salud, David Orencio López, Nerea Sebastián Ugarteche, Maria Rosario de la Fuente, Sergio Diez-Berart, M. B. Ros, "Influence of the chain length on the nematic-to-isotropic phase transition for the odd members of a highly non-symmetric pyrene-based series of liquid crystal dimers: J. Salud ... [et al.]", *Liq. cryst.*, vol. 43, no. 1, pp. 102-111, 2016.
31. Nerea Sebastián Ugarteche *et al.* (13 authors), "Mesophase structure and behaviour in bulk and restricted geometry of a dimeric compound exhibiting a nematic-nematic transition", *PCCP. Phys. chem. chem. phys.*, vol. 18, no. 28, pp. 19299-19308, 2016.
32. M. Shuai, Alenka Mertelj, Darja Lisjak, Martin Čopič, et al., "Spontaneous liquid crystal and ferromagnetic ordering of colloidal magnetic nanoplate", *Nature communications*, vol. 7, pp. 10394-1- 10394-8, 2016.
33. A. V. Shumilin, Vladimir V. Baranov, Viktor V. Kabanov, "Upper critical field in the model with finite range interaction between electron", *Physical review. B*, vol. 94, no. 17, pp. 174506-1-174506-7, 2016.
34. Peter Topolovšek, Luka Cmok, Christoph Gadermaier, Miloš Borovšak, Janez Kovač, Aleš Mrzel, "Thiol click chemistry on gold-decorated MoS_2:

elastomer composites and structural phase transitions", *Nanoscale*, vol. 8, no. 19, pp. 10016-10020, 2016.
35. Tinkara Troha, Irena Drevenšek Olenik, Mateus Webba da Silva, Lea Spindler, "Surface-adsorbed long G-quadruplex nanowires formed by G:C linkages", *Langmuir*, vol. 32, iss. 28, pp. 7056-7063, 2016.
36. Tinkara Troha *et al.* (11 authors), "UV second harmonic generation in AlN waveguides with modal phase matching", *Opt. mater. express*, vol. 6, iss. 6, 2014-2023, 2016.
37. Igor Vaskivskyi, Ian Mihailović, Serguei Brazovskii, Jan Gospodarič, Tomaž Mertelj, Damjan Svetin, Petra Šutar, Dragan Mihailović, "Fast electronic resistance switching involving hidden charge density wave states", *Nature communications*, vol. 7, pp. 11442 -1-11442 -5, 2016.
38. Victor Vega Mayoral, Claudia Backes, Damien Hanlon, Umar Khan, Zahra Gholamvand, Maria O'Brien, Georg S. Duesberg, Christoph Gadermaier, Jonathan N. Coleman, "Photoluminescence from liquid-exfoliated WS[sub]2 monomers in poly(vinyl alcohol) polymer composites", *Adv. funct. mater.*, vol. 26, issue 7, pp.1028-1039, 2016.
39. Victor Vega Mayoral *et al.* (12 authors), "Exciton and charge carrier dynamics in few-layer WS_2", *Nanoscale*, vol. 8, no. 10, pp. 5428-5434, 2016.
40. Damjan Vengust, Jan Ravnik, Aleš Mrzel, Mojca Vilfan, "Molybdenum carbide nanowires: facile synthesis, a new hybrid phase and their use as transparent electrodes", *RSC advances*, vol. 6, no. 93, pp. 90806-90812, 2016.
41. Gleb Veryasov, Katsuhiko Matsumoto, Rika Hagiwara, "Homoleptic octahedral coordination of CH_3CN to Mg^{2+} in the $Mg[N(SO_2CF_3)_2]_2$-CH_3CN system", *Dalton trans. (2003)*, vol. 45, no. 7, str. 2810-2813, 2016.
42. Eduard Westphal, Hugo Gallardo, Giovanni Finoto Caramori, Nerea Sebastián Ugarteche, Tamba Maria-Gabriela, Alexey Eremin, Susumu Kawauchi, Marko Prehm, Carsten Tschierske, "Polar order and symmetry breaking at the boundary between bent-core and rodlike molecular forms: when 4-cyanoresorcinol meets the carbosilane end group", *Chemistry (Weinh.)*, vol. 22, no. 24, pp. 8181-8197, 2016.
43. Anna Zimina, Igor Vilfan, Daniel Vrbanić, Valeria Nicolosi, David Batchelor, Ralph Steininger, Dragan Mihailović, "Electronic structure of purified $Mo_6S_{(9-x)}I_x$ nanowires studied by X-ray spectroscopy", *J. electron spectrosc. relat. phenom.*, vol. 207, pp. 29-33, 2016.

Review Article

1. Claudio Giannetti, Massimo Capone, Daniele Fausti, Michele Fabrizio, Fulvio Parmigiani, Dragan Mihailović, "Ultrafast optical spectroscopy of strongly correlated materials and high-temperature superconductors: a non-equilibrium approach", *Adv. Phys.*, vol. 65, no. 2, pp. 58-238, 2016.

Published Conference Contribution (invited lecture)

1. Isabella Avigo, Igor Vaskivskyi, Manuel Ligges, Matthias Kalläne, Kai Rossnagel, Ljupka Stojchevska, Dragan Mihailović, "Accessing and probing of the photo-induced hidden state in $1T-TaS_2$ with time- and angle-resolved photoemission spectroscopy", In: *Spintronics IX: September 26, 2016, San Diego, California, United State*, (Proceedings of SPIE, vol. 9931), pp. 99313V-1-1-99313V-8.

Published Conference Contribution

1. Aysen Kaya, Matejka Podlogar, Damjan Vengust, Damjan Svetin, Süleyman Kahraman, Aleksander Rečnik, Slavko Bernik, "Hydrothermal growth of doped ZnO films on amorphous substrates", In: *Conference proceedings 2016*, 52nd International Conference on Microelectronics, Devices and Materials and the Workshop on Biosensors and Microfluidics, September 28 - 30 2016, Ankaran, Slovenia, pp. 37-42.
2. Matija Milanič, Boris Majaron, "Influence of the scattering phase function in numerical modeling of hyperspectral imaging", In: *Optical interactions with tissue and cells XXVII: 13-18 February, San Francisco California, United Satets*, (Proceedings of SPIE, vol. 9706), (Progress in biomedical optics and imagins, vol. 1, no. 1), pp. 97060Z-1-97060Z-13.

Patent

1. Xinzheng Zhang, Jingjun Xu, Wei Li, Irena Drevenšek Olenik, Wei Cui, Bin Shi, Zhenhua Wang, Qiang Wu, Yongfa Kong, *Micro/nano region liquid crystal alignment method and system thereof based on laser direct writing,* CN103995394 (B), Chinese Patent Office, 17. 08. 2016.
2. Igor Vaskivskyi, Dragan Mihailović, Ian Mihailović, *Switchable macroscopic quantum state devices and methods for their operation,* SI24776 (A), Urad RS za intelektualno lastnino, 29. 01. 2016.
3. Matjaž Lukač, Zdenko Vižintin, Boris Cenčič, *Method for lightening or eradicating pigments in human skin,* US9254174 (B2), US Patent Office, 09. 02. 2016.
4. Andrej Kovič, Adolf Jesih, Aleš Mrzel, *Process for the synthesis of the molybdenum carbide in the form of quasi-one-dimensional structures, that is, nano-wires, micro-wires, nano-strips and micro-strips,* SI24925 (A), Urad RS za intelektualno lastnino, 31. 08. 2016.

Mentoring

1. Víctor Vega Mayoral, *Photophysics of transition metal dichalcogenides obtained from liquid phase exfoliation:* doctoral dissertation, Ljubljana, 2016 (mentor Christoph Gadermaier).
2. Daniele Vella, *Photophysics of atomically thin MoS_2 devices:* doctoral dissertation, Ljubljana, 2016 (mentor Christoph Gadermaier).
3. Luka Cmok, *Dynamics of swollen liquid-crystal elastomers:* doctoral dissertation, Ljubljana, 2016 (mentor Martin Čopič).
4. Nevena Ćelić, *The influence of MoSI nanowires on the efficiency of P3HT:PCBM solar cells:* doctoral dissertation, Ljubljana, 2016 (mentor Dragan D. Mihailović).
5. Sabina Hrašan, *The impact of noise to production and education process:* master's thesis, Ljubljana, 2016 (mentor Nataša Vujica Herzog; co-mentor Lea Spindler).
6. Jan Fišer, *Formation and transfer of metallic nano-droplets to a substrate by means of femtosecond laser pulses:* master's thesis, Ljubljana, 2016 (mentor Tomaž Mertelj).
7. Jan Gospodarič, *Broadband spectral response of the hidden state in 1T-TaS_2*: master's thesis, Ljubljana, 2016 (mentor Tomaž Mertelj).
8. Hana Majaron, *Anisotropic diffusion of microspheres in ferromagnetic liquid crystal:* master's thesis, Ljubljana, 2016 (mentor Alenka Mertelj; co-mentor Mojca Vilfan).
9. Jan Ravnik, *Investigation of the phase transition to the hidden quantum state on femtosecond timescale:* master's thesis, Ljubljana, 2016 (mentor Dragan D. Mihailović; co-mentor Igor Vaskivskyi).
10. Jošt Stergar, *Photothermal manipulation of individual submicron particle:* master's thesis, Ljubljana, 2016 (mentor Natan Osterman).
11. Peter Šušnjar, *A source of extreme ultraviolet light based on high harmonic generation in noble gases:* master's thesis, Ljubljana, 2016 (mentor Irena Drevenšek Olenik; co-mentor Thomas Udem).
12. Nina Verdel, *Silicon Photomultiplier as Cherenkov light sensor in Time-of-Flight Positron Emission Tomography:* master's thesis, Ljubljana, 2016 (mentor Peter Križan; co-mentor Rok Dolenec).

DEPARTMENT OF REACTOR PHYSICS F-8

During the past year we have been working mainly on:

- ***theoretical, experimental and applied reactor physics***
- ***plasma physics***
- ***neutron transport calculations***
- ***physics of semiconductors***
- ***medical physics***

Head:
Asst. Prof. Luka Snoj

Our continuing research in **reactor physics** was directed towards the development of novel methods for research and power reactor analysis. Preparations are on-going for an experimental campaign at the TRIGA reactor in collaboration with colleagues from CEA – Cadarache, which is planned for 2017. The aim of the experimental campaign is a study of fission chambers with alternative fissile coating materials – neptunium and plutonium. Preliminary calculations of the fission chamber's response in relation to the position in the reactor core, the control rod positions, the type of fissile coating and the use of transmission filters (cadmium, gadolinium and boron) have been carried out. In collaboration with colleagues from CEA – Cadarache and the JSI Department of Low and Medium Energy Physics and the Experimental Particle Physics Department, an experimental campaign was performed, the aim of which was the characterization of the gamma fields in the TRIGA reactor through measurements using thermoluminescent and optically stimulated luminescent dosimeter detectors (TLD, OSLD), RadFET detectors, a scintillation spectrometer and fission and ionization chambers. The results of the experimental campaign will serve for the validation of Monte Carlo calculations using a two-step method, under development at the Reactor Physics Department, which enables transport calculations of prompt and delayed gamma rays, emitted by radioactive fission and activation products in the reactor. We have recently shown experimentally that the delayed contribution to the total gamma field is significant. In the field of theoretical reactor physics we proposed and developed a method for the calculation of the angular neutron flux. In the framework of the international NATO Science for Peace and Security research project Engineering Silicon Carbide for Enhanced Border and Ports Security we have commenced the development of silicon-carbide-based neutron detectors, applicable for fissile material detection.

We continued international collaboration within the framework of the OECD/NEA coordinated WPEC Subgroup-41. The main objective of the SG-41 is improvement of nuclear data for ^{241}Am and ^{237}Np. In 2016 we analysed thermal neutron capture cross sections in ^{241}Am and ^{237}Np and their influence on integral parameters. The methodology of activation analysis of measurement in reactor neutron spectra has been upgraded for the case of low-energy resonances and/or bound states as a function of the spectral ratio.

Within the framework of the European CHANDA project we were involved in the process of improving nuclear data for the accelerator-driven reactor MYRRHA, a Generation IV concept. For materials and reaction which have a significant influence on the uncertainty of integral parameters and for which improvement of nuclear data would contribute most to a reduction of the overall uncertainty of the integral parameters, evaluated nuclear data libraries were compared with the available experimental data. The nuclear data libraries were also tested on other integral benchmark experiments, which have sensitivity profiles similar to MYRRHA. Recommendations for re-evaluations and the planning of new experiments is currently under way.

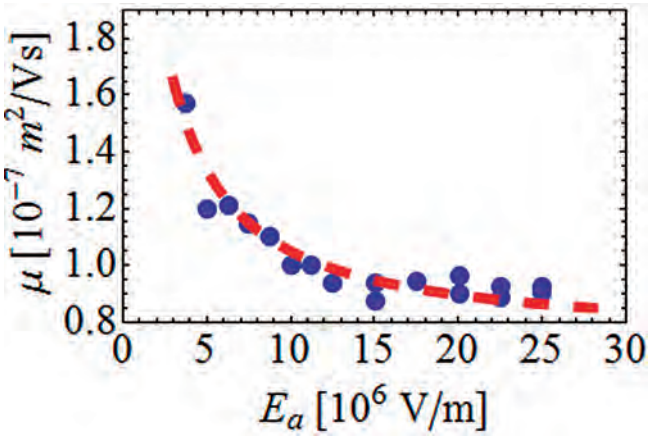


Figure 1: Comparison of the calculated negative hole mobility (dashes) using the bias independent effective hole mobility μeff = 2.12 × 10^{-7} m^2/Vs and the linearly increasing electric field at the hole injecting interface on E_a, to the time-of-flight measurements in an 8300-nm-thick layer of PTB7 organic (solid points). The data are adapted from Fig. 1 (b) of Ebenhoch et al., Org. Electron. 22 (2015) 62.

Researchers from the Reactor Physics Department provided technical support for the safe operation of the Krško nuclear power plant (NPP) in 2016. We have independently confirmed nuclear design calculations for the fuel cycle 29 and performed start-up tests after the fuel reloading. A neutron dose rate at several different positions throughout the reactor building has been determined with the MCNP code. Analysis was needed to verify the relocation of the electronic modules for DSM vibration monitoring of the ventilation units at locations with a lower neutron radiation. It is suspected that the reason for DSM modules' failure is an exposure to high neutron radiation. The neutron dose rate at the new location is 20–40 times lower than at the old locations, confirming the

suitability of the modification. As an authorized expert organization in the field of radiation and nuclear safety, we have finalized an independent expertise on the Krško NPP reload safety evaluation for cycle 29.

In the field of **plasma physics** we have continued our collaboration in two projects under the EUROfusion flag in 2016. In the project WP15-MST2-14 we have been developing a new probe head for the three EUROfusion MST type tokamaks together with Austrian, Italian and Danish researchers. During 2016 the prototypes of the designed probe head parts were tested in the environment of the Linear Magnetized Plasma Device (LMPD) in our department's Laboratory for Plasma Physics. As a part of the project we also began preparing the bases for calculations of the thermal heat load on the probe head. We were again taking part in measurements on the EUROfusion experiments WP15-MST1-AUG15/TCV15-2.2-3 dealing with the filamentary transport in the SOL of tokamaks AUG and TCV. Our task was evaluating the signals from the Langmuir probes. We continued to work together with our colleagues from the University St. Kliment Ohridski from Sofia on the development of the plasma parameter measurements in strongly magnetized plasmas using Langmuir probes. We have made a series of measurements in the LMPD using a triple Langmuir probe in a strong magnetic field and confirmed our theoretical predictions. We have continued our collaboration on the further development of electron-screening probes with the University of Innsbruck. We worked on an improved design of the bunker probe named the bullet probe, but the first results are not as convincing as at the former. We made progress in our theoretical work of the one-dimensional, two-fluid plasma model in front of a negative electrode by adding the energy equation for ions into the equation set, which is an important step in modelling fusion-relevant plasmas. Even though the ions are born cold it was shown that they gain energy when approaching the limiting walls; however, they reach their maximum temperature before entering the plasma sheath. We also calculated the spatial profiles of the polytropic coefficient for ions. The maximum of the product of the polytropic coefficient profile and the ion temperature profile again marks the sheath edge. The agreement between the model and the kinetic particle-in-cell simulations is good.

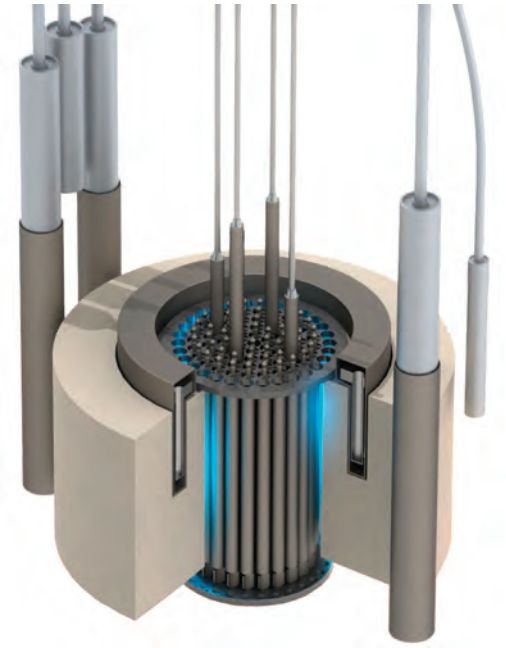


Figure 2: Photorealistic schematic of the TRIGA reactor where the core, graphite reflector and ex-core detectors are depicted.

In the field of **neutron transport calculations for fusion reactors** co-workers of the Reactor physics division have, in collaboration with colleagues from Culham Centre for Fusion Energy, United Kingdom, participated in preparations for the calibration of neutron detectors to 14-MeV neutrons. As part of these preparations we modelled a DT neutron generator and participated in the analysis of the responses to the various detectors in its surroundings. The DT generator was used as a calibration source for the calibration of the JET Tokamak in early 2017.

For the success of the calibration a good knowledge of the characteristics of the generator as a calibration source and the influence of the anisotropic source on the response of neutron detectors. The computational support in the characterization of the generator is crucial for the successful calibration of the detectors with a target uncertainty of 10%.

A parametric neutron source is used for the description of the plasma neutron source and we performed the analysis of the TT (tritium - tritium) plasma source, which will be used in the TT campaign of the JET Tokamak. The neutrons, originating from this reaction, are of particular interest, as three important reaction channels exist, through which neutrons with different energies are generated and the intensities of these channels are poorly known. Determination of the relative intensities of these three channels will be an important outcome of the TT campaign and the co-workers of F8 are engaged in computational support of the experiment. In 2016 we thus started the search for suitable detectors (mainly activation foils), to distinguish between the peaks in the TT reaction.

Co-workers of the F8 department have performed calculations of the neutron field inside the torus and along the tangential channel KM6_T. It turned out that the flux and spectrum of the neutrons on the detectors in this channel are mainly due to direct neutrons of the plasma and from neutrons scattering from the collimator, and to a much smaller extent due to neutrons that are scattered through the remaining vacuum ports. This work is performed as part of the co-operation within the framework of the EUROfusion project within H2020.

In the framework of the European Fusion for Energy programme we collaborated in the following activities:

- Preparation and analysis of a benchmark experiment, which included the irradiation of a copper block (60 cm × 60 cm × 70 cm) with 14 MeV D-T neutrons. The aim was the validation of the neutron cross-sections of copper.
- Irradiation and analysis of Mn samples in the TRIGA reactor for the monitoring of tritium production.
- Evaluation and validation of the neutron cross-sections of iron.
- Validation of the photon data libraries on the basis of benchmark experiments from the SINBAD database.
- Analysis and validation of the DT neutron source modelling in the MCUNED code.

– In 2016 we commenced activities related to the ITER reactor, our task being the calculation of the effects of runaway electrons, specifically the production of gamma rays and their effect on the detection of gamma radiation originating from the plasma. The main part of the activities was aimed at the modification of the MCNP computational code to be able to perform calculations with an asymmetrical runaway neutron source using the existing ITER model. In the ITER project we are also involved in the computational support in the design of a neutron attenuator, which is required for the shielding of the detector of hard X rays.

Organic semiconductors, i.e., *organic light-emitting diodes*, *OLEDs* in displays of mobile devices and TV panels, *field-effect transistors, FETs,* photodiodes and organic photovoltaic cells, OPVCs, already represent nowadays the vital parts of various electronic devices that are available on the market. However, a wider use of these electronic elements is still effectively limited on account of the relatively slow transport of charges (holes as well as electrons) occurring within such materials. The stated shortcoming is evidenced, for instance, through the relatively weak current density in passive matrix displays and the switching time of FET transistors and due to the considerable difference in the velocity of electrons as compared to holes the reduction in the efficiency of the organic semiconductor light-emitting devices (recombination holes and electrons) as well as the resulting feeble electrical current from photovoltaic cells (due to the time delay in the arrival on the metal electrodes of each charge species arising from the electron-hole pairs).

However, it turns out (when considering a number of cases) that the current density diminishes with the increasing external electric field, which may be interpreted as an augmentation of the transparency for the charge transport within the organic semiconductor. On this basis it is conjectured that the increase of the relative degree of the crystalline order of the organic sample induces an enhancement of the effective charge mobility, resulting in the augmentation of the charge injection from the metal/organic interface into the organic bulk.

In the field of **medical physics** we continued the research focused on positron emission tomography (PET) image analysis, image-guided therapy of cancer, and modelling.

We performed a kinetic analysis study of dynamic FLT PET images, where sixteen canine cancer subjects were imaged dynamically with FLT PET/CT before and during radiotherapy. Kinetic analysis was assessed as a means to create multiple imaging biomarkers of resistance to radiotherapy from a dynamic FLT PET scan. A worse outcome after radiotherapy was associated with higher pre- or mid-therapy overall FLT K_i. Additionally, our data indicates that various imaging biomarkers derived from vascular parameters or their change through the therapy, contains even stronger prognostic information than the FLT transport parameter. The results will be published in a scientific journal.

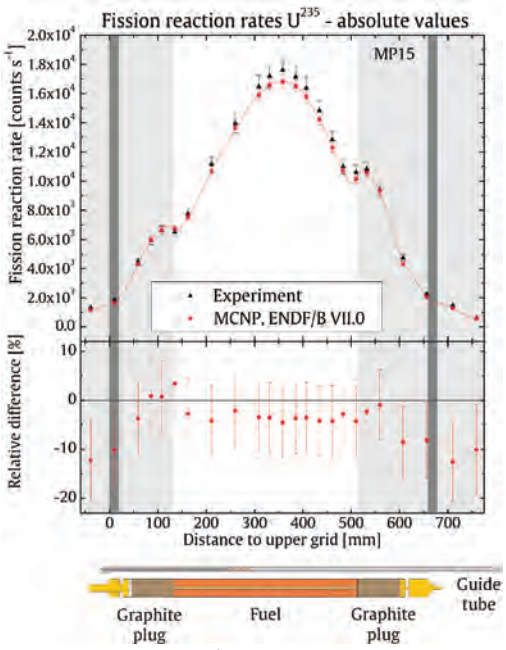


Figure 3: Comparison of measured and computed fission rate axial profiles in the core of the TRIGA reactor. The profiles were measured using miniature fission chambers. Schematics of the fuel element, fission chamber and instrumentation guide tube are shown in the bottom.

We continued with the computational modelling of combined treatment with immunotherapy (programmed cell death 1 antibodies (anti-PD-1)) and radiotherapy. Preliminary results indicate that the expression of major histocompatibility complex I (MHC-I) on tumour cells might play an important role in tumour response to the aforementioned treatment. The model also predicts that hypofractionation should outperform stereotactic radiotherapy (SBRT) when combining radiotherapy with anti-PD-1. The results were presented at the AACR special conference *Tumour Immunology and Immunotherapy* in Boston, MA (20–23.10. 2016).

In collaboration with the Institute of Oncology Ljubljana we started a prospective study enrolling patients diagnosed with metastatic lung cancer after the failure of first- and second-line treatment, who will be treated with anti-PD-1 immunotherapy and imaged with diagnostic CT and FDG PET/CT. The aim of the study is to investigate whether radiomics analysis of FDG PET/CT scans better and more rapidly predicts the response to treatment with anti-PD-1 comparing with current standards (irRC).

Like all recent years, also in 2016 we had a close collaboration with the University of Wisconsin – Madison (USA).

Some outstanding publications in the past year

1. Pregledni članek v ugledni reviji: Popov, Tsviatko K., Dimitrova, Miglena, Ivanova, Pavlina, Kovačič, Jernej, Gyergyek, Tomaž, Dejarnac, Renaud, Stöckel, Jan, Pedrosa, M. A., López-Bruna, D., Hidalgo, C. Advances in Langmuir probe diagnostics of the plasma potential and electron-energy distribution function in magnetized plasma. *Plasma sources science & technology*, ISSN 0963-0252, 2016, vol. 25, str. 1-18, ilustr. http://iopscience.iop.org/article/10.1088/0963-0252/25/3/033001?fromSearchPage=true, doi: 10.1088/0963-0252/25/3/033001.

2. Gyergyek, Tomaž, Kovačič, Jernej. Ion temperature profiles in front of a negative planar electrode studied by a one-dimensional two-fluid model. *Physics of plasmas*, ISSN 1070-664X, Jun. 2016, vol. 23, no. 6, str. 1-18, ilustr. http://dx.doi.org/10.1063/1.4953545, doi: 10.1063/1.4953545.
3. Costea, Stefan, Fonda, Boris, Kovačič, Jernej, Gyergyek, Tomaž, Schneider, Bernd Sebastian, Schrittwieser, Roman, Ioniţa, Codrina. Bunker probe : a plasma potential probe almost insensitive to its orientation with the magnetic field. *Review of scientific instruments*, ISSN 0034-6748, 2016, vol. 87, no. 5, str. 1-4, ilustr. http://scitation.aip.org/content/aip/journal/rsi/87/5/10.1063/1.4951688, doi: 10.1063/1.4951688
4. M. Koželj, B. Cvikl, The negative mobility: An outcome of the electric field at the hole-injecting metal/organic semiconductor interface that varies as a linear function of the applied bias, *Thin Solid Films, 616 (2016) 786-792.*
5. Lengar, Igor, Čufar, Aljaž, Conroy, S., Batistoni, P., Popovichev, Sergei, Snoj, Luka, Syme, Brian, Vila, Rafael, Stankunas, Gediminas, et al, JET Contributors. Radiation damage and nuclear heating studies in selected functional materials during the JET DT campaign. Fusion engineering and design, ISSN 0920-3796. [Print ed.], 2016, vol. 109, str. 1011-1015, doi: /10.1016/j.fusengdes.2016.01.033.

Awards and Appointments

1. Tanja Kaiba: Prešeren Award, Ljubljana, Slovenia, 6. 12. 2016, Faculty of Mathematics and Physics, University of Ljubljana, for the master thesis entitled: Fission and ionization chambers response at the JSI TRIGA reactor
2. Bor Kos: Young author award. Young author award committee at the international conference NENE 2016, Portorož, 5.-8. 9. 2016, for the contribution entitled "Variance Reduction of Fusion and Fission Neutron Transport Problems using the ADVANTG Hybrid Code" co-authored by Ivan A. Kodeli
3. Luka Snoj: Name of the Month on the Radio Val 202, June 2016, Ljubljana, Slovenia, awarded by RTV Slovenia, Radio Val 202

Organization of Conferences, Congresses and Meetings

1. 25th International Conference "Nuclear Energy for New Europe" – NENE 2016, Portorož, Slovenia, 5.–8. 9. 2016
2. Student conference of the Reactor physics department (F-8) »Jožef Stefan« Institute, Ljubljana, Slovenia, 29. 2. 2016
3. 7FP GENTLE Intersemester Course »Nuclear Data Processing and Use in Nuclear Applications«, EC-JRC, Geel, Belgium, 14.–18. 11. 2016

Patent granted

1. P. E. Galavis, Bhudatt R. Paliwal, James E. Holden, Robert Jeraj, System and method for gradient assisted non-connected automatic region (GANAR) analysis, US9355447 (B2), US Patent and Trademark Office, 31. 05. 2016

INTERNATIONAL PROJECTS

1. Development of Radiation Resistant Cameras
   Asst. Prof. Luka Snoj
   Isec Industrial Security Ab
2. Overheating of Containers for Dry Storage of Spent Fuel after Full Blockage of Ventilation Channels
   Dr. Marjan Kromar
   Areva Gmbh
3. 7FP - CHANDA; solving CHAllenges in Nuclear Data
   Prof. Ivan Aleksander Kodeli
   European Commission
4. F4E-GRT-168.02; Specific Grant Agreement: Nuclear Data Improvements and Development of Tools - Nuclear Data Evaluation
   Prof. Ivan Aleksander Kodeli
   European Commission
5. F4E-FPA-327 (PMS-DG): SG04; Conceptual Design and Interface Definitions for the Enabled ITER Radial Gamma-Ray Spectrometer Diagnostic
   Dr. Igor Lengar
   The European Joint Undertaking For The Development
6. F4E-FPA-395-02; Gas Production Experiment and TBM Nuclear Instrumentation
   Prof. Ivan Aleksander Kodeli
   The European Joint Undertaking For The Development
7. Integral Measurements for the Validation of the Dosimetry Cross Sections; F41031 Testing and Improving the IAEA International Dosimetry Library for Fission and Fusion (IRDFF)
   Prof. Ivan Aleksander Kodeli
   IAEA - International Atomic Energy Agency
8. Benchmarks of Computational Tools against Experimental Data on Fuel Burnup and Material Activation for Utilization, Operation and Safety Analysis of Research Reactors; Activation Rate Benchmark at the JSI TRIGA Mark-II Reactor
   Dr. Vladimir Radulović
   IAEA - International Atomic Energy Agency
9. Training Costs for IAEA Fellowship for Mr. Mustafa Jaradat, JOR/14080; from 11 January 2016 to 10 March 2016
   Asst. Prof. Luka Snoj
   IAEA - International Atomic Energy Agency
10. Training Costs for IAEA Fellowship for Mr. Mahmoud Mohamed, EGY/12023; from 1 August to 30 September 2016
    Asst. Prof. Luka Snoj
    IAEA - International Atomic Energy Agency
11. E-SiCure - Engineering Silicon Carbide for Enhanced Border and Ports Security
    Asst. Prof. Luka Snoj
    Nato - North Atlantic Treaty Organisation
12. H2020 - AIDA-2020; Advanced European Infrastructures for Detectors at Accelerators
    Dr. Vladimir Radulović
    European Commission

13. RU-FU, EUROFUSION; Research Unit - Administration and Services
    Asst. Prof. Luka Snoj
    European Commission
14. Exploatation of DT Operation for ITER-JET3-FU, EUROFUSION
    Asst. Prof. Luka Snoj
    European Commission
15. Education-ED-FU, EUROFUSION
    Asst. Prof. Luka Snoj
    European Commission
16. JET Enhancements-JET4-FU, EUROFUSION
    Dr. Igor Lengar
    European Commission
17. Impact of Neutron Irradiation in the Fusion Environment on Tritium Production, Tritium Retention and Nuclear Damage in Plasma Facing Materials
    Prof. Ivan Aleksander Kodeli
    Slovenian Research Agency
18. Experimental on-line neutron spectra adjustment method using various fission chambers with adequate fissile isotopes
    Dr. Gašper Žerovnik
    Slovenian Research Agency
19. Eksperimental validation of the gamma flux simulation scheme and measurment techniques by TLD, OSLD and ionization chamber in the mixed neutron-photon high dose rate environment of the JSI TRIGA reactor
    Asst. Prof. Luka Snoj
    Slovenian Research Agency
20. Mathematical methods for the nuclear data and code validation applied to improved safety of new nuclear reactor core design
    Prof. Ivan Aleksander Kodeli
    Slovenian Research Agency

RESEARCH PROGRAM

1. Reactor Physics
   Asst. Prof. Luka Snoj
2. Medical physics
   Prof. Robert Jeraj

R & D GRANTS AND CONTRACTS

1. Development of methodology for calibration of neutron detectors with a 14.1 MeV neutron generator - JET fusion reactor case
   Asst. Prof. Luka Snoj
2. Analysis of material damage and activation in large scale fusion reactors - application to the reactor JET
   Dr. Igor Lengar

NEW CONTRACTS

1. Reload operational core analysis, post refueling nuclear design check tests, PIS and KFSS cycle specific data for future fuel cycles
   Dr. Marjan Kromar
   Nuklearna Elektrarna Krško
2. Independent Evaluation of Modified Krško 16x16 VANTAGE+Fuel design fully in accordance with NEK Technical Specification SP-ES1250 Rev.0
   Dr. Marjan Kromar
   Nuklearna Elektrarna Krško d. o. o.

VISITORS FROM ABROAD

1. Niklas Barringer, ISEC, Sweden, 12.–13. 1. 2016
2. Mustafa Jaradat, IAEA stipend, Jordan Atomic Energy Commission, Amman, Jordan, 11. 1.–10. 3. 2016
3. Stefan Costea, University Innsbruck, Innsbruck, Austria, 25. 4.–6. 5. 2016
4. Dr. Mitja Majerle, Nuclear Physics Institute, Řež, Czech Republic, 16. 5. 2016
5. Mahmoud Mohamed, IAEA stipend, Egyptian Nuclear and Radiological Regulatory Authority, Cairo, Egypt, 31. 7.–2. 10. 2016
6. Dr. Simon Pinches, scientific coordinator, ITER Organization, Confinement & Modelling Section, St Paul lez Durance, Cedex, France, 7.–8. 9. 2016
7. Prof. Gilles Bignan and dr. Christophe Destouches, CEA, Cadarache, France, 5. 9.–8. 9. 2016
8. Fausto Francescini, Westinghouse, Cranberry Township, Pennsylvania, USA, 5. 9.–8. 9. 2016
9. Prof. Helmuth Böck, TRIGA Reactor, Vienna, Austria, 5. 9.–8. 9. 2016
10. Stefan Costea, University Innsbruck, Innsbruck, Austria, 12. 9.–31. 10. 2016
11. Lars Öhlin, Head of Engineering Dept. and Jan Gunnarsson, ISEC, Helsingborg, Sweden, 13. 10. 2016
12. Prof. Tsviatko K. Popov, Faculty for Physics, University St. Kliment Ohridski, Sofia, Bulgaria, 20. 10.–30. 10. 2016
13. Shintaro Inoue, EUJEP2 student exchange, Tokyo Institute of Technology, School of Environment and Society, Transdisciplinary Science and Engineering – Nuclear Engineering, Tokio, Japan, 21. 11. 2016–18. 2. 2017
14. Mael Le Guillou and Adrien Gruel, CEA, Cadarache, France, 28. 11.-2. 12. 2016

STAFF

Researchers

1. Prof. Tomaž Gyergyek*
2. Prof. Robert Jeraj
3. Prof. Ivan Aleksander Kodeli
4. Dr. Marjan Kromar
5. Dr. Igor Lengar
6. **Asst. Prof. Luka Snoj, Head**
7. Prof. Andrej Trkov
8. Dr. Gašper Žerovnik

Postdoctoral associates

9. *Dr. Jure Beričič, left 29.03.16*
10. Dr. Dušan Ćalić*
11. Dr. Jernej Kovačič
12. *Dr. Lucijan Plevnik, left 01.08.16*
13. Dr. Vladimir Radulović
14. Dr. Urban Simončič

Postgraduates

15. Klemen Ambrožič, B. Sc.
16. Aljaž Čufar, B. Sc.
17. Tanja Kaiba, B. Sc.
18. Bor Kos, B. Sc.
19. Vid Merljak, B. Sc.
20. Žiga Štancar, B. Sc.
21. Damijan Valentinuzzi, B. Sc.

Technical and administrative staff

22. Slavko Slavič, B. Sc.
23. Uršula Turšič, B. Sc.
24. Bojan Žefran

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. V. Adhikarla, Robert Jeraj, "An imaging-based computational model for simulating angiogenesis and tumour oxygenation dynamics", *Phys. Med. Biol.*, vol. 61, no. 10, str. 3885-3902, 2016.
2. Stefan Costea, Boris Fonda, Jernej Kovačič, Tomaž Gyergyek, Bernd Sebastian Schneider, Roman Schrittwieser, Codrina Ionită, "Bunker probe: a plasma potential probe almost insensitive to its orientation with the magnetic field", *Rev. sci. instrum.*, vol. 87, no. 5, pp. 1-4, 2016.
3. Aljaž Čufar, Igor Lengar, Ivan Aleksander Kodeli, Alberto Milocco, Patrick Sauvan, S. Conroy, Luka Snoj, "Comparison of DT neutron production codes MCUNED, ENEA-JSI source subroutine and DDT", *Fusion eng. des.*, vol. 109, pp. 164-168, 2016.
4. Dušan Ćalić, Andrej Trkov, Marjan Kromar, Luka Snoj, "Use of Effective Diffusion Homogenization method with the Monte Carlo code for light water reactor", *Ann. nucl. energy*, vol. 94, pp. 392-398, 2016.
5. Dušan Ćalić, Gašper Žerovnik, Andrej Trkov, Luka Snoj, "Validation of the Serpent 2 code on TRIGA Mark II benchmark experiments", *Appl. radiat. isotopes*, vol. 107, pp. 165-170, 2016.
6. Tomaž Gyergyek, Jernej Kovačič, "Ion temperature profiles in front of a negative planar electrode studied by a one-dimensional two-fluid model", *Phys. plasmas*, vol. 23, no. 6, pp. 1-18, Jun. 2016.
7. Tomaž Gyergyek, Jernej Kovačič, "Plazemski plašč v poševnem magnetnem polju", *Elektrotehniški vestnik*, vol. 83, no. 4, pp. 162-176, 2016.
8. Stephanie A. Harmon, Michael J. Tuite, Robert Jeraj, "Molecular image-directed biopsies: improving clinical biopsy selection in patients with multiple tumors", *Phys. Med. Biol.*, vol. 61, no. 20, str. 7282-7299, 2016.
9. Mustafa K. Jaradat, Vladimir Radulović, Chang Je Park, Luka Snoj, Salih M. Alkhafaji, "Verification of MCNP6 model of the Jordan Research and Training Reactor (JRTR) for calculations of neutronic parameters", *Ann. nucl. energy*, vol. 96, pp. 96-103, 2016.
10. Ivan Aleksander Kodeli, K. Kondo, R.L. Perel, U. Fischer, "Cross-section sensitivity and uncertainty analysis of the FNG copper benchmark experiment", *Fusion eng. des.*, vol. 109-111, pp.1222-1226, 2016.
11. Matjaž Koželj, Bruno Cvikl, "The negative mobility: An outcome of the electric field at the hole-injecting metal/organic semiconductor interface that varies as a linear function of the applied bias", *Thin solid films*, vol. 616, str. 786-792, 2016.
12. Marjan Kromar, Dušan Ćalić, Bojan Kurinčič, "Analysis of the Krško NPP spent fuel storage criticality safety under hypothetical degraded conditions", *Journal of energy technology*, iss. 1, vol. 9, pp. 11-27, apr. 2016.
13. Sara Leibfarth, Urban Simončič, David Mönnich, Stefan Welz, Holger Schmidt, Nina Schwenzer, Daniel Zips, Daniela Thorwarth, "Analysis of pairwise correlations in multi-parametric PET/MR data for biological tumor characterization and treatment individualization strategies", *Eur. j. nucl. med. mol. imaging*, vol. 43, no. 7, pp. 1199-1208, 2016.
14. Igor Lengar, Aljaž Čufar, S. Conroy, P. Batistoni, Sergei Popovichev, Luka Snoj, Brian Syme, Rafael Vila, Gediminas Stankunas and JET Contributors, "Radiation damage and nuclear heating studies in selected functional materials during the JET DT campaign", *Fusion eng. des.*, vol. 109, pp. 1011-1015, 2016.
15. Christie Lin *et al.* (15 avtorjev), "Repeatability of quantitative ^{18}F-NaF PET: a multicenter study", *J Nucl Med (1978)*, vol. 57, no. 12, str. 1872-1879, 2016.
16. Lucijan Plevnik, "On a matrix trace inequality due to Ando, Hiai and Okubo", *Indian j. pur. appl. math.*, vol. 47, iss. 3, pp. 491-500, 2016.
17. Lucijan Plevnik, Gašper Žerovnik, "Computer code ENDSAM for random sampling and validation of the resonance parameters covariance matrices of some major nuclear data libraries", *Ann. nucl. energy*, vol. 94, pp. 510-517, 2016.
18. Gregor Primc, Tomaž Gyergyek, Zlatko Kregar, Slobodan Milošević, Alenka Vesel, Miran Mozetič, "Gostota kisikovih atomov v plazemskem reaktorju s pomičnim rekombinatorjem", *Vakuumist*, vol. 36, no. 3, pp. 4-14, 2016.
19. Vladimir Radulović, Andrej Trkov, Radojko Jaćimović, G. Gregoire, Christophe Destouches, "Use of boron nitride for neutron spectrum characterization and cross-section validation in the epithermal range through integral activation measurements", *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 840, pp. 5-14, 2016.
20. Matthew Scarpelli, Justine Yang Bruce, Lakeesha L. Carmichael, Jens C. Eickhoff, Jill M. Kolesar, Scott Perlman, Robert Jeraj, Glenn Liu, "^{18}F-FLT PET/CT imaging in patients with advanced solid malignancies treated with axitinib on an intermittent dosing regimen", *Cancer Chemother Pharmacol*, vol. 78, iss. 6, str. 1245-1252, 2016.
21. A1 Collaboration, F. Schulz *et al.,* "Ground-state binding energy of $^{4}_{\Lambda}$H from high-resolution decay-pion spectroscopy", *Nucl. phys., Sect. A*, vol. 954, pp. 149-160, 2016.
22. Luka Snoj, Igor Lengar, Aljaž Čufar, B. Syme, Sergei Popovichev, P. Batistoni, S. Conroy and JET contributors, "Neutronic analysis of JET external neutron monitor response", *Fusion eng. des.*, vol. 109, pp. 99-103, 2016.

Review Article

1. Tsviatko K. Popov, Miglena Dimitrova, Pavlina Ivanova, Jernej Kovačič, Tomaž Gyergyek, Renaud Dejarnac, Jan Stöckel, M. A. Pedrosa, D. López-Bruna, C. Hidalgo, "Advances in Langmuir probe diagnostics of the plasma potential and electron-energy distribution function in magnetized plasma", *Plasma sources sci. technol.*, vol. 25, pp. 1-18, 2016.

Published Conference Contribution (invited lecture)

1. Tomaž Gyergyek, Jernej Kovačič, "Sheath formation in an oblique magnetic field - some comments on length scales and source terms", In: *6th International Workshop & Summer School on Plasma Physics 2014 (IWSSPP'14)*, (Journal of physics. Conference series, vol. 768), IWSSPP'14, 30 June to 6 July 2014, Kiten, Bulgaria, pp. 1-10.

Published Conference Contribution

1. Klemen Ambrožič, "Uporaba in karakterizacija RadFET-ov kot dozimetrov", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 17-22.
2. Klemen Ambrožič, Luka Snoj, "Delayed gamma ray modeling around activated JSI TRIGA fuel elements by R2S method", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 9 pp.
3. L. Barbot, Vladimir Radulović, Christophe Destouches, Jean-François Villard, V. Dewynter-Marty, F. Malouch, Franck Lopez, "Experimental validation of a Monte Carlo based toolbox for self-powered neutron and gamma detector simulation in the OSIRIS MTR", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, 10 pp.
4. P. Batistoni, D. Campling, S. Conroy, D. Croft, T. Giegerich, T. Huddleston, X. Lefebvre, Igor Lengar, John S. Lilley, A. Peacock, M. Pillon, Sergei Popovichev, S. Reynolds, Rafael Vila, R. Villari, N. Bekris and JET Contributors, "Technological exploitation of Deuterium-Tritium operations at JET in support of ITER design, operation and safety", In: *Proceedings*, (Fusion Engineering and Design, Vol. 109-111), Proceedings of the 12th International Symposium on Fusion Nuclear Technology-12 (ISFNT-12), 14-18 September 2015, Juju Island, South Korea, part A, pp. 278-285, 2016.
5. Jure Beričič, "Določanje kotnega fluksa nevtronov s programom MCNP", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 45-48.
6. Aljaž Čufar, "Karakterizacija DT generatorja nevtronov", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 27-30.
7. Aljaž Čufar, P. Batistoni, Igor Lengar, Sergei Popovichev, Luka Snoj and JET Contributors, "Calculations to support JET neutron yield calibration: Effects of the neutron source anisotropy", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 9 pp.
8. Dušan Ćalić, Andrej Trkov, "2-D reflector modelling for VENUS-2 MOX Core Benchmark", In: *Proceedings*, 25th International Conference

Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 7 pp.

9. Dušan Ćalić, Andrej Trkov, "Monte Carlo simulation on Krško NPP", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, 10 pp.
10. D. Fourmentel, Vladimir Radulović, L. Barbot, Jean-François Villard, Gašper Žerovnik, Luka Snoj, M. Tarchalski, K. Pytel, F. Malouch, "Delayed gamma measurements in different nuclear research reactors bringing out the importance of their contribution in gamma flux calculations", In: *Proceedings*, 4th International Conference on Advancements in Nuclear Instrumentation Measurement Methods and their Applications (ANIMMA), 20-24 April, 2015, Lisbon, *IEEE T. Nucl. Sci.,* vol. 63, iss. 6, pp. 2875-2879, 2016.
11. A. T. Godfrey, Matthew Jessee, Shane Stimpson, B. S. Collins, T. M. Evans, Marjan Kromar, F. Franceschini, David Salazar, "VERA benchmarking results for Krško nuclear power plant cycle 1", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, 11 pp.
12. Tomaž Gyergyek, Jernej Kovačič, "Robni pogoji na robu plazemskega plašča v enodimenzionalnem dvotekočinskem modelu", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. A, pp. 195-198.
13. Tomaž Gyergyek, Jernej Kovačič, "A self-consistent one-dimensional multi-fluid model of the plasma-wall transition in the presence of two species of negatively biased particles", In: *VEIT 2015*, (Journal of physics, vol. 700), 19th International Summer School on Vacuum, Electron and Ion Technologies (VEIT2015), 21-25 September 2015, Sozopol, Bulgaria, pp. 1-5.
14. Romain Henry, Iztok Tiselj, Luka Snoj, "Multi-physics simulation of the Triga reactor", In: *Annual Meeting of the American Nuclear Society, June 12-16, 2016, New Orleans, USA*, (Transactions of the American Nuclear Society, Vol. 114, 2016), pp. 678-681.
15. Anže Jazbec, Luka Snoj, "3D model of Jožef Stefan Institute TRIGA Mark II Reactor", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 7 pp.
16. Igor Jenčič, Luka Snoj, "The use of Ljubljana TRIGA reactor for training and public information", In: *Role of research reactors in providing support to nuclear power programmes*, Report of the IAEA Technical Meeting on "Role of Research Reactors in providing support to Nuclear Power Programmes ", 21-24 June 2016, Vienna, pp. 44.
17. Tanja Kaiba, "Analiza spreminjanja nevtronskega fluksa in fisijske hitrosti s fisijskimi celicami v reaktorju TRIGA", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan : povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 9-12.
18. Tanja Kaiba, Gašper Žerovnik, Luka Snoj, "Evaluation of criticality and reaction rate experimental benchmark in spherical geometry", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 13 pp.
19. Ivan Aleksander Kodeli, Manuele Aufiero, W. Zwermann, "Comparison of deterministic and Monte Carlo codes SUSD3D, SERPENT and XSUSA for Beta-effective sensitivity calculations", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, 10 pp.
20. Ivan Aleksander Kodeli, V. Mastrangelo, Evgeny Ivanov, Alexander Aures, W. Zwermann, Manuele Aufiero, Yannick Peneliau, Kostadin N. Ivanov, Enrico Sartori, "OECD/NEA intercomparison on deterministic and Monte Carlo cross-section sensitivity codes using SNEAK-7 benchmarks", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, 10 pp.
21. Ivan Aleksander Kodeli, Slavko Slavič, "Recent development and examples of the use of the Windows interface environment XSUN-2016 for transport and sensitivity-uncertainty analysis", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 12 pp.
22. Bor Kos, "Hibridne kode za transport delcev", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 59-64.
23. Bor Kos, Ivan Aleksander Kodeli, "Variance reduction of fusion and fission neutron transport problems using the ADVANTG hybrid code", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 7 pp.
24. Bor Kos, Marjan Kromar, Žiga Štancar, Peter Klenovšek, Luka Snoj, "Neutron streaming analysis and shielding determination for the Krško nuclear power plant", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 8 pp.
25. Bor Kos, Luka Snoj, "On using Grasshopper add-on for CAD to MCNP conversion", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, 10 pp.
26. Domen Kotnik, Luka Snoj, "Validation of the ADVANTG on the ICSBEP shielding benchmarks", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 9 pp.
27. Marjan Kromar, Bojan Kurinčič, "Validation of the CORD - 2 system for the nuclear design calculations of the NPP Krško core", In: *Conference proceedings and book of abstracts: former "Nuclear Option in Countries with Small and Medium Electricity Grids"*, 11th International Conference of the Croatian Nuclear Society, June 05-08, 2016, Zadar, Croatia, 10 pp.
28. Igor Lengar, Vid Merljak, Marjan Kromar, Luka Snoj, "Control rod measurements by rod insertion using signal from multiple fission chambers at TRIGA reactor", In: *PHYSOR 2016, The physics of reactor meeting*, The physics of reactor meeting, Unifying theory and experiment in the 21th century, May 1-5, 2016, Sun Valley, Idaho, Sun Valley, American Nuclear Society, 2016, 10 pp.
29. Vid Merljak, "3D Cartesian TRIGA reactor model quality assessment by radial power distribution", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 6 pp.
30. Vid Merljak, "Simulacija metode vstavitve kontrolne palice s programom SKETCH-N", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 65-68.
31. Vid Merljak, Marjan Kromar, Luka Snoj, Andrej Trkov, "Control rod insertion method analysis - dynamic vs. static reactivity", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, Sun Valley, American Nuclear Society, 2016, 10 pp.
32. Lucijan Plevnik, "Korelacije in naključno vzorčenje jedrskih podatkov", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 39-44.
33. Vladimir Radulović, "Jedrske reakcije za meritve specifičnih področij nevtronskega spektra", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 3-7.
34. Slavko Slavič, Andrej Trkov, Bojan Žefran, " DMReS, digital reacivity meter of the new generation", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 12 pp.
35. Luka Snoj, Igor Lengar, Anže Jazbec, Vladimir Radulović, Gašper Žerovnik, Aljaž Kolšek, Patrick Sauvan, Francisco Ogando, Javier Sanz, Andrej Trkov, "Feasibility study of installing a thermal to 14 MeV neutron converter into a reseach nuclear reactor", In: *Conference proceedings*, Berlin, 2016, 12 pp.
36. Luka Snoj, Žiga Štancar, Vladimir Radulović, Tanja Kaiba, Igor Lengar, Gašper Žerovnik, Vid Merljak, Andrej Trkov, L. Barbot, D. Fourmentel, Christophe Destouches, Jean-François Villard, "Benchmark experiments at the TRIGA Mark II reactor", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, Sun Valley, American Nuclear Society, 2016, 12 pp.
37. Žiga Štancar, "Modeliranje sredice Nuklearne elektrarne Krško za izračune Monte Carlo", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 53-54.
38. Žiga Štancar, Marjan Kromar, Bor Kos, Luka Snoj, "Construction of a Monte Carlo Benchmark pressurized water reactor core model", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 16 pp.
39. Žiga Štancar, Luka Snoj, L. Barbot, "Evaluation of the effect of burn-up on neutron flux and reaction rate distributions in the TRIGA Mark II reactor", In: *PHYSOR 2016, The physics of reactor meeting*, May 1-5, 2016, Sun Valley, Idaho, Sun Valley, American Nuclear Society, 2016, 10 pp.
40. Damijan Valentinuzzi, "Radiomska analiza ^{18}F-FDG PET/CT odziva na radioterapijo in kemoterapijo pri pacientih s pljučnim rakom", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 49-50.
41. Andrej Žohar, Luka Snoj, "Analysis of the primary water activation in a typical PWR", In: *Proceedings*, 25th International Conference Nuclear

Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 10 pp.

Independent Component Part or a Chapter in a Monograph

1. Jernej Jerman, Andrej Lešnjak, Luka Snoj, Borut Smodiš, "Inspection of the TRIGA reactor tank", In: *History, development and future of TRIGA research reactors*, (Technical report series, no. 482), Vienna, IAEA = International Atomic Energy Agency, 2016, 10 pp.
2. Borut Smodiš, Luka Snoj, "The JSI TRIGA Mark II reactor, Slovenia", In: *History, development and future of TRIGA research reactors*, (Technical report series, no. 482), Vienna, IAEA = International Atomic Energy Agency, 2016, pp. 76-89.
3. Luka Snoj, "TRIGA research calculations, Specific technical areas", In: *History, development and future of TRIGA research reactors*, (Technical report series, no. 482), Vienna, IAEA = International Atomic Energy Agency, 2016, pp. 11-22.

Professional Monograph

1. Gašper Žerovnik, S. Kopecky, A.J.M. Plompen, P. Schillebeeckx, *Comparison of resonance integrals of cross sections from JEFF-3.2 library for some problematic reactions*, (EUR EN, 27802), Geel, European Commission, 2016.
2. Gašper Žerovnik, P. Romojaro, A. Stankovsky, L. Fiorito, Ivan Aleksander Kodeli, P. Schillebeeckx, F. Alvarez-Velarde, O. Cabellos, C. J. Diez, G. Van den Eynde, N. Garcia-Herranz, J. Heyse, Andrej Trkov, *Assessment of evaluations for MYRRHA*, (JRC Technical Reports, EUR 28240 EN), Luxembourg, European Commission, 2016.

Patent

1. P. E. Galavis, Bhudatt R. Paliwal, James E. Holden, Robert Jeraj, *System and method for gradient assisted non-connected automatic region (GANAR) analysis,* US9355447 (B2), US Patent and Trademark Office, 31. 05. 2016.

Mentoring

1. Dušan Ćalić, *Validation and modification of fuel burnup with the use of ISOlib library in the CORD-2 program:* doctoral dissertation, Maribor, 2016 (mentor Andrej Trkov).
2. Tanja Kaiba, *Fission and ionization chambers response at the JSI TRIGA reactor:* master's thesis, Ljubljana, 2016 (mentor Luka Snoj; co-mentor Gašper Žerovnik).
3. Vanja Sandrin, *Use of ^{18}F-FDG PET/CT for therapy response assessment:* master's thesis, Ljubljana, 2016 (mentor Robert Jeraj; co-mentors Primož Strojan, Urban Simončič).

DEPARTMENT OF EXPERIMENTAL PARTICLE PHYSICS F-9

Departmental research is devoted to experimental studies of elementary particles, to reveal the ultimate building blocks of matter and the nature of the interactions between them. Experiments are carried out within large collaborative programmes at international centres for particle physics at CERN near Geneva and at KEK in Tsukuba. The department is also engaged in developing and applying the technologically advanced particle detectors that are demanded by such measurements. Astroparticle physics is an emerging field applying the experimental techniques of particle physics to solve astrophysical problems. Slovenian researchers are participating in measurements of ultra-high-energy cosmic rays with the Pierre Auger observatory spread over a surface of 3000 km² near Malargue in Argentina.

Head:
Prof. Marko Mikuž

In order to reveal the ultimate secrets of nature in the world of elementary particles, accelerators with higher and higher energies are needed. Their cost, both in terms of money and human resources, has grown to the level where they are affordable only as joint international enterprises. Thus, future accelerators will be unique facilities of their kind, the first being the Large Hadron Collider (LHC), just completed at the European Organization for Nuclear Research (CERN) near Geneva. Researchers will exploit this facility to perform experiments in presently inaccessible regions of energy, which, though pushed higher and higher, still remain minute compared to that of the vast blast of the Big Bang that led to the creation of the Universe.

Together with colleagues from the Physics Department of the Faculty of Mathematics and Physics and the Faculty of Electrical Engineering of the University of Ljubljana, and from the Faculty of Chemistry and Chemical Technology of the University of Maribor, we are performing measurements at CERN and the Japanese centre KEK in Tsukuba. We are taking part in two experiments, each conducted as an international collaboration:

- ATLAS at the Large Hadron Collider (LHC) at CERN (3000 researchers, 174 institutions from 38 countries),
- Belle at the asymmetric electron-positron collider (KEK-B) at KEK (409 researchers, 62 institutions from 15 countries)

In the field of astroparticle physics we are part of the Pierre Auger collaboration (250 researchers, 94 institutions from 17 countries), which uses a giant-scale (3000 km²) observatory near Malargue in Argentina for the detection of ultra-high-energy cosmic rays. This endeavour is carried out in collaboration with colleagues from the University of Nova Gorica.

A more detailed report on the 2016 activities follows, focused on the contributions of our researchers:

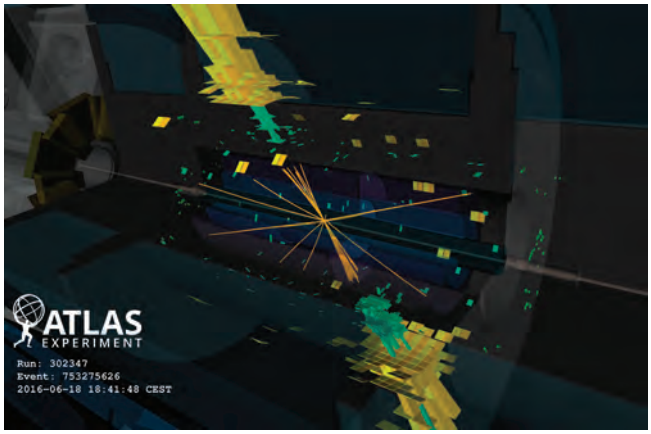


Figure 1: The event display of a proton-proton collision at the centre-of-mass energy of 13 TeV with the highest invariant mass of two jets in the resonance searches in the data collected in 2016 (Event 753275626, Run 302347). The two central jets have an invariant mass of 7.5 TeV.

ATLAS experiment

In 2015 the upgraded Large Hadron Collider LHC began its operation at CERN and reached the record centre-of-mass energy of 13 TeV, which marks the beginning of the "Run 2" of LHC operation. In the following year 2016 the LHC then exceeded all expectations and facilitated the recording of the largest quantity of data at the ATLAS experiment so far. The amount of the ATLAS experiment proton-proton collision data at 13 TeV (Fig. 1) in 2016 is ten times larger than the data set collected in 2015, which led to the most precise Run 2 searches of new physics beyond the Standard Model achieved hitherto. In the analysed data a considerable number of different theories was excluded and there are some indications for potential new discoveries in the particle physics [1,2] – however, for confirming or refuting these a larger amount of data needs to be recorded and analysed. Subsequently, the next two years will be full of challenges and expectations of pivotal events. In 2016 the ATLAS collaboration published more than 100 scientific papers in the most distinguished scientific journals, bringing the total number of scientific papers published by the collaboration to 600, with more than a hundred additional papers in preparation.

In 2016 the LHC exceeded all expectations and facilitated the recording of the largest quantity of data at the ATLAS experiment so far.

The ATLAS Ljubljana group had a leading role in designing, building and operating several beam and radiation monitoring systems, namely: ATLAS Beam Condition Monitor (BCM), Beam Loss Monitor (BLM), Radiation Monitor (RADMON) and Diamond Beam Monitor (DBM). BCM was built to monitor conditions of the LHC beams and issue warnings at unexpected and potentially dangerous situations. In the first part of LHC operation it served as the main luminosity monitor of ATLAS. BLM on the other hand is solely a safety system and protected the ATLAS Inner Detector from potential damage by LHC beams which fired and extracted LHC beams a few times. RADMON records the doses received by different parts of the ATLAS Inner Detector. Newly built DBM was installed during the last shutdown and was used for the first time in 2015. Its readout is currently being developed. It is built from pCVD diamond sensor and pixel readout chip with pixels of size 250×50 μm^2. It will provide luminosity measurement complementary to the BCM and other luminosity monitors in ATLAS. It has prospects to become the main luminosity monitor with increasing luminosity when other detectors will start saturating.

Collaboration ATLAS intends to upgrade the detector in the next decade. The upgraded detector will be able to record the data even at the highest luminosity (5 10^{34} cm^2s^{-1}) delivered by HL-LHC collider (High Luminosity LHC).

Collaboration ATLAS intends to upgrade the detector in the next decade. The upgraded detector will be able to record the data even at the highest luminosity (5 10^{34} cm^2s^{-1}) delivered by HL-LHC collider (High Luminosity LHC). The inner part of the detector will be replaced by a new tracker of charged particles with sensors based on semiconductor technology. Our department is involved in the development of sensors, readout electronics and support structures. The company ELGOLINE from Podskrajnik is fabricating multilayer flexible circuits, which will serve as the interface between the detector modules and the control electronics.

Belle detector at the asymmetric electron positron collider KEKB at KEK

The data collected by the Belle detector at the electron-positron collider KEKB in Tsukuba, Japan, are being exploited by members of the department to carry out precise measurements of rare processes in the world of subatomic particles. By comparing the results of measurements and theoretical predictions it is possible to check for possible contributions from New Physics, the yet unknown particles and processes. These processes are – among others - also responsible for the fact that we live in a universe in which matter (particles) completely dominates over antimatter (antiparticles). The measurements performed by the Belle and Belle II collaborations are part of the so-called intensity frontier that complements research efforts in the Cosmic and Energy Frontiers. The measurements performed using the collision data collected by the Atlas experiment at the LHC in CERN falls into the latter group.

A large fraction of the activity of the Ljubljana Belle team was devoted to the preparation of the follow-up Belle II experiment.

In 2016, the most interesting results published by the researchers of the international research group Belle (542 researchers from 89 institutions and 20 countries) were measurements of branching fractions of the decays $B>D^{(*)}\tau\mu$ and measurement of tau lepton polarisation in these decays and full angular analysis of $B \rightarrow K^* l^+ l$ decays, where l represents light lepton: electron or muon [3].

Both types of decays probe lepton flavour universality, which is one of the most profound properties of the Standard Model of interactions between the fundamental particles. Lepton flavour universality states that the coupling of the leptons to gauge bosons are flavour-independent (i.e., the interactions between leptons and gauge bosons are the same for all leptons). Using above decays we can test whether the couplings to leptons in nature are really flavour-independent. The results of the measurements indicate that the couplings are not flavour-independent and that the lepton flavour universality is violated, however the significance of the violation is not high enough. The much larger data sample that will be collected by the Belle II experiment will allow for more precise tests and a confirmation of the current deviation, which would represent an unambiguous proof of New Physics (Fig. 2).

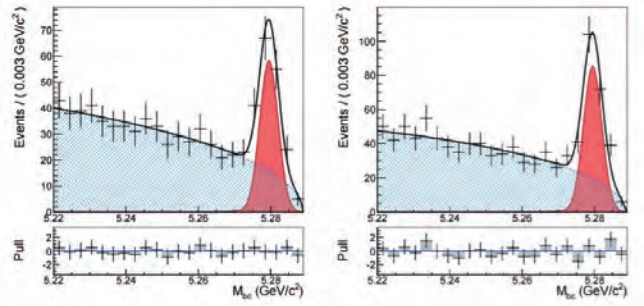


Figure 2: Signal of B -> K e+ e- (left) and B ->K* μ+ μ- (right) decays [3]. Possible difference in the heights of the two signal peaks would be a sign of lepton universality violation.*

In the past year we have performed as well a study of radiative charm decays, which resulted in the first observation of the D_0 -> ργ decays, first measurement of CP violation in radiative charm decays [4] and improved measurement of branching fractions of D0 -> Φγ and $K(892)^{*0}\gamma$ decays. Measurements will enable tests of long-distance dynamics calculations on the lattice that dominate in these decays. Measurements of CP violation in radiative decays are sensitive to the contributions of non-standard chromomagnetic dipole operators and complementary to the existing measurements performed using hadronic or (semi-)leptonic decays. The results are consistent with the Standard Model predictions with uncertainties. More stringent tests will be performed using the data collected by the Belle II experiment.

A large fraction of the activity of the Ljubljana Belle team was devoted to the preparation of the follow-up Belle II experiment. Belle II is again an international collaboration with more than 700 scientists from 96 institutions and 23 countries. In 2016, the group reached several important milestones. The central drift chamber was successfully installed in the Belle II spectrometer.

In 2016 we have also successfully completed the assembly of one of the most delicate parts of the detector, the TOP (Time-Of-Propagation) counter (Fig. 3). This detector component is intended for the identification of charged particles through the detection of Cherenkov light; this light is emitted by very fast particles in a 2-cm-thick quartz plate. All 16 modules were installed in the spectrometer, and are currently being tested with cosmic rays. In the meantime, we have also started the assembly of the detector to identify particles in the forward region, the ARICH (Aerogel Ring Imaging Cherenkov) counter, our main responsibility in the Belle II detector preparation. We note that one of the key components, the low noise read-out electronics printed circuit boards for the ARICH counter were manufactured in Slovenia.

Figure 3: Placement of quartz radiators for Time-Of-Propagation counter

Pierre Auger observatory

The Pierre Auger Observatory is an international cosmic-ray observatory in Argentina designed to detect ultra-high-energy cosmic rays: sub-atomic particles traveling nearly at the speed of light and each with energies beyond 10^{18} eV. In Earth's atmosphere such particles interact with air nuclei and produce various other particles. Secondary particles forming the so-called "air shower" can be detected and measured in order to clarify the origin of the highest-energy primary particles and their properties like energy, arrival direction and the particle type (photons, protons, atomic nuclei). But since these high-energy particles have an estimated arrival rate of just 1 per km^2 per century, the Auger Observatory has created a detection area of 3000 km^2 to be able to record a large number of these events. It is located in the western Mendoza Province, Argentina, near the Andes.

The Pierre Auger Collaboration had shown that the energy spectrum of cosmic rays exhibits a sharp drop around 10^{20} eV.

The Pierre Auger Observatory combines two complementary techniques to measure air showers. On their way through the atmosphere the secondary particles stimulate nitrogen molecules in the air to emit fluorescence light. This light is measured with large telescopes. In addition, secondary particles reaching ground level are registered in an array of particle detectors. The latter are water Cherenkov detectors, measuring the light emitted by relativistic particles passing through a water tank.

The Pierre Auger Collaboration had shown that the energy spectrum of cosmic rays exhibits a sharp drop around 10^{20} eV. This drop is compatible with the Greisen-ZatsepinKuz'min (GZK) cut-off caused by the universe becoming opaque due to resonant collisions between ultra-high-energy protons and the photons of the cosmic microwave 2.7-K background radiation. Past measurements by the Pierre Auger Collaboration already have cast some doubt on this explanation, and this year's results further established that the GZK cut-off cannot be the entire story and even the extent of its contribution to the cut-off remains unclear.

Collisions of ultra-high-energy cosmic rays with atmospheric molecules provide hadronic interactions at an energy that exceeds the LHC centre-of-mass energy by one-to-two orders of magnitude. Although progress was made in incorporating LHC results, some mysteries were not solved. The number of muons in Monte Carlo simulations is very significantly smaller than the number measured in experimental data. Also the depth at which most muons are produced that reach the Earth's surface cannot be described by Monte Carlo simulation for any reasonable composition mix of cosmic rays.

The weak anisotropy signal that remains in the Auger data is affected by cosmic ray masses and charges. Auger data indicate that the most energetic particles are not only protons but mostly heavy, highly-charged, nuclei. These are deflected by cosmic magnetic fields, which makes it difficult to track back to their origin.

To addresses this challenge the Pierre Auger observatory is currently upgrading its detection capabilities. The key element of the upgrade will be the installation of a plastic scintillator on top of each existing surface detector station. It will provide a complementary measurement of the showers allowing the reconstruction of muons and electromagnetic particles. The surface scintillator detector stations (SSD) will be deployed over the full 3,000-km^2 area of the overall surface detector (SD). To enhance the capabilities of the surface detector, especially for composition measurements, it will be equipped with upgraded electronics with a larger sampling rate and a larger dynamic range.

Distributed computing

The SiGNET Tier-2 distributed computing centre with a computing power of 5200 cores and storage capacity of 4000TB continued to provide resources to ATLAS, Belle II and Pierre Auger experiments. The local storage sys-

tem was upgraded with CephFS technology, which delivers much higher throughput and faster data access than the previous NFS-based solution, reaching data-processing rates up to 200TB per day. An automatic execution of payloads within Linux containers has been deployed using Singularity and Docker. This will enable customized operating-system environments to the experiments. Existing LHCONE network bandwidth was frequently reaching the bandwidth saturation in 2016 due to unexpectedly successful LHC operation delivering 50% more data than initially expected, so preparations for the upgrade to 20 Gb/s bandwidth were initiated end of 2016.

As a constitutive member of the Slovenian National Grid Initiative SLING/NGI the site had supported and maintained the Slovenian grid infrastructure together with Arnes. The Slovenian distributed infrastructure incorporates seven clusters from Jožef Stefan Institute, Arnes, Acrtur, University of Nova Gorica, and several others are in the process of joining with a vision to create a powerful distributed computing infrastructure in Slovenia. The SiGNET is a full member of international organizations EGI/InSPIRE, wLCG and Nordugrid and had participated in several joint projects related to the support, maintenance and planning of the computing infrastructure as well as the development, distribution and deployment of the distributed computing infrastructure.

Detector development

We continued the research of particle detectors developed in HV-CMOS technology, which enables cost effective and large series production of sensors. The HV processes allow the connection of a substrate to high voltage, which makes the charge drift the dominant component contributing to the signal. The ability to integrate first amplification and further processing stages in the sensor allows for excellent signal-to-noise ratio and very efficient operation. In 2016 we measured the charge-collection properties of many detectors after irradiations with reactor neutrons and 24-GeV protons. We have systematically determined the changes of space-charge concentration with a fluence for detectors with different substrate resistivities (Fig.4). The measurements included almost all prototype detectors for application at the upgraded LHC.

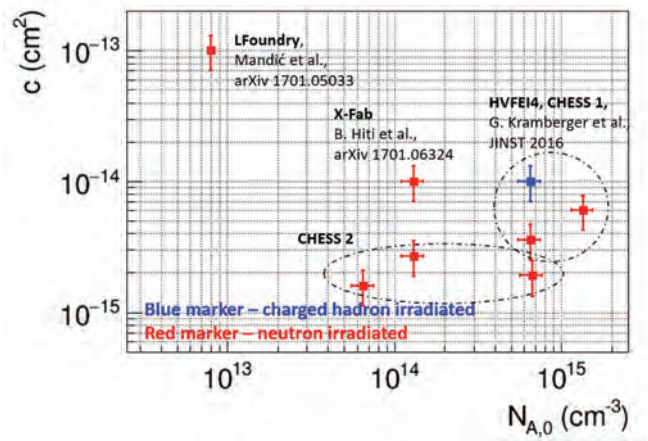


Figure 4: Variation of space charge concentration with fluence for detectors with different substrate resistivities.

In the past year we joined the project that aims at building a High Granularity Timing Detector for ATLAS. We took the leading role in radiation studies of Low Gain Avalanche Detectors (LGAD), which are the baseline choice for the sensor technology. We have determined the dependence of gain on fluence and voltage and showed that for thin LGAD detectors the decrease of gain with voltage can be compensated by higher applied voltage for almost the entire range of expected fluences at HL-LHC. A single sensor (50 μm) time resolutions of 26 ps was achieved before irradiation.

Explorations of diamond detectors lead to first measurements of charge multiplication in diamond particle detectors. We showed that electric fields of 100 V/um were required and could be achieved by special electrode configuration.

A multichannel system for simultaneous readout of different dosimetric sensors was intensively tested. Apart from its use in medical applications the system is used also for precise dosimetric measurement during irradiations at the JSI reactor facility.

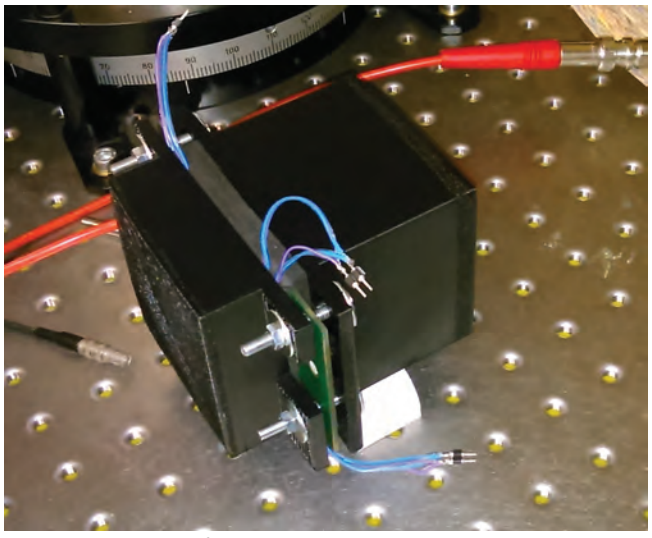


Figure 5: A prototype of annihilation gamma photon detector with improved spatial resolution, based on LYSO crystal matrix segmented to cells with sides of 1.5 mm.

We continued with the development of new methods for the detection of annihilation gamma rays in positron emission tomography (PET), one of the most important medical imaging methods. We have already shown that the difference in the time of flight of the two gamma rays can be measured with a very high precision of 80ps (FWHM) if a Cherenkov radiator is used as a gamma-ray converter instead of a scintillator. With such a resolution, we can directly obtain a three-dimensional information on the emission point of the two gamma rays, which substantially reduces the time needed to determine the activity distribution in the patient. While this first result was achieved with a microchannel plate photomultiplier tube (MCP PMT) as the low level light sensor, we have in 2016 continued with the examination of possibilities offered by silicon photomultipliers (SiPM), compact semiconductor based light sensors that can be operated in high magnetic fields (important for multimodal imaging in combination with MRI), and would be much cheaper. The results are have shown that by using single Cherenkov photon hits, a resolution can be achieved that is better than 200 ps. We have also started to investigate how the resolution could be improved in multi-hit cases.

Within the frame of research of particle physics detectors in medical physics we have performed characterization of low-gain avalanche diodes (LGAD) matrices. The measurements will be used in element selection for suitability study of a Compton camera with LGAD detectors for proton therapy.

We developed a prototype of annihilation gamma photon detector with improved spatial resolution, based on LYSO crystal matrix segmented to cells with sides of 1.5 mm. The prototype is shown in the attached photograph (Fig. 5). Tasks related to LYSO prototype development and evaluation were also performed.

Explorations of diamond detectors led to the first measurements of charge multiplication in diamond particle detectors.

Within the CIMA international collaboration consisting of scientists from Ohio State University (OSU), University of Michigan (UM), University of Valencia and JSI we have continued to evaluate the prototype of a high-resolution PET system with silicon detectors at OSU. We have continued the analysis of recorded images.

Within the framework of the European project AIDA 2020 (Advanced European Infrastructures for Detectors at Accelerators) more than 180 irradiations by neutrons were performed at the reactor centre at the request of 22 different institutions. The focus was on the development of components for planned upgrades of ATLAS, CMS and Belle detectors.

Organization of Conferences, Congresses and Meetings

1. The 9th International Workshop on Ring Imaging Cherenkov Detectors (RICH 2016), Bled, Slovenia, 5 – 9 September 2016
2. 2nd TCT Workshop 2016, Jožef Stefan Institute, Ljubljana, Slovenia, 17 - 18 October 2016

INTERNATIONAL PROJECTS

1. COST TD1401; Fast Advanced Scintillator Timing (FAST)
   Prof. Peter Križan
   Cost Office
2. COST CA16108 - VBSCan; Vector Boson Scattering Coordination and Action Framework
   Prof. Borut Paul Kerševan
   Cost Office
3. H2020 - JENNIFER; Japan and Europe Network for Neutrino and Intensity Frontier Experimental Research
   Prof. Peter Križan
   European Commission
4. H2020 - AIDA-2020; Advanced European Infrastructures for Detectors at Accelerators
   Prof. Marko Mikuž
   European Commission
5. Measurement of Rare Semileptonic B Meson Decays and Construction of Belle II Detector
   Asst. Prof. Anže Zupanc
   Slovenian Research Agency
6. Development of New Detectors for Medical Imaging
   Prof. Marko Mikuž
   Slovenian Research Agency
7. Development of Silicon and Diamond Semiconductor Detectors for Particle Physics Experiments and Medical Imaging
   Prof. Vladimir Cindro
   Slovenian Research Agency
8. Studies of Silicon Detector Properties by Using Transient Current Technique
   Dr. Gregor Kramberger
   Slovenian Research Agency

RESEARCH PROGRAMS

1. Experimental Particle Physics
   Prof. Marko Mikuž
2. Astroparticle Physics
   Prof. Marko Zavrtanik

R & D GRANTS AND CONTRACTS

1. ATLAS Diamond Beam Monitor
   Prof. Marko Mikuž
2. Search for microscopic black hole signatures with ultra-high energy cosmic rays
   Prof. Marko Zavrtanik
3. Novel scintillation detectors for precision particle physics experiments
   Prof. Peter Križan
4. History of Doctoral Dissertations by Slovene Candidates in the Austro Hungarian Empire (18721918)
   Prof. Boštjan Golob
5. Novel detection methods based on Cherenkov radiation
   Prof. Peter Križan
6. Development of in-vivo dosimetry for applications in radiotherapy
   Dr. Gregor Kramberger
7. Collaboration CERN RD-39
   Prof. Marko Mikuž
   Cern
8. Collaboration CERN RD-50
   Prof. Marko Mikuž
   Cern
9. Collaboration DELPHI
   Prof. Borut Paul Kerševan
   Cern
10. Collaboration ATLAS
    Prof. Marko Mikuž
    Cern
11. Collaboration CERN RD-42
    Prof. Marko Mikuž
    Cern
12. Collaborations Belle in Belle II
    Prof. Peter Križan
    Kek - High Energy Accelerator Research
13. Design, Procurement and QA of Flex-rigid Hybrids
    Prof. Marko Mikuž
    European Organization For Nuclear Research
14. Conference „RICH 2016“ - The 9the International Workshop on Ring Imaging Cherenkov Detectors; Bled, Slovenia, 5.-9.9.2016
    Prof. Peter Križan

VISITORS FROM ABROAD

1. Kazuho Kobayashi, University of Nagoya, Nagoya, Japan, 30. 5. – 15. 7. 2016
2. Mosee Mariotti, INFN - Istituto Nazionale di Fisica Nucleare, Padova, Italy, 19. 5. – 20. 5. 2016
3. Riccard Rand, INFN - Istituto Nazionale di Fisica Nucleare, Padova, Italy, 19. 5. – 20. 5. 2016
4. Marko Milovanović, Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany, 20. 6. – 24. 6. 2016
5. Emanuell Callvaro, IFAE - Institute for High Energy Physics, Barcelona, Spain, 13. 6. – 24. 6. 2016
6. Maizura Binti Ibrahim, Waste Technology Development Center (Malaysian Nuclear Agency), Malaysia, 14. 8. – 30. 9. 2016
7. Mario del Mar Carulla iz "Centro Nacional de Microelectrónica (IMB-CNM-CSIC), Univ. Autónoma de Barcelona", Barcelona, Spain, 21. 8. – 13. 9. 2016
8. Sachi Tamechika, Tokyo Metropolitan University, Tokyo, Japan, 30. 9. – 2. 11. 2016
9. Emanuell Callvaro, IFAE - Institute for High Energy Physics, Barcelona, Spain, 16. 10. – 20. 10. 2016
10. Dania Consuegra Rodriguez, master of physics, University of Santa Cruz, Bahia, Brazil, 3. 11. – 31. 12. 2016
11. Marko Milovanović, Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany, 16. – 19. 11. 2016
12. Nataša Savić, Max Planck Institut fur Physick, Munich, Germany, 11. 12. – 15. 12. 2016

STAFF

Researchers

1. Asst. Prof. Marko Bračko*
2. Prof. Vladimir Cindro
3. Prof. Andrej Filipčič
4. Prof. Boštjan Golob*
5. Dr. Andrej Gorišek
6. Prof. Borut Paul Kerševan*
7. Prof. Samo Korpar*
8. Dr. Gregor Kramberger
9. Prof. Peter Križan*
10. Dr. Boštjan Maček
11. Asst. Prof. Igor Mandić
12. **Prof. Marko Mikuž*, Head**
13. Dr. Rok Pestotnik
14. Asst. Prof. Tomaž Podobnik*
15. Prof. Marko Starič
16. Prof. Marko Zavrtanik
17. Prof. Danilo Zavrtanik*
18. Asst. Prof. Anže Zupanc
19. Asst. Prof. Dejan Žontar*

Postdoctoral associates

20. *Dr. Jyoti Prakash Biswal, left 01.11.16*
21. Dr. Andrej Studen

Postgraduates

22. Bojan Hiti, B. Sc.
23. Luka Kanjir, B. Sc.
24. Matic Lubej, B. Sc.
25. Manca Mrvar, B. Sc.
26. Miha Muškinja, B. Sc.
27. Tara Nanut, B. Sc.
28. Tadej Novak, B. Sc.
29. Grygorii Sokhrannyi, B. Sc.
30. Tina Šfiligoj, B. Sc.
31. *Dr. Elvedin Tahirović, left 01.02.16*

Technical and administrative staff

32. Andreja Butina
33. Jurij Eržen
34. Dejan Lesjak
35. Erik Margan

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. AUGER Collaboration, A. Aab *et al.,* "Azimuthal asymmetry in the risetime of the surface detector signals of the Pierre Auger Observatory", *Phys. rev., D*, vol. 93, no. 7, pp. 072006-1-072006-16, 2016.
2. AUGER Collaboration, A. Aab *et al.,* "Energy estimation of cosmic rays with the Engineering Radio Array of the Pierre Auger Observatory", *Phys. rev., D*, vol. 93, iss. 12, pp. 122005-1-122005-15, 2016.
3. AUGER Collaboration, A. Aab *et al.,* "Measurement of the radiation energy in the radio signal of extensive air showers as a universal estimator of cosmic-ray energy", *Phys. rev. lett.*, vol. 116, iss. 24, pp. 241101-1-241101-9, 2016.
4. AUGER Collaboration, A. Aab *et al.,* "Nanosecond-level time synchronization of autonomous radio detector stations for extensive air showers", *Journal of instrumentation*, vol. 11, pp. P01018-0- P01018-31, 2016.
5. AUGER Collaboration, A. Aab *et al.,* "Prototype muon detectors for the AMIGA component of the Pierre Auger Observatory", *Journal of instrumentation*, vol. 11, pp. P02012-0- 02012-26, Feb. 2016.
6. AUGER Collaboration, A. Aab *et al.,* "Search for ultrarelativistic magnetic monopoles with the Pierre Auger Observatory", *Phys. rev., D*, vol. 94, no. 8, pp. 082002-1-082002-12, 2016.
7. AUGER Collaboration, A. Aab *et al.,* "Testing hadronic interactions at ultrahigh energies with air showers measured by the Pierre Auger Observatory", *Phys. rev. lett.*, vol. 117, iss. 19, pp. 192001-1-192001-9, 2016.
8. AUGER Collaboration, A. Aab *et al.,* "Ultrahigh-energy neutrino follow-up of gravitational wave events GW150914 and GW151226 with the Pierre Auger Observatory", *Phys. rev., D*, vol. 94, no. 12, pp. 122007-1-122007-10, 2016.
9. AUGER Collaboration, A. Aab *et al.,* "Evidence for a mixed mass composition at the 'ankle' in the cosmic-ray spectrum", *Phys. lett., Sect. B*, vol. 762, pp. 288-295, Nov. 2016.
10. ATLAS Collaboration, M. Aaboud *et al.,* "Charged-particle distributions at low transverse momentum in $\sqrt{s} = 13$ TeV pp interactions measured with the ATLAS detector at the LHC", *The European physical journal. C*, vol. 76, no. 9, pp. 502-1-502-22, 2016.
11. ATLAS Collaboration, M. Aaboud *et al.,* "Charged-particle distributions in pp interactions at $\sqrt{s} = 8$ TeV measured with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 7, pp. 392-1-392-29, 2016.
12. ATLAS Collaboration, M. Aaboud *et al.,* "Dark matter interpretations of ATLAS searches for the electroweak production of supersymmetric particles in $\sqrt{s} = 8$ TeV proton-proton collisions", *J. high energy phys.*, vol. 2016, no. 9, pp. 175-1-175-43, 2016.
13. ATLAS Collaboration, M. Aaboud *et al.,* "Luminosity determination in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector at the LHC", *The European physical journal. C*, vol. 76, no. 12, pp. 653-1-653-54, 2016.
14. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of W^+W^- production in association with one jet in proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 763, pp. 114-133, 2016.
15. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of exclusive $\gamma\gamma \rightarrow W^+W^-$ production and search for exclusive Higgs boson production in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector", *Phys. rev., D*, vol. 94, issue 3, pp. 032011-1-032011-32, 2016.
16. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of jet activity in top quark events using the $e\mu$ final state with two b-tagged jets in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 9, pp. 074-1-074-61, 2016.
17. ATLAS Collaboration, M. Aaboud *et al.,* "A measurement of material in the ATLAS tracker using secondary hadronic interactions in 7 TeV pp

collisions", *Journal of instrumentation*, vol. 11, pp. P11020-1-P11020-40, 2016.
18. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of the $b\bar{b}$ dijet cross section in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 12, pp. 670-1-670-24, 2016.
19. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of the $W^{\pm}Z$ boson pair-production cross section in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 762, pp. 1-22, 2016.
20. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of the inelastic proton-proton cross section at $\sqrt{s} = 13$ TeV with the ATLAS detector at the LHC", *Phys. rev. lett.*, vol. 117, no. 18, pp. 182002-1-182002-19, 2016.
21. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of the photon identification efficiencies with the ATLAS detector using LHC Run-1 data", *The European physical journal. C*, vol. 76, no. 12, pp. 666-1-666-42, 2016.
22. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of the relative width difference of the $B^0 - \bar{B}^0$ system with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 6, pp. 81-1-81-39, 2016.
23. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of top quark pair differential cross sections in the dilepton channel in pp collisions at $\sqrt{s} = 7$ and 8 TeV with ATLAS", *Phys. rev., D*, vol. 94, no. 9, pp. 092003-1-092003-33, 2016.
24. ATLAS Collaboration, M. Aaboud *et al.,* "Search for bottom squark pair production in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 10, pp. 526-1-526-47, 2016.
25. ATLAS Collaboration, M. Aaboud *et al.,* "Search for bottom squark pair production in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 10, pp. 547-1-547-25, 2016.
26. ATLAS Collaboration, M. Aaboud *et al.,* "Search for dark matter produced in association with a hadronically decaying vector boson in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 763, pp. 251-268, 2016.
27. ATLAS Collaboration, M. Aaboud *et al.,* "Search for Higgs and Z boson becays to $\phi\gamma$ with the ATLAS detector", *Phys. rev. lett.*, vol. 117, no. 11, pp. 111802-1-111802-19970, 2016.
28. ATLAS Collaboration, M. Aaboud *et al.,* "Search for high-mass new phenomena in the dilepton final state using proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 761, pp. 372-392, 2016.
29. ATLAS Collaboration, M. Aaboud *et al.,* "Search for minimal supersymmetric standard model Higgs bosons H/A and for a Z' boson in the $\tau\tau$ final state produced in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 11, pp. 585-1-585-30, 2016.
30. ATLAS Collaboration, M. Aaboud *et al.,* "Search for new phenomena in different-flavour high-mass dilepton final states in pp collisions at $\sqrt{s} =$ 13 Tev with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 10, pp. 541-1-541-28, 2016.
31. ATLAS Collaboration, M. Aaboud *et al.,* "Search for new phenomena in events with a photon and missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 6, pp. 59-1-59-41, 2016.
32. ATLAS Collaboration, M. Aaboud *et al.,* "Search for new phenomena in final states with an energetic jet and large missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV using the ATLAS detector", *Phys. rev., D*, vol. 94, no. 3, pp. 032005-1-032005-32, 2016.
33. ATLAS Collaboration, M. Aaboud *et al.,* "Search for new resonances in events with one lepton and missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 762, pp. 334-352, 2016.
34. ATLAS Collaboration, M. Aaboud *et al.,* "Search for pair production of Higgs bosons in the $b\bar{b}b\bar{b}$ final state using proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. rev., D*, vol. 94, issue 5, pp. 052002-1- 052002-29, 2016.
35. ATLAS Collaboration, M. Aaboud *et al.,* "Search for resonances in diphoton events at $\sqrt{s} = 13$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 9, pp. 001-1-001-49, 2016.
36. ATLAS Collaboration, M. Aaboud *et al.,* "Search for scalar leptoquarks in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS experiment", *New journal of physics*, vol. 18, no. 9, pp. 093016-1-093016-25, 2016.
37. ATLAS Collaboration, M. Aaboud *et al.,* "Search for squarks and gluinos in events with hadronically decaying tau leptons, jets and missing transverse momentum in proton-proton collisions at $\sqrt{s} = 13$ TeV recorded with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 12, pp. 683-1-683-33, 2016.
38. ATLAS Collaboration, M. Aaboud *et al.,* "Search for the Higgs boson produced in association with a W boson and decaying to four b-quarks via two spin-zero particles in pp collisions at 13 TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 11, pp. 605-1-605-31, 2016.
39. ATLAS Collaboration, M. Aaboud *et al.,* "Search for the Standard Model Higgs boson produced by vector-boson fusion and decaying to bottom quarks in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 11, pp. 112-1-112-36, 2016.
40. ATLAS Collaboration, M. Aaboud *et al.,* "Search for top squarks in final states with one isolated lepton, jets, and missing transverse momentum in $\sqrt{s} = 13$ TeV pp collisions with the ATLAS detector", *Phys. rev., D*, vol. 94, no. 5, pp. 052009-1-052009-32, 2016.
41. ATLAS Collaboration, M. Aaboud *et al.,* "Searches for heavy diboson resonances in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 9, pp. 173-1-173-45, 2016.
42. ATLAS Collaboration, M. Aaboud *et al.,* "Study of hard double-parton scattering in four-jet events in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS experiment", *J. high energy phys.*, vol. 2016, no. 11, pp. 110-1-110-51, 2016.
43. ATLAS Collaboration, M. Aaboud *et al.,* "Study of the rare decays of B_s^0 and B^0 into muon pairs from data collected during the LHC Run 1 with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 10, pp. 513-1-513-13, 2016.
44. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of the $t\bar{t}$ production cross-section using $e\mu$ events with b-tagged jets in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 761, pp. 136-157, 2016.
45. ATLAS Collaboration, M. Aaboud *et al.,* "Measurement of the total cross section from elastic scattering in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 761, pp. 158-178, 2016.
46. ATLAS Collaboration, M. Aaboud *et al.,* "Search for charged Higgs bosons produced in association with a top quark and decaying via $H^{\pm} \rightarrow \tau\nu$ using pp collision data recorded at $\sqrt{s} = 13$ TeV by the ATLAS detector", *Phys. lett., Sect. B*, vol. 759, pp. 555-574, 2016.
47. ATLAS Collaboration *et al.,* "Search for heavy long-lived charged R-hadrons with the ATLAS detector in 3.2 fb^{-1} of proton-proton collision data at $\sqrt{s}$ = 13 TeV", *Phys. lett., Sect. B*, vol. 760, pp. 647-665, 2016.
48. ATLAS Collaboration, M. Aaboud *et al.,* "Search for metastable heavy charged particles with large ionization energy loss in pp collisions at $\sqrt{s} = 13$ TeV using the ATLAS experiment", *Phys. rev., D*, vol. 93, no. 11, pp. 112015-1-112015-25, 2016.
49. ATLAS Collaboration, G. Aad *et al.,* "Charged-particle distributions in pp interactions at $\sqrt{s} = 8$ TeV measured with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 7, pp. 403-1-403-32, 2016.
50. ATLAS Collaboration, G. Aad *et al.,* "Charged-particle distributions in $\sqrt{s} = 13$ TeV pp interactions measured with the ATLAS detector at the LHC970", *Phys. lett., Sect. B*, vol. 758, pp. 67-88, 2016.
51. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the angular coefficients in Z-boson events using electron and muon pairs from data taken at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 8, pp. 159-1-159-99, 2016.
52. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the double-differential high-mass Drell-Yan cross section in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 8, pp. 009-1-009-61, 2016.
53. ATLAS Collaboration, G. Aad *et al.,* "Measurements of $Z\gamma$ and $Z\gamma\gamma$ production in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *Phys. rev., D*, vol. 93, no. 11, pp. 112002-1-112002-41, 2016.
54. ATLAS Collaboration, G. Aad *et al.,* "Muon reconstruction performance of the ATLAS detector in proton-proton collision data at $\sqrt{s} = 13$ TeV", *The European physical journal. C*, vol. 76, no. 5, pp. 292-1-292-30, 2016.
55. ATLAS Collaboration, G. Aad *et al.,* "Search for gluinos in events with an isolated lepton, jets and missing transverse momentum at $\sqrt{s} = 13$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 10, pp. 565-1-565-29, 2016.
56. ATLAS Collaboration, G. Aad *et al.,* "Search for pair production of gluinos decaying via stop and sbottom in events with b-jets and large missing transverse momentum in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. rev., D*, vol. 94, no. 3, pp. 032003-1-032003-32, 2016.
57. ATLAS Collaboration, G. Aad *et al.,* "Search for resonances in the mass distribution of jet pairs with one or two jets identified as b-jets in

proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 759, pp. 229-246, 2016.
58. ATLAS Collaboration, G. Aad *et al.,* "Transverse momentum, rapidity, and centrality dependence of inclusive charged-particle production in $\sqrt{S_{NN}} = 5.02$ TeV $p + Pb$ collisions measured by the ATLAS experiment", *Phys. lett., Sect. B*, vol. 763, pp. 313-336, 2016.
59. ATLAS Collaboration, G. Aad *et al.,* "Measurement of $W^{\pm}$ and Z-boson production cross sections in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 759, pp. 601-621, 2016.
60. ATLAS Collaboration, G. Aad *et al.,* "Measurements of the charge asymmetry in top-quark pair production in the dilepton final state at $\sqrt{s} = 8$ TeV with the ATLAS detector", *Phys. rev., D*, vol. 94, no. 3, pp. 032006-1-032006-31, 2016.
61. ATLAS Collaboration, G. Aad *et al.,* "Beam-induced and cosmic-ray backgrounds observed in the ATLAS detector during the LHC 2012 proton-proton running period", *Journal of instrumentation*, vol. 2016, no. 11, pp. P05013-1-P05013-77, 2016.
62. ATLAS Collaboration, G. Aad *et al.,* "Measurement of event-shape observables in $Z \rightarrow \ell^+\ell^-$ events in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector at the LHC", *The European physical journal. C*, vol. 76, no. 7, pp. 375-1-375-40, 2016.
63. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the charged-particle multiplicity inside jets from $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 6, pp. 322-1-322-23, 2016.
64. ATLAS Collaboration, G. Aad *et al.,* "Combination of searches for WW, WZ, and ZZ resonances in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 755, pp. 285-305, 2016.
65. ATLAS Collaboration, G. Aad *et al.,* "Constraints on non-Standard Model Higgs boson interactions in an effective Lagrangian using differential cross sections measured in the $H \rightarrow \gamma\gamma$ decay channel at $\sqrt{=}$ 8 TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 753, pp. 69-85, 2016.
66. ATLAS Collaboration, G. Aad *et al.,* "Dijet production in $\sqrt{s} = 7$ TeV pp collisions with large rapidity gaps at the ATLAS experiment", *Phys. lett., Sect. B*, vol. 754, pp. 214-234, 2016.
67. ATLAS Collaboration, G. Aad *et al.,* "Evidence for single top-quark production in the s-channel in proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector using the Matrix Element Method", *Phys. lett., Sect. B*, vol. 756, pp. 228-246, 2016.
68. ATLAS Collaboration, G. Aad *et al.,* "Identification of boosted, hadronically decaying W bosons and comparisons with ATLAS data taken at $\sqrt{s} = 8$ TeV", *The European physical journal. C*, vol. 76, no. 3, pp. 154-1-154-47, 2016.
69. ATLAS Collaboration, G. Aad *et al.,* "Identification of high transverse momentum top quarks in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 6, pp. 93-1-93-81, 2016.
70. ATLAS Collaboration, G. Aad *et al.,* "Measurement of $D^{*\pm}$, $D^{\pm}$ and $D_s^{\pm}$ meson production cross sections in pp collisions at $\sqrt{=}$ 7 TeV with the ATLAS detector", *Nucl. phys, Sect. B*, vol. 907, pp. 717-763, 2016.
71. ATLAS Collaboration, G. Aad *et al.,* "Measurement of fiducial differential cross sections of gluon-fusion production of Higgs bosons decaying to $WW^* \rightarrow e\nu\mu\nu$ with the ATLAS detector at $\sqrt{s} = 8$ TeV", *J. high energy phys.*, vol. 2016, no. 8, pp. 104-1-104-63, 2016.
72. ATLAS Collaboration, G. Aad *et al.,* "Measurement of jet charge in dijet events from $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector", *Phys. rev., D*, vol. 93, no. 5, pp. 052003-1-052003-35, 2016.
73. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the ZZ production cross section in pp collisions at $sqrts = 13$ TeV with the ATLAS detector", *Phys. rev. lett.*, vol. 116, no. 10, pp. 101801 -1-101801-19, 2016.
74. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the branching ratio $\Gamma(\lambda_b^0 \rightarrow \phi(2S)\lambda^0/\Gamma(\lambda_b^0 \rightarrow J/\psi\lambda^0)$ with the ATLAS detector", *Phys. lett., Sect. B*, vol. 751, pp. 63-80, 2016.
75. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the charge asymmetry in highly boosted top-quark pair production in $\sqrt{s} = 8$ TeV pp collision data collected by the ATLAS experiment", *Phys. lett., Sect. B*, vol. 756, pp. 52-71, 2016.
76. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the charge asymmetry in top-quark pair production in the lepton-plus-jets final state in pp collision data at $\sqrt{s} = 8$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 2, pp. 87-1-87-30, 2016.
77. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the correlation between the polar angles of leptons from top quark decays in the helicity basis at $\sqrt{s} = 7$ TeV using the ATLAS detector", *Phys. rev., D*, vol. 93, no. 1, pp. 012002-1-012002-23, 2016.
78. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the CP-violating phase ϕ_s and the B_s^0 meson decay width difference with $B_0 \rightarrow J/\psi\phi$ decays in ATLAS", *J. high energy phys.*, vol. 2016, no. 8, pp. 147-1-147-44, 2016.
79. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the dependence of transverse energy production at large pseudorapidity on the hard-scattering kinematics of proton-proton collisions at $\sqrt{s} = 2.76$ TeV with ATLAS", *Phys. lett., Sect. B*, vol. 756, pp. 10-28, 2016.
80. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the differential cross-section of highly boosted top quarks as a function of their transverse momentum in $\sqrt{s} = 8$ TeV proton-proton collisions using the ATLAS detector", *Phys. rev., D*, vol. 93, no. 3, pp. 032009-1- 032009-34, 2016.
81. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the differential cross-sections of prompt and non-prompt production of J/ψ and $\psi(2S)$ in pp collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 5, pp. 283-1-283-47, 2016.
82. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the production cross-section of a single top quark in association with a W boson at 8 TeV with the ATLAS experiment", *J. high energy phys.*, vol. 2016, no. 1, pp. 64-1-64-48, 2016.
83. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the transverse momentum and ϕ_η^* distributions of Drell-Yan lepton pairs in proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 5, pp. 291-1-291-61, 2016.
84. ATLAS Collaboration, G. Aad *et al.,* "Measurement of total and differential W^+W^- production cross sections in proton-proton collision at $\sqrt{s} = 8$ TeV with the ATLAS detector and limits on anomalous triple-gauge-boson coupling", *J. high energy phys.*, vol. 2016, no. 9, pp. 029-1-029-79, 2016.
85. ATLAS Collaboration, G. Aad *et al.,* "Measurements of $W^{\pm}Z$ production cross sections in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector and limits on anomalous gauge boson self-couplings", *Phys. rev., D*, vol. 93, no. 9, pp. 092004-1- 092004-36, 2016.
86. ATLAS Collaboration, G. Aad *et al.,* "Measurements of fiducial cross-sections for $t\bar{t}$ production with one or two additional b-jets in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector", *The European physical journal. C*, vol. 76, issue 1, pp. 11-1-11-37, 2016.
87. ATLAS Collaboration, G. Aad *et al.,* "Measurements of four-lepton production in pp collisions at $\sqrt{=}$ 8 TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 753, pp. 552-572, 2016.
88. ATLAS Collaboration, G. Aad *et al.,* "Measurements of the Higgs boson production and decay rates and constraints on its couplings from a combined ATLAS and CMS analysis of the LHC pp collision data at $\sqrt{s} =$ 7 and 8 TeV", *J. high energy phys.*, vol. 2016, no. 8, pp. 045-1-045-113, 2016.
89. ATLAS Collaboration, G. Aad *et al.,* "Measurements of top-quark pair differential cross-sections in the lepton+jets channel in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector", *The European physical journal. C*, vol. 76, no. 10, pp. 538-1-538-39, 2016.
90. ATLAS Collaboration, G. Aad *et al.,* "A new method to distinguish hadronically decaying boosted Z bosons from W bosons using the ATLAS detector", *The European physical journal. C*, vol. 76, no. 5, pp. 238-1-238-33, 2016.
91. ATLAS Collaboration, G. Aad *et al.,* "Observation of long-range elliptic azimuthal anisotropies in $\sqrt{s} = 13$ and 2.76 TeV pp collisions with the ATLAS detector", *Phys. rev. lett.*, vol. 116, no. 17, pp. 172301-1- 172301-20, 2016.
92. ATLAS Collaboration, G. Aad *et al.,* "Performance of b-jet identification in the ATLAS experiment", *Journal of instrumentation*, vol. 2016, no. 11, pp. P04008-1- P04008-123, 2016.
93. ATLAS Collaboration, G. Aad *et al.,* "Probing lepton flavour violation via neutrinoless $\tau \rightarrow 3\mu$ decays with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 5, pp. 232-1-232-25, 2016.
94. ATLAS Collaboration, G. Aad *et al.,* "Reconstruction of hadronic decay products of τ leptons with the ATLAS experiment", *The European physical journal. C*, vol. 76, no. 5, pp. 295-1-295-26, 2016.
95. ATLAS Collaboration, G. Aad *et al.,* "Search for a high-mass Higgs boson decaying to a W boson pair in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detecto", *J. high energy phys.*, vol. 2016, no. 1, pp. 32-1-32-66, 2016.
96. ATLAS Collaboration, G. Aad *et al.,* "Search for an additional, heavy Higgs boson in the $H \rightarrow ZZ$ decay channel at $\sqrt{s} = 8$ TeV in pp collision data with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 1, pp. 45-1-45-42, 2016.

97. ATLAS Collaboration, G. Aad *et al.,* "A search for an excited muon decaying to a muon and two jets in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *New journal of physics*, vol. 18, no. 7, pp. 073021-1-073021-21, 2016.
98. ATLAS Collaboration, G. Aad *et al.,* "Search for anomalous couplings in the Wtb vertex from the measurement of double differential angular decay rates of single top quarks produced in the t-channel with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 4, pp. 23-1-23-46, 2016.
99. ATLAS Collaboration, G. Aad *et al.,* "Search for charged Higgs bosons in the $H^{\pm} \rightarrow tb$ decay channel in pp collisions at $\sqrt{s} = 8$ TeV using the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 4, pp. 127-1-127-48, 2016.
100. ATLAS Collaboration, G. Aad *et al.,* "Search for dark matter produced in association with a Higgs boson decaying to two bottom quarks in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detecto", *Phys. rev., D*, vol. 93, no. 7, pp. 072007-072007-33, 2016.
101. ATLAS Collaboration, G. Aad *et al.,* "Search for direct top squark pair production in final states with two tau leptons in pp collisions at $\sqrt{s} =$ 8 TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 2, pp. 81-1-81-30, 2016.
102. ATLAS Collaboration, G. Aad *et al.,* "Search for flavour-changing neutral current top-quark decays to qZ in pp collision data collected with the ATLAS detector at $\sqrt{s} = 8$ TeV", *The European physical journal. C*, vol. 76, issue 1, pp. 12-1-12-24, 2016.
103. ATLAS Collaboration, G. Aad *et al.,* "Search for invisible decays of a Higgs boson using vector-boson fusion in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 1, pp. 172-1-172-44, 2016.
104. ATLAS Collaboration, G. Aad *et al.,* "Search for magnetic monopoles and stable particles with high electric charges in 8 TeV pp collisions with the ATLAS detector", *Phys. rev., D*, vol. 93, no. 5, pp. 052009-1-052009-25, 2016.
105. ATLAS Collaboration, G. Aad *et al.,* "Search for new phenomena in dijet mass and angular distributions from pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *Phys. lett., Sect. B*, vol. 754, pp. 302-322, 2016.
106. ATLAS Collaboration, G. Aad *et al.,* "Search for new phenomena in events with at least three photons collected in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 4, pp. 210-1-210-26, 2016.
107. ATLAS Collaboration, G. Aad *et al.,* "Search for new phenomena in final states with large jet multiplicities and missing transverse momentum with ATLAS using $\sqrt{s} = 13$ TeV proton-proton collisions", *Phys. lett., Sect. B*, vol. 757, pp. 334-355, 2016.
108. ATLAS Collaboration, G. Aad *et al.,* "Search for new phenomena with photon+jet events in proton-proton collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 3, pp. 041-1-041-37, 2016.
109. ATLAS Collaboration, G. Aad *et al.,* "A search for prompt lepton-jets in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 2, pp. 062-1-061-51, 2016.
110. ATLAS Collaboration, G. Aad *et al.,* "A search for prompt lepton-jets in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 3, pp. 026-1-026-38, 2016.
111. ATLAS Collaboration, G. Aad *et al.,* "Search for single production of a vector-like quark via a heavy gluon in the 4b final state with the ATLAS detector in pp collisions at $\sqrt{8}$ TeV", *Phys. lett., Sect. B*, vol. 758, pp. 294-268, 2016.
112. ATLAS Collaboration, G. Aad *et al.,* "Search for single production of vector-like quarks decaying into Wb in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 8, pp. 442-1-442-26, 2016.
113. ATLAS Collaboration, G. Aad *et al.,* "Search for single top-quark production via flavour-changing neutral currents at 8 TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 2, pp. 55-1-55-30, 2016.
114. ATLAS Collaboration, G. Aad *et al.,* "Search for supersymmetry at $\sqrt{s} =$ 13 TeV in final states with jets and two same-sign leptons or three leptons with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 5, pp. 259-1-259-26, 2016.
115. ATLAS Collaboration, G. Aad *et al.,* "Search for the electroweak production of supersymmetric particles in $\sqrt{s} = 8$ TeV pp collisions with the ATLAS detector", *Phys. rev., D*, vol. 93, no. 5, pp. 052002-1-052002-50, 2016.
116. ATLAS Collaboration, G. Aad *et al.,* "Search for the production of single vector-like and excited quarks in the Wt final state in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 2, pp. 110-1-110-46, 2016.
117. ATLAS Collaboration, G. Aad *et al.,* "Search for the Standard Model Higgs boson decaying into $b\bar{b}$ produced in association with top quarks decaying hadronically in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *J. high energy phys.*, vol. 2016, no. 5, pp. 160-1-160-51, 2016.
118. ATLAS Collaboration, G. Aad *et al.,* "Search for the standard model Higgs boson produced in association with a vector boson and decaying into a tau pair in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *Phys. rev., D*, vol. 93, no. 9, pp. 092005-1-092005-25, 2016.
119. ATLAS Collaboration, G. Aad *et al.,* "A search for top squarks with R-parity-violating decays to all-hadronic final states with the ATLAS detector in $\sqrt{s} = 8$ TeV proton-proton collisions", *J. high energy phys.*, vol. 2016, no. 6, pp. 67-1-67-69, 2016.
120. ATLAS Collaboration, G. Aad *et al.,* "Searches for scalar leptoquarks in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, issue 1, pp. 5-1-5-28, 2016.
121. ATLAS Collaboration, G. Aad *et al.,* "Test of CP invariance in vector-boson fusion production of the Higgs boson using the *Optimal Observable method in the ditau decay channel with the ATLAS detector", The European physical journal. C, vol. 76, no. 12, pp. 658-1-658-25, 2016.*
122. ATLAS Collaboration, G. Aad *et al.,* "Centrality, rapidity, and transverse momentum dependence of isolated prompt photon production in lead-lead collisions at $\sqrt{s_{NN}} = 2.76$ TeV measured with the ATLAS detector", *Phys. rev., C*, vol. 93, no. 3, pp. 034914-1-034914-28, 2016.
123. ATLAS Collaboration, G. Aad *et al.,* "Measurement of the centrality dependence of the charged-particle pseudorapidity distribution in proton-lead collisions at $\sqrt{s_{NN}} = 5.02$ TeV with the ATLAS detector", *The European physical journal. C*, vol. 76, no. 4, pp. 199-1-199-30, 2016.
124. ATLAS Collaboration, G. Aad *et al.,* "Measurements of the Higgs boson production and decay rates and coupling strengths using pp collision data at $\sqrt{s} = 7$ and 8 TeV in the ATLAS experiment", *The European physical journal. C*, vol. 76, issue 1, pp. 6-1-6-51, 2016.
125. ATLAS Collaboration, G. Aad *et al.,* "Study of the $B_c^+ \rightarrow J/\psi D_s^+$ and $B_c^+ \rightarrow J/\psi D_s^{*+}$ decays with the ATLAS detector", *The European physical journal. C*, vol. 76, issue 1, pp. 4-1-4-24, 2016.
126. The IceCube, Pierre Auger and Telescope Array collaborations, M. G. Aartsen *et al.,* "Search for correlations between the arrival directions of IceCube neutrino events and ultrahigh-energy cosmic rays detected by the Pierre Auger Observatory and the Telescope Array", *Journal of cosmology and astroparticle physics*, vol. 2016, pp. 1-33, Jan. 2016.
127. A. Affolder *et al.* (55 authors), "Charge collection studies in irradiated HV-CMOS particle detectors", *Journal of instrumentation*, vol. 11, pp. P04007-1-P04007-15, 2016.
128. Belle Collaboration, V. Bhardwaj *et al.,* "Inclusive and exclusive measurements of B decays to χ_{c1} and χ_{c2} at Belle", *Phys. rev., D*, vol. 93, no. 5, pp. 052016-1-052016-13, 2016.
129. K. Brzeziński *et al.* (11 authors), "Experimental evaluation of the resolution improvement provided by a silicon PET probe", *Journal of instrumentation*, vol. 11, pp. P09016-1-P09016-11, 2016.
130. Belle Collaboration, V. Chobanova *et al.,* "First observation of the decay $B^0 \rightarrow \psi(2S)\pi^0$", *Phys. rev., D*, vol. 93, no. 3, pp. 031101-1-031101-7, 2016.
131. Nina Djurić, Janez Podobnik, Dejan Žontar, "Protokol preverjanja kakovosti za magnetno resonančni tomograf", *Bilten*, vol. 33, no. 2, pp. 4-13, 2016.
132. Belle Collaboration, A. Garmash *et al.,* "Observation of $Z_b(10610)$ and $Z_b(10650)$ decaying to B mesons", *Phys. rev. lett.*, vol. 116, no. 21, pp. 212001-1-212001-7, 2016.
133. Belle Collaboration, R. Glattauer *et al.,* "Measurement of the decay $B \rightarrow D\ell\nu_\ell$ in fully reconstructed events and determination of the Cabibbo-Kobayashi-Maskawa matrix element $|V_{cb}|$", *Phys. rev., D*, vol. 93, no. 3, pp. 032006-1-032006-14, 2016.
134. Belle Collaboration, P. Hamer *et al.,* "Search for $B^0 \rightarrow \pi^-\tau^+\nu_\tau$ with hadronic tagging at Belle", *Phys. rev., D*, vol. 93, no. 3, pp. 032007-1-032007-10, 2016.
135. S. Iwata *et al.* (20 authors), "Particle identification performance of the prototype aerogel RICH counter for the Belle II experiment", *Prog. theor. exp. phys.*, vol. 2016, art. no. 033H01, 16 pp., 2016.
136. Belle Collaboration, Z. King *et al.,* "Search for the decay $B^0 \rightarrow \phi\gamma$", *Phys. rev., D*, vol. 93, no. 11, pp. 111101-1-111101-6, 2016.
137. Belle Collaboration, M. Masuda *et al.,* "Study of π^0 pair production in single-tag two-photon collisions", *Phys. rev., D*, vol. 93, no. 3, pp. 032003-1-032003-34, 2016.
138. Belle Collaboration, K. Negishi *et al.,* "First model-independent Dalitz analysis of $B^0 \rightarrow DK^{*0}$, $D \rightarrow K_S^0\pi^+\pi^-$ decay", *Prog. theor. exp. phys.*, vol. 2016, pp. 043C01-1-043C01-16, 2016.

139. Belle Collaboration, N. K. Nisar *et al.,* "Search for the rare decay $D^0 \to \gamma\gamma$ at Belle", *Phys. rev., D*, vol. 93, iss. 5, pp. 051102-1-051102-7, 2016.
140. Belle Collaboration, B. Pal *et al.,* "Observation of the decay $B_s^0 \to K^0\overline{K}^0$", *Phys. rev. lett.*, vol. 116, no. 16, pp. 161801-1-161801-6, 2016.
141. Belle Collaboration, D. Santel *et al.,* "Measurements of the $\Upsilon(10860)$ and $\Upsilon(11020)$ resonances via $\sigma(e^+e^- \to \Upsilon(nS)\pi^+\pi^-)$", *Phys. rev., D*, vol. 93, no. 1, pp. 011101-1-011101-6, 2016.
142. Belle Collaboration, Y. Sato *et al.,* "Measurement of the lepton forward-backward asymmetry in $B \to X_s\ell^+\ell^-$ decays with a sum of exclusive modes", *Phys. rev., D*, vol. 93, no. 3, pp. 032008-1-032008-11, 2016.
143. Belle Collaboration, C. P. Shen *et al.,* "First observation of $\gamma\gamma \to p\bar{p}K^+K^-$ and search for exotic baryons in pK systems", *Phys. rev., D*, vol. 93, no. 11, pp. 112017-1-112017-9, 2016.
144. Belle Collaboration, Marko Starič *et al.,* "Improved measurement of $D^0 - \overline{D}^0$ mixing and search for CP violation in $D^0 \to K^+K^-, \pi^+\pi^-$ decays with the full Belle data set", *Phys. lett., Sect. B*, vol. 753, pp. 412-418, 2016.
145. Igor Šabič, Damjana Ključevšek, Martin Thaler, Dejan Žontar, "The effect of anti-scatter grid on radiation dose in chest radiography in children", *Pedijatr Danas*, vol. 12, no. 1, pp. 75-80, 2016.
146. Belle Collaboration, P. Vanhoefer *et al.,* "Study of $B^0 \to \rho^+\rho^-$ decays and implications for the CKM angle ϕ_2", *Phys. rev., D*, vol. 93, iss. 3, pp. 032010-1-032010-20, 2016.
147. Belle Collaboration, Shi-Bing Yang *et al.,* "First observation of doubly Cabibbo-suppressed decay of a charmed baryon: $\Lambda_c^+ \to pK^+\pi^-$", *Phys. rev. lett.*, vol. 117, no. 1, pp. 011801-1-011801-6, 2016.

Published Conference Contribution (invited lecture)

1. AUGER Collaboration, Darko Veberič *et al.,* "Measurement of the muon content in air showers at the Pierre Auger Observatory", In: *XLV International Symposium on Multiparticle Dynamics (ISMD 2015), Munich, Germany, October 4-9, 2015*, (EPJ web of conferences, vol. 120), pp. 04004-1-04004-6.

Published Conference Contribution

1. M. Artuso *et al.* (128 authors), "A 3D diamond detector for particle tracking", In: *Frontier Detectors for Frontier Physics*: Proceedings of the 13th Pisa Meeting on Advanced Detectors, La Biodola, Isola d'Elba, May 24–30, 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 824, pp. 402-405, 2016.
2. Andrej Gorišek, Vladimir Cindro, Gregor Kramberger, Igor Mandić, Marko Mikuž, Miha Muškinja, Marko Zavrtanik, "The edge transient-current technique (E-TCT) with high energy hadron beam", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831, pp. 250-253, 2016.
3. Borut Grošičar, Gregor Črv, Vladimir Cindro, Kice Krsteski, "Embedded tehnologija v bivalnem prostoru", In: *Zbornik recenziranih znanstvenih prispevkov*, (Ventil, Posebna številka, 2016, okt.), pp. 133-137.
4. Borut Grošičar, Tomaž Kompara, Vladimir Cindro, Jose Bernabeu Verdu, "Integracija elementov na osnovi poliamida in alu substrata CCL v bivanjsko okolje", In: *Zbornik recenziranih znanstvenih prispevkov*, (Ventil, Posebna številka, 2016, okt.), pp. 123-128.
5. K. Hara *et al.* (101 authors), "Charge collection and field profile studies of heavily irradiated strip sensors for the ATLAS inner tracker upgrade", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831, pp. 181-188, 2016.
6. L. B. A. Hommels *et al.* (106 authors), "Detailed studies of full-size ATLAS12 sensors", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831,pp. 167-173, 2016.
7. B. T. Huffman *et al.* (59 authors), "Radiation hardness of two CMOS prototypes for the ATLAS HL-LHC upgrade project", In: *Topical Workshop on Electronics for Particle Physics, September 2015 to 2 October 2015 Lisbon, Portugal*, (Journal of instrumentation, vol. 11, 2016), pp. C02005-1-C02005-10.
8. Z. Liang *et al.* (58 authors), "Study of built-in amplifier performance on HV-CMOS sensor for the ATLAS phase-II strip tracker upgrade", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831, pp. 156-160, 2016.
9. M. Mikestikova *et al.* (97 authors), "Study of surface properties of ATLAS12 strip sensors and their radiation resistance", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831, pp. 197-206, 2016.
10. Aleš Moljk, Marko Mikuž, Jose Bernabeu Verdu, "Gibka vezja in ogrevalni sistemi za uporabo v objektih", In: *Zbornik recenziranih znanstvenih prispevkov*, (Ventil, Posebna številka, 2016, okt.), pp. 129-132.
11. R. Mori *et al.* (106 authors), "Evaluation of the performance of irradiated silicon strip sensors for the forward detector of the ATLAS Inner Tracker Upgrade", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831, pp. 207-212, 2016.
12. Hartmut F.-W. Sadrozinski *et al.* (33 authors), "Ultra-fast silicon detectors (UFSD)", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831, pp. 18-23, 2016.
13. Miguel Ullan *et al.* (99 authors), "Embedded pitchadapters: a high-yield interconnection solution for strip sensors", In: *Proceedings of the 10th International "Hiroshima" Symposium on the Development and Application of Semiconductor Tracking Detectors*, Xi'an, China, 25–29 September 2015, *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 831, pp. 221-228, 2016.

Mentoring

1. Jyoti Prakash Biswal, *Measurement of $c\bar{c}c\bar{c}$ production in e^+e^- annihilation:* doctoral dissertation, Ljubljana, 2016 (mentor Marko Bračko).
2. Elvedin Tahirović, *Aerogel ring imaging Cherenkov detector with silicon photomultipliers:* doctoral dissertation, Ljubljana, 2016 (mentor Rok Pestotnik).
3. Barbara Krašovec, *Distributed computing as a service with ARC middleware:* master's thesis, Ljubljana, 2016 (mentor Mojca Ciglarič; co-mentor Andrej Filipčič).
4. Miha Kovačič, *Retrospective analysis of the ferquency and severity of radiation-induced skin injuries from interventional radiology procedures:* master's thesis, Ljubljana, 2016 (mentor Dejan Žontar; co-mentor Nejc Mekiš).
5. Martin Lozar, *Sistem za verzioniranje dokumentov:* master's thesis, Nova Gorica, 2016 (mentor Andrej Filipčič).
6. Anže Medved, *Karakterizacija čitalne elektronike za detektor obročev Čerenkova pri Belle II:* master's thesis, Ljubljana, 2016 (mentor Rok Pestotnik).
7. Tadej Novak, *Zaznavanje nabitih delcev s pasovnimi silicijevimi detektorji pri preletu pod velikimi koti:* master's thesis, Ljubljana, 2016 (mentor Marko Mikuž; co-mentor Gregor Kramberger).
8. Nina Verdel, *Silicijeva fotopomnoževalka kot senzor svetlobe Čerenkova pri pozitronski tomografiji:* master's thesis, Ljubljana, 2016 (mentor Peter Križan; co-mentor Rok Dolenec).

DEPARTMENT OF INORGANIC CHEMISTRY AND TECHNOLOGY K-1

The Department of Inorganic Chemistry and Technology is one of the leading groups in the world for the synthesis of new inorganic compounds containing fluorine. The main research fields are: the synthesis of new coordination compounds with different ligands, the chemistry of noble gases, the chemistry of elements of the main groups and the synthesis of new inorganic materials with special properties. A great deal of the activity of the group has been devoted to technological, ecological and safety problems in Slovenia. The group has already been cooperating closely with Slovenian industry for more than 30 years. It is also active in the field of education and in the field of the promotion of natural sciences among students at colleges and elementary schools.

Head:
Asst. Prof. Gašper Tavčar

The structural chemistry of inorganic fluorides is dominated by the simple electrostatic and geometrical principles for which the coordination number of six with an octahedral coordination is favoured for nearly all transition metals. Instead of being isolated, the resulting octahedra can share their F ligands, forming oligomeric or polymeric species. The crystal-structure determination of $[XeF_5]_5[Ti_{10}F_{45}]$ reveals the largest known oligomeric fluorido-metallate $[Ti_{10}F_{45}]^{5-}$ anion built from ten TiF_6 octahedra, sharing vertices, in the shape of a double-star. The study of the XeF_6/TiF_4 system has been reported by Z. Mazej and E. Goreshnik (JSI) in New J. Chem. The contribution was selected for the inside-front cover of the September issue. Additional studies were also made with group-12 metal cations and the TaF_5 Lewis acid. Reactions in a 1:2 ratio yielded $M(TaF_6)_2$ compounds, while excess of TaF_5 led to the formation of undecafluoridoditantalate anions connecting metal cations into a 1D structure.

New fluorinating reagent, based on the N-heterocyclic carbine, was synthesized.

Within the research of nanostructured metal fluorides, the course of solvothermal processes under different temperature regimes was followed on a modified device for the preparation of these materials. The established methodology provides a better insight into the development of the morphology of the primary fluoride nanoparticles during processing, which is the basis for the further development and optimization of these synthetic procedures.

In the research of solid acids based on $H_3(P(W_3O_{10})_4)$, a series of solid products was prepared by a partial or complete replacement of H^+ in the original heteropolyacid with some metal cations (eg. Zn^{2+}, Al^{3+} or Ga^{3+}), and their acidity was studied. These materials can serve as perspective (super)acidic catalysts for the technically interesting conversion of methane into higher hydrocarbons. This research is conducted in collaboration with the National Institute of Chemistry.

In cooperation with the K5 and K9 departments and other research institutions, we have studied domain-wall conduction in ferroelectric $BiFeO_3$ controlled by the accumulation of charged defects and published the results in Nature Materials.

The search for a nucleophilic fluorinating agent in an organic solvent led to reactions of N-heterocyclic carbene (1,3-Bis(2,6-diisopropylphenyl)-1,3-dihydro-2H-imidazol-2-ylidene; (L^{Dipp})) with different sources of hydrofluoric acid ($Et_3N{\cdot}3HF$, anhydrous hydrogen fluoride and KHF_2) in 1:1, 1:2, 1:3 ratios. Isolated salts $[(L^{Dipp})H]^+[F]^-$, $[(L^{Dipp})H]^+[(HF)F]^-$ and $[(L^{Dipp})H]^+[(HF)_2F]^-$ show such possibilities. $[(L^{Dipp})H]^+[F]^-$, which shows the characteristics of a free fluoride reagent, can be obtained with a good yield and without the contaminants usually present in such compounds.

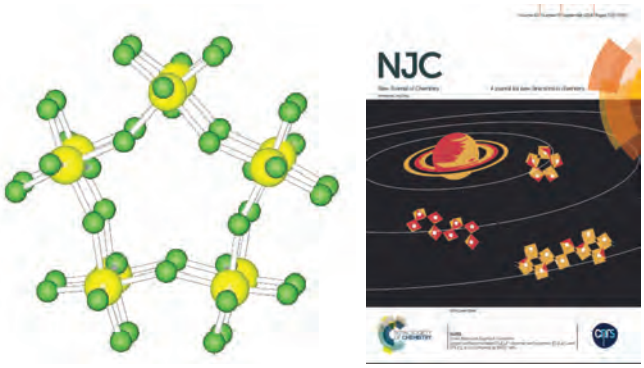


Figure 1: a.) the largest known discrete decameric $[Ti_{10}F_{45}]^{5-}$ anion built from ten TiF_6 octahedra, sharing vertices, in the shape of a double-star. b.) Inside cover of the New Journal of Chemistry issue 9, 2016 (cover designed by M. Mazej)

In 2016 the direct synthesis of copper compounds was performed. Dissolving elemental copper in a CBr_4-DMSO mixture in the presence of hexamethylenetetramine (*hex*) resulted in the formation of $CuBr(hex)_2$ and $Cu(DMSO)_6{\cdot}Cu_4Br_6$ compounds. Using *dabco* (1,4-diaza- bicyclo [2.2.2] octane) instead of *hex* $[Cu^I(\mu\text{-}Br)_2(H^+dabco)Cu^I(\mu\text{-}Br)(\kappa S\text{-}DMSO)]_n$ compound was obtained. The comproportionation reaction of $CuCl_2{\cdot}2H_2O$ and copper powder in the presence of *dabco* in DMSO results in the formation of the $Cu_3Cl_3(dabco)(DMSO)$ complex. All the mentioned complexes were characterized by the X-ray single-crystal technique and by Raman spectroscopy.

The new composite materials (MoS_2/C) containing MoS_2 particles embedded in a carbon matrix were synthesized in a single-step process by sulphidation of the $MoO_2(AcAc)_2$ (AcAc = acetylacetonato) coordination compound. The

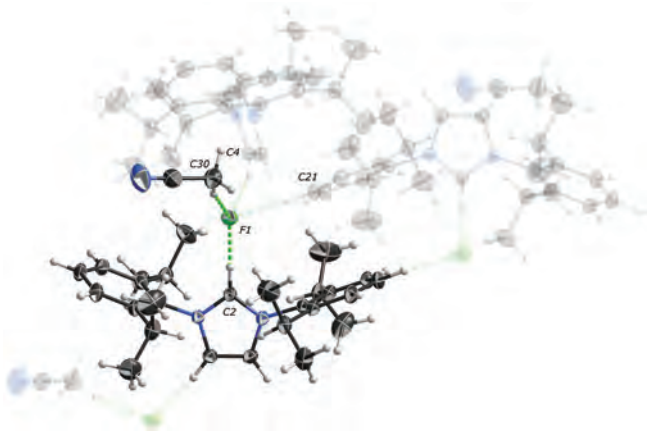


Figure 2: Structure of the [(LDipp)H]+[F]-

lower temperature MoS_2/C composites exhibit a higher activity compared to the commercial MoS_2 powder in hydrodeoxygenation reactions.

The composition dependence of radio-frequency plasma polymerized toluene on a composition of starting plasma gases toluene and ammonia was studied by vibrational spectroscopy and contact-angle measurements. The plasma-polymerized surfaces where the ammonia concentration in the plasma gas varied between 10 % to 50 % exhibit very similar surface properties, which was revealed by the contact angles appearing in the range from 95.4 to 98.9 degrees.

Within the topic of the process safety, we concluded the EU 7th FP project TOSCA (Total Operations Management for Safety Critical Activities) in which we participated as a partner. The project was dealing with the integration of the individual management aspects industrial operations as a total safety, quality and productivity management system (at the company level). In this year we concluded the reporting about the implementation, testing and evaluation of the efficiency of TOSCA products (methods and tools) in 12 case studies, where we contributed as a lead author in four papers in recognized scientific journals. Partners, industrial stakeholders and reviewers positively evaluated the proposed project solutions, tools and methods, for example, related to the management of safety-relevant changes in organizations, planning of rare potentially hazardous work procedures, as well as modelling of hazardous material releases in complex conditions.

Technical leadership of the international consortium for the large audit of the process safety management system at a client from the oil and gas industry outside Slovenia.

In this year we took a technical lead of an international consortium for consultation project for industrial client outside Slovenia. More specifically, it was about the initial audit of the process safety management system within the rather large organization in the oil and gas industry. The work done was the basis for setting the priorities for the safety management system improvements in 2017 and beyond.

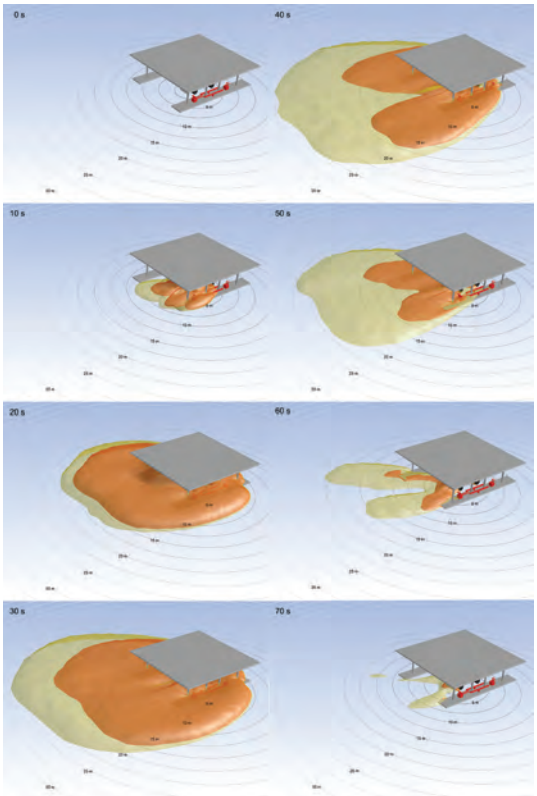


Figure 3: Results from the CFD simulation of propane jet release, impingement and dispersion under the roof - cloud shape animation based on time. Orange and yellow colours represent LFL and LFL/2 propane concentrations in the air, respectively.

In this year, we were in the end-user platform of the EU 7FP project EDEN (End User Driven Demo for CBRNe) which started in September 2013 and ended this year. In the project, which dealt with the assessment and preparedness for terrorist risks (aspect of security), we participated on the basis of our previous experiences in the assessment of such threats to industrial operations.

A supermonitoring of guarantee measurements of the Flue Gas Desulphurization Plant of unit 6 in the Šoštanj Thermal Power Plant in collaboration with partners was conducted. In collaboration with the Materials Synthesis department the dissolution mechanism of upconverting AYF4:Yb,Tm (A = Na or K) nanoparticles in aqueous media was suggested. Degradation of NaYF4:Yb,Tm-based upconversion nanoparticles in phosphate buffered saline solution was studied and the luminescence lifetime of the 800-nm upconversion emission was identified as an optimum parameter for stability screening of and monitoring of changes in particle surface chemistry. We continued with writing review articles for Structural Chemistry journal; to a short summary of each article, a thermochemical comment and suggestions for future research are added.

The activity in the field of education and the promotion of sciences should be mentioned. Members of the department were actively engaged in the work of the Jožef Stefan International Postgraduate School as lecturers and as mentors to M.Sc. and Ph.D. students. In addition, the School of Experimental Chemistry maintained its very important relations with elementary, secondary schools and even kindergartens through experimental courses performed in a specialised laboratory or through direct demonstrations at the schools. With demonstrations of chemical experiments, we participated at the 22th Slovenian Science Festival, organized by the Slovenian Science Foundation and at the Hokus pokus and Lupa festival. Some of the activities of the School of the experimental chemistry were carried out within the project, which is funded by the JSI and the City of Ljubljana.

Some outstanding publications in the past year

1. Zoran Mazej, Evgeny A. Goreshnik, Largest perfluorometallate $[Ti_{10}F_{45}]^{5-}$ oligomer and polymeric $([Ti_3F_{13}]^-)_\infty$ and $([TiF_5]^-)_\infty$ anions prepared as $[XeF_5]^+$ salts, *New J. Chem.* 40, (2016) 7320-7325.

2. Tadej Rojac, Andreja Benčan, Goran Dražić, Naonori Sakamoto, Hana Uršič, Boštjan Jančar, Gašper Tavčar, Maja Makarovič, Julian Walker, Barbara Malič, Dragan Damjanović, Domain-wall conduction in ferroelectric $BiFeO_3$ controlled by accumulation of charged defects", *Nature materials*, (2016) 7 , [in press]
3. Dominik Kurzydłowski, Tomasz Jaroń, Andrzej Ozarowski, Stephen Hill, Zvonko Jagličić, Yaroslav Filinchuk, Zoran Mazej, Wojciech Grochala, Local and cooperative Jahn-Teller effect and resultant magnetic properties of M_2AgF_4 (M = Na-Cs) phases, *Inorg. Chem.*, 55 (2016) 11479-11489.
4. Blaž Alič, Gašper Tavčar, "Reaction of N-heterocyclic carbene (NHC) with different HF sources and ratios: a free fluoride reagent based on imidazolium fluoride", *J. Fluorine Chem.*, 192 (2016) 141-146.
5. Marko Gerbec, "Safety change management - a new method for integrated management of organizational and technical changes", *Saf. sci.*, (2016) 10 [in press]
6. Matic Lozinšek, Gary J. Schrobilgen, "The world of krypton revisited", *Nature Chem. (Print)*, 8 (2016) 732.

Patent granted

1. Andrej Kovič, Adolf Jesih, Aleš Mrzel, Process for the synthesis of the molybdenum carbide in the form of quasi-one-dimensional structures, that is, nano-wires, micro-wires, nano-strips and micro-strips, SI24925 (A), Slovenian Intellectual Property Office , 31. 08. 2016.

INTERNATIONAL PROJECTS

1. Export of the Fluorinated Carbons
   Dr. Zoran Mazej
2. Extraction of Tantalum and Niobium from Ores
   Asst. Prof. Gašper Tavčar
   Prg Ltd.
3. 7FP - TOSCA; Total Operations Management for Safety Critical Activities
   Asst. Prof. Marko Gerbec
   European Commission
4. 7FP - FluoCoorChem; Fluorinated Weakly Coordinating Anions for Coordination Chemistry of Unusual Ligands
   Dr. Matic Lozinšek
   European Commission

R & D GRANTS AND CONTRACTS

1. Direct Conversion of Methane to Higher Hydrocarbons Using Superacid Catalysts
   Asst. Prof. Gašper Tavčar
2. Implementation of Process Safety Management System (PSMS) into NIS j.s.c.
   Asst. Prof. Marko Gerbec
   European Virtual Institute For Integrated Risk

NEW CONTRACT

1. A supermonitoring of the guarantee measurements of the Flue Gas Desulphurization Plant of unit 6 of the Šoštanj Thermal Power Plant
   Prof. Maja Ponikvar-svet
   Teš d. o. o.

RESEARCH PROGRAM

1. Inorganic Chemistry and Technology
   Asst. Prof. Gašper Tavčar

VISITORS FROM ABROAD

1. Prof. dr. Wojciech Grochala, Working visit, University of Warsaw, Warsaw, Poland, 7.10. – 11.10. 2016
2. Kristiina Penttila, Sanna Holappa, Working visit, Raahen ammattiopisto, Raahe, Finland, 7.6. – 9.6. 2016
3. Estela Herbst, Student exchange, Universidade Federal de São Paulo, São Paulo, Brazil, 10.8. – 10.10. 2016

STAFF

Researchers
1. Asst. Prof. Marko Gerbec
2. Asst. Prof. Evgeny Goreshnik
3. Dr. Adolf Jesih
4. Asst. Prof. Robert Kocjančič
5. Dr. Zoran Mazej
6. Prof. Maja Ponikvar-Svet
7. Asst. Prof. Tomaž Skapin
8. **Asst. Prof. Gašper Tavčar, Head**
9. Dr. Melita Tramšek

Postdoctoral associates
10. Dr. Matic Lozinšek

Postgraduates
11. Blaž Alič, B. Sc.
12. David Levovnik, B. Sc.
13. Dona Pavlović, B. Sc.
14. *Dr. Igor Shlyapnikov, left 30.03.16*
15. Žiga Zupanek, B. Sc.

Technical officers
16. Peter Frkal, B. Sc.
17. Tine Oblak, M. Sc.
18. Tomaž Ogrin, M. Sc.

Technical and administrative staff
19. Pero Kolobarić
20. Robert Moravec
21. Mira Zupančič

BIBLIOGRAPHY

Original Article

1. Blaž Alič, Gašper Tavčar, "Reaction of N-heterocyclic carbene (NHC) with different HF sources and ratios: a free fluoride reagent based on imidazolium fluoride", *J. fluorine chem.*, vol. 192, part A, pp. 141-146, 2016.
2. Ermira Begu, Yaroslav Shlyapnikov, Andrej Stergaršek, Peter Frkal, Jože Kotnik, Milena Horvat, "A method for semi-continuous measurement of dissolved elemental mercury in industrial and natural waters", *Int. j. environ. anal. chem.*, vol. 96, iss. 7, pp. 609-626, 2016.
3. Tomasz Gilewski, Piotr J. Leszczyński, Armand Budzianowski, Zoran Mazej, Adam Grzelak, Tomasz Jaroń, Wojciech Grochala, "$Ag_2S_2O_8$ meets $AgSO_4$: the second example of metal-ligand redox isomerism among inorganic systems", *Dalton trans. (2003)*, vol. 45, issue 45, pp. 18202-18207, 2016.
4. Evgeny A. Goreshnik, Gleb Veryasov, D. I. Morozov, Yurii Slyvka, Bogdan Ardan, Marian G. Mys'kiv, "Solvated copper(I) hexafluorosilicate π-complexes based on $[Cu_2(amtd)_2]^{2+}$ (amtd = 2-allylamino-5-methyl-1,3,4-thiadiazole) dimer", *J. organomet. chem.*, vol. 810, pp. 1-11, 2016.
5. Dominik Kurzydłowski, Mariana Derzsi, Zoran Mazej, Wojciech Grochala, "Crystal, electronic, and magnetic structures of M_2AgF_4 (M = Na-Cs) phases as viewed from the DFT+U method", *Dalton trans. (2003)*, vol. 45, no. 41, pp. 16255-16261, 2016.
6. Dominik Kurzydłowski, Tomasz Jaroń, Andrzej Ozarowski, Stephen Hill, Zvonko Jagličić, Yaroslav Filinchuk, Zoran Mazej, Wojciech Grochala, "Local and cooperative Jahn-Teller effect and resultant magnetic properties of M_2AgF_4 (M = Na-Cs) phases", *Inorg. chem.*, vol. 55, no. 21, pp. 11479-11489, 2016.
7. Darja Lisjak, Olivija Plohl, Janja Vidmar, Boris Majaron, Maja Ponikvar-Svet, "Dissolution mechanism of upconverting AYF_4: Yb, Tm (A = Na or K) nanoparticles in aqueous media", *Langmuir*, vol. 32, no. 32, pp. 8222-8229, 2016.
8. Zoran Mazej, Evgeny A. Goreshnik, "Influence of the increasing size of the M^{2+} cation on the crystal structures of $XeF_5M(SbF_6)_3$ (M = Ni, Mg, Cu, Zn, Co, Mn, Pd) and $(XeF_5)_3[Hg(HF)_2(SbF_6)_7]$", *European Journal of Inorganic Chemistry*, vol. 2016, no. 20, pp. 3356-3364, 2016.
9. Zoran Mazej, Evgeny A. Goreshnik, "Largest perfluorometallate $[Ti_{10}F_{45}]^{5-}$ oligomer and polymeric $([Ti_3F_{13}]^-)_\infty$ and $([TiF_5]^-)_\infty$ anions prepared as $[XeF_5]^+$ salts", *New j. chem. (1987)*, vol. 40, nol. 9, pp. 7320-7325, 2016.
10. Mykhaylo Monchak, Evgeny A. Goreshnik, Marian G. Mys'kiv, "Synthesis and crystal structure of N,N'-diallyl-N,N,N',N'-tetramethylethylenediammonium ($dalltmen^{2+}$) compounds: $(dalltmen)(ClO_4)_2$ and the copper(I) nitrate π-complex $[(dalltmen)_{0.5}Cu(NO_3)_2]$", *Chem. met. alloys*, vol. 9, pp. 90-97, 2016.
11. Marijan Nečemer, Marko Gerbec, "Automated preparation of water samples for low-level gamma spectrometry", *Acta chim. slov. (Print ed.)*, vol. 63, no. 1, pp. 204-212, 2016.
12. Piotr Połczyński, Tomasz Gilewski, Jakub Gawranczyński, Mariana Derzsi, Piotr J. Leszczyński, Wojciech Gadomski, Zoran Mazej, Rafał Jurczakowski, Wojciech Grochala, "Efficient electrosynthesis of $Ag^{II}SO_4$: a powerful oxidizer and narrow band gap semiconductor", *European Journal of Inorganic Chemistry*, vol. 2016, no. 35, pp. 5401-5404, 2016.
13. Yurii Slyvka, Evgeny A. Goreshnik, Marian G. Mys'kiv, "Diverse coordination of CuX (X = Cl, Br) towards N-allylbenzotriazole", *Chem. met. alloys*, vol. 9, pp. 61-65, 2016.
14. Yurii Slyvka, Evgeny A. Goreshnik, Nazariy Pokhodylo, O. V. Pavlyuk, Marian G. Mys'kiv, "Two related copper(I) [pi]-complexes based on 2-allyl-5-(2-pyridyl)-2H-tetrazole ligand: synthesis and structure of $[Cu(2-apyt)NO_3]$ and $[Cu(2-apyt)(H_2O)](BF_4)$ compound", *Acta chim. slov. (Print ed.)*, vol. 63, no 2, pp. 399-405, 2016.
15. Gašper Tavčar, Evgeny A. Goreshnik, "One dimensional group 12 metal undecafluoridoditantalates", *J. fluorine chem.*, vol. 189, pp. 33-38, 2016.
16. Melita Tramšek, Evgeny A. Goreshnik, Gašper Tavčar, "Oxidation of ruthenium and iridium metal by XeF_2 and crystal structure determination of $[Xe_2F_3][RuF_6] \cdot XeF_2$ and $[Xe_2F_3][MF_6]$(M = Ru, Ir)", *Acta chim. slov. (Print ed.)*, vol. 63, no. 2, pp. 369-375, 2016.

Review Article

1. Maja Ponikvar-Svet, Joel F. Liebman, "Interplay of thermochemistry and Structural Chemistry, the journal (Volume 26, 2015, issues 3-4) and the discipline", *Struct. chem.*, vol. 27, no. 6, pp. 1869-1878, 2016.
2. Maja Ponikvar-Svet, Diana D. Zeiger, Joel F. Liebman, "Interplay of thermochemistry and Structural Chemistry, the journal (Volume 26, 2015, Issues 1-2) and the discipline", *Struct. chem.*, vol. 27, no. 3, pp. 1017-1026, 2016.

Short Article

1. Matic Lozinšek, Gary J. Schrobilgen, "The world of krypton revisited", *Nat. chem.*, vol. 8, no. 7, pp. 732, 2016.

Published Conference Contribution

1. M. Pontiggia, Marko Gerbec, J. Sužnik, M. Sbaouni, R. Lelong, "CFD simulation of a time varying release of LPG in geometrical complex environment", In: *Risk, reliability and safety: innovating theory and practice: 26th European Safety and Reliability Conference, ESREL 2016, September 25th-29th 2016, Glasgow, UK*, pp. 181-186.

Independent Component Part or a Chapter in a Monograph

1. Zoran Mazej, Dominik Kurzydłowski, Wojciech Grochala, "Unique silver(II) fluorides: the emerging electronic and magnetic materials", In: *Photonic and electronic properties of fluoride materials*, (Progress in fluorine science series), Alain Tressaud, ed., Kenneth Poeppelmeier, ed., Amsterdam, Oxford, Cambridge, Elsevier, 2016, pp. 231-260.

Patent

1. Andrej Kovič, Adolf Jesih, Aleš Mrzel, *Process for the synthesis of the molybdenum carbide in the form of quasi-one-dimensional structures, that is, nano-wires, micro-wires, nano-strips and micro-strips,* SI24925 (A), Urad RS za intelektualno lastnino, 31. 08. 2016.

Mentoring

1. Igor Shlyapnikov, *Increasing dimensionality of hybrid and alkali metal fluoridotitanates(IV):* doctoral dissertation, Ljubljana, 2016 (mentor Zoran Mazej).

DEPARTMENT OF PHYSICAL AND ORGANIC CHEMISTRY K-3

The basic research of the department is focused on the experimental and theoretical study of various physico-chemical processes at surfaces and in atmospheric chemistry. The main attention in the field of organic chemistry is directed to green chemical approach to transformation of organic compounds.

Head:
Prof. Ingrid Milošev

Experimental research in the field of electrochemistry is oriented to the protection of biomedical materials and modern types of corrosion protection for technological materials.

Our investigations were focused on the functional protection of biomedical materials, titanium-based and cobalt-chromium alloys, used for temporary bone and dental implants. The synthesis of fluoroapatite (FA) and fluorohydroxyapatite (FHA) was followed by *in situ* FTIR to determine the mechanism of sol formation. The initial triethyl phosphite precursor was hydrolyzed to phosphate after the addition of ammonium fluoride and calcium nitrate. Following the addition of calcium nitrate, the process proceeded at a higher temperature and a slightly alkaline pH to achieve the formation of the final sols. Depending on the amount of ammonium fluoride added, fluoroapatite or fluorohydroxyapatite sol gels resulted. Both types of coating were macroscopically dense and uniform, consisting of nano-sized particles. The microstructures of both FHA and FA coatings are the same as that for hexagonal calcium phosphate fluoride, as shown by X-ray diffraction. Both fluoroapatite and fluorohydroxyapatite coatings performed better than an uncoated CoCrMo substrate in Fusayama artificial saliva that simulates dental applications. The coatings exhibit the hydrophilic behaviour that is recommended for osteoblast differentiation in tissue engineering. The present work demonstrates the possibility of applying fluoroapatite and fluorohydroxyapatite coatings to a CoCrMo substrate, thus increasing the functional ability of the substrate for osseointegration.

Sol-gel routes were demonstrated as desirable routes for tailoring materials with functional properties suitable for biomedical materials: corrosion protection, osseointegration ability and antibacterial properties.

Another paper is focused on the elaboration of ZrO_2 films on pure zirconium via anodizing in phosphoric acid with and without fluoride at constant potentials of 30 V and 60 V. The structure and composition of the films were investigated using scanning electron microscopy, Raman spectroscopy and X-ray photoelectron spectroscopy. The composition of the oxides formed at both potentials can be identified as monoclinic ZrO_2. In addition to Zr and O, layers formed in phosphoric acid contain phosphorus originating from phosphoric acid. When the phosphoric acid solution contains NaF, fluorine is also incorporated in the oxide layer. Anodized samples exhibit smaller current densities during anodic polarization in artificial saliva compared to the as-received zirconium covered with *native* oxide. The surface treatment achieved by anodizing Zr at 60 V in the mixture of phosphoric acid and NaF seems to be the most promising from the point of view of corrosion behaviour. Further studies regarding the bioactivity of this alloy with the optimal surface treatment should be conducted.

Sol-gel TiO_2 and Ag-TiO_2 coatings were synthesized and deposited on a titanium substrate by spin-coating in order to increase the functionality of the surface for biomedical applications. Synthesis under acidic conditions using $TiCl_4$, HCl and H_2O_2 resulted in the formation of TiO_2 with predominantly rutile microstructure according to the X-ray diffraction data. Its morphology is homogeneous and dense. The addition of $AgNO_3$ to the synthesis route results in the formation of Ag-TiO_2. Spherical particles are nano-sized and present throughout the coating surface. The silver particles shift the absorption of TiO_2 to the visible region, as shown by UV/Vis spectroscopy. This eliminates the need for the UV illumination of TiO_2 in order to activate its antibacterial ability.

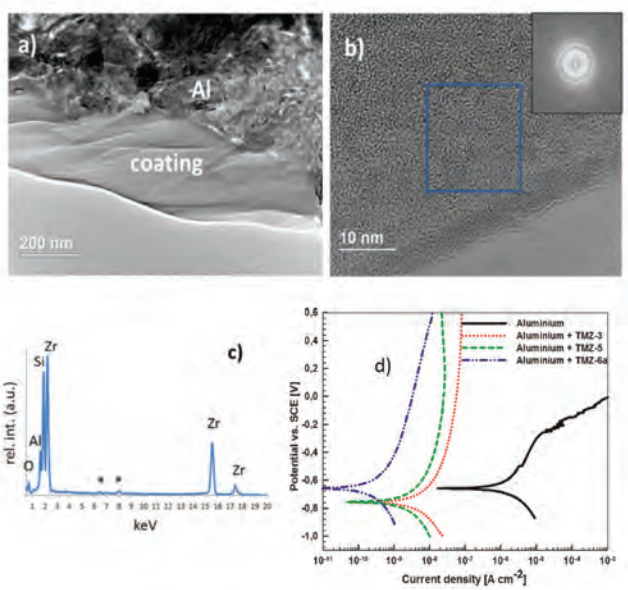


Figure 1: (a) Bright-field transmission electron micrograph (BF-TEM) of TMZ-6a hybrid amorphous sol-gel coating on aluminium, (b) high-resolution TEM micrograph of coating with the corresponding Fast Fourier Transform (FFT) the marked region, (c) TEM - EDXS (Energy-dispersive X-ray spectroscopy) pattern obtained from the coating, peaks denoted by * are due to TEM holder, (d) potentiodynamic polarization curves measured in simulated aircraft conditions (Harrison`s solution, 0.35% $(NH_4)_2SO_4$ + 0.05% NaCl) for uncoated aluminium and aluminium coated with TMZ-3, TMZ-5 and TMZ-6a coatings. dE/dt = 1 mV/s.*

Electrochemical polarization measurements of deposited coatings in simulated physiological solution confirm their protective properties, which are reflected in a larger polarization resistance and a smaller corrosion current density compared to uncoated titanium. The presence of Ag can be detected electrochemically by the peak at 0.11 V *vs*. Ag/AgCl electrode. This peak disappears after prolonged immersion (120 h), indicating the release of silver particles. The latter process does not affect the structural or protective properties of TiO_2 coatings, which retain a highly protective ability with resistance values in the MΩ cm^2 range, as confirmed by polarization and electrochemical impedance measurements. The antibacterial properties of deposited coatings were investigated in the presence of *Pseudomonas aeruginosa*, a biofilm forming bacteria. The adhesion of bacteria is reduced on coated titanium in comparison to uncoated substrate. Although the difference was not statistically significant, the imaging of bacteria after exposure to coated surfaces clearly shows the destruction of the 'sbacteria shape and leaching of the cell interior. Therefore, the coatings, especially those containing silver particles, express antibacterial ability that is mainly related to morphological changes and destruction of bacteria cells. The presence of silver in TiO_2 coatings prepared in this work is not cytotoxic to human osteoblastoma cells. The presented coatings offer the potential for use in biomedical applications.

Cerium acetate salt is a suitable corrosion inhibitor for aluminium alloys, not only because its inhibitor efficiency, but also its ability to re-passivate and self-heal surface defects during immersion in chloride solution.

In the area of technological materials we were concentrated primarily on alloys based on aluminium. Aluminium alloys are widely used in different industries and are one of most important materials today, especially in transportation industry due to the need to reduce vehicle weight and, consequently, to reduce the fuel consumption. Traditional ways of corrosion protection of aluminium alloys, i.e., chromate coatings, are not applicable due to ecological restrictions. In the last decade numerous alternatives are being explored, among which the most important are sol-gel coatings, conversion coatings and inorganic and organic inhibitors. In our laboratory all alternatives are being investigated and even combined with each other, i.e., sol-gel and inhibitors, in order to achieve not only a barrier type of protection but active protection, aiming to self-heal the corrosion damage at the surface. We were particularly successful in the development of hybrid sol-gel coatings comprising tetraethyl orthosilicate (TEOS), 3-(trimethoxysilyl)propyl methacrylate (MAPTMS) and zirconium(IV) propoxide (ZTP). The contents of ZTP and methacrylic acid (MAA) have an important influence on the ageing process, which was studied using dynamic light scattering. Sols with smaller amounts of MAA and ZTP stabilized more slowly, which was more suitable for subsequent deposition. Coatings are amorphous, as shown by transmission electron microscopy. Thus, the synthesis leads to the incorporation of zirconium into an inorganic-organic silicon oxide matrix and not to the formation of ZrO_2 nanoparticles. The hydrophobic character of the coating increases with increasing molar content of ZTP and MAA. Two-component sol-gel synthesis thus enables a relatively simple procedure for the production of hybrid coatings with properties that can be tailored depending on the composition of the sol and conditions of ageing and curing. The obtained properties, amorphous structure, homogeneity and low wettability are the basis for their use in corrosion protection, which was tested under simulating aircraft conditions.

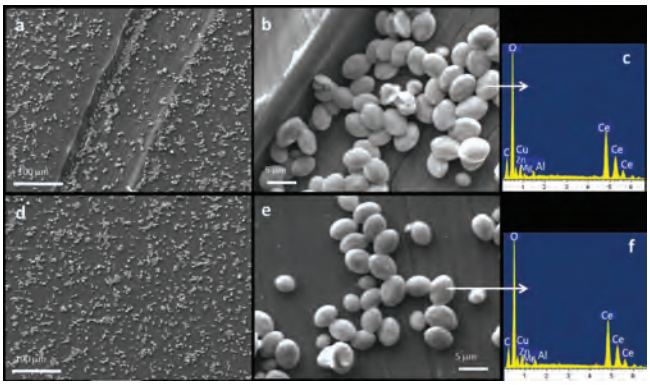


Figure 2: Scanning electron microscopy/energy-dispersive X-ray spectroscopy (SEM/EDS) analysis of the aluminium alloy 7075-T6 surface after 72 h scratch immersion test in 0.1-M NaCl containing 3 mM $Ce(Ac)_3$. The samples were immersed for 24 h, scratched using a ceramic knife, and immersed for another 48 h. (a) SEM low secondary-electron image at the scratch, (b) SEM compositional mode image and (c) EDS spectrum of the surface within the scratch showing deposits of cerium oxide, and (d) and (e) SEM low secondary-electron image of the surface away from the scratch at (d) high and (e) low magnification showing deposits of cerium oxide, as shown by (f) EDS spectrum.

Another alternative to chromate coatings are rare-earth salts (cerium and lanthanum) used either as corrosion inhibitors added to solution or as conversion coatings. When added as inhibitors, the inhibitory actions on Al, AA2024-T3 and AA7075-T6 of various cerium salts, Ce(III) chloride, Ce(III) nitrate, Ce(III) acetate and Ce(IV) sulphate, in 0.1 M NaCl were compared. Although in all cases protection is achieved by the deposition of cerium hydroxide on cathodic sites, the course of inhibition is dependent on the type of anion and on the substrate, i.e., the composition of intermetallic particles in the alloy. The inhibitory action of all cerium(III) salts was the greatest on AA7075-T6, followed by Al, and the smallest on AA2024-T3. The reason for this is interpreted in terms of the different compositions of intermetallic particles in the particular alloy and of the dependence of corrosion protection on the type of anion and pH. The addition of the same concentration of different cerium(III) salts leads to different pHs, consequently affecting the stability, not only of the intermetallic particles, but also of the surrounding aluminium oxide matrix. Ce(III) acetate was the most effective inhibitor for all three materials studied, followed by Ce(III) nitrate and chlo-

We demonstrated that the surprising counter-intuitive attractive lateral interactions between negatively charged O adatoms on Al surfaces are a consequence of an electrostatic stabilization that stems from an interplay between ionic interactions and geometric effects.

ride. This is reflected, not only in the increase in polarization resistance and decrease in corrosion current density, but also in the increase in resistance to pit nucleation. Long-term immersion testing confirmed the good corrosion-inhibition properties. Even after 2 months corrosion products were not formed, in contrast to uninhibited samples in which corrosion products were observed after 3 h. Cerium acetate is thus established as the best corrosion inhibitor for AA7075-T6 in a chloride medium, not only because of its good inhibition effectiveness but also because of its low price and lack of toxicity. Moreover, it enables the re-passivation of the surface defects, which was not observed in the case of cerium chloride.

In 2016 we started to work on the project COR_ID within M-ERA.NET (European Research Area, an EU funded network). The main aim of the project "**Design of corrosion resistant coatings targeted for versatile applications**" (acronym COR_ID) is to design and engineer new coatings for aluminium alloys with targeted properties of increased corrosion resistance, specific hydrophobic properties, prolonged service life-time and reduced ecological impact. Industry-driven needs will be solved using an integrated computational materials engineering (ICME) approach and produce economic material benefiting with increased market competitiveness. The project consortium, coordinated by Prof. Ingrid Milošev, comprises researchers from Slovenia, France and Hungary: Department of Physical and Organic Chemistry of the Jožef Stefan Institute, Talum d.d. Kidričevo (partner mag. Dejan Lorber), Chimie ParisTech (CNRS) from Paris (partner Prof. Philippe Marcus) and Eötvös Loránd University from Budapest (partner Prof. József Rábai). The project consortium links scientists from three partner countries and one technological company (Talum Kidričevo d.d.) aiming to stimulate advances in basic and applied research and technology transfer.

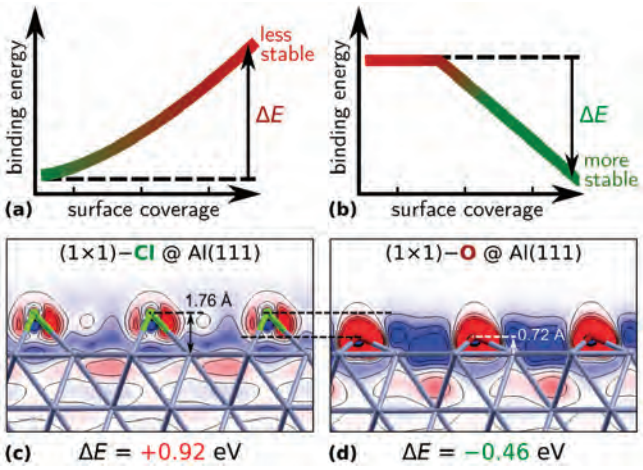


Figure 3: (a) Typical dependence of adatom binding energy on the surface coverage, i.e., the adatom–surface binding becomes less stable as the coverage increases due to repulsive lateral interactions between the adatoms; such a dependence is exhibited by Cl on Al(111). In contrast, for O adatoms on Al surfaces the opposite occurs and the lateral interactions between adatoms are attractive; the corresponding anomalous dependence of binding energy on the coverage is shown in (b). (Bottom) Charge density difference for Cl (left, c) and O (right, d) adatoms on Al(111) at high coverage. The blue colour represents the electron deficit regions, while the electron excess regions are coloured in red.

For the past several years we have studied by means of first principle density-functional-theory (DFT) based computer modelling the interaction of several azole type corrosion inhibitors with reduced and oxidized surfaces of copper and to a smaller extent with reduced surfaces of iron. Our principal aim is to better understand how organic corrosion inhibitors act against corrosion at the molecular level and to discern the fundamental principles that govern their corrosion-inhibition characteristics. Recently, we also started to model the oxidation of aluminium surfaces. The oxidation of a metal generally begins with the dissociation of a molecular oxidizing agent. For oxidizing agents, such as O_2, this initially results in chemisorbed oxygen adatoms. It is known that during the adsorption of electronegative atoms on a more electropositive metal surface, charge transfer occurs and adatoms become negatively charged, typically resulting in repulsive lateral interactions. However, in the case of O on Al surfaces the opposite occurs and the lateral interactions between adatoms are attractive. Although this O/Al anomaly has been noticed, no sound explanation as to why this occurs has been given in the literature. We demonstrated that the surprising counter-intuitive attractive lateral interactions between negatively charged oxygen adatoms on Al surfaces are a consequence of an electrostatic stabilization that stems from an interplay between ionic interactions and geometric effects. Namely, for the high-coverage (1×1) overlayer the positive charge of surface Al ions is considerably larger compared to lower coverage situations, which strengthens the O–Al bonds. However, to take advantage of this effect, the adatoms have to be located close enough to the surface, i.e., there exists a critical adatom height above the surface, below which the lateral interactions are attractive and above which they are repulsive (see Figure 3). There is nothing specific to O and Al in this explanation and our calculations suggest that the model should be generally applicable, provided that (i) the adsorption bonding is sufficiently ionic and (ii) adatoms are sufficiently small to come close enough to the metal surface.

The direct hydrogen abstraction from the HOSO radical by NO_2 becomes barrier-less already in the presence of a single water molecule. The process is spontaneous and very feasible under tropospheric conditions, as well as at the combustion temperatures.

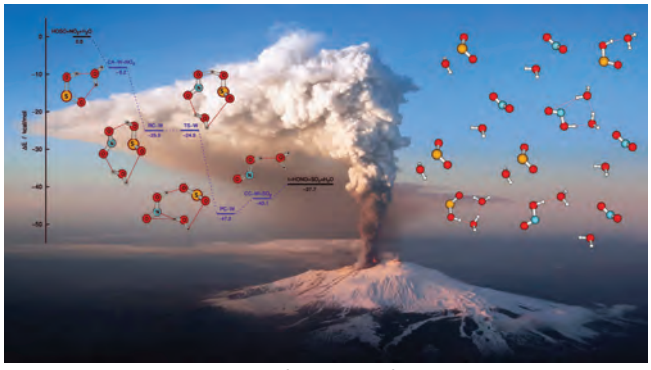


Figure 4: Water-mediated transformation of HOSO radical to HONO radical.

In the field of atmospheric chemistry the effect of water molecules on the direct hydrogen abstraction from HOSO by NO_2 were investigated. The potential energy surface for naked reaction and for one or two water molecules catalysed reactions are qualitatively identical but shifted to more

negative energies. The results demonstrate that the barrier for the direct hydrogen abstraction is low and the barrier for the one water-catalysed reaction decreases practically to zero. The second water molecules have no further effect either on the barrier height nor on the mechanism, thus, already in the presence of a single water molecule the hydrogen abstraction process becomes barrier-less. The process is spontaneous and very feasible under atmospheric conditions as well as at the combustion temperatures.

Seven new masked analogues of phosphopantothenate, suitable for an evaluation of their potential ability to restore intracellular coenzyme A (CoA) levels, were successfully synthesized in good-to-moderate yields.

Subsequent studies on the thermodynamic parameters for the deactivation of HOSO radical and its complexes with water and formic acid molecules in the reactions with the hydrogen atoms and the hydroxy radicals have shown that the complex transformations into the final products are less exothermic compared to the deactivation of the free radical. On the other hand, the Gibbs free energy changes remain almost the same due to the increased entropy contributions.

In the framework of Laboratory for Organic and Bioorganic Chemistry we continued the investigation on the application of principles of green chemistry to the transformations of organic compounds.

The new method for direct preparation of vicinal halohidrines or vicinal halo methoxy alkanes from tertiary phenyl substituted alcohols bearing at least one vicinal proton using N-halosuccinimides in aqueous or methanolic reaction media was developed.

We have continued the development of the new method of cross-coupling reaction between benzyl alcohols and phenyl-substituted alkenes catalysed by molecular iodine under solvent-free reaction conditions. The scope of the transformation resulting in the formation of 1-pnenyl-2-benzylalkenes was comprehensively tested on a variety of benzyl alcohols and few examples of convenient alkenes.

Two new methods for the aerobic oxidation of alcohols have been discovered, tested and evaluated using fluoro alcohols as template catalysts. Primary benzyl alcohols we selectively and efficiently transformed to aldehydes using the new reaction system *oxygen/(cat)HNO_3/1,1,1,3,3,3-heksafluoropropan-2-ol (HFIP, solvent and template catalyst).* Oxygen has the role of the terminal oxidant, HNO_3 is the oxidant and the source of nitrogen oxides, while the activation of the system was obtained by HFIP, which acts as a template catalyst and the reaction media. Its activation is high enough that no additional co-catalysis using metal ions or TEMPO derivatives was necessary. Secondary alcohols were selectively oxidised into ketones with no reaction on the primary alcohol group. Reactions were performed at room temperature with excellent yields. The oxidation of alcohols was catalysed by inexpensive and easily available $FeCl_3$ and HNO_3. As the terminal oxidant O_2 was used. 1,1,1,3,3,3-heksafluoropropan-2-ol (HFIP) has a dual role as it works as a solvent as well as a template catalyst. HFIP can be easily recovered under reduced pressure. An explanation of the mechanism is proposed (Figure 5).

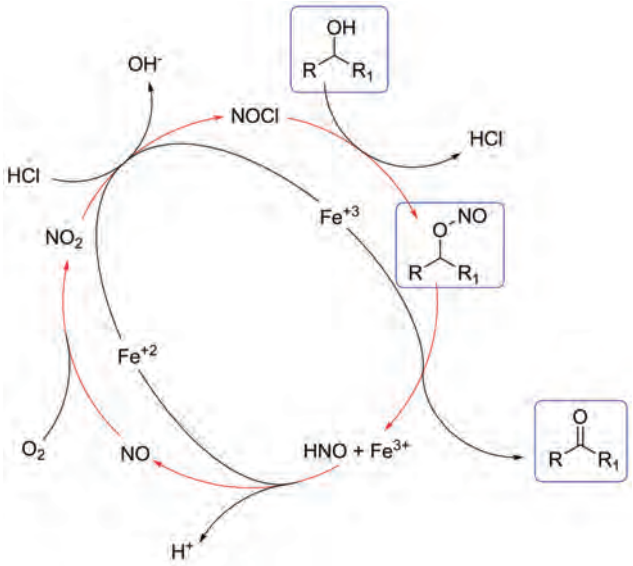


Figure 5: The proposed reaction pathway of the aerobic oxidation of secondary alcohols using the reaction system oxygen/(cat.)$FeCl_3$/(cat.)HNO_3/hexafluoro isopropanol.

In the framework of Centre of Excellence CIPKeBiP and the collaboration of the high-tech company ACIS BIO we were continuing investigations of the directed synthesis building blocks of potential bioactive compounds from the family of pantothenic acid and derivatives of maleic acid as precursors in polyketide biosynthesis. We concluded and published the results of the development of new reagents for a phosphorylation of alcohols and one of them was successfully used on derivatives of pantothenic acid, which carry a potential function as prodrugs of phosphates. We were developing new products used in non-human cosmetics for the company ECOT. In the Jožef Stefan International Postgraduate School we are performing two organic green-chemistry courses and at the Faculty for Chemistry and Chemical Technology at the University of Maribor a few undergraduate courses of organic chemistry

Some outstanding publications in the past year

1. P. Rodič, A. Mertelj, M. Borovšak, A. Benčan, D. Mihailović, B. Malič, I. Milošev, Composition, structure and morphology of hybrid acrylate-based sol-gel coatings containing Si and Zr composed for protective applications, Surf. Coat. Technol., 286 (2016) 388-396
2. D. Covaciu Romonti, J. Iskra, M. Bele, I. Demetrescu, I. Milošev, Elaboration and characterization of fluoro-hydroxyapatite and fluoroapatite sol-gel coatings on CoCrMo alloy, J. Alloys Compds, 665 (2016) 355-364
3. M. Poberžnik, A. Kokalj, Origin of surprising attractive interactions between electronegative oxygen adatoms on aluminium surfaces, J. Phys. Chem. C, 120 (2016), 25915-25922

4. S. Tušar, A. Lesar, Hydrogen bonding in the hydroxysulfinyl radical-formic acid-water system: a theoretical study, J. Comput. Chem., 37 (2016), 1611-1625
5. J. Pahor, S. Stavber, A. Čusak, G. Kosec, H. Petković, A. Podgoršek, Toward the efficient synthesis of new phosphopantothenate derivatives by using chlorophosphate reagents, Synthesis, 48 (2016), 3763-7881

Awards and appointments

1. Ingrid Milošev: Pregl Award for Exceptional Achievements in the field of chemistry and related disciplines
2. Klara Čebular: IUPAC Poster Prize, on 6th International IUPAC Conference on Green Chemistry, Venice, Italy, September 2016

Organization of conferences, congresses and meetings

1. EUSpec COST Action MP1306, EWinS 2016: EUSpec Winter School on Core Level Spectroscopies, Ajdovščina, Slovenia, 1.2.-11.2.2016
2. 4th CARISMA Meeting, CMST COST Action CM1205, Ljubljana, Slovenia, 21.3.-23.3.2016
3. Kick-off Meeting, M-ERA.NET Project »COR_ID«, Ljubljana, Slovenia, 11.4-12.4.2016
4. Kick-off Meeting, M-ERA.NET Project »COIN DESC«, Ljubljana, Slovenia, 27.10.-28.10.2016

Patent granted

1. Rok Zupet, Jernej Iskra, Miloš Ružič, Anica Pečavar, Ivanka Kolenc, Jože Pucelj, Igor Plaper, A process for a preparation of marbofloxacin and intermediate thereof, EP2501680 (B1), European Patent Office, 10. 02. 2016

INTERNATIONAL PROJECTS

1. CARISMA; Catalytic Routines for Small Molecule Activation; CMST COST Action CM1205
   Prof. Jernej Iskra
   Cost Office
2. EUSpec, COST MP1306; Modern Tools for Spectroscopy on Advanced Materials: A European Modelling Platform
   Asst. Prof. Anton Kokalj
   Cost Office
3. Exploring Antimalarial Peroxides from Bench-side to Bed-side: Synthesis, Chemistry, Antimalarial Assessment and SAR studies of Novel functionalized 1, 2, 4-Trioxanes and 1, 2, 4, 5-Tetraoxanes against Multi-drug Resistant Malaria
   Prof. Jernej Iskra
   Slovenian Research Agency
4. CECICORR - Computational Modeling and Experimental Characterization of Interfaces relevant for CORRosion: Passive Films and Corrosion Inhibitors
   Asst. Prof. Anton Kokalj
   Slovenian Research Agency
5. Corrosion Protection of Technologically Important Materials using Environmentally-friendly Coatings
   Prof. Ingrid Milošev
   Slovenian Research Agency
6. Study of the Synthesis of Bioactive Furans and their Inhibitory Role in Antimicrobial Hybrid Coatings
   Prof. Jernej Iskra
   Slovenian Research Agency

RESEARCH PROGRAMS

1. Chemistry for sustainable development
   Prof. Stojan Stavber
2. Advanced materials for low-carbon and sustainable society
   Prof. Ingrid Milošev

R & D GRANTS AND CONTRACTS

1. Lightweight alloys based on aluminium as materials with increasing potential in transport industry
   Prof. Ingrid Milošev
2. Development of Molecularly Imprinted Polymers and their application in environmental and bio-analysis
   Prof. Jernej Iskra
3. New technology for design of novel polyketide drug-leads with chemically ameanable moieties
   Prof. Stojan Stavber
4. COR_ID: Design of corrosion resistant coatings targeted for versatile applications
   Prof. Ingrid Milošev
5. Small Services
   Prof. Ingrid Milošev

VISITORS FROM ABROAD

1. Prof. dr. Lorenzo Fedrizzi, University of Udine, Italy, 18.5.-18.5.2016
2. Gregor Ekart, B.Sc. student. Imperial College London, England, 4.7.-8.9.2016
3. Dominique Costa, Chemie Paris Tech, Ecole Nationale Superiore de Chemie de Paris, Paris, France, 19.12.-23.12.2016
4. Dr. Bojan Božič, University of Belgrade, Faculty of Technology and Metallurgy, Serbia, 1.10.-31.12.2016

STAFF

Researchers
1. Prof. Jernej Iskra*
2. Asst. Prof. Anton Kokalj
3. Dr. Antonija Lesar
4. **Prof. Ingrid Milošev, Head**
5. Prof. Stojan Stavber

Postdoctoral associates
6. Dr. Tina Bakarič
7. Dr. Peter Rodič

Postgraduates
8. Dunja Gustinčič, B. Sc.
9. *Dr. Jerca Pahor, left 01.08.16*
10. Matic Poberžnik, B. Sc.
11. Griša Grigorij Prinčič, B. Sc.
12. *Dr. Katarina Starkl Renar, left 01.06.16*
13. Gavrilo Šekularac, B. Sc.
14. Urša Tiringer, B. Sc.
15. *Dr. Simona Tušar, left 01.06.16*
16. Barbara Volarič, B. Sc.

Technical officers
17. Barbara Kapun, B. Sc.

Note:

* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Njomza Ajvazi, Stojan Stavber, "Direct halogenation of alcohols with halosilanes under catalyst- and organic solvent-free reaction conditions", *Tetrahedron lett.*, vol. 57, no. 22, pp. 2430-2433, 2016.
2. Njomza Ajvazi, Stojan Stavber, "Transformation of tertiary benzyl alcohols into the vicinal halo-substituted derivatives using N-halosuccinimides", *Molecules (Basel)*, vol. 21, no. 1, pp. 1325-1-1325-9, 2016.
3. Nicoleta Cotolan, Mitja Rak, Marjan Bele, Andrej Cör, Liana Maria Mure.an, Ingrid Milošev, "Sol-gel synthesis, characterization and properties of TiO_2 and Ag − TiO_2 coatings on titanium substrate", *Surf. coat. technol.*, vol. 307, part A, pp. 790-799, 2016.
4. D. Covaciu Romonti, Jernej Iskra, Marjan Bele, Ioana Demetrescu, Ingrid Milošev, "Elaboration and characterization of fluorohydroxyapatite and fluoroapatite sol-gel coatings on CoCrMo alloy", *J. alloys compd.*, vol. 665, pp. 355-364, 2016.
5. Daniela Covaciu Romonti, Ingrid Milošev, Ioana Demetrescu, "Effect of sodium fluoride on the stability of dental alloys in artificial saliva", *Rev. chim. (Bucur.)*, vol. 67, iss. 6, pp. 1097-1103, 2016.
6. Antonija Lesar, Simona Tušar, "Water mediated hydrogen abstraction mechanism in the radical reaction between HOSO and NO_2", *Chem. Phys. Lett.*, vol. 651, pp. 209-215, 2016.
7. Ingrid Milošev, Nataša Kovačević, Anton Kokalj, "Effect of mercapto and methyl groups on the efficiency of imidazole and benzimidazole-based inhibitors of iron corrosion", *Acta chim. slov. (Print ed.)*, vol. 63, no. 3, pp. 544-559, 2016.
8. Ingrid Milošev, Peter Rodič, "Cerium chloride and acetate salts as corrosion inhibitors for aluminium alloy AA7075-T6 in sodium chloride solution", *Corrosion (Houst., Tex.)*, vol. 72, no. 8, pp. 1021-1034, 2016.
9. Jerca Pahor, Stojan Stavber, Alen Čusak, Gregor Kosec, Hrvoje Petković, Ajda Podgoršek, "Toward the efficient synthesis of new phosphopantothenate derivatives by using chlorophosphate reagents", *Synthesis (Stuttg.)*, vol. 48, no. 21, pp. 3763-3772, 2016.
10. Andraž Pavlišič, Primož Jovanovič, Vid Simon Šelih, Martin Šala, Marjan Bele, Goran Dražić, Iztok Arčon, Samo B. Hočevar, Anton Kokalj, Nejc Hodnik, Miran Gaberšček, "Atomically resolved dealloying of structurally ordered Pt nanoalloy as an oxygen reduction reaction electrocatalyst", *ACS catal.*, vol. 6, iss. 8, pp. 5530-5534, Aug. 2016.
11. Matic Poberžnik, Anton Kokalj, "Origin of surprising attractive interactions between electronegative oxygen adatoms on aluminum surfaces", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, no. 45, pp. 25915-25922, 2016.
12. Matic Poberžnik, Miha Purg, Matej Repič, Janez Mavri, Robert Vianello, "Empirical valence bond simulations of the hydride-transfer step in the monoamine oxidase A catalyzed metabolism of noradrenaline", *J. phys. chem., B Condens. mater. surf. interfaces biophys.*, vol. 120, iss. 44, pp. 11419-11427, Nov. 2016.
13. Matej Ravber, Darja Pečar, Andreja Goršek, Jernej Iskra, Željko Knez, Mojca Škerget, "Hydrothermal degradation of rutin: identification of degradation products and kinetics study", *J. agric. food chem.*, vol. 64, iss. 48, pp. 9196-9202, 2016.
14. Peter Rodič, Alenka Mertelj, Miloš Borovšak, Andreja Benčan, Dragan Mihailović, Barbara Malič, Ingrid Milošev, "Composition, structure and morphology of hybrid acrylate-based sol-gel coatings containing Si and Zr composed for protective applications", *Surf. coat. technol.*, vol. 286, pp. 388-396, 2016.
15. Peter Rodič, Ingrid Milošev, "Corrosion inhibition of pure aluminium and alloys AA2024-T3 and AA7075-T6 by cerium(III) and eerium(IV) salts", *J. Electrochem. Soc.*, vol. 163, no. 3, pp. C85-C93, 2016.
16. Daniela E. Romonti, Andrea Gomez Sanchez, Ingrid Milošev, Ioana Demetrescu, Silvia Ceréa, "Effect of anodization on the surface characteristics and electrochemical behaviour of zirconium in artificial saliva", *Mater. sci. eng., C, Biomim. mater., sens. syst.*, vol. 62, pp. 458-466, 2016.
17. Rihard Trebše, Anže Mihelič, Vesna Levašič, Andrej Cör, Ingrid Milošev, "Results of revision of total hip arthroplasty for alumina ceramic-on-ceramic bearing fracture", *Hip int.*, vol. 26, no. 3, pp. 237-243, 2016.
18. Simona Tušar, Antonija Lesar, "Hydrogen bonding in the hydroxysulfinyl radical-formic acid-water system: a theoretical study", *J. comput. chem.*, vol. 37, no. 17, pp. 1611-1625, 2016.
19. Gregor Žerjav, Ingrid Milošev, "Corrosion protection of brasses and zinc in simulated urban rain. Part II., The combination of inhibitors benzotriazole and 2-mercaptobenzimidazole with stearic acidi", *Mater. corros. (1995)*, vol. 67, no. 1, pp. 92-103, 2016.

Review Article

1. Katarina Starkl, Jernej Iskra, Igor Križaj, "Understanding malarial toxins", *Toxicon (Oxford)*, vol. 119, pp. 319-329, 2016.

Published Conference Contribution

1. Njomza Ajvazi, Stojan Stavber, "New method for C-O and C-N bond formation catalysed by N-halo compounds under green reaction conditions", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 205-215.
2. Klara Čebular, Monika A. Horvat, Stojan Stavber, "Metal - free azidation of alcohols catalysed by molecular iodine", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 13-19.
3. Klara Čebular, Stojan Stavber, "Molecular iodine as a mild catalyst for cross - coupling of alkenes and alcohols", In: *Zbornik referatov in povzetkov*, 22. Slovenski kemijski dnevi, Portorož, 28.-30. september 2016, 6 pp.
4. Tjaša Gornik, Anja Krajnc, Amadeja Koler, Marko Turnšek, Ester Heath, Jernej Iskra, Peter Krajnc, Karel Jeřábek, Tina Kosjek, "Implementing molecularly imprinted polymer (MIP) in the analytical method for determining sertraline residues in aqueous environment", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 39-45.
5. Štefan Možina, Stojan Stavber, Jernej Iskra, "Mimicking nature - iron catalysed oxidation of alcohols", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 69-75.
6. Jerca Pahor, Ajda Podgoršek, Alen Čusak, Gregor Kosec, Hrvoje Petković, Stojan Stavber, "Razvoj metod za pripravo aciloksialkilnih predzdravil fosfatov ter uporaba topil, primernih za farmacevtsko industrijo", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 81-90.
7. Mojca Škerget, Darja Pečar, Andreja Goršek, Jernej Iskra, Matej Ravber, Željko Knez, "Kinetika razpada kvercetin rutinozida v subkritični vodi", In: *Zbornik referatov in povzetkov*, 22. Slovenski kemijski dnevi, Portorož, 28.-30. september 2016, 4 pp.
8. Monika Žnidaršič, Črtomir Podlipnik, Ingrid Milošev, "The effect of benzene ring and mercapto group in imidazoles on the corrosion inhibition of copper alloy with 10% zinc", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 273-277.

Independent Component Part or a Chapter in a Monograph

1. Jernej Iskra, "Synthesis by substitution of hydrogen: (update 2015)", In: *Science of synthesis: Houben-Weyl methods of molecular transformations*, (Knowledge updates, 2015/2), Klaus Banert, Stuttgart, New York, Georg Thieme Verlag, 2016, pp. 375-386.
2. Jernej Iskra, "Synthesis by substitution of hydrogen: (update 2015)", In: *Science of synthesis: Houben-Weyl methods of molecular transformations*, (Knowledge updates, 2015/2), Klaus Banert, Stuttgart, New York, Georg Thieme Verlag, 2016, pp. 387-390.
3. Jernej Iskra, Shaun S. Murphree, "Synthesis by substitution of hydrogen: (update 2015)", In: *Science of synthesis: Houben-Weyl methods of molecular transformations*, (Knowledge updates, 2015/2), Klaus Banert, Stuttgart, New York, Georg Thieme Verlag, 2016, pp. 359-373.
4. Ingrid Milošev, "Surface treatments of titanium with antibacterial agents for implant applications", In: *Biomedical and pharmaceutical applications of electrochemistry*, (Modern aspects of electrochemistry, 60), Stojan S. Djokić, ed., Cham, Springer, [2016], pp. 1-87.

Patent

1. Rok Zupet, Jernej Iskra, Miloš Ružič, Anica Pečavar, Ivanka Kolenc, Jože Pucelj, Igor Plaper, *A process for a preparation of marbofloxacin and intermediate thereof,* EP2501680 (B1), European Patent Office, 10. 02. 2016.

Mentoring

1. Njomza Ajvazi, *N-halo organic compounds as catalysts or reagents for comprehensive transformation of alcohols:* doctoral dissertation, Ljubljana, 2016 (mentor Stojan Stavber).
2. Jerca Pahor, *New approaches to the synthesis of prodrugs of phosphates and phosphorylated derivatives of pantothenic acid:* doctoral dissertation, Ljubljana, 2016 (mentor Ajda Podgoršek Berke; co-mentor Stojan Stavber).
3. Katarina Starkl Renar, *Study of the synthesis of unsymmetrical tetraoxanes and evaluation of their potential biological activity:* doctoral dissertation, Ljubljana, 2016 (mentor Jernej Iskra).
4. Simona Tušar, *Modeling of Water and Acid Mediated Radical Reactions in the Atmosphere:* doctoral dissertation, Ljubljana, 2016 (mentor Antonija Lesar; co-mentor Tomaž Urbič).

ELECTRONIC CERAMICS DEPARTMENT

K-5

The Electronic Ceramics Department is active in the research of the synthesis, properties and applications of materials for electronics and energetics, mainly complex multifunctional materials and structures that can perform multiple functions (multifunctional materials). The materials of interest include ceramic piezoelectrics, ferroelectrics, relaxors, multiferroics and conductive oxides. The emphasis is on the creation of the properties by the synthesis and structure on the nano-, micro- and macro-levels. The group also works on the principles of the basic technologies of ceramic pressure sensors, ceramic MEMS and flexible electronics.

Head:
Prof. Barbara Malič

In the framework of **lead-free piezoelectric materials** we were particularly interested in alkali-niobate-based ceramics. In collaboration with the National Institute of Chemistry, University of Ljubljana, University of Nova Gorica, Montanuniversität Leoben, Austria, and the University of Milan, Italy, we explained the mechanism of grain-growth inhibition in perovskite ceramics due to the addition of an aliovalent dopant for the case of strontium-doped ceramic $K_{0.5}Na_{0.5}NbO_3$ (KNN). The investigations of highly doped samples suggested that the system tends to segregate the A-site vacancies, which occur as a result of doping, in a secondary phase. Together with increasing lattice disorder and microstrain, these effects are correlated with the increasing number of low-angle grain boundaries, which finally limit the grain growth and consequently result in a significant grain-size decrease. Furthermore, the effect of the Sr dopant on the solid-state synthesis of KNN was studied by thermal analysis and in-situ high-temperature X-ray diffraction. Strontium doping had an insignificant influence on the course of the solid-state synthesis. On the other hand, the particle size distribution of the Nb_2O_5 reagent proved to be a crucial factor influencing the temperature interval of the KNN solid-state synthesis.

Researchers from the "Jožef Stefan" Institute and National Institute of Chemistry, in collaboration with colleagues from Switzerland and Japan, were the first to identify the accumulation of charged defects at domain walls in ferroelectric $BiFeO_3$. This finding explains the conduction at the domain walls in $BiFeO_3$ and thus represents the missing piece for explaining the intriguing electrical properties of domain walls in ferroelectrics. The study was published in Nature Materials, currently one of the highest-impact scientific journals.

Within the activities on **lead-based piezoelectric ceramics**, we studied the ferroelectric domain structure of the $Pb(Sc_{0.5}Nb_{0.5})O_3$ ceramics, prepared by mechanochemical activation of powder, by piezoresponse force microscopy. Micrometre-sized domains with different morphologies exist in the material at room temperature. Slightly below the ferroelectric–relaxor phase transition, i.e., at 90 °C, the fraction of micrometre-sized domains is reduced, while the nanometre-sized domains prevail in accordance with the ferroelectric–relaxor crossover at ~98°C.

The tilting of oxygen octahedra in perovskites has been proposed to profoundly affect the macroscopic domain switching behaviour in undoped, rhombohedral **$Pb(Zr,Ti)O_3$ (PZT)** ceramics, resulting in pinched ferroelectric hysteresis loops. A similar effect, however, is expected because of the presence of defect complexes involving oxygen vacancies. We revisited the early studies on rhombohedral PZT ceramics revealing that the observed pinched loops are likely associated with the presence of defect complexes and not octahedral tilts, as previously suggested.

Within the 7 **FP EU CERAMPOL** project and in collaboration with our research partner HIPOT-RR, we fabricated an innovative **vibrating system for wastewater purification**. The system is based on a porous ceramic membrane that vibrates under the influence of an electrically-driven PZT piezoelectric integrated into the membrane. We optimised the system's operation conditions using finite-element modelling and measurements of the displacement amplitudes of the system in a wide frequency range. We demonstrated with tests under real operating conditions that the novel vibrational system can be effectively used for water purification. With the project partner LEITAT, Spain, we submitted a PCT patent application.

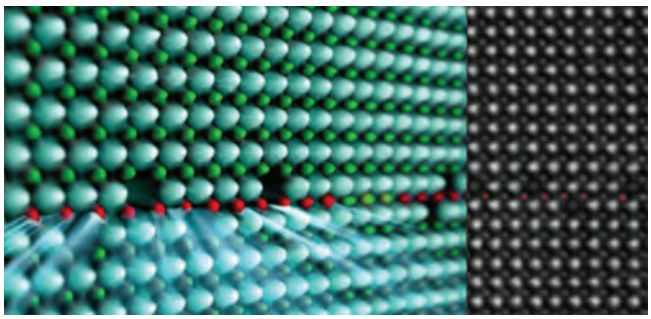


Figure 1: Artistic presentation of accumulated defects at a domain wall in $BiFeO_3$ (painter Mito Gegič) and image of bismuth (larger) and iron (smaller) atomic columns taken with a scanning transmission electron microscope.

Within the activities on **multiferroic ceramic $BiFeO_3$**, in cooperation with colleagues from the Department of Advanced Materials, Department of Inorganic Chemistry and Technology, National Institute of Chemistry, Ecole Polytechnique Fédérale de Lausanne (EPFL), Switzerland and the University of Shizuoka, Japan, we studied the mechanism of domain con-

ductivity in ferroelectric $BiFeO_3$. We were the first to identify the accumulation of charged defects at domain walls in ferroelectric $BiFeO_3$. This finding explains the p-type hopping conduction at the domain walls in $BiFeO_3$. The study was published in Nature Materials with a 2015 impact factor of 38.89, which currently makes it one of the highest-impact scientific journals. (Figure 1)

$BiFeO_3$-based ferroelectric solid solutions suffer from a high electrical conductivity, which represents one of the major obstacles for the use of these materials in high-temperature piezoelectric applications. We investigated this problem in $BiFeO_3$-$SrTiO_3$ ceramics and thus developed ways for controlling the electrical conductivity by annealing ceramics in different atmospheres. An alternative approach using manganese as a dopant has not only eliminated the original high conductivity but also stabilized the decreased conductivity against subsequent annealing in air and by the application of elevated electric fields.

The electrocaloric (EC) effect is defined as the adiabatic and reversible temperature change that occurs in a polar material upon the application of an external electric field. In collaboration with the Condensed Matter Physics Department and Laboratory for Refrigeration and District Energy, Faculty of Mechanical Engineering, University of Ljubljana, we analysed the energy efficiency of an EC cooling system in view of the polarization–electric field ($P-E$) hysteresis losses of the EC materials, and recovery of the electric energy needed to induce the EC effect. We showed that the energy efficiency of the materials with large hysteresis losses, i.e., $100(1\text{-}x)Pb(Mg_{1/3}Nb_{2/3})O_3$–$100x\ PbTiO_3$ (PMN-100xPT) compositions close to the morphotropic phase boundary, i.e., PMN-35PT, is significantly reduced as compared to the PMN-rich relaxor compositions. Therefore, we proposed that the EC materials with low $P-E$ hysteresis losses, such as PMN-100xPT with $x \leq 0.1$, and a high degree of the electric-energy recovery should be implemented in an EC cooling system in order to achieve a high energy efficiency.

Researchers from the "Jožef Stefan" Institute, in collaboration with colleagues from Poland and South Korea, prepared a multicaloric $0.8Pb(Fe_{1/2}Nb_{1/2})O_3$–$0.2Pb(Mg_{1/2}W_{1/2})$ material. The work is the first experimental confirmation of the electrocaloric and magnetocaloric coexistence in relaxor-ferroelectric and opens up new possibilities in the field of caloric cooling. The article was published in the journal Scientific Reports.

Electric-field amplitudes needed to reach EC temperature changes (ΔT), suitable for applications in cooling technology, that is at least 2K, are close to the dielectric breakdown strength of respective bulk ceramic materials, typically about 100 kV/cm. In order to reduce the applied voltage for a given EC ΔT, we prepared **multilayer cooling elements** of relaxor ferroelectric $0.9Pb(Mg_{1/3}Nb_{2/3})O_3$–$0.1PbTiO_3$ (PMN-10PT) with internal platinum electrodes by tape-casting and lamination in collaboration with the company KEKO-Equipment, Žužemberk. The thickness of the individual layers was about 60 μm. The EC temperature changes of multilayer elements were measured between 55 and 105 °C at electric field amplitudes of up to 100 kV/cm in a high-resolution calorimeter. The highest EC ΔT was 2.26 K at 100 kV/cm at 105 °C. The obtained result is in good agreement with the values obtained in the bulk ceramic of the same composition with typical thicknesses exceeding 100 μm, but it was obtained at a much lower applied voltage, thus presenting another step towards the application of EC ceramic materials in solid-state cooling.

Using the **finite-element** method we **modelled** the behaviour of an EC solid-state cooler for its possible use in microelectronics. The essential parts of the cooler are multifunctional **cantilevers** fabricated from PMN-10T, which exhibit simultaneous bending and change of temperature upon the application of an electric field. The results of the modelling confirmed that by introducing thermal contacts between the cantilevers a temperature gradient is formed across the structure, resulting in a promising cooling capacity.

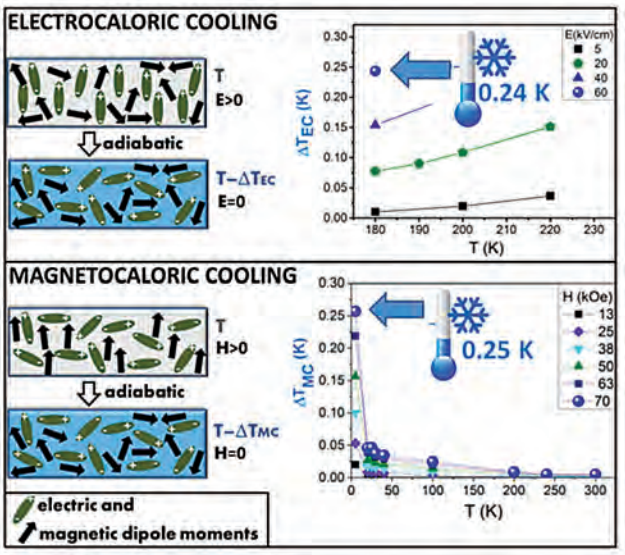


Figure 2: Multicaloric properties of $0.8Pb(Fe_{1/2}Nb_{1/2})O3$–$0.2Pb(Mg_{1/2}W_{1/2})$ material.

Furthermore, we prepared a **multicaloric ceramic material** $0.8Pb(Fe_{1/2}Nb_{1/2})O_3$–$0.2Pb(Mg_{1/2}W_{1/2})O_3$ that shows both an electrocaloric and a magnetocaloric temperature change. The work is the first experimental confirmation of the electrocaloric and magnetocaloric coexistence in relaxor-ferroelectric and opens up new possibilities in the field of caloric cooling (Figure 2)

In the frame of the **M-ERA.NET PiezoMEMS** project we continued the research of ferroelectric thin films based on lead-free perovskites for piezoelectric energy-harvesting applications together with partners from Poland and Romania. The influence of donor doping on microstructure, ferro- and piezoelectric properties of $K_{0.5}Na_{0.5}NbO_3$ films was studied.

In collaboration with LETI, Grenoble, France, Faculty of Physics, Vilnius University, Lithuania, School of Electronic and Information Engineering, Xi'an Jiaotong University, China, and the Condensed Matter Physics Department, JSI, we investigated the dielectric properties of $Ba_{0.5}Sr_{0.5}TiO_3$ (BST) thin films on alumina substrates with film thicknesses between 90 nm to 600 nm

and predominantly columnar microstructures. The dielectric permittivity measured at room temperature exhibited a non-monotonous thickness dependence that was connected to the residual biaxial stress, developed in the BST films due to the thermal expansion mismatch between the film and the substrate. The dielectric permittivity of 170-nm-thick films with 75-nm-sized grains was 1180 measured at 5 kHz, which is one of the highest reported values for BST films with similar microstructures.

By understanding the influence of different thermal expansion coefficients of the thick film and the substrate and by controlling the chemical interactions between them, we successfully prepared by screen printing a few-10-µm-**thick films of bismuth ferrite** ($BiFeO_3$) with appropriate phase composition and microstructure. Bismuth ferrite is difficult to pole because it requires the use of high external electric field. We suggested an alternative way of poling by sintering the $BiFeO_3$ films at a temperature above the ferroelectric-paraelectric phase transition. The presence of a compressive strain gradient across the film thickness cooled from above the ferroelectric-paraelectric phase transition was experimentally confirmed and was suggested to be responsible for the self-poling effect. These self-poled films exhibited a microstructure with randomly oriented columnar grains. (Figure 3)

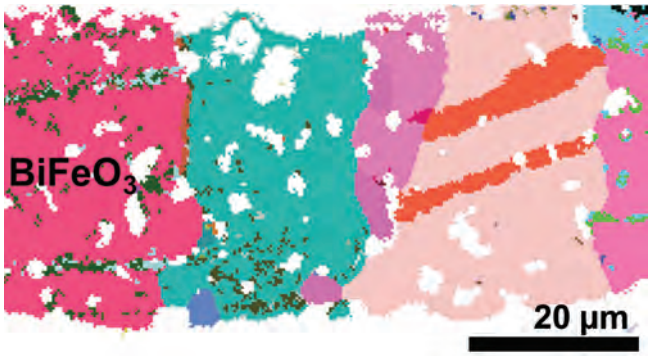


Figure 3: Distribution of the crystallographic orientations in columnar grains in thick $BiFeO_3$ film with pronounced domain structure.

Danjela Kuščer Hrovatin and Janez Holc, together with colleagues from ETI Elektroelement, Izlake, received a Silver recognition for the invention "Non-porous C410 cordierite materials for electrotechnics" by the Regional Chamber of Commerce Zasavje in June 2016.

We investigated the preparation of environmentally friendly **thick-film** piezoelectrics based on $K_{0.5}Na_{0.5}NbO_3$ on metallic substrates by the **electrophoretic deposition method**.

We prepared $Pb(Zr,Ti)O_3$-based thick-film structures by **inkjet printing**. We dispersed the ceramic powder in water and afterwards adjusted the viscosity and surface tension of the ink to be suitable for printing. We prepared arrays of linear structures with a line width of ~80 µm and a micrometre-sized distance between the lines. After sintering at 850 °C the 20-µm-thick structures exhibited a dielectric permittivity of 1100 and dielectric losses of 0.057, which are comparable to the properties of thick films prepared using screen-printing technology.

We inkjet printed **high-K dielectric** tantalum-aluminium-silicon-oxide nanostructures on indium-tin-oxide-coated glass as components for **transparent electronics**. The ink formulations with 2-methoxyethanol as the main solvent and highly viscous glycerol and/or 1,3-propanediol co-solvents exhibited the optimal values of the viscosity and surface tension for piezoelectric inkjet printing. By a suitable combination of all solvents in the ink the coffee-stain effet of the printed nanostructures could be avoided. We printed about 40-nm-thick, flat and uniform transparent capacitors with a good dielectric permittivity of ~15, tan(δ) ~0.034 at 100 kHz and a low leakage current density of 2.4×10^{-7} A cm^{-2} at 200 kV cm^{-1}. The study was performed in collaboration with the Condensed Matter Physics Department and the Department of Thin Films and Surfaces. (Figure 4)

In the framework of p-type **semiconductors**, the mechanism of formation of nanocrystalline Co_3O_4 powder by cobalt nitrate-glycine solution combustion synthesis was studied. By controlling the reaction conditions and by using the sub-stoichiometric amount of glycine we prepared phase-pure Co_3O_4. The prepared powder contained soft cauliflower-shaped agglomerates with a high specific surface area (64.4 m^2/g). In collaboration with researchers from Eberhard Karls University of Tübingen, Germany, thick-film sensors were produced from the respective powder by drop-coating. The sensor annealed at 600 °C showed an excellent sensing performance for acetone detection at a low operating temperature of 150 °C in a humid environment. Such a sensor would be suitable for the detection of diabetes in exhaled air. (Figure 5)

We continued investigations of **LTCC** (Low Temperature Co-fired Ceramics) and thick-film materials and processes, used for fabrication of three-dimensional structures for different micro-electro-mechanical systems (MEMS) and chemical microsystems. The traditional co-operation with our research partners HIPOT-RR and Centre of Excellence NAMASTE

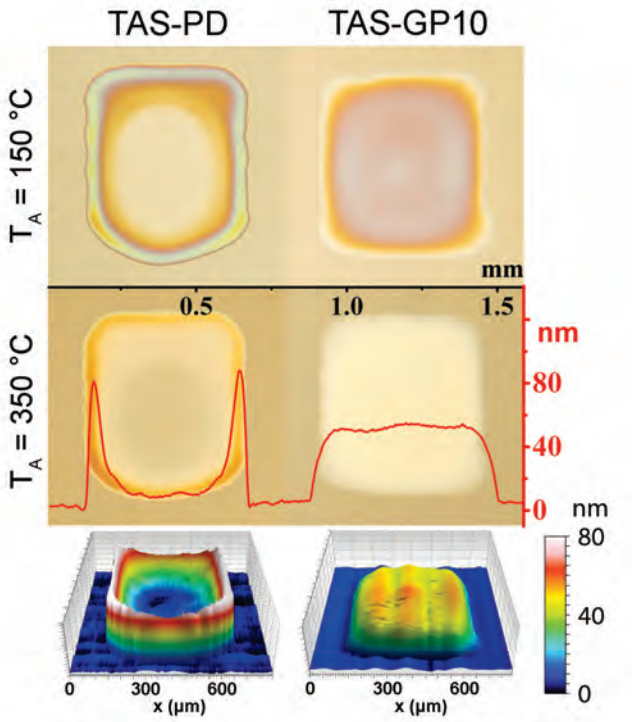


Figure 4: Optical images of the dried (150 °C) and heated (350 °C) inkjet-printed tantalum-aluminium-silicon oxide (TAS) based thin-film capacitors and the corresponding profilometry micrographs. By optimizing the TAS-ink formulation from 1,3 propanediol (PD)-based to a mixture of PD and glycerol (GP10) nano-structures with a uniform thickness of about 40 nm could be patterned.

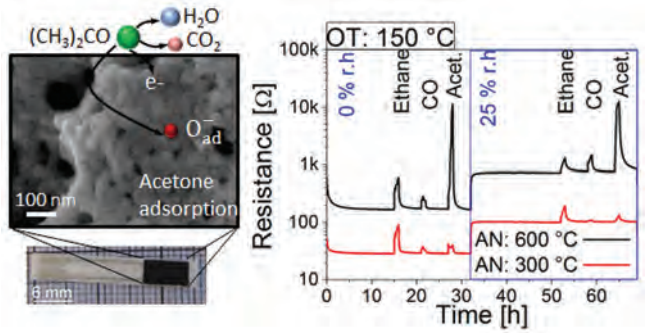


Figure 5: Image of a sensor surface of the active Co_3O_4 layer taken with a scanning electron microscope with the schematic representation of acetone adsorption (left). DC resistance of sensors annealed at 300 and 600 °C, during exposure to ethanol (Ethane), carbon monoxide (CO) and acetone (acetyl) at an operating temperature of 150 °C in dry and humid environments (right). Cooperation with Eberhard Karls University, Tübingen.

continued resulting in several test structures and demonstration products. Examples include microfluidic components for electrochemical sensors and ceramic packaging for piezoelectric elements in the frame of **INTcerSEN** and **PiezoMEMS** projects, respectively, both from the **M-ERA.NET** programme, and pressure sensors designed as demonstration products from LTCC tapes developed by the company KEKO equipment.

In collaboration with the company **ETI Elektroelement** d.d., Izlake, we studied the manufacturing of the non-porous cordierite ceramic, which is used in products exposed to high-temperature differences in short periods of time. The material is suitable for automatic, large-scale production.

Some outstanding publications in the past year

1. Rojac, Tadej, Benčan, Andreja, Dražić, Goran, Sakamoto, Naonori, Uršič, Hana, Jančar, Boštjan, Tavčar, Gašper, Makarovič, Maja, Walker, Julian, Malič, Barbara, Damjanović, Dragan. Domain-wall conduction in ferroelectric $BiFeO_3$ controlled by accumulation of charged defects. Nature materials, ISSN 1476-1122, [in press] 2016, 7 str., doi: 10.1038/nmat4799.
2. Khomyakova, Evgeniya, Šadl, Matej, Uršič, Hana, Daniels, John, Malič, Barbara, Benčan, Andreja, Damjanović, Dragan, Rojac, Tadej. Self-poling of $BiFeO_3$ thick films. ACS applied materials & interfaces, ISSN 1944-8244. [Print ed.], 2016, vol. 8, no. 30, str. 19626-19634, doi: 10.1021/acsami.6b05885.
3. Uršič, Hana, Bobnar, Vid, Malič, Barbara, Filipič, Cene, Vrabelj, Marko, Drnovšek, Silvo, Younghun, Jo., Wencka, Magdalena, Kutnjak, Zdravko. A multicaloric material as a link between electrocaloric and magnetocaloric refrigeration. Scientific reports, ISSN 2045-2322, 2016, vol. 6, str. 26629-1-26629-5, doi: 10.1038/srep26629.
4. Matavž, Aleksander, Frunza, Raluca-Camelia, Drnovšek, Aljaž, Bobnar, Vid, Malič, Barbara. Inkjet printing of uniform dielectric oxide structures from sol-gel inks by adjusting the solvent composition. Journal of materials chemistry. C, Materials for optical and electronic devices, ISSN 2050-7526. [Print ed.], 2016, vol. 4, no. 24, str. 5634-5641, doi: 10.1039/C6TC01090C.
5. Kuščer, Danjela, Bernardo, Mara, Santo-Zarnik, Marina, Malič, Barbara. Patterning of lead-zirconate-titanate thick-film structures by electrophoretic deposition from ethanol-based dispersions. Journal of the European ceramic society, ISSN 0955-2219. [Print ed.], 2016, vol. 36, no. 2, str. 291-297, doi: 10.1016/j.jeurceramsoc.2015.08.033.

Awards and Appointments

1. Darko Belavič: Elected to the serving member of Electrotechnical Association Slovenia, MIDEM – Proposer: Society For Microelectronics, Electronic Components And Materials, Ljubljana, Slovenia May, 2016
2. Ines Bantan, Jožo Prašnikar, Helena Razpotnik from ETI d.d., Danjela Kuščer, Janez Holc, from JSI, Electronic ceramics department K-5: Silver Award for innovation: "Neporozni kordieritni material C410 za elektrotehniko", Gospodarska zbornica Slovenije, Zasavje, Slovenia, June 8, 2016
3. Lovro Fulanovič: SHAPING VI, Student poster award winner, Montpellier, France, July 20, 2016
4. Andraž Bradeško: Best poster award, Institute of Electrical and Electronics Engineers (IEEE), ISAF/ECAPD/PFM Conference 2016 – IEEE, Darmstadt, Germany, August, 21-25, 2016
5. Tomaž Kos, Tadej Rojac (co-mentor): Prešeren's Award, Faculty of Electrical Engineering, Ljubljana, Slovenia, December 6, 2016

Organization of Conferences, Congresses and Meetings

1. MIDEM 2016: 52nd International Conference on Microelectronics, Devices and Materials with the Workshop on Terahertz and Microwave Systems, Ankaran Slovenia, September 28-30, 2016
2. COST TO-BE Fall Meeting 2016, Ljubljana, Slovenia, September 28-30, 2016

INTERNATIONAL PROJECTS

1. Feasibility Study and Fabrication of LTCC based PCB Multilayer
   Prof. Barbara Malič
   Ctr Carinthian Tech Research Ag
2. Fabrication of LTCC SAW Module Package and Plates
   Prof. Barbara Malič
   Ctr Carinthian Tech Research Ag
3. 7FP - CERAMPOL; Ceramic and Polymeric Membrane for Water Purification of Heavy Metal and Hazardous Organic Compound
   Asst. Prof. Danjela Kuščer Hrovatin
   European Commission
4. COST MP1308; Towards Oxide Based Electronics (TO-BE)
   Dr. Katarina Vojisavljević
   Cost Office
5. Functional Heterogeneity in Complex Oxides: Chemical Clustering, Atomic Displacements, and Polar Nanoregions
   Asst. Prof. Hana Uršič Nemevšek
   Slovenian Research Agency
6. Fabrication and Modelling of Integrated Piezoelectric Structures for High-frequency Ultrasound Applications
   Asst. Prof. Danjela Kuščer Hrovatin
   Slovenian Research Agency
7. Piezoelectric Films for Microelectromechanical Systems Based on Environment Friendly Perovskite Materials
   Prof. Barbara Malič
   Slovenian Research Agency

RESEARCH PROGRAM

1. Electronic Ceramics, Nano-, 2D and 3D Structures
   Prof. Barbara Malič

R & D GRANTS AND CONTRACTS

1. Nanostructures for high-efficiency solar cells and photovoltaic
   Prof. Barbara Malič
2. New advanced electrocaloric materials for novel environmentally-friendly dielectric refrigeration technology
   Prof. Barbara Malič
3. Multifunctional materials for actuator and cooling devices
   Asst. Prof. Tadej Rojac
4. Photovoltaic cell and modul inhomogenity analysis and performace monitoring in power plants through lifetime
   Prof. Barbara Malič
5. Tunable ferroelectric thin film capacitors for agile microwave antennas
   Prof. Barbara Malič
6. High-performance piezoelectric materials for sensors and actuators in high-temperature applications
   Asst. Prof. Tadej Rojac
7. Micro-electromechanical and electrocaloric layer elements
   Prof. Barbara Malič
8. Advanced electrocaloric energij conversion
   Prof. Barbara Malič
9. Integrated sensors with microfluidic features using LTCC technology
   Asst. Prof. Hana Uršič Nemevšek
   Piezoelectric MEMS for efficient energy harvesting
   Prof. Barbara Malič

NEW CONTRACTS

1. Research of compatibility of LTCC materials and conductive pastes, with the emphasis on appropriate adhesion of the conductive material on LTCC and on simultaneous densification of both materials
   Prof. Barbara Malič
   Keko - Oprema d. o. o. Žužemberk

VISITORS FROM ABROAD

1. Hugo Mercier, Université François-Rabelais de Tours, Tours, France, 1. Januar-8. October 2016
2. Mag. Stjepan Golubić, Visoka Tehnička Škola u Bjelovaru, Bjelovar, Croatia, 18. January 2016
3. Alen Britvić, Visoka Tehnička Škola u Bjelovaru, Bjelovar, Croatia,18. January-18. April 2016
4. Dr. Carmen Galassi, Istituto di Scienza e Tecnologia dei Materiali Ceramici (ISTEC), Consiglio Nazionale delle Ricerche (CNR); Faenza, Italy, 16.-18. March 2016
5. Prof. Franck Levassort, Université François-Rabelais de Tours, Tours, France, 16.-18. March 2016
6. Alexandre-Benoît Bourgoin, Université de y of Limoges, Limoges, France, 2. April-31. July 2016
7. Dragana Vasiljević, Univerzitet ua v Novoem Sadu, Novi Sad, Serbia, 3.-23. April 2016
8. Jelena Vukmirović, Univerzitet ua v Novoem Sadu, Novi Sad, Serbia, 3.-23. April 2016
9. Prof. dr. Hisao Suzuki, Research Institute of Electronics, Shizuoka University, Hamamatsu, Japan, 16.-18. April 2016
10. Prof. dr. Jacob L. Jones, North Carolina State University, Raleigh, US, 19.-22. June 2016
11. Dr. Vincenzo Buscaglia, Consiglio Nazionale delle Ricerche - IENI, Genova, Italy, 20.-22. June 2016
12. Prof. dr. Tomoya Ohno, Department of Materials Science, Kitami Institute of Technology; Kitami, Japan, 30. June-1. July 2016
13. Prof. Naonori Sakamoto, Research Institute of Electronics and Materials Science Course Department of Engineering, Graduate School of Integrated Science and Technology, Shizuoka University, Shizuoka, Japan, 30. June-8. July 2016
14. Mateusz Firynowicz, Politechnika Poznańska, Poznań, Poland, 4. July-10. October 2016
15. Anna Włódarkiewicz, Politechnika Poznańska, Poznań, Poland, 13. July-22. September 2016
16. Prof. Klaus Reichmann, Technische Universität Graz, Graz, Austria, 20. July 2016
17. Dong Hou, North Carolina State University, US, 29. August-3. September 2016
18. Reyhan Eşiyok, Yildiz Teknik Üniversitesi – Istanbul, Istanbul, Turkey, 1. September-26. November, 2016
19. Dr. Theodor Schneller, RWTH Aachen, Institut für Werkstoffe der Elektrotechnik II, RWTH Aachen, Aachen, Germany, 18.- 20. September 2016
20. Mihael Štefić, Visoka Tehnička Škola u Bjelovaru, Bjelovar, Croatia, 26. September-23. December, 2016
21. Prof. Anatoliy Panich, Southern Federal University, Rostov-on-Don, Russia, 24. October 2016
22. Dr. Julian Walker, Pennsylvania State University, USA, 27.-28. October 2016
23. Agnieszka Monika Paszkowska, Uniwersytet Marii Curie-Skłodowskiej, Lublin, Poland, 24. October-31. December 2016
24. Karolina Szymanek, Uniwersytet Marii Curie-Skłodowskiej, Lublin, Poland, 24. October-31. December 2016
25. Dr. Denis Alikin, Ferroelectric Laboratory, Institute of Natural Sciences, Ural Federal University, Russia, 5.-18. November 2016
26. Assoc. Prof. Sverre Magnus Selbach, Norges teknisk-naturvitenskapelige universitet, Trondheim, Norway, 23.-25. November 2016
27. Krunoslav Kušec, Visoka Tehnička Škola u Bjelovaru, Bjelovar, Croatia, 19.-31. December 2016

STAFF

Researchers

1. Asst. Prof. Andreja Benčan Golob
2. Asst. Prof. Goran Dražić*
3. Asst. Prof. Danjela Kuščer Hrovatin
4. **Prof. Barbara Malič, Head**
5. Asst. Prof. Tadej Rojac
6. Asst. Prof. Hana Uršič Nemevšek
7. Dr. Katarina Vojisavljević

Postdoctoral associates

8. Dr. Mirela Dragomir
9. Dr. Kostja Makarovič*
10. Dr. Mojca Otoničar
11. Dr. Tanja Pečnik
12. Dr. Marko Vrabelj

Postgraduates

13. Andraž Bradeško, B. Sc.
14. Lovro Fulanović, B. Sc.
15. *Dr. Jitka Hreščak, 01.10.16, transferred to Department CEMM*
16. Dr. Evgeniya Khomyakova
17. Uroš Prah, B. Sc.

Technical officers

18. Darko Belavič, B. Sc.
19. Silvo Drnovšek, B. Sc.
20. Brigita Kmet, B. Sc.
21. Maja Makarovič, B. Sc.

Technical and administrative staff

22. Tina Ručigaj Korošec, B. Sc.
23. Matejka Šmit, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLE

1. Anže Abram, Andreja Eršte, Goran Dražić, Vid Bobnar, "Structural and dielectric properties of hydrothermally prepared boehmite coatings on an aluminium foil", *J. mater. sci., Mater. electron.*, vol. 27, no. 10, pp. 10221-10225, 2016.
2. Moom Sinn Aw, Goran Dražić, Petar Djinović, Albin Pintar, "Transition metal pairs on ceria-promoted, ordered mesoporous alumina as catalysts for the CO_2 reforming reaction of methane", *Catalysis science & technology*, vol. 6, iss. 11, pp. 3797-3805, Jun. 2016.
3. Tina Bakarič, Barbara Malič, Danjela Kuščer, "Lead-zirconate-titanate-based thick-film structures prepared by piezoelectric inkjet printing of aqueous suspensions", *J. Eur. Ceram. Soc.*, vol. 36, no. 16, pp. 4031-4037, 2016.
4. Tina Bakarič, Tadej Rojac, Andre-Pierre Abellard, Barbara Malič, Franck Levassort, Danjela Kuščer, "Effect of pore size and porosity on piezoelectric and acoustic properties of $Pb(Zr_{0.53}Ti_{0.47})O_3$ ceramics", *Advances in applied ceramics*, vol. 115, no. 2, pp. 66-71, 2016.
5. Barbara Bertoncelj, Katarina Vojisavljević, Janez Rihteršič, Gregor Trefalt, Miroslav Huskić, Ema Žagar, Barbara Malič, "A Voronoi-diagram analysis of the microstructures in bulk-molding compounds and its correlation with the mechanical properties", *Express polym. lett.*, vol. 10, no. 6, pp. 493-505, 2016.
6. Klemen Bohinc, Goran Dražić, Anže Abram, Mojca Jevšnik, Barbara Jeršek, Damijan Nipič, Marija Kurinčič, Peter Raspor, "Metal surface characteristics dictate bacterial adhesion capacity", *Int. j. adhes. adhes.*, vol. 68, pp. 39-46, July 2016.
7. Sabina Božič Abram, Jana Aupič, Goran Dražić, Helena Gradišar, Roman Jerala, "Coiled-coil forming peptides for the induction of silver nanoparticles", *Biochem. biophys. res. commun.*, vol. 472, iss. 3, pp. 566-571, 8. Apr. 2016.
8. Andraž Bradeško, Đani Juričić, Marina Santo-Zarnik, Barbara Malič, Zdravko Kutnjak, Tadej Rojac, "Coupling of the electrocaloric and electromechanical effects for solid-state refrigeration", *Appl. phys. lett.*, vol. 109, no. 14, pp. 143508-1-143508-7, 2016.
9. Elena Buixaderas, Viktor Bovtun, Martin Kempa, Dmitri Nuzhnyy, Maxim Savinov, Přemysl Vaněk, Ivan Gregora, Barbara Malič, "Lattice dynamics and domain wall oscillations of morphotropic $Pb(Zr,Ti)O_3$ ceramics", *Phys. rev., B, Condens. matter mater. phys.*, vol. 94, no. 5, pp. 054315-1-054315-10, 2016.
10. Tihomir Car, Nikolina Nekić, Marko Jerčinović, Krešimir Salamon, Iva Bogdanović-Radović, Ida Delač Marion, Jasna Dasović, Goran Dražić, Mile Ivanda, Sigrid Bernstorff, Branko Pivac, Marko Kralj, Nikola Radić, Maja Buljan, "Closely packed Ge quantum dots in ITO matrix: influence of Ge crystallization on optical and electrical properties", *Materials research express*, vol. 3, no. 6, 065003-1-065003-10, Jun. 2016.
11. Mirela Dragomir, Matjaž Valant, Mattia Fanetti, Yurij Mozharivskyj, "A facile chemical method for the synthesis of 3C-SiC nanoflakes", *RSC advances*, iss. 26, pp. 21795-21801, 2016.
12. Andreja Eršte, Lovro Fulanović, Lucija Čoga, M. Lin, Y. Thakur, Qiming M. Zhang, Vid Bobnar, "Stable dielectric response of low-loss aromatic polythiourea thin films on Pt/SiO_2 substrate", *Journal of advanced dielectrics*, vol. 6, no. 1, pp. 1650003-1-1650003-4, 2016.
13. Tanja Jurkin, Martina Guliš, Goran Dražić, Marijan Gotić, "Synthesis of gold nanoparticles under highly oxidizing conditions", *Gold bull. (Internet)*, vol. 49, iss. 1, pp. 21-33, Sep. 2016.
14. Tanja Jurkin, Goran Štefanić, Goran Dražić, Marijan Gotić, "Synthesis route to δ − FeOOH nanodiscs", *Mater. lett.*, vol. 173, pp. 55-59, 15. Jun. 2016.
15. Stanislav Kamba, E. Simon, Volodymyr Skoromets, Viktor Bovtun, Martin Kempa, J. Pokorný, Maxim Savinov, Jurij Koruza, Barbara Malič, "Broad-band dielectric response of $0.5Ba(Ti_{0.8}Zr_{0.2}O_3$-$0.5(Ba_{0.7}Ca_{0.3})TiO_3$ piezoceramics: soft and central mode behaviour", *Phase transit.*, vol. 89, iss. 7-8, pp. 785-793, 2016.
16. Renata Kaplan, Boštjan Erjavec, Goran Dražić, Jože Grdadolnik, Albin Pintar, "Simple synthesis of anatase/rutile/brookite TiO_2 nanocomposite with superior mineralization potential for photocatalytic degradation of water pollutant", *Appl. catal., B Environ.*, vol. 181, pp. 465-474, Feb. 2016.
17. Evgeniya Khomyakova, Jernej Pavlič, Maja Makarovič, Hana Uršič, Julian Walker, Vladimir Shur, Tadej Rojac, Barbara Malič, Andreja Benčan, "Screen-printed $BiFeO_3$ thick films on noble metal foils", *Ferroelectrics*, vol. 496, no. 1, pp. 196-203, 2016.
18. Evgeniya Khomyakova, Matej Šadl, Hana Uršič, John Daniels, Barbara Malič, Andreja Benčan, Dragan Damjanović, Tadej Rojac, "Self-poling of $BiFeO_3$ thick films", *ACS appl. mater. interfaces*, vol. 8, no. 30, pp. 19626-19634, 2016.
19. Jurij Koruza, Pedro Groszewicz, Hergen Breitzke, Gerd Buntkowsky, Tadej Rojac, Barbara Malič, "Grain-size-induced ferroelectricity in $NaNbO_3$", *Acta mater.*, vol. 126, pp. 77-85, 2016.
20. Davor Kovačević, Rok Pratnekar, Karmen Godič Torkar, Jasmina Salopek, Goran Dražić, Anže Abram, Klemen Bohinc, "Influence of polyelectrolyte multilayer properties on bacterial adhesion capacity", *Polymers (Basel)*, vol. 8, no. 10, pp. 345-1-345-12, 2016.
21. Marija Kurinčič, Barbara Jeršek, Anja Klančnik, Sonja Smole Možina, Rok Fink, Goran Dražić, Peter Raspor, Klemen Bohinc, "Effects of natural antimicrobials on bacterial cell hydrophobicity, adhesion, and zeta potential", *Arh. hig. rada toksikol.*, vol. 67, pp. 39-45, 2016.
22. Danjela Kuščer, Mara Bernardo, Marina Santo-Zarnik, Barbara Malič, "Patterning of lead-zirconate-titanate thick-film structures by electrophoretic deposition from ethanol-based dispersions", *J. Eur. Ceram. Soc.*, vol. 36, no. 2, pp. 291-297, 2016.
23. Maja Makarovič, Julian Walker, Evgeniya Khomyakova, Andreja Benčan, Barbara Malič, Tadej Rojac, "Control of electrical conductivity in $0.7BiFeO_3 - 0.3SrTiO_3$ ferroelectric ceramics via thermal treatment in nitrogen atmosphere and Mn doping", *Inf. MIDEM*, vol. 46, no. 3, pp. 154-159, 2106.
24. Katja Makovšek, Irena Ramšak, Barbara Malič, Vid Bobnar, Danjela Kuščer, "Processing of steatite ceramic with a low dielectric constant and low dielectric losses", *Inf. MIDEM*, vol. 46, no. 2, pp. 100-105, 2016.
25. Aleksander Matavž, Raluca-Camelia Frunză, Aljaž Drnovšek, Vid Bobnar, Barbara Malič, "Inkjet printing of uniform dielectric oxide structures from sol-gel inks by adjusting the solvent composition", *J. mater. chem. C*, vol. 4, no. 24, pp. 5634-5641, 2016.
26. Mina M. Medić, Marija Vasić, Aleksandra R. Zarubica, Lidija V. Trandafilović, Goran Dražić, Miroslav D. Dramićanin, Jovan Nedeljković, "Enhanced photoredox chemistry in surface-modified Mg_2TiO_4 nanopowders with bidentate benzene derivatives", *RSC advances*, vol. 6, iss. 97, pp. 94780-94786, 2016.
27. Mojca Otoničar, Angelika Reichmann, Klaus Reichmann, "Electric field-induced changes of domain structure and properties in La-doped PZT-from ferroelectrics towards relaxors", *J. Eur. Ceram. Soc.*, vol. 36, iss. 10, pp. 2495-2504, 2016.
28. Andraž Pavlišič, Primož Jovanovič, Vid Simon Šelih, Martin Šala, Marjan Bele, Goran Dražić, Iztok Arčon, Samo B. Hočevar, Anton Kokalj, Nejc Hodnik, Miran Gaberščček, "Atomically resolved dealloying of structurally ordered Pt nanoalloy as an oxygen reduction reaction electrocatalyst", *ACS catal.*, vol. 6, iss. 8, pp. 5530-5534, Aug. 2016.
29. Tanja Pečnik, Andreja Eršte, Aleksander Matavž, Vid Bobnar, Maksim Ivanov, Juras Banys, Feng Xiang, Hong Wang, Barbara Malič, Sebastjan Glinšek, "Dielectric dynamics of the polycrystalline $Ba_{0.5}Sr_{0.5}TiO_3$ thin films", *Europhys. lett.*, vol. 114, no. 4, pp. 47009-1-47009-5, 2016.
30. Tanja Pečnik, Sebastjan Glinšek, Brigita Kmet, Barbara Malič, "Solution-derived $Ba_{0.5}Sr_{0.5}TiO_3$ thin-film capacitors in metal-insulator-metal configuration", *Inf. MIDEM*, vol. 46, no. 3, pp.136-141, 2016.
31. Peter Rodič, Alenka Mertelj, Miloš Borovšak, Andreja Benčan, Dragan Mihailović, Barbara Malič, Ingrid Milošev, "Composition, structure and morphology of hybrid acrylate-based sol-gel coatings containing Si and Zr composed for protective applications", *Surf. coat. technol.*, vol. 286, pp. 388-396, 2016.
32. Tadej Rojac, Silvo Drnovšek, Andreja Benčan, Barbara Malič, Dragan Damjanović, "Role of charged defects on the electrical and electromechanical properties of rhombohedral $Pb(Zr,Ti)O_3$ with oxygen octahedra tilts", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 1, pp. 014102-1-014102-11, 2016.
33. Tadej Rojac, Maja Makarovič, Julian Walker, Hana Uršič, Dragan Damjanović, Tomaž Kos, "Piezoelectric response of BiFeO[sub]3 ceramics at elevated temperatures", *Appl. phys. lett.*, vol. 109, no. 4, pp. 042904-1- 042904-4, 2016.
34. Blanca del Rosal, Alberto Pérez-Delgado, Elisa Carrasco, Dragana J. Jovanović, Miroslav D. Dramićanin, Goran Dražić, Ángeles Juarranz de la Fuente, Francisco Sanz-Rodriguez, Daniel Jaque, "Neodymium-based stoichiometric ultrasmall nanoparticles for multifunctional deep-tissue

photothermal therapy", *Adv. opt. mater.*, vol. 4, iss. 5, pp. 782-789, May 2016.
35. Slavica M. Savić, Gordana Stojanović, D. Vasiljević, Katarina Vojisavljević, Aleksandra Dapčević, A. Radojković, Sanja Pršič, Goran Branković, "Nanoindentation study of nickel manganite ceramics obtained by a complex polymerization method", *Ceram. int.*, vol. 42, no. 10, pp. 12276-12282, 2106.
36. Erika Švara Fabjan, Mojca Otoničar, Miran Gaberšček, Andrijana Sever Škapin, "Surface protection of an organic pigment based on a modification using a mixed-micelle system", *Dyes pigm.*, vol. 127, pp. 100-109, Apr. 2016.
37. Hana Uršič, Vid Bobnar, Barbara Malič, Cene Filipič, Marko Vrabelj, Silvo Drnovšek, Jo. Younghun, Magdalena Wencka, Zdravko Kutnjak, "A multicaloric material as a link between electrocaloric and magnetocaloric refrigeration", *Scientific reports*, vol. 6, pp. 26629-1-26629-5, 2016.
38. Hana Uršič, Silvo Drnovšek, Barbara Malič, "Complex domain structure in polycrystalline $Pb(Sc_{0.5}Nb_{0.5})O_3$", *J. phys., D, Appl. phys.*, vol. 49, pp. 115304-1-115304-4, 2016.
39. Hana Uršič, Lovro Fulanović, Marko Vrabelj, Zdravko Kutnjak, Brigita Rožič, Silvo Drnovšek, Barbara Malič, "Electrocaloric properties of $0.7Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.3PbTiO_3$ ceramics with different grain sizes", *Advances in applied ceramics*, vol. 115, no. 2, pp. 77-80, 2016.
40. Marko Vrabelj, Hana Uršič, Zdravko Kutnjak, Brigita Rožič, Silvo Drnovšek, Andreja Benčan, Vid Bobnar, Lovro Fulanović, Barbara Malič, "Large electrocaloric effect in grain-size-engineered $0.9Pb(Mg_{1/3}Nb_{2/3})O_3 - 0.1PbTiO_3$", *J. Eur. Ceram. Soc.*, vol. 36, iss. 1, pp. 75-80, 2016.
41. Julian Walker, Hana Uršič, Andreja Benčan, Barbara Malič, Hugh Simons, Ian Reaney, Giuseppe Viola, Nagarajan Valanoor, Tadej Rojac, "Temperature dependent piezoelectric response and strain-electric-field hysteresis of rare-earth modified bismuth ferrite ceramics", *J. mater. chem. C*, vol. 4, iss. 33, pp. 7859-7868, 2016.
42. Julian Walker *et al.* (11 authors), "Dual strain mechanisms in a lead-free morphotropic phase boundary ferroelectric", *Scientific reports*, vol. 6, pp. 19630-1-19630-8, 2016.

Published Conference Contribution (invited lecture)

1. Hana Uršič, Evgeniya Khomyakova, Silvo Drnovšek, Barbara Malič, Andreja Benčan, Kostja Makarovič, Darko Belavič, Ionel-Florinel Mercioniu, Cristina Schreiner, Romeo Ciobanu, P. Fanjul Bolado, "Screen-printed $Pb(Mg,Nb)O_3 - PbTiO_3$ thick films on ceramic substrates for sensor application", In: *Proceedings of the of the 2016 International Conference and Exposition on Electrical and Power Engineering, EPE 2016, October 20-22, 2016, Iasi, Romania*, 4 pp.

Published Conference Contribution

1. Darko Belavič, Marjan Hodnik, Marina Santo-Zarnik, Hana Uršič, Andraž Bradeško, Barbara Malič, Andreja Benčan, Kostja Makarovič, P. Fanjul Bolado, Ionel-Florinel Mercioniu, Romeo Ciobanu, Cristina Schreiner, "LTCC-based ceramic microsystems with integrated fluidic elements and sensors", In: *Proceedings of the of the 2016 International Conference and Exposition on Electrical and Power Engineering, EPE 2016, October 20-22, 2016, Iasi, Romania*, 5 pp.
2. Andreja Benčan, Hana Uršič, Evgeniya Khomyakova, Silvo Drnovšek, Ionel-Florinel Mercioniu, Kostja Makarovič, Darko Belavič, Christian Schreiner, Ramona Ciobanu, P. Fanjul Bolado, Barbara Malič, "Screen-printed $Pb(Mg,Nb)O_3 - PbTiO_3$ thick films on LTCC substrates", In: *Conference proceedings 2016*, 52nd International Conference on Microelectronics, Devices and Materials and the Workshop on Biosensors and Microfluidics, September 28 - 30 2016, Ankaran, Slovenia, pp. 47-51.
3. Barbara Bertoncelj, Katarina Vojisavljević, Janez Rihtaršič, Gregor Trefalt, Barbara Malič, "Microstructural analysis of Bulk Molding Compounds and correlation with the flexural strength", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 3-12.
4. Klemen Bohinc, Ágota Deák, Karmen Godič Torkar, Goran Dražić, Anže Abram, László Janovák, Imre Dékány, "Bacterial adhesion to material surfaces covered by thin films", In: *EURADH 2016 [and] Adhesion '16*, 11th European Adhesion Conference and 13th International Triennial Conference on the Science and Technology of Adhesion and Adhesives, 21 - 23 September 2016, Glasgow, UK, pp. 54-57.
5. Alja Kupec, Klemen Breskvar, Mitjan Kalin, "Changes in dimensional stability and mass of polymer gears due to water absorption", In: *Zbornik predavanj posvetovanja o tribologiji, mazivih in tehnični diagnostiki*, SLOTRIB 2016, Ljubljana, Slovenija, 17. november 2016, f. 137-144.
6. Stefan-Cristian Macovei, Ilas Tudor Alexandru, Drobotă Mihai, Darko Belavič, "Electrochemical techniques used to characterize electrochemical cells", In: *Proceedings of the of the 2016 International Conference and Exposition on Electrical and Power Engineering, EPE 2016, October 20-22, 2016, Iasi, Romania*, 6 pp.
7. Aleksander Matavž, Raluca-Camelia Frunză, Aljaž Drnovšek, Barbara Malič, Vid Bobnar, "Inkjet printing of thin metal-oxide structures from sol-gel-precursor inks", In: *2016 Joint IEEE International Symposium on the Applications of Ferroelectrics, European Conference on Application of Polar Dielectrics, (ISAF/ECAPD/PFM), 21-25 August 2016 Darmstadt, Germany*.
8. Antonio Petošić, Marko Horvat, Marko Budimir, Nikola Pavlović, Tadej Rojac, Barbara Malič, Silvo Drnovšek, "Electromechanical characterization of piezoceramic elements around resonance frequencies at high excitation levels and different thermodynamic conditions", In: *2016 Joint IEEE International Symposium on the Applications of Ferroelectrics, European Conference on Application of Polar Dielectrics, (ISAF/ECAPD/PFM), 21-25 August 2016 Darmstadt, Germany*, 4 pp..

Independent Component Part or a Chapter in a Monograph

1. Klemen Bohinc, Mojca Jevšnik, Rok Fink, Goran Dražić, Peter Raspor, "Surface characteristics dictate microbial adhesion ability", In: *Biological and pharmaceutical applications of nanomaterials*, Polina Prokopovich, ed., Boca Raton, CRC Press, Taylor & Francis, 2016, pp. 193-213.
2. Angelja Kjara Surca, Boris Orel, Goran Dražić, Philippe Colomban, "Vibrational spectroscopy and analytical electron microscopy studies of Fe-V-O and In-V-O thin films", In: *Nanostructured materials*, Heinrich Hofmann, ed., Wien, New York, Springer, cop. 2002, pp. 153-172.
3. Gregor Trefalt, Bosiljka Tadić, Barbara Malič, "Modeling of colloidal suspensions for the synthesis of the ferroelectric oxides with complex chemical composition", In: *Nanoscale ferroelectrics and multiferroics: key processing and characterization issues, and nanoscale effects. Vol. I and II*, Miguel Algueró, J. Marti Gregg, ed., Liliana Mitoseriu, ed., New York, Wiley, 2016, pp. 100-117.

Patent Application

1. Irena Ramšak, Marija Razpotnik, Katja Makovšek, Danjela Kuščer, Silvo Drnovšek, Janez Holc, *Steatite ceramics with improved electrocal properties and a method for the production thereof,* WO2016093771 (A1), European Patent Office, 16. 06. 2016.
2. Barbara Malič, Hana Uršič, Marija Kosec, Silvo Drnovšek, Jena Cilenšek, Zdravko Kutnjak, Brigita Rožič, Uroš Flisar, Andrej Kitanovski, Marko Ožbolt, Uroš Plaznik, Alojz Poredoš, Urban Tomc, Jaka Tušek, *Method for electrocaloric energy conversion,* US2016187034 (A1), US Patent Office, 30. 06. 2016.
3. Luka Suhadolnik, Matic Krivec, Miran Čeh, Kristina Žagar, Goran Dražič, *Photocatalytic reactor,* WO2016034253 (A1), WIPO International Bureau, 10. 03. 2016.

Patent

1. Luka Suhadolnik, Matic Krivec, Miran Čeh, Kristina Žagar, Goran Dražič, *Photocatalytic reactor,* SI24802 (A), Urad RS za intelektualno lastnino, 31. 03. 2016.

Mentoring

1. Tina Bakarič, *Processing of porous $Pb(Zr_{0.53}Ti_{0.47})O_3$ ceramics with a designed microstructure and patterning of thick films by inkjet printing:* doctoral dissertation, Ljubljana, 2016 (mentor Danjela Kuščer Hrovatin; co-mentor Tadej Rojac).
2. Jovana M. Ćirković, *Structural and dielectric characterization of barium strontium titanate synthesized by hydrothermally assissted modified Pechini method:* doctoral dissertation, Beograd, 2016 (mentor Katarina Vojisavljević; co-mentor Nikola Cvjetićanin).

3. Jitka Hreščak, *Synthesis and characterization of undoped and strontium-doped potassium sodium niobate ceramics:* doctoral dissertation, Ljubljana, 2016 (mentor Andreja Benčan Golob; co-mentor Barbara Malič).
4. Evgeniya Khomyakova, *Integration of screen-printed bismuth ferrite thick films onto ceramic and metal substrates:* doctoral dissertation, Ljubljana, 2016 (mentor Andreja Benčan Golob; co-mentor Tadej Rojac).
5. Tanja Pečnik, *Microstructure and dielectric properties of solution-derived (Ba,Sr)TiO_3 thin films:* doctoral dissertation, Ljubljana, 2016 (mentor Barbara Malič).
6. Marko Vrabelj, *Investigations of the electrocaloric effect in the polycrystalline 0.9Pb($Mg_{1/3}Nb_{2/3}$)O_3-0.1$PbTiO_3$ relaxor ferroelectric:* doctoral dissertation, Ljubljana, 2016 (mentor Barbara Malič).
7. Maja Makarovič, *Synthesis, structural and functional characterization of ferroelectric solid solutions based on bismuth ferrite:* master's thesis, Ljubljana, 2016 (mentor Tadej Rojac; co-mentor Andreja Benčan Golob).
8. Tomaž Kos, *Measurement system for automated low-frequency and high-temperature characterization of dielectric materials:* master's thesis, Ljubljana, 2016 (mentor Gregor Klančar; co-mentor Tadej Rojac).

DEPARTMENT FOR NANOSTRUCTURED MATERIALS K-7

One of our biggest advantages is our interdisciplinary team. The basic and applied research of the Department for Nanostructured Materials includes metals, intermetallic alloys, biomaterials, ceramic materials, and minerals. Our research encompasses conventional processing as well as the development of new technologies and methods for preparing new materials with advanced properties. It includes experimental and theoretical investigations of structures, analyses of chemical compositions at the atomic level, and measurements and calculations of physical properties, all of which help us to improve the properties of micro- and nanostructured materials.

Head:
Prof. Spomenka Kobe

Magnetic Materials.

The European project **MAG-DRIVE**, coordinated by one of the members of the department, was successfully concluded. The research in MAG-DRIVE was focused on developing novel microstructural-engineering strategies that dramatically improved the properties of magnets based on light rare-earth elements, especially the coercivity, which enables them to be used for electric vehicle (EV) applications above 100°C. These magnets were also designed-to-recycle, with an emphasis on reducing conventional rare-earth magnets' need for easily oxidizing grain boundaries.

The European project **REProMag** entered its second year. The goal is to develop and validate an innovative resource-efficient manufacturing route for **rare-earth magnets** that allows for the economic and efficient production of net-shape magnetic parts with complex structures and geometries, while being 100% waste-free along the whole manufacturing chain. We have successfully prepared a hard magnet from recycled magnetic materials. The rare earths are on the top of the list of **CRMs** (critical raw materials), so the recycling of Nd-Fe-B magnets is one of the top European priorities.

This is also one of the important research topics of the **DEMETER Marie-Curie European Training Network**. Our research is focused on utilizing a contemporary technique of spark plasma sintering (SPS), offering a minimized grain coarsening for the restoration and improvement of the magnetic performance. SPS experiments have demonstrated an improvement of coercivity of the raw HDDR (hydrogenation-disproportionation-desorption-recombination) powder to H_C = 1120 kA/m in a sintered magnet. A post-sinter annealing even resulted in an enhanced H_C= 1190 kA/m, most possibly due to the redistribution of the grain boundary Nd-rich phase. The synthesis part of the work was significantly supported by transmission electron microscopy **studies of interfaces in reprocessed HDDR Nd-Fe-B permanent magnets**. We developed a special Protective Atmosphere Transfer System, which enables advanced micro- and nano-characterization without exposing samples to oxidation. In the frame of DEMETER we also cover the fields of the development of novel hard magnetic $NdFe_{12}N_x$-based magnets by electrodeposition. Recent experiments were performed in ionic-liquid-based 1-Ethyl-3-methylimidazolium dicyanamide ([EMIM][DCA]) electrolytes in a protective atmosphere. Nd-Fe-based microns-thick films were successfully deposited with the composition close to the desired $NdFe_{12}$ ratio. The EDS spectra did not show a significant oxygen content, which shows that these films have the potential to be used as novel permanent magnets.

Complex Intermetallic Alloys.

In the frame of the **International Associated Laboratory (LIA) PACS2** in which the main goal is to improve our understanding of the mechanisms that promote complexity in metallic alloys, we studied the magnetic structure of a single crystal of the composition $Cu_{84}Gd_9Ca_7$ (at.%), which was grown by Czochralski pulling from the melt. Although Ca and Gd do not mix in the binary phase diagram, we could find on which atomic sites Gd and Ca are randomly distributed and completely determine the crystal structure. The low-temperature random anisotropy of the ferromagnetic structure was pointed out and its lock-in behaviour below a critical temperature of 24K was studied. We placed quite some effort on studying the crystallization path of a glass prepared by melt-spinning the well-known $Al_{62}Cu_{25}Fe_{13}$ alloy, which leads to a stable quasicrystal, but replacing Al by another trivalent element such as Ce or Gd. The rare earth kills the aperiodic order at low concentrations, but favours glass formation to such an extent that we could prepare bulk amorphous samples by pulsed electric current sintering of melt-spun ribbons. The crystallization products of these samples were identified and the reaction kinetics is under study. The Al-Cr-Sc system looks very promising so far. For the first time, we discovered a ternary compound in this system, which is still under investigation. It is reminiscent of the γ-brass phase known in the Al-Cr and derived systems. Superstructures with large lattice parameters were also pointed out. Complex lattice defects are observed and delight the electron

microscopy experts attached to the LIA. Finally, we dedicated a substantial amount of work to publish our results as well as those obtained by companion groups at the Faculty of Metallurgy and the Institute of Chemistry, respectively. The first stream of results ends up in the possibility to develop a new family of light alloys that will compete with alloys containing CRMs such as Mg. The second stream of work evidences the catalytic performance for the formation of water of the $Cu_5(Ca,Gd)$ alloy (already mentioned) just above room temperature in the presence of a mixture of H_2 and O_2. More work is required to fully interpret this data.

Structural Materials.

For more than 10 years **fusion** has been one of our important research activities. To achieve high efficiency and safe operation of the future fusion power plants, large efforts are related to the selection and optimization of suitable structural materials capable of withstanding extreme conditions. One of the key problems is the selection of materials for the divertor, which is responsible for power exhaust and impurity removal via guided plasma exhaust and is therefore subjected to very high heat fluxes. The main task of the High-Heat-Flux Materials (HHFM) division within the EUROfusion program, in which we are a partner, is thus the development of the **components for the DEMO divertor**. Tungsten is considered as a primary candidate for high-heat-loaded structural parts in the DEMO device, mainly due to its very high melting point, good thermal conductivity, low sputtering yield and relatively low activation in terms of long-term waste management. Unfortunately, these advantages are accompanied by a low fracture toughness in the lower-temperature regime, and the onset of recrystallization resulting in a loss of strength at high temperatures that severely limits the operating temperature window. We are trying to overcome the disadvantages of pure W by the incorporation of SiC fibres (to increase the fracture toughness) and/or W_2C nanoparticles (to prevent the recrystallization and grain growth of W) into the W matrix. So far we have determined the most suitable carbon precursor and amount of it for the *in-situ* synthesis of W_2C nanoparticles. Furthermore, we have also optimized the sintering conditions for **W-W_2C composites**. Additionally, we have shown that the incorporation of W_2C nanoparticles prevents the W-grain growth, even at temperatures higher than 1000 °C (operating temperature).

Materials for Health and Clean Environment.

Part of the research of the department is focused on **bio materials**. In the frame of the **COST Action NEWGEN** ("New generation biomimetic and customized implants for bone engineering") we continued with the synthesis and physical and biological characterization of fibroin composite scaffolds for the treatment of osteochondral defects. Using HRTEM analysis we were able to explain how the Ca^{2+} ions that are released from the bioactive glass can change the protein secondary structure, mainly the size of beta-sheets domains, that effectively control the scaffold's properties (in collaboration with the Biochemistry Department B2 and the Veterinary Faculty). In collaboration with Animacel d.o.o. we have expanded the knowledge of fibroin to the synthesis of films and patches for the treatment of large skin wounds in animals. Different surface modifications of fibroin films by conjugation with biological molecules were tested and their biological responses were compared. Several films were already used in the **experimental stem-cell treatment** of large skin/underskin wounds on dogs.

A national project on magnetooptically coupled nanomaterials for innovative cancer treatments continued with in-vitro studies of biofunctionalized FePt/SiO_2/Au nanoparticles (NPs) on three cell lines: normal porcine urothelial cells (NPU), low-grade (RT4) and high-grade (T24) cancer urothelial cells in collaboration with the Institute for Cell Biology, University of Ljubljana. After photothermal treatment, a drop in cell viability by 50 % was observed, which is in accordance to the NPs uptake of the RT4 and T24 cell lines, which was 15 and 13 %, respectively. The hybrid FePt/SiO_2/Au NPs, which we have developed produce a significant photothermal effect and can be effectively used on cancerous cells (Figure 1).

In collaboration with Belgrade University, new methods for the production of graded and biphasic scaffolds based on GG (gellan gummi) and BAG (bioactive glass) were utilized and optimized. The obtained results confirmed the possibility to produce scaffolds by the electrophoretic deposition (EPD) technique based on GG with a graded concentration of BAG aimed at osteochondral tissue engineering.

3D printing was investigated for the printing of various scaffolds (Figure 2). Thermosensitive bio-inks based on gellan gum, fibroin and calcium were developed, measuring the rheological properties of ink composites. We also started with the development of a powder-bed 3D printer for printing inorganic scaffolds, i.e., hydroxyapatite.

Within the **Era Chair ISOFood** project, a colorimetric assay for TiO_2 nanoparticle detection in complex matrices of food samples was developed. An established colorimetric method was adopted for the specific detection of the presence of nanosized TiO_2. The influence of surfactants, titania crystallinity and buffer medium on the accuracy of spectrophotometric detection was evaluated.

We analysed the physical and chemical properties of different industrial and commercially used nanoparticles in the frame of the project "Evaluation of possible harmful effects of nanoparticles and underlying mechanisms – from

physio-chemical and in **vitro toxicity characterization** to innate immune system activation". The main focus was on the colloidal properties in different cell media and on the solubility of possible harmful ions from the particles under physiological conditions. The results obtained in a collaboration with the Faculty of Electrical Engineering will help us to understand the response of cells to specific materials.

In the field of **dental ceramics** we are addressing major issues concerning the production of zirconia (3Y-TZP) dental restorations, their cementation and behaviour in clinical conditions (*in vivo*) in close cooperation with the Department of Prosthetic Dentistry, Medical Faculty, University of Ljubljana. An extensive study was published in *Dental Materials* on the complexity of the relationships between the sandblasting, ageing and strength of 3Y-TZP with different grain sizes and therefore different transformability. It was shown that fine-grained ceramic exhibited superior degradation resistance, while the coarse-grained ceramic experienced higher surface strengthening and a substantially improved ageing resistance upon sandblasting.

In the framework of the **Climate-KIC Accelerator programme**, which we have been part of, we have successfully met with a few companies that are spending a substantial amount of money for the treatment of their wastewater and need a highly efficient solution to reduce their treatment costs. An analysis of our device for the purification of their wastewater is planned after testing the new device's efficiency for the degradation of model organic substances such as caffeine and phenol, which we have already successfully mineralized in the past.

In the field of sensing and with the foreseen environmental application, we have developed Ni-based receptor elements for sensing different organic analytes using formaldehyde as an example. The modified Ni (Ni-OOH) electrode displays a remarked electro-catalytic activity for the oxidation of HCHO and exhibits a linear relationship in a wide concentration range with LOD 0.001 M. These advantages of porous Ni film make it promising for providing a low cost and **simple sensing method in real environments**.

In the last year we also studied **the fabrication and design of functionalised coatings** on metals. Such coating is attractive because of the wide range of applications and consequently the large impact, which such materials potentially have. We evaluated the possibilities of hydro- and solvothermal treatment along with simple post-processing methods on metallic aluminium and zinc to obtain **new materials** with novel or improved properties, such as self-cleaning, superhydrophilicity, superhydrophobicity, photocatalytic degradation of organics and dielectric properties. These improved properties were achieved by the formation of nano- and micro-sized coatings of titanium dioxide (TiO_2), zinc oxide (ZnO) and aluminium oxide hydroxide – boehmite (γ-AlO(OH)).

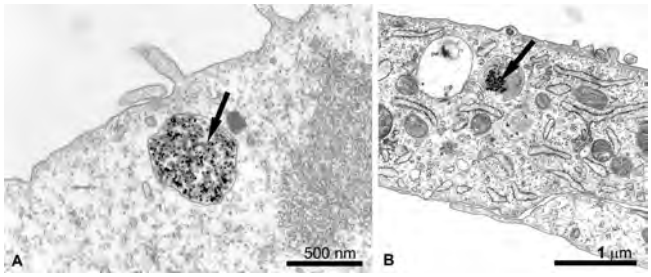


Figure 1: Internalization of hybrid NPs into high-grade cancer urothelial cells in vitro (A and B). (Curtesy of Mateja Erdani Kreft and Samo Hudoklin, Institute for Cell Biology, Medical Faculty, University of Ljubljana)

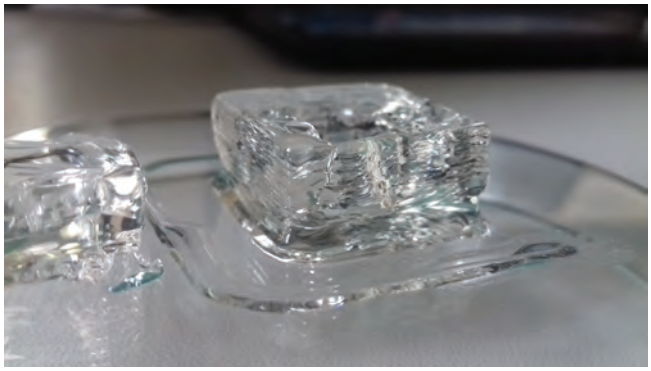


Figure 2: 3D printed gellan gum hydrogel

In the field of photocatalysis we have developed a new, innovative device for efficient water and air purification at relatively high flow rates. The main part of the device is a photocatalytically active material, which we synthesized using an anodic oxidation process. For the purpose of making a bigger device, we have developed a process that enables the simple synthesis of the photocatalytically active titania nanotubes that are rigidly attached to a specially shaped metal titanium foil used in our device.

Engineering and Functional Ceramics.

In collaboration with the Materials Science Institute of Madrid, we have developed cellulose nanofibre-reinforced engineering electro-conductive ceramics and filed a Great Britain patent application. Imparting electrical conductivity to a dielectric ceramic like alumina or zirconia with conducting nanocarbons (nanotubes or graphene) is challenging due to colloidal instability, particle segregation resulting in inhomogeneity. Instead, we used a small addition of cellulose nanofibres, which render highly homogeneous ceramic dispersions due to the increased hydrophilicity character. Nanofibres not only significantly reinforce the ceramic green body, but upon sintering also convert to finely distribute graphitic ex-cellulose carbon nanofibres within a dense and refined ceramic matrix, resulting in highly electro-conducting alumina and zirconia ceramics.

Translucent, self-reinforced mullite ceramic was developed by SPS sintering. Small amounts of yttria and silica in combination with SPS sintering provided enhanced densification, also provoking anisotropic grain growth at low sintering temperatures and pressures. Thus, it was possible to meet the conflicting demands for obtaining a dense mullite with anisotropic grains, ensuring good mechanical properties, while preserving a high light transmittance. The results were published in the *Journal of the American Ceramic Society* and received a best poster award

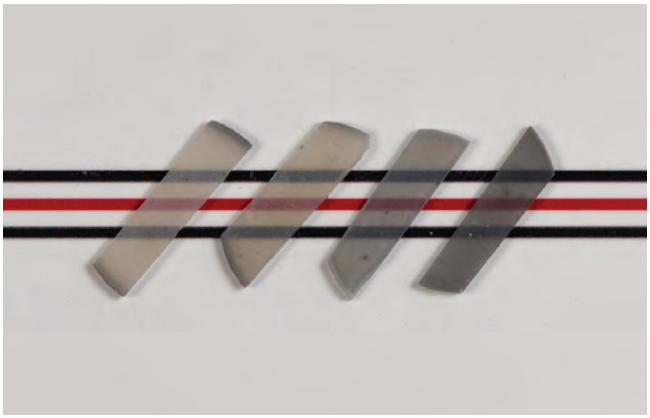


Figure 3: Translucent mullite ceramics.

among 129 competitors at the 41st International Conference and Expo on Advanced Ceramics and Composites, in Daytona Beach, Florida (Figure 3).

In the field of **thermoelectrics**, we studied the nanostructure and thermoelectric properties of an n-type thermoelectric material based on $Sr(Ti,Nb)O_3$ that has a perovskite structure. The addition of SrO and CaO into this structure caused the formation of a three-dimensional network of Rudlesden-Popper-type planar faults within the material. The random stacking of planar faults increased the phonon scattering and lowered the thermal conductivity. Consequently, the material exhibited an increased figure of merit ZT. The influence of the synthesis parameters on the microstructure development and consequently the thermoelectric characteristics was also studied in a p-type $Ca_3Co_4O_9$ ceramics and n-type ceramics of $Zn_kIn_2O_{k+3}$ (k=5,11,18) homologous phases. The thermoelectric characteristics of the $Ca_3Co_4O_9$ ceramics were significantly improved by optimizing the microstructural texturing. In the $ZnO\text{-}In_2O_3$ system, we determined a mechanism of the $Zn_kIn_2O_{k+3}$ homologous phase formation and explained its influence on the microstructure development and consequently thermoelectric characteristics of ceramics.

The influence of the hydrothermal synthesis process on the development of ZnO crystals with a specific morphology was studied. We associated the diverse morphology of the precipitated crystals to the differences in the transient crystallization processes during the precipitation. By altering the pH of the suspension after the precipitation, we gain control over the morphology of the ZnO and show how to grow identical crystallites with different shapes and crystal sizes. We were the first to find how ZnO platelets grow in a certain Zn^{2+}/OH^- ratio along the basal and one of the prismatic directions to form **spherolites** with a very high surface area. We also explained how sphere-like hierarchical structures composed of plate- or rod-like ZnO crystals form through self-assembly driven processes. The research on the hydrothermal synthesis of the **transparent conductive ZnO films** was focused on the influence of the Al-doping on growth, microstructure and optical properties of the ZnO films. The applications are foreseen in LC displays, touch screens and photovoltaic panels.

Within the frame of collaboration with the research group from Sabanci University, Istanbul, Turkey, we successfully realized several studies related to structure-property relationships of **functional oxide ceramics**. One is related to the development of long persistence phosphors as promising materials for energy-saving applications, due to their ability to temporarily store and release light. We confirmed that boron dramatically extends the afterglow persistence to longer than 8 h in strontium aluminates. A second study is related to flash sintering experiments that were for the first time performed on sodium potassium niobate (KNN) ceramics. A theoretical density of 94% was achieved in 30 s under a 250 V/cm electric field at 990°C. These conditions are around 100°C lower and faster than the conventional sintering conditions. Detailed microstructural and chemical investigations of the sample showed that there was inhomogeneous Na, K distribution, resembling a coreshell structure where K is more in the shell and Na is more in the core region (Figure 4). Our latest study deals with the structural and electronic modifications on TiO_2 anatase by Li, K or Nb doping below and above the solubility limit. XRD results have shown that the anatase-to-rutile phase transition as a function of temperature was suppressed by potassium and niobium incorporation, whereas it was facilitated by lithium incorporation.

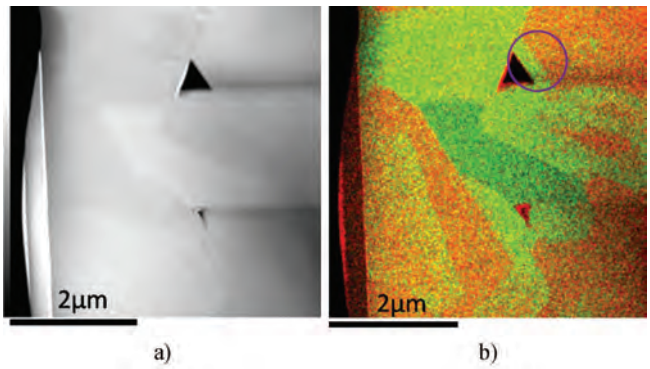


Figure 4: Flash sintering experiments, a) STEM-ADF image, b) STEM-EDX colour maps: K and Na ion atom distribution (K: green, Na: red).

The theoretical part of our research encompassed the density-functional theory to investigate the influence of the substrate on the potentially technologically interesting properties of **the borophene- a single atomic layer of boron atoms**, similar to graphene.

Minerals.

Part of the activities of the Department for Nanostructured Materials is focused on minerals as natural heritage. These basic studies help us to understand and use the knowledge in tailoring new materials. In the area of **twinning, epitaxies and phase transformations in minerals** we studied twinning in **pyrite (FeS_2)** from the Mt. Katarina locality near Ljubljana, where interpenetration pyrite twins occur in addition to single pyrite crystals. Analyses of twin boundaries and inclusions in pyrite crystals with techniques of high-resolution transmission electron microscopy showed that remnants of mineralizing fluids entrapped at the interfaces between the inclusions and hosting pyrite contain trace amounts of Pb and Cu, indicating their presence in the surrounding solutions throughout the

pyrite crystallization period. The atomic-scale analysis of the twin boundaries revealed that the formation of the interpenetrating twins is a consequence of complex 3D intergrowths of primary {110} twins enriched in Cu and secondary interfaces along {100} planes which are chemically unchanged. The results indicate that the formation of twins in pyrite is in accordance with the chemically induced twinning mechanism.

We have explained the mechanism of self-assembling of rutile mesocrystals under hydrothermal synthesis conditions leading to the formation of hierarchical nanostructures which exhibit superior efficiency in photo-electrochemical production of hydrogen and **improved solar-energy conversion efficiency**. We have shown that complex branched structures form as a result of the oriented assembly of precipitated fibres along {110} and {101} planes, resulting in lateral attachment and twinning. As precipitates are thermally agitated, their electromagnetic fields are coupled, and nanocrystals are aligned parallel to their longer axis. Due to a multiplicity of interactions, the particles are first attracted into a loosely associated arrangement. However, as the distance between the fibres becomes shorter the crystallographic alignment along the lowest energy planes becomes dominant. Our pioneering study was the first to clearly indicate the presence of electromagnetic force fields that convey critical structural information through which the oriented attachment of nanocrystals is accomplished. The results are published in the prestigious "Scientific Reports". In collaboration with our colleagues from Novosibirsk we studied the conditions that lead to the perfect splicing of beryl seeds into one larger single crystal under hydrothermal conditions. In our group we characterized the contact region between the intergrown crystals down to the atomic scale. We found that the presence of Si-rich amorphous pockets at the interface compensates for the small angular misfit between the oppositely growing domains (Figure 5).

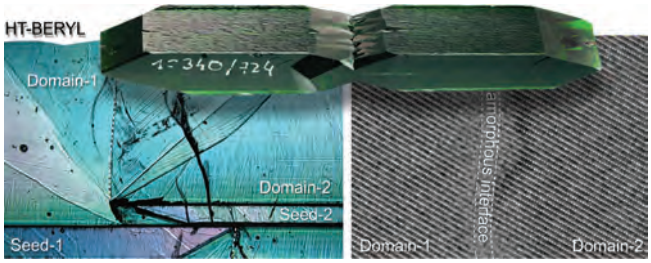


Figure 5: The possibility of the intergrowth of two bulk crystals to a single crystal was demonstrated on the example of beryl, growing under hydrothermal conditions.

Analytical Electron Microscopy

For the microstructural characterization of modern materials, we have applied advanced high-resolution scanning electron microscopy (FEGSEM) and analytical methods of energy-dispersive and wavelength-dispersive spectroscopy (EDS, WDS) for qualitative and quantitative elemental analysis. With the implementation of the method of electron backscatter diffraction (EBSD) we have investigated crystallographic characteristics of the materials: crystallinity, orientation of phases and texture.

The FEGSEM, EDS, WDS and EBSD methods were modified and optimized taking into account the specificity of individual materials with the aim to achieve the most precise and accurate analytical results. We investigated a variety of innovative materials such as ceramic thermoelectrics, complex metallic alloys and quasicrystalline alloys, magnetic materials, abrasives, and phosphorescent ceramics.

Using the EBSD analysis we have confirmed the presence and determined the type of twins in thermoelectrics based on polycrystalline SnO_2. We investigated the effects of heat treatment on the microstructure and phase composition of complex metallic alloys formed in Al-Cr-Sc materials. With advanced quantitative WDS analysis we have accurately determined small concentrations of rare-earth dopants Dy and Eu in phosphorescent ceramics based on $Sr_4Al_{14}O_{25}$.

We successfully finished the **ESTEEM2 project**, which was the only EU project dealing with methodology in **electron microscopy** analytical techniques. In view of this, we have successfully implemented electron microscopy techniques such as electron energy-loss spectroscopy (EELS), high-resolution scanning transmission electron microscopy (STEM, HAADF-STEM), electron holography and mechanical preparation of the TEM samples. Implementation of various electron microscopy analytical techniques and the possibility for the researchers to access research infrastructure for electron microscopy within the **Center for Electron Microscopy and Microanalysis** (CEMM) is of utmost importance for the research group.

The main part of our research within the frame of Liquid TEM studies was focused on the nucleation and early growth of TiO_2 and yttrium-based nanoparticles using the liquid cell inside of a transmission electron microscope (TEM). During heating of the solution to elevated temperatures we were able to record high-frame-rate videos of dynamic changes in electron diffraction patterns during the entire nucleation and growth process of the crystals, enabling us to later exactly reconstruct crystallographic changes during the whole process (Figure 6).

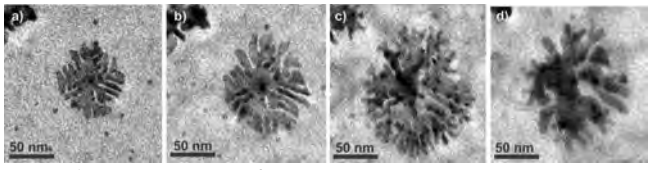


Figure 6: Growth sequence of dendritic nanoparticles in solution observed under dynamic conditions using the liquid TEM method (a-c).

Industrial partners.

We have provided high-temperature laboratory ceramics to Lithoz GmbH Vienna, Hidria Rotomatika Spodnja Idrija, ESAL d.o.o., and Brno Universtiy of Technology, Brno. We have collaborated with many partners from

industry and other research institutions by performing the analyses of specific materials. Main collaborations were with Domel Železniki, Akrapovič Ivančna Gorica, Ustna Medicina Ljubljana, Silkem Kidričevo and Errantech Hangzhou. For SwatyComet, we have conducted analyses of innovative composite abrasives within the project "Microstructural investigations of abrasive materials", which are intended to develop and manufacture improved cutting and grinding tools with a significantly prolonged lifetime. For RC eNeM we were developing microvaristor powder for composites with nonlinear resistivity.

Education and outreach activities.

The members of the Department are heavily involved in the educational system in Slovenia and abroad. Especially, our members dedicate themselves to the educational process of the Jožef Stefan International Postgraduate School, FKKT, NTF, and FMF.

In the frame of the project **Science on the street** (Znanost na cesti - ZnC) founded and coordinated by the members of the department, we are closely involved in raising public awareness in the promotion of science. For the last 4 years, the project activities were performed under the patronage of SATENA (the Slovenian Scientific–Technological Association). In the last year, we organized two cycles of popular scientific talks, scientific slam, round table, and we published several scientific blogs. We organized the scientific competitions for young scientists and students.

Awards and appointments

1. **Luka Suhadolnik**, 3rd Best Oral Presentation at the 24th International Conference on Materials and Technology, Portorož, Slovenia, 28-30 September 2016. Title of the awarded contribution: Optimization of Photoelectrocatalytic Activity of TiO_2-based Microreactor (co-authors: Andrej Pohar, Blaž Likozar and Miran Čeh)
2. **Ana Gantar**, Nataša Drnovšek, Rok Kocen, Saša Novak, Special prize for Innovations for Economy for "SilkPatch - Innovative Solution for Chronic Skin Wounds", 9th International Technology Transfer Conference & Innovation Day 2016, Brdo pri Kranju, 21 September 2016
3. **Nina Kostevšek**, Best Young Lecturer Award, 2nd International Symposium on Nanoparticles-Nanomaterials and Applications (ISN2A-2016), Lisbon, Portugal, 8-21 January 2016. Title of the awarded contribution: "Multimodal hybrid FePt/SiO_2/Au nanoparticles for nanomedical applications: New synthesis approach for improved magnetic and optical properties" (co-authors: Sašo Šturm, Igor Serša, Ana Sepe, Matjaž Spreitzer, Spomenka Kobe, Kristina Žužek Rožman)

Organization of conferences, congresses and meetings

1. Symposium: Design and Recycling of Rare-Earth (RE) Permanent Magnet (PM) Motors and Generators in Hybrid and Full Electric Vehicles – DEMETER, Ljubljana, 14 March 2016
2. EMAS 2016 - 12th Regional Workshop on Electron Probe Microanalysis of Materials Today - Practical Aspects, Bagnols-sur-Cèze, France, 8–11 May 2016 (members of European Microbeam Analysis Society Board)
3. 24th International Conference on Materials and Technology – 24 ICM&T, 28–30 September, Portorož (co-organisers)
4. C-MAC Days 2016, Bratislava, Slovakia, 21–23 November 2016 (members of Science Board and General Assembly in European Integrated Center for the Development of New Metalic Alloys and Compounds (C-MAC))

Patent granted

1. Luka Suhadolnik, Matic Krivec, Miran Čeh, Kristina Žagar, Goran Dražič, Photocatalytic reactor, SI24802 (A), Slovenian Intellectual Property Office, 31. 03. 2016

INTERNATIONAL PROJECTS

1. Selective Laser Melting (SLM) and Spark Plasma Sintering (SPS) of Cost Effective Rare-earth based Permanent Magnets for Electrical Machines
   Prof. Spomenka Kobe
   Abb Switzerland Ltd
2. PurBox - Prototype of the Photoelectriocatalitic Reactor
   Luka Suhadolnik, B. Sc.
   Provadis School Of International
3. 7FP - ESTEEM 2; Enabling Science and Technology through European Electron Microscopy
   Prof. Miran Čeh
   European Commission
4. 7FP - MAG-DRIVE; New Permanent Magnets for Electric-Vehicle Drive Application
   Asst. Prof. Matej Andrej Komelj
   European Commission
5. 7 FP; ERA CHAIR ISO-FOOD - Era Chairs for Isotope Techniques in Food Quality, Safety and Traceability
   Prof. Saša Novak Krmpotič
   European Commission
6. COST MP1301 NEWGEN; New Generation Biomimetic and Customized Implants for Bone Engineering
   Prof. Saša Novak Krmpotič
   Cost Office
7. COST ES1205; The Transfer of Engineered Nanomaterials from Wastewater Treatment & Stormwater to Rivers
   Prof. Saša Novak Krmpotič
   Cost Office
8. H2020 - REProMag; Resource Efficient Production Route for Rare Earth Magnets
   Dr. Benjamin Podmiljšak
   European Commission
9. H2020 - DEMETER; Training Network for the Design and Recycling of Rare-Earth Permanent Magnet Motors and Generators in Hybrid and Full Electric Vehicles
   Asst. Prof. Kristina Žužek Rožman
   European Commission

10. H2020, EUROFUSION;Materials-PPPT-FU: WC and SiC Reinforced Tungsten
    Prof. Saša Novak Krmpotič
    European Commission
11. H2020, Education-ED-FU, EUROFUSION
    Prof. Saša Novak Krmpotič
    European Commission
12. Advanced Methods and Technologies for Processing of a New Generation of ZnO-based Varistor Ceramics
    Prof. Slavko Bernik
    Chinese Academy of Sciences, Shanghai
13. Irradiation and Analysis of Nano SiC Samples
    Dr. Aljaž Iveković
    National Nuclear Research Center, Azerbaijan
14. Determination of Minority Phases, Quantitative Analysis and Determination of Lattice Parameters in SPS Sintered Samples Analysis and Determination of Lattice Parameters in SPS Sintered Samples
    Dr. Petra Jenuš Brdnik
    Jecs Trust
15. Electron Microscopy Study of the Degradation Kinetics of Porous Bioactive Glass based Novel Drug Eluting Implants (Coating/3D Scaffolds) as a Function of Hard Tissue Regeneration for Treatment of Osteoporotic Fractures in Elderly Patients
    Asst. Prof. Nina Daneu
    BI-IN/15-17-015
    Slovenian Research Agency
16. Nucleation and Photocatalytic Activity of Nanoparticles Studied in Actual Liquid Environment under Transmission Electron Microscope
    Prof. Sašo Šturm
    Slovenian Research Agency
    BI-JP/15-17-001
17. Atomic-scale Studies of Topotaxial Reactions in Minerals with the Rutile and Corundum-type Structures
    Asst. Prof. Nina Daneu
    Slovenian Research Agency
    BI-US/15-16-065
18. 0D to 3D ZnO Nanostructures for Optical, Electonic and Energy Applications
    Dr. Matejka Podlogar
    Slovenian Research Agency
    BI-RS/16-17-053
19. Synthesis of Core/Shell MgAl2O4 Spinel Powders for Transparent Armor and IR Applications – CSMASP
    Prof. Slavko Bernik
    Slovenian Research Agency
    BI-TR/16-18-003
20. Processing of High-performance Zirconia Bioceramics for Dental Application
    Asst. Prof. Andraž Kocjan
    Slovenian Research Agency
    BI-HR/16-17-035
21. Investigations of Twinning and Topotaxial Reactions in Sulphide Minerals
    Prof. Aleksander Rečnik
    Slovenian Research Agency
    BI-HR/16-17-029
22. Crystal and Electronic Structure of NbS3 Phases
    Prof. Sašo Šturm
    Slovenian Research Agency
    BI-RU/16-18-048
23. Crystallography, Twinning and Phase Transformations in Minerals with Aragonite-Type Structure (CaCO3, SrCO3, BaCO3, PbCO3)
    Prof. Aleksander Rečnik
    Slovenian Research Agency
    BI-RU/16-18-004
24. Structural and Microstructural Engineering of ZnO Thermoelectrics (SMEZ)
    Prof. Slavko Bernik
    Slovenian Research Agency
    BI-FR/15-16-PROTEUS-007

RESEARCH PROGRAMS

1. Engineering and bio-ceramics
   Asst. Prof. Andraž Kocjan
2. Nanostructured Materials
   Prof. Spomenka Kobe

R & D GRANTS AND CONTRACTS

1. Atomic-scale studies of initial stages of phase transformations in minerals
   Asst. Prof. Nina Daneu
2. Structure and Chemical Composition Study of Surfaces and Interfaces with Highresolution Scanning Transmission Electron Microscopy at Atomic Level
   Prof. Aleksander Rečnik
3. Bio-responsive magneto-optically coupled nanomaterial-based systems for innovative skin cancer treatments
   Prof. Sašo Šturm
4. High-Performance Nanostructured Coatings - breakthrough in concentrated solar power
   Asst. Prof. Andraž Kocjan
5. From the synthesis of metal oxides to the humidity and oxygen prototype nanosensors
   Dr. Kristina Žagar Soderžnik
6. High-coercivity Nd-Fe-B permanent magnets with minimum amount of heavy rare earths
   Dr. Marko Soderžnik

NEW CONTRACTS

1. Preparation of microvaristor powder for composites with nonlinear resistivity
   Prof. Slavko Bernik
   Razvojni Center eNeM Novi Materiali d. o. o.
2. Research & development of dental materials
   Dr. Nataša Drnovšek, Asst. Prof. Andraž Kocjan
   Ustna medicina, d.o.o.
3. Microstructural investigations of abrasive materials
   Dr. Zoran Samardžija
   SwatyComet, d.o.o.

VISITORS FROM ABROAD

1. Dr. Cristina Echevarria-Bonet, Institute for Energy Technology (IFE), Physics Department, Kjeller, Norway, 30 January – 7 February 2016
2. Nerea Gonzales, Marta Navarro, Universidad Rey Juan Carlos, Madrid, Spain, 16 February – 14 May 2016
3. Prof. Mihály Pósfai, University of Pannonia, Veszprém, Hungary, 18–22 February 2016
4. Prof. István Dódony, dr. Ildikó Cora, Erzsi Dodony, Eötvös Loránd University, Budapest, Hungary, 18 – 22 February 2016
5. Dr. Milivoj Plodinec, Ruđer Bošković Institute, Zagreb, Croatia, 25–27 February 2016
6. Prof. Cleva Ow Yang, Sabanci University, Istanbul, Turkey, 6–10 March 2016
7. Dr. Milivoj Plodinec, Dr. Irena Kereković, Ruđer Bošković Institute, Zagreb, Croatia, 14–26 March 2016
8. Dr. Julian Ledieu, Joris Kadok, Institut Jean Lamour, Nancy, France, 25–29 March 2016
9. Prof. Kazuhiro Hono, National Institute for Materials Science (NIMS), Tsukuba, Japan, 7–9 May 2016
10. Dr. Elinor Grace Castle, Queen Mary University of London – QMUL, London, United Kingdom, 13 May – 4 June 2016
11. Dr. Goran Štefanić, Ruđer Bošković Institute, Zagreb, Croatia, 17–18 May 2016
12. Dr. Magnus H. Sørby, Institute for Energy Technology, Physics Department, Kjeller, Norway, 25–28 May 2016
13. Dr. Richard Wheeler, Edinburgh Scientific, Edinburgh, Scotland, 28 May – 1 June 2016
14. Dr. Goran Branković, Marina Vuković, Vesna Ribić, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, 1–8 June 2016
15. Dr. Bernd Wicklein, Instituto de Ciencia de Materiales de Madrid – ICMM, Madrid, Spain, 13–24 June 2016
16. Dr. Émilie Gaudry, Institut Jean Lamour, Nancy, France, 8–15 July 2016
17. Fabian Burkhardt, University of Applied Sciences Aalen, Engelsbrand, Germany, 1 Avgust 2016 – 28 January 2017
18. Dr. Mauro Alini, AO Foundation, Davos, Switzerland, 24–25 August 2016
19. Dr. Yuki Kimura, Dr. Jun Kawano, Tomoya Yamazaki, University of Hokaido, Hokaido, Japan, 24–27 August 2016
20. Dr. Pavel Gavryushkin, Sobolev Institute of Geology and Mineralogy, Novosibirsk, Russia, 2–19 September 2016
21. Prof. Makoto Shiojiri, Kyoto Institute of Technology, Kyoto, Japan, 4–7 September 2016
22. Dr. Richard Wheeler, Edinburgh Scientific, Edinburgh, Scotland, 4–9 September, 2016
23. Matej Baláž, Institute of Geotechics, Slovak Academy of Sciences, Košice, Slovakia, 10–16 September 2016
24. Dr. Ulrike Wolff, Leibniz-Institut für Festkörper- und Werkstoffforschung, Dresden, Germany, 3 October – 31 December 2016
25. Prof. Peter A. van Aken, Stuttgart Center for Electron Microscopy, Max Planck Institute for Solid State Research, Stuttgart, Germany, 11–13 October 2016
26. Sayanthan Ray, Central Glass and Ceramic Research Institute – CSIR, Kolkata, India, 20 October – 20 November 2016
27. Dr. Richard Wheeler, Edinburgh Scientific, Edinburgh, Scotland, 23–28 October 2016
28. Jovana Zvicer, Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia, 29 October – 4 December 2016

29. Dr. Reinhard Simon, ABB Corporate Research Center, Baden-Dättwil, Switzerland, 9 November 2016
30. Dr. Andrea Čobić, Prof. Vladimir Bermanec, Dr. Snježana Mikulčić Pavlaković, Marin Soufek, M.Sc., Faculty of Science, Universty of Zagreb, Zagreb, Croatia, 10 November 2016
31. Vesna Ribić, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, 16 November – 16 December 2016
32. Dr. Goran Branković, Marina Vuković, Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, 16–23 November 2016
33. Prof. Mehmet Ali Gülgün, Sabanci University, Istanbul, Turkey, 23–25 November 2016
34. Dr. Andrea Čobić, Dr. Snježana Mikulčić Pavlaković, Faculty of Science, Universty of Zagreb, Zagreb, Croatia, 24–29 November 2016
35. Prof. Emmanuel Guilmeau, Cédric Bourgès, Laboratoire CRISMAT, Caen, France, 28 – 30 November 2016
36. Asst. Prof. Ismail Özgür Özer, Anadolu University, Department of Materials Science and Engineering, Eskişehir, Turkey, 7–11 December 2016
37. Dr. Julian Ledieu, Dr. Vincent Fournée, Dr. Marie-Cécile de Weerd, Institut Jean Lamour, Nancy, France, 12–15 December 2016

STAFF

Researchers
1. Prof. Slavko Bernik
2. Prof. Miran Čeh
3. Asst. Prof. Nina Daneu
4. Prof. Jean Marie Dubois
5. **Prof. Spomenka Kobe, Head**
6. Asst. Prof. Andraž Kocjan
7. Asst. Prof. Matej Andrej Komelj
8. Prof. Saša Novak Krmpotič
9. Dr. Benjamin Podmiljšak
10. Prof. Aleksander Rečnik
11. Dr. Zoran Samardžija
12. Prof. Sašo Šturm
13. Dr. Kristina Žagar Soderžnik
14. Asst. Prof. Kristina Žužek Rožman

Postdoctoral associates
15. Dr. Nataša Drnovšek
16. Dr. Ana Gantar
17. *Dr. Aljaž Iveković, on leave 01.03.16*
18. Dr. Petra Jenuš Brdnik
19. *Dr. Martina Lorenzetti, left 21.12.16*
20. *Dr. Darja Pečko, left 01.03.16*
21. Dr. Matejka Podlogar
22. Dr. Marko Soderžnik

Postgraduates
23. Anže Abram, B. Sc.
24. Bojan Ambrožič, B. Sc.
25. Sandra Drev, B. Sc.
26. Hermina Hudelja, B. Sc.
27. Awais Ikram, B. Sc.
28. *Dr. Marja Jerič, left 01.11.16*
29. Vanja Jordan, B. Sc.
30. Luka Kelhar, B. Sc.
31. Rok Kocen, B. Sc.
32. Matej Kocen, B. Sc.
33. Nina Kostevšek, B. Sc.
34. *Mateja Košir, B. Sc., left 01.12.16*
35. Ana Lazar, B. Sc.
36. Muhammad Farhan Mehmood, B. Sc.
37. Luka Suhadolnik, B. Sc.
38. Sara Tominc, B. Sc.
39. Tomaž Tomše, B. Sc.
40. Špela Trafela, B. Sc.
41. Xuan Xu, B. Sc.

Technical officers
42. *Dr. Jana Ferčič, left 01.07.16*
43. Sanja Fidler, B. Sc.
44. *Martin Topole, B. Sc., left 01.10.16*

Technical and administrative staff
45. Teja Đukić
46. Darko Eterović
47. *Mojca Hren, left 21.12.16*
48. Tomislav Pustotnik

BIBLIOGRAPHY

Original Article

1. Somayeh Abdi, Matthias Bönisch, Steffen Oswald, Mohsen Samadi Khoshkhoo, Wolfgang Gruner, Martina Lorenzetti, Ulrike Wolff, Mariana Calin, Jürgen Eckert, Annett Gebert, "Thermal oxidation behavior of glass-forming Ti-Zr-(Nb)-Si alloys", *J. mater. res.*, vol. 31, no. 9, pp. 1264-1274, 2016.
2. Anže Abram, Andreja Eršte, Goran Dražić, Vid Bobnar, "Structural and dielectric properties of hydrothermally prepared boehmite coatings on an aluminium foil", *J. mater. sci., Mater. electron.*, vol. 27, no. 10, pp. 10221-10225, 2016.
3. Guliz Inan Akmehmet, Sašo Šturm, Laura Bocher, Mathhieu Kociak, Bojan Ambrožič, Cleva Ow-Yang, "Structure and luminescence in long persistence Eu, Dy, and B codoped strontium aluminate phosphors: the boron effect", *J. Am. Ceram. Soc.*, vol. 99, iss. 6, pp. 2175-2180, 2016.
4. Muhammad Shahid Arshad, Mariana P. Proenca, Špela Trafela, Volker Neu, Ulrike Wolff, Sven Stienen, Manuel Vazques, Spomenka Kobe, Kristina Žužek Rožman, "The role of the crystal orientation (c-axis) on switching field distribution and the magnetic domain configuration in electrodeposited hcp Co-Pt nanowires", *J. phys., D, Appl. phys.*, vol. 49, no. 18, pp. 1-13, May 2016.
5. Slavko Bernik, Mateja Košir, Emmanuel Guilmeau, "Microstructure and thermoelectric characteristics of $(ZnO)_kIn_2O_3$- based ceramics (k = 5 and 11", *Zašt. mater.*, vol. 57, no. 2, pp. 318-345, 2016.
6. Klemen Bohinc, Goran Dražić, Anže Abram, Mojca Jevšnik, Barbara Jeršek, Damijan Nipič, Marija Kurinčič, Peter Raspor, "Metal surface characteristics dictate bacterial adhesion capacity", *Int. j. adhes. adhes.*, vol. 68, pp. 39-46, July 2016.
7. Danielle Cavalcante Guedes de Lima, Tibério Andrade Dos Passos, Marie-Cecile De Weerd, Samuel Kenzari, Rodinei Gomes Medeiros, Severino Jackson Guedes De Lima, Jean-Marie Dubois, "Indirect assessment of the surface energy of the Al-Cu-Fe quasicrystal", *J. Mater. Sci.*, vol. 51, no. 8, pp. 4070-4078, 2016.
8. Gulcan Corapcioglu, Mehmet Ali Gülgün, Kim Kisslinger, Sašo Šturm, Shikhar K. Jha, Rishi Raj, "Microstructure and microchemistry of flash sintered $K_{0.5}Na_{0.5}NbO_3$", *J. Ceram. Soc. Jpn.*, vol. 124, no. 4, pp. 321-328, 2016.
9. Jasna Cotič, Peter Jevnikar, Andraž Kocjan, Tomaž Kosmač, "Complexity of the relationships between the sintering-temperature-dependent grain size, airborne-particle abrasion, ageing and strength of 3Y-TZP ceramics", *Dent Mater*, vol. 32, iss. 4, pp. 510-518, Apr. 2016.
10. Aleš Dakskobler, Andraž Kocjan, Paul Bowen, "Predicting the yield stress of paraffin-wax suspensions", *Powder technol.*, vol. 291, pp. 1-6, 2016.
11. Nataša Drnovšek, Rok Kocen, Ana Gantar, Marinka Drobnič-Košorok, Adrijana Leonardi, Igor Križaj, Aleksander Rečnik, Saša Novak, "Size of silk fibroin β-sheet domains affected by Ca^{2+}", *J. mater. chem. B* , vol. 4, iss. 40, pp. 6597-6608, 2016.
12. Ana Gantar, Nataša Drnovšek, Pablo Casuso, Adrián Pérez-San Vicente, Javier Rodriguez, Damien Dupin, Saša Novak, Irada Loinaz, "Injectable and self-healing dynamic hydrogel containing bioactive glass nanoparticles as a potential biomaterial for bone regeneration", *RSC advances*, vol. 6, no. 73, pp. 69156-69166, 2016.
13. Petra Jenuš, Martin Topole, Paul J. McGuiness, Cecilia Granados-Miralles, Marian Stingaciu, Mogens Christensen, Spomenka Kobe, Kristina Žužek Rožman, "Ferrite-based exchange-coupled hard-soft magnets fabricated by spark plasma sintering", *J. Am. Ceram. Soc.*, vol. 99, iss. 6, pp. 1927-1934, 2016.

14. Marja Jerič, Johannes de Boor, Boštjan Jančar, Miran Čeh, "An enhanced thermoelectric figure of merit for $Sr(Ti_{0.8}Nb_{0.2})O_3$ based on a Ruddlesden-Popper-polytype-induced microstructure", *J. Eur. Ceram. Soc.*, vol. 36, nol. 5, pp. 1177-1182, 2016.
15. Marja Jerič, Johannes de Boor, Janez Zavašnik, Miran Čeh, "Lowering the thermal conductivity of $Sr(Ti_{0.8}Nb_{0.2})O_3$ by SrO and CaO doping emicrostructure and thermoelectric properties: microstructure and thermoelectric properties", *J. Mater. Sci.*, vol. 51, no. 16, pp. 7660-7668, 2016.
16. Vanja Jordan, Uroš Javornik, Janez Plavec, Aleš Podgornik, Aleksander Rečnik, "Self-assembly of multilevel branched rutile-type TiO_2 structures via oriented lateral and twin attachment", *Scientific reports*, vol. 6, pp. 24216-1-24216-13, 2016.
17. Tjaša Kanduč, Zoran Samardžija, Nataša Mori, Andreja Jerebic, Ines Levačić, Miha Kračun, Johanna A. Robinson, Stojan Žigon, Željko Blaženka, David Kocman, "Hydrogeochemical and isotopic characterization of Pesnica River, Slovenia", *Geologija*, vol. 59, no. 2, pp. 179-192, 2016.
18. Luka Kelhar, Jana Bezjak, Pascal Boulet, Marjeta Maček, Sašo Šturm, Martin Lamut, Boštjan Markoli, Spomenka Kobe, Jean-Marie Dubois, "Stabilisation of Ce-Cu-Fe amorphous alloys by addition of Al", *Philos. mag. (2003)*, vol. 96, iss. 30, pp. 3143-3185, 2016.
19. Luka Kelhar, Janez Zavašnik, Paul J. McGuiness, Spomenka Kobe, "The impact of processing parameters on the properties of Zn-bonded Nd-Fe-B magnet", *J. magn. magn. mater.*, vol. 419, pp. 171-175, 2016.
20. Andraž Kocjan, Marko Češnovar, Damjan Vengust, Tomaž Kosmač, Aleš Dakskobler, "Translucent yttria- and silica-doped mullite ceramics with anisotropic grains produced by spark plasma sintering", *J. Am. Ceram. Soc.*, vol. 99, iss. 9, pp. 3090-3069, 2016. [COBISS.SI-ID 29511719]
21. Nina Kostevšek *et al.* (13 authors), "The one-step synthesis and surface functionalization of dumbbell-like gold-iron oxide nanoparticles: a chitosan-based nanotheranostic system", *Chem. commun. (Lond., 1996)*, vol. 52, issue 2, pp. 378-381, 2016.
22. Davor Kovačević, Rok Pratnekar, Karmen Godič Torkar, Jasmina Salopek, Goran Dražić, Anže Abram, Klemen Bohinc, "Influence of polyelectrolyte multilayer properties on bacterial adhesion capacity", *Polymers (Basel)*, vol. 8, no. 10, pp. 345-1-345-12, 2016.
23. Mitja Krnel, Stanislav Vrtnik, Primož Koželj, Andraž Kocjan, Zvonko Jagličić, Pascal Boulet, Marie-Cecile De Weerd, Jean-Marie Dubois, Janez Dolinšek, "Random-anisotropy ferromagnetic state in the $Cu_5Gd_{0.54}Ca_{0.42}$ intermetallic compound", *Phys. rev., B, Condens. matter mater. phys.*, vol. 93, no. 9, pp. 094202-1-094202-14, 2016.
24. Daniel Kytýř, Tomáš Doktor, Marcel Adorna, Michaela Neuhauserova, Jan Šleichrt, Nela Fenclová, Ana Gantar, Saša Novak, "Deformation behaviour of gellan gum based scaffold subjected to compression loading", *Appl. mech. mater.*, vol. 821, pp. 665-670, 2016.
25. Martina Lorenzetti, Ekaterina Gongadze, Mukta Vishwanath Kulkarni, Ita Junkar, Aleš Iglič, "Electrokinetic properties of TiO[sub]2 nanotubular surfaces", *Nanoscale research letters*, vol. 11, pp. 378-1-378 -13, 2016.
26. Ivana Marković, Svetlana Nestorović, Boštjan Markoli, Milena Premović, Sašo Šturm, "Anneal hardening in cold rolled PM Cu-Au alloy", *Mater. sci. eng., A Struct. mater.: prop. microstruct. process.*, vol. 658, pp. 393-399, March 2016.
27. Branko Matović, Fatima Živić, Slobodan Mitrović, Dragan Pršić, Vesna Maksimović, Tatjana Volkov Husović, Ravi Kumar, Nina Daneu, "Ultra-high pressure densification and properties of nanostructured SiC", *Mater. lett.*, vol. 164, pp. 68-71, 2016.
28. Iztok Naglič, Semjon Ilić, Boštjan Markoli, Matej Dolenec, Blaž Leskovar, Žan Filipič, Matej Perhoč, Jakob Kraner, Matej Bizjak, Božo Skela, Luka Kelhar, Špela Kozole, David Gerčar, Teja Ramšak, "Modifikacija zlitine AlSi7Mg lite v peščeno formo", *Livar. vestn.*, vol. 63, no. 1, pp. 37-47, 2016.
29. Saša Novak, Martina Lorenzetti, Anja Drame, Janja Vidmar, Janez Ščančar, Metka Filipič, "Diversity of TiO_2 nanopowders' characteristics relevant to toxicity testing", *J. nanopart. res.*, vol. 18, pp. 130-1-130-13, 2016.
30. Matejka Podlogar, Aleksander Rečnik, Gurkan Yilmazoglu, İsmail Özgür Özer, Matjaž Mazaj, Ender Suvaci, Slavko Bernik, "The role of hydrothermal pathways in the evolution of the morphology of ZnO crystals", *Ceram. int.*, vol. 42, no. 14, pp. 15358-15366, 2016.
31. Mojca Presečnik, Slavko Bernik, "Influence of a mechano-chemical treatment on the synthesis and characteristics of p-type thermoelectric $Ca_3Co_4O_9$", *J. alloys compd.*, vol. 686, pp. 708-716, 2016.
32. Mojca Presečnik, Slavko Bernik, "Microstructural and thermoelectric properties of WO_3-doped $Ca_3Co_4O_9$ ceramics", *Ceram. int.*, vol. 42, no. 14, pp. 16103-16108, 2016.
33. Mojca Presečnik, J. de Boor, Slavko Bernik, "Synthesis of single-phase $Ca_3Co_4O_9$ ceramics and their processing for a microstructure-enhanced thermoelectric performance", *Ceram. int.*, vol. 42, no. 6, pp. 7315-7327, 2016.
34. Aleksander Rečnik, Janez Zavašnik, Lei Jin, Andrea Čobić, Nina Daneu, "On the origin of "iron-cross" twins of pyrite from Mt. Katarina, Slovenia", *Mineralogical Magazine*, vol. 80, no. 6, pp. 937-948, 2016.
35. Marko Soderžnik, Matic Korent, Kristina Žagar, Matthias Katter, Kaan Üstüner, Spomenka Kobe, "High-coercivity Nd-Fe-B magnets obtained with the electrophoretic deposition of submicron TbF_3 followed by the grain-boundary diffusion process", *Acta mater.*, vol. 115, pp. 278-284, 2016.
36. Urška Stankovič Elesini, Mirjam Leskovšek, Slavko Bernik, Boštjan Šumiga, Raša Urbas, "Influence of co-current spray drying conditions on agglomeration of melamine-formaldehyde microcapsules", *Dry. technol.*, vol. 34, no. 12, pp. 1510-1520, 2016.
37. Nadežda Stanković, Aleksander Rečnik, Nina Daneu, "Topotaxial reactions during oxidation of ilmenite single crystal", *J. Mater. Sci.*, vol. 51, iss. 2, pp. 958-968, 2016.
38. Luka Suhadolnik, Ivan Jerman, Amadej Kujan, Kristina Žagar, Matic Krivec, Miran Čeh, "Morphological, optical and electrical characterization of titania-nanotubes-based dye-sensitized solar cells", *Sol. energy*, vol. 127, pp. 232-238, 2016.
39. Luka Suhadolnik, Andrej Pohar, Blaž Likozar, Miran Čeh, "Mechanism and kinetics of phenol photocatalytic, electrocatalytic and photoelectrocatalytic degradation in a TiO_2-nanotube fixed-bed microreactor", *Chem. eng. j. (1996)*, vol. 303, pp. 292-301, 2016.
40. Nikola Tasić, Zorica Marinković Stanojević, Zorica Branković, Uroš Lacnjevac, Vesna Ribić, Milan Žunić, Tatjana Novaković, Matejka Podlogar, Goran Branković, "Mesoporous films prepared from synthesized TiO_2 nanoparticles and their application in dye-sensitized solar cells (DSSCs)", *Electrochim. acta*, vol. 210, pp. 606-614, 2016.
41. Tian Tian, Lihong Cheng, Liaoying Zheng, Juanjuan Xing, Hui Gu, Slavko Bernik, Zeng Huarong, Wei Ruan, Kunyu Zhao, Guorong Li, "Defect engineering for a markedly increased electrical conductivity and power factor in doped ZnO ceramic", *Acta mater.*, vol. 119, pp. 136-144, 2016.
42. Janja Vidmar, Radmila Milačič, Viviana Golja, Saša Novak, Janez Ščančar, "Optimization of the procedure for efficient dispersion of titanium dioxide nanoparticles in aqueous samples", *Analytical methods*, vol. 8, no. 5, pp. 1194-1201, 2016.
43. Miloš Vittori, Vesna Šrot, Kristina Žagar, Birgit Bussmann, Peter van Aken, Miran Čeh, Jasna Štrus, "Axially aligned organic fibers and amorphous calcium phosphate form the claws of a terrestrial isopod (Crustacea)", *J Struct Biol*, vol. 195, iss. 2, pp. 227-237, 2016.
44. Jonathan P. Winterstein, Meltem Sezen, Aleksander Rečnik, C. Barry Carter, "Electron microscopy observations of the spinel-forming reaction using MgO nanocubes on Al2O[sub]3 substrates", *J. Mater. Sci.*, vol. 51, nol. 1, pp. 144-157, 2016.
45. Melike Melike Yildizhan, Sašo Šturm, Mehmet Ali Gülgün, "Structural and electronic modifications on TiO[sub]2 anatase by Li, K or Nb doping below and above the solubility limit", *J. Mater. Sci.*, vol. 51, no. 12, pp. 5912-5923, 2016.
46. Maša Zalaznik, Mitjan Kalin, Saša Novak, "Influence of the processing temperature on the tribological and mechanical properties of poly-ether-ether-ketone (PEEK) polymer", *Tribol. int.*, vol. 94, pp. 92-97, Feb. 2016.
47. Maša Zalaznik, Mitjan Kalin, Saša Novak, Gregor Jakša, "Effect of the type, size and concentration of solid lubricants on the tribological properties of the polymer PEEK", *Wear*, vol. 364-365, pp. 31-39, Oct. 2016.
48. Maša Zalaznik, Saša Novak, Miroslav Huskić, Mitjan Kalin, "Tribological behaviour of a PEEK polymer containing solid MoS2 lubricants", *Lubr. sci.*, vol. 28, iss. 1, pp. 27-42, 2016.
49. Kristina Žagar, Andraž Kocjan, Spomenka Kobe, "Magnetic and microstructural investigation of high-coercivity net-shape Nd-Fe-B-type magnets produced from spark-plasma-sintered melt-spun ribbons blended with DyF_3", *J. magn. magn. mater.*, vol. 403, pp. 90-96, 2016.

Published Conference Contribution (invited lecture)

1. Blaž Leskovar, Iztok Naglič, Zoran Samardžija, Boštjan Markoli, "Influence of modification of Al-Mn-based alloy on ability to form quasicrystals", In: *Innovation: the foundation of competitive casting production: proceedings book*, 15th International Foundrymen Conference, Opatija, May 11th-13th, 2016, pp. 25-34.

Published Conference Contribution

1. Klemen Bohinc, Ágota Deák, Karmen Godič Torkar, Goran Dražić, Anže Abram, László Janovák, Imre Dékány, "Bacterial adhesion to material surfaces covered by thin films", In: *EURADH 2016 [and] Adhesion '16*, 11th European Adhesion Conference and 13th International Triennial Conference on the Science and Technology of Adhesion and Adhesives, 21 - 23 September 2016, Glasgow, UK, pp. 54-57.
2. Marja Jerič, Johannes de Boor, Miran Čeh, "High-temperature thermoelectric materials based on $SrTiO_3$", In: *Conference proceedings 2016*, 52nd International Conference on Microelectronics, Devices and Materials and the Workshop on Biosensors and Microfluidics, September 28 - 30 2016, Ankaran, Slovenia, pp. 11-15.
3. Aysen Kaya, Matejka Podlogar, Damjan Vengust, Damjan Svetin, Süleyman Kahraman, Aleksander Rečnik, Slavko Bernik, "Hydrothermal growth of doped ZnO films on amorphous substrates", In: *Conference proceedings 2016*, 52nd International Conference on Microelectronics, Devices and Materials and the Workshop on Biosensors and Microfluidics, September 28 - 30 2016, Ankaran, Slovenia, pp. 37-42.
4. Matej Komelj, "Development of permanent mahnets for electric vehicles", In: *Moving forward: innovative solutions for tomorrow's mobility*, 6th European Transport Research Conference, TRA 2016, 18-21 April 2016, Warsaw, Poland, 8 pp.
5. Mateja Košir, Etienne Savary, Sylvain Marinel, Emmanuel Guilmeau, Slavko Bernik, "Preparation of $(ZnO)_k \cdot In_2O_3$ thermoelectric ceramics by microwave sintering", In: *Conference proceedings 2016*, 52nd International Conference on Microelectronics, Devices and Materials and the Workshop on Biosensors and Microfluidics, September 28 - 30 2016, Ankaran, Slovenia, pp. 16-21.
6. Ivana Kumpová, D. Vavřík, T. Fila, Petr Koudelka, I. Jandejsek, J. Jakůbek, Daniel Kytýř, Petr Zlámal, M. Vopálenský, Ana Gantar, "High resolution micro-CT of low attenuating organic materials using large area photon-counting detector", In: *Proceedigs of the 17th International Workshop on Radiation Imaging Detectors (IWORID2015) June 28-July 2, 2015, Hamburg, Germany*, (Journal of instrumentation, vol. 11, 2016), pp. C02003-1-C02003-8.
7. Branko Matović, Dušan Bučevac, Vladimir Urbanović, Nadežda Stanković, Nina Daneu, Tatjana Volkov Husović, Biljana Babić, "Monolithic nanocrystalline SiC ceramics", In: *Engineering Ceramics 2015 Materials for Better Life, 10-14 May 2015, Smolenice, Slovakia*, (Journal of the European Ceramic Society, vol. 36, iss. 12, 2016), pp. 3005-3010.
8. Emina Požega, Pantelija Nikolić, Slavko Bernik, Lidija Gomidželović, Djordje Veljović, Stevan Vujatović, Milan Radovanović, "Hall measurements of BiSbTeSe single crystal doped with Zr. Part 1.", In: *Proceedings*, 48th International October Conference on Mining and Metallurgy - IOC 2016, Bor, Serbia, September 28 - October 01, 2016, pp. 192-195.
9. Emina Požega, Pantelija Nikolić, Slavko Bernik, Lidija Gomidželović, Djordje Veljović, Stevan Vujatović, Milan Radovanović, "Hall measurements of BiSbTeSe single crystal doped with Zr. Part 2.", In: *Proceedings*, 48th International October Conference on Mining and Metallurgy - IOC 2016, Bor, Serbia, September 28 - October 01, 2016, pp. 196-199.
10. Zoran Samardžija, "Electron probe microanalysis of the dopant concentrations in complex perovskite ferroelectrics", In: *Proceedings of the 14th European Workshop on Modern Developments and Applications in Microbeam Analysis (EMAS 2015), Portorož*, (IOP conference series, Materials science and engineering, Vol. 109), pp. 012015-1-012015-11, 2016.

Patent Application

1. Andraž Kocjan, Bernd Wicklein, Eduardo Ruiz-Hitzky, *Electro-conductive reinforced engineering ceramics and preparation therefore,* GB 1618594.4, Intellectual Property Office, 04. 11. 2016.
2. Simon Reinhard, Jacim Jacimovic, Darren Tremelling, Felix Greuter, Erik Johansson, Tomaž Tomše, *Magnet having regions of different magnetic properties and method for forming such a magnet,* WO2016023961 (A1), WIPO International Bureau, 18. 02. 2016.
3. Luka Suhadolnik, Matic Krivec, Miran Čeh, Kristina Žagar, Goran Dražič, *Photocatalytic reactor,* WO2016034253 (A1), WIPO International Bureau, 10. 03. 2016.

Patent

1. Luka Suhadolnik, Matic Krivec, Miran Čeh, Kristina Žagar, Goran Dražič, *Photocatalytic reactor,* SI24802 (A), Urad RS za intelektualno lastnino, 31. 03. 2016.

Mentoring

1. Ana Gantar, *Bioactive glass-based composite scaffolds for tissue engineering applications:* doctoral dissertation, Ljubljana, 2016 (mentor Saša Novak Krmpotič).
2. Marja Jerič, *Thermoelectric materials based on doped strontium titanates:* doctoral dissertation, Ljubljana, 2016 (mentor Miran Čeh).
3. Nina Kostevšek, *Synthesis of hybrid nanoparticles with combined magneto-photothermal effect for medical applications:* doctoral dissertation, Ljubljana, 2016 (mentor Kristina Žužek Rožman).
4. Mojca Presečnik, *Microstructural and thermoelectric characteristics of p-type ceramics in the Ca-Co-O system:* doctoral dissertation, Ljubljana, 2016 (mentor Slavko Bernik).
5. Rok Rudež, *Development of thick-film oxide-based electronic ceramics:* doctoral dissertation, Ljubljana, 2016 (mentor Slavko Bernik).
6. Nadežda Stanković, *Chemical and structural aspects of ilmenite to rutile/hematite transformation:* doctoral dissertation, Ljubljana, 2016 (mentor Nina Daneu; co-mentor Aleksander Rečnik).

DEPARTMENT FOR MATERIALS SYNTHESIS K-8

The research of the Department for Materials Synthesis is mainly related to the synthesis of various advanced materials, especially magnetic materials, semiconducting oxides, and optical materials. Special attention is given to nanostructured materials, such as ferrofluids, functionalized nanoparticles for use in biomedicine, multifunctional nanocomposites, magnetic coatings, and fluorescent nanoparticles.

Head:
Prof. Darko Makovec

In 2016 our investigations focused on several important materials, i.e., materials containing magnetic nanoparticles, multifunctional nanocomposites, fluorescent nanoparticles, and semiconducting materials for the preparation of thermistors.

The research on nanoparticles-based materials is continuously focused on engineering the nanoparticles' surface properties. Engineering of the surface properties is of key importance for nanoparticle applications, as well as for their assembly into composite materials. The surface properties are usually engineered by bonding different functionalization molecules onto the nanoparticles' surfaces. The functionalization molecules provide specific functional groups for the further (bio)conjugation of different molecules needed for a specific application. The layer of organic molecules also defines the electric charge at the surfaces and interactions between the nanoparticles in a liquid medium. It also significantly determines the interactions of the nanoparticles with biological systems. Research in 2016 was focused on the colloidal stability of nanoparticles dispersed in biological fluids. For reliable biomedical testing any agglomeration of the nanoparticles in different aqueous media at a neutral pH and at an increased ionic strength has to be completely prevented. Moreover, the nanoparticles should not display a large surface charge. Therefore, the suspensions have to be stabilized sterically, with bonding large hydrophilic molecules, e.g., polyethylene glycol (PEG), polysaccharides, or polypeptides, onto the nanoparticle surfaces. The layer of molecules has to be bonded by forming stable covalent bonds, not to be desorbed or exchanged with other ligands from the medium. The surfaces of oxide materials are chemically relatively inert and in general they do not allow covalent bonding of organic molecules. To enable covalent bonding the nanoparticles are coated with a thin silica layer. The silica provides surface silanol -Si-OH functional groups, which enable the covalent bonding of molecules, for example, different silanes. Different strategies for the covalent bonding of PEG, carboxymethyl dextran, and dextran with different molar masses onto the surfaces of different nanoparticles have been tested. Maintaining the colloidal stability was specially challenging in the case of barium hexaferrite ($BaFe_{12}O_{19}$) nanoplatelets, because of their hard-magnetic properties additionally causing agglomeration with magnetic dipole-dipole interactions. The colloidally entirely stable suspensions of such nanoplatelets in a phosphate buffer saline (PBS) were prepared by coating polysaccharide dextran onto the glycidoxypropyl silane (GLYMO) functionalized, silica-coated nanoplatelets. The bonding was enabled with a reaction of epoxy groups of GLYMO at the nanoplatelets' surfaces with hydroxyl groups of dextran. A part of the research was devoted to the synthesis of polypeptide coatings. The polypeptides were synthesized with the covalent crosslinking of amino acids adsorbed on the nanoparticles' surfaces. As we showed in previous research the amino acids adsorb onto the nanoparticles' surfaces in the form of molecular associates in very high surface concentrations, exceeding several tens of molecules per nm^2. The associate is formed by binding the amino-acid molecules together with relatively weak hydrogen or electrostatic bonds. As a result, the layer of the adsorbed molecules at the nanoparticle surfaces is very sensitive to different external conditions. To form a stable polypeptide layer two different amino acids, aspartic acid ($HOOC\text{-}CH_2\text{-}CH\text{-}(NH_2)COOH$) and lysine ($H_2N\text{-}(CH_2)_4\text{-}CH\text{-}(NH_2)COOH$), were adsorbed onto the nanoparticles. The molecules in the adsorbed layer at the nanoparticles' surfaces were then cross-linked with peptide bonds using activation of the carboxyl groups with carbodiimide (EDC) and their reaction with the amino group of the adjacent molecules.

Immobilization of (bio)catalysts onto superparamagnetic nanoclusters for their magnetic separation.

Functionalization of nanoparticles with polypeptides is also the topic of a newly established collaboration with researchers from the University of Trieste. New approaches for the covalent bonding of amino acids and short peptides onto nanoparticles have been developed. Preliminary research was focused on binding hydrophobic amino acids, such as phenylalanine. These kinds of functionalized nanoparticles are suitable for further co-assembly with peptide-based superstructures for the synthesis of functional composite materials. The development of new approaches for the binding of polar amino acids to the magnetic nanoparticles is in progress. It is expected that

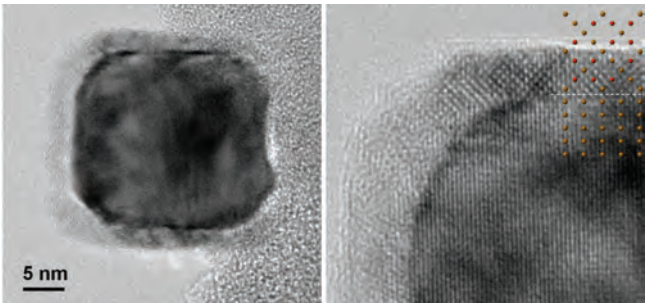


Figure 1: Metal-iron nanoparticles protected with a surface layer of iron oxide magnetite. Magnetite grows epitactically at the iron surface.

functionalization with polar amino acids will enable the colloidal stability of the nanoparticles in biological media.

A large part of the research in 2016 was devoted to the synthesis of metallic iron nanoparticles. The metallic iron displays a saturation magnetization M_S of over 220 Am^2/kg. This is much higher than the oxide materials normally used for magnetic nanoparticles. For example, magnetic iron oxide maghemite displays M_S of approximately 80 Am^2/kg. However, the problem of the metal nanoparticles (apart from noble metals) is in their very high reactivity, resulting in rapid oxidation when they come into contact with ambient oxygen. To enable handling the iron nanoparticles are usually coated with a layer of crystalline carbon. For the simultaneous synthesis and passivation of the iron nanoparticles, relatively expensive methods based on pyrolysis in the vapour phase are usually applied. We developed an inexpensive method for the synthesis of metal iron nanoparticles based on the heating of specially designed, iron-oxyhydroxide nanoparticles in a reducing atmosphere. The nanoparticles very slowly oxidize, resulting in epitactic growth of magnetic iron oxide magnetite (M) on their surfaces ($(100)_{Fe} \parallel (10\text{-}1)_M$, $(010)_{Fe} \parallel (010)_M$, $[001]_{Fe} \parallel [101]_M$). The formed oxide surface layer protects the nanoparticle from further oxidation (Figure 1). At an increased temperature in air the passivation is not effective anymore. The nanoparticles oxidize entirely with the diffusion of the Fe atoms through the magnetite surface layer, leaving a void in the nanoparticle's interior. Thus, hollow, rectangular nanoparticles of magnetic iron oxide can be synthesized.

We also cooperated in nanotoxicology research with the Biotechnical Faculty, University of Ljubljana, where we provided our expertise in the synthesis, functionalization and characterization of nanoparticles.

An important part of the research has been devoted to the testing of clusters of superparamagnetic iron-oxide nanoparticles (superparamagnetic nanoclusters) in applications based on magnetic separation. In magnetic separation the commercially available superparamagnetic nanoclusters produced by Nanos Sci. (http://nanos-sci.com/), a spin-out company of the JSI, are normally used. The core of the spherical nanocluster represents an assembly of around 100 nanoparticles. Because of its larger volume the magnetic force acting in a magnetic-field gradient on the nanocluster is much larger than the force acting on the individual superparamagnetic nanoparticle. The large magnetic force enables the effective magnetic separation of the nanoclusters from the suspension, whereas the individual nanoparticles cannot be separated. The nanoclusters' core is coated with a thin silica shell, which enabled the effective covalent bonding of different functionalization molecules onto their surfaces. The fluorescent molecules are incorporated into the silica shell for tracking of the nanoclusters with methods based on fluorescence microscopy.

A new method for the synthesis of metal-iron nanoparticles was developed. The nanoparticles are protected from rapid oxidation by a surface magnetite layer.

A typical example of such applications is the use of superparamagnetic nanoclusters for the immobilization of (bio)catalysts, which enables their magnetic separation from the medium after catalytic reactions. Different strategies for the bio-conjugation of chloroperoxidase and aldolase enzymes onto the functionalized nanoclusters were studied in cooperation with researchers from Universidad Autònoma de Barcelona (Spain) to prepare magnetically separable nanobiocatalysts. Nanobiocatalysts were tested in multienzymatic synthesis procedures for the stereo-selective synthesis of aminopolyols and iminocyclitols, important in pharmacy and nutraceutics.

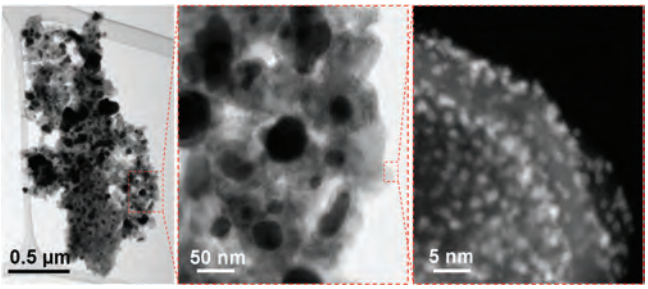


Figure 2: Images of a magnetically retractable catalyst recorded with STEM at increasing magnifications. The catalyst is composed of magnetic particles of metallic iron coated with graphitic carbon, on which small catalytic Ru nanoparticles are deposited (images on the left-hand side and in the middle represent ABF, the image on the right-hand side represents HAADF).

Superparamagnetic nanoclusters are also used as supports for catalysts, such as ruthenium. In collaboration with the National Institute of Chemistry we tested a magnetically separable ruthenium catalyst for chemical reactions of hydrogenation and deoxygenation. Because the previous research showed that the silica shell present at the surfaces of our usual superparamagnetic nanoclusters is not a suitable support for the ruthenium catalyst in the mentioned reactions, we have developed carbon-coated superparamagnetic nanoclusters (Figure 2). The carbon layer on the magnetic nanoparticles was formed by a hydrothermal treatment of the carbohydrates followed by pyrolysis in an inert atmosphere. The temperature of the pyrolysis has a major impact on the amount of graphite, on the amount of oxygen surface groups, and on the amount of defects in the graphite structure. Ru nanoparticles were deposited onto the carbon coating using reduction of a Ru precursor by isopropanol at an elevated temperature. The concentration of the precursor and the temperature of reduction have a major impact on the average size of the Ru nanoparticles. The catalyst exhibited comparable catalytic activity to the commercial one. It can be magnetically

separated from the reaction mixture after completion of the reaction and even heated by exposure to an alternating magnetic field. In collaboration with the Department for Nanostructured Materials, JSI, a simple procedure for the preparation of superparamagnetic clusters coated with AlOOH and Al_2O_3 coatings has been developed. Both types of coatings exhibit a large specific surface area. We have successfully prepared $Ru(OH)_3$ nanoparticles on the surface of the Al_2O_3 coating. In cooperation with the Faculty of Chemistry and Chemical Technology, University of Ljubljana, the catalysts were tested in oxidations of molecules relevant for pharmacy.

Besides in the magnetic separation, superparamagnetic nanoclusters could also be interesting in many other applications where a large force acting on the nanocluster in a magnetic field gradient could be beneficially exploited. Magnetic drug delivery and cell-transfection (magnetofection) using magnetic nanoclusters are the most promising applications in the biomedical field. Our joint project with researchers from Faculty of Pharmacy, University of Ljubljana, devoted to magnetic drug-delivery systems has been continued. The coating of magnetic nanoclusters with a specially designed porous silica layer allowed the controlled dissolution of one part of iron-oxide nanoparticles from the nanocluster in a strong acid. Thus, a delivery system was developed which retains a sufficient magnetic responsiveness and enables loading and the controlled release of an active pharmaceutical substance through the porous silica shell. A potential anti-cancer drug orlistat was chosen to test the effectiveness of the hollow magnetic nanoclusters. Orlistat is highly hydrophobic and due to its physico-chemical properties very challenging for the preparation of polymeric and lipid-based drug-delivery systems and other pharmaceutical formulations. The remarkable rigidity and robustness of our hollow delivery system enabled loading with orlistat in various solvents. A mixture of ethanol and 1-tetradecanol has been used as a first choice in the on-going research. The tetradecanol displays the solid-to-liquid transformation at temperatures between 38 and 40 °C. Our research efforts were focused on the preparation of a delivery system with controlled drug release. The active substance orlistat was first incorporated into the solid 1-tetradecanol inside the hollow nanoclusters and released once the temperature was increased above a certain value. This thermo-responsive release of the drug at a desired place in the human body can potentially be triggered with heat released during exposure of the remaining magnetic nanoparticles in the hollow nanoclusters to an alternating magnetic field (magnetic hyperthermia).

An equilibrium structure of barium-hexaferrite nanoplatelets was determined using an atomic-resolution scanning-transmission microscope.

We continued our research of the magnetic assembly of the superparamagnetic nanoclusters into one-dimensional nanochains in the suspensions. Novel magnetic nanostructures were prepared with magnetic assembly of the nanoclusters coated with silica shells of various thicknesses. First, the nanoclusters with a thin silica shell were assembled into short nanochains. Subsequently, the nanoclusters with a thick silica shell were added to one or both ends of the initial short nanochains under the applied magnetic field. The formed nanochains were fixed with an additional thin silica layer. The magnetic nanoparticles inside the nanoclusters with a thin silica shell were then dissolved in acid to form nanochains composed of hollow silica shells and the superparamagnetic nanoclusters coated with the thick non-permeable silica. This strategy will make a basis for the further development of new magnetic drug-delivery systems.

In the research led by Institute of Cell Biology, University of Ljubljana, magnetic nanoclusters labelled with two fluorescent dyes, fluorescein and rhodamine were applied for the labelling of urothelial nanotubes. The tunnelling membrane nanotubes are spontaneously formed between urothelial cancer cells to transfer information in the form of genetic material and other cellular building blocks between the cells. An important part of the project was aimed at investigating synthetic approaches for the preparation of small nanoclusters with a size of around 70–80 nm, which is the upper limit for urothelial nanotubes labelling. Additionally, the nanoclusters conjugated with targeting ligands for the recognition of urothelial cancer cells were developed in the frame of the project.

In a recently established collaboration with a research team from the University of Cyprus an encapsulation of the magnetic nanoclusters into polymer electrospun fibres was investigated. The carbon-based nanocomposites obtained with calcination of the fibres were tested as anode materials in Li-ion batteries. In another project the superparamagnetic nanoclusters labelled with fluorescein were applied in the development of new materials for gas sensing.

We continued the research devoted to nanocomposites containing magnetic nanoparticles dispersed in a polymethyl methacrylate polymer matrix. The knowledge developed in this research enabled the preparation of magnetic nanoparticles with liquid-crystal (5CB)-bearing polymer chains at the surfaces. The procedure for their preparation is based on bonding monomer methyl methacrylate onto the surfaces of the magnetic nanoparticles. During the polymerization of the acrylic monomer bearing the 5CB moiety in the presence of the nanoparticles a part of the polymer chains grew from the surface of the nanoparticles. The mixtures of the nanoparticles with the liquid crystals are further studied at the Department of Complex Matter, JSI.

An important part of our research was devoted to $BaFe_{12}O_{19}$ nanoplatelets. A part of that was dedicated to a determination of their crystal structure. The hexaferrite crystal structure can be represented as a stacking of two

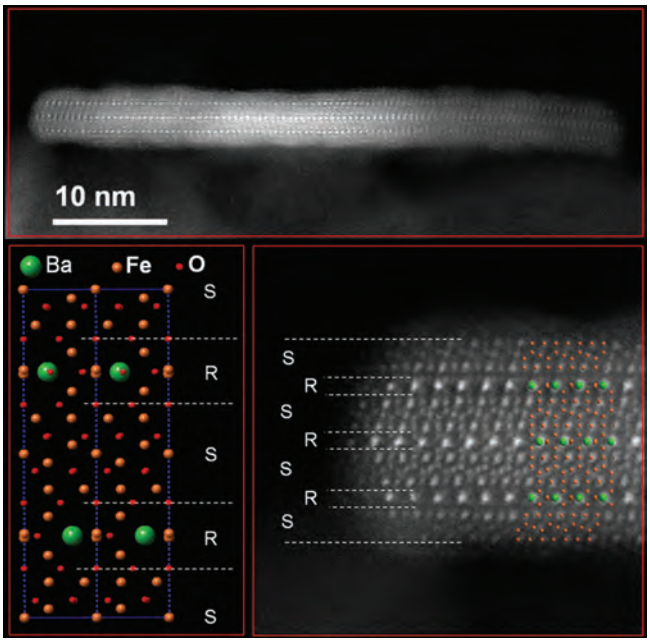


Figure 3: HAADF image of hexaferrite nanoplatelet. Image below shows the structure of hexaferrite along [10-10]. On a magnified image below, columns containing Ba and Fe atoms are marked.

structural blocks, which alternate along the c-direction of the hexagonal cell: the hexagonal "R" block ($(BaFe^{3+}_6O^{2-}_{11})^{2-}$) and the cubic "S" block ($(Fe^{3+}_6O^{2-}_8)^{2+}$). Growth of the hexaferrite crystals is limited in the c-direction. The hexagonal nanoplatelets, approximately 50 nm wide but only few nm thick, can be synthesized using an appropriate hydrothermal method. Due to the small dimension in the c-direction of the structure corresponding to their small thickness, the nanoplatelets display a specific structure. The structure of the hexaferrite nanoplatelets was an important topic of our research some years ago. However, even many different methods (high-resolution electron microscopy (HRTEM), x-ray diffractometry (XRD), x-ray adsorption spectroscopy (EXAFS), Mossbauer spectroscopy, etc.) were applied, the structure could not be determined. Only the application of a new, atomic-resolution scanning-transmission electron microscope (ARM) in 2016 enabled a detailed determination of the structure. It appeared that the nanoplatelets display a very uniform structure. A vast majority of the nanoplatelets contain only two hexagonal "R" blocks, or less frequently they contained three "R" blocks. The nanoplatelet structure always terminates with the cubic "S" block (Figure 3). Thus, the thickness of the nanoplatelets is either 3.0 nm for the two "R" blocks, or 4.2 nm for the three "R" blocks. Very seldom were the thicker nanoplatelets, containing four or more "R" blocks, found.

The structure of hexaferrite nanoplatelets is reflected in their unique magnetic properties, defined by their very large, uniaxial magnetic anisotropy with easy axis pointing perpendicular to the platelet. This property enables very effective aligning of the nanoplatelets with an applied magnetic field, which has been the key to the development of new materials, e.g., ferromagnetic fluids, soft magneto-electrics, or magneto-optic composites, and new applications, especially in medicine.

The disadvantage of the hexaferrite nanoplatelets is in their relatively low saturation magnetization M_S. As a typical hard-magnetic material the hexaferrite displays a relatively low M_S of 72 Am^2/kg in the bulk, whereas in the form of nanoplatelets the magnetizations are lower. With long-term research we managed to increase the M_S of the hexaferrite nanoplatelets above 30 Am^2/kg, however, some applications require even higher magnetizations. The M_S can be strongly improved by coating nanoplatelets with a shell of iron oxide maghemite (γ-Fe_2O_3), which displays soft-magnetic properties with a relatively high M_S. If the properties of the two magnetic materials are exchange-coupled, the formed composite nanoplatelet will magnetize homogeneously as a single-phase particle. The hexaferrite core provides the desired large and uniaxial anisotropy, while the surface layer strongly improves the M_S. Moreover, the hysteresis shape of the composite nanoplatelets can be precisely adapted to requirements of their application simply with changing the shell thickness.

Fluorescent fluoride nanoparticles, alternative biomarkers in biomedicine, dissolve substantially and relatively quickly in aqueous media, specifically in the presence of phosphates. Their dissolution can be significantly decreased by protective amphiphilic coatings made from two cross-linked polymers.

The maghemite shell is deposited using simple co-precipitation of iron ions from the aqueous solution. The shell is formed after heterogeneous nucleation of the products at the core surfaces. The key factor is control of the supersaturation of the products. The necessary control of the supersaturation was achieved by bonding iron (III) ions into a complex with urea, which enables the controlled release of the ions into the reaction mixture with thermal decomposition of the complex. The research in 2016 was devoted to adaptation of the synthesis procedure to allow close control of the maghemite shell thickness. The thickness can be increased to some extent simply by increasing the concentration of the iron precursors. For thicker shells the coating process had to be repeated several times. The structural properties of the synthesized composite nanoplatelets were analysed using ARM. It appeared that the composite nanoplatelets could be synthesized with exceptional control using our method. They showed incredibly uniform structure, which was to a large extent defined by the uniform structure of the hexaferrite cores. The spinel maghemite layers grow epitactically exclusively at the basal surfaces of the hexaferrite core nanoplatelets (Figure 4). The maghemite surface layers are of uniform thicknesses; the thickness of the layers at the individual core is equal on the both basal surfaces of the core

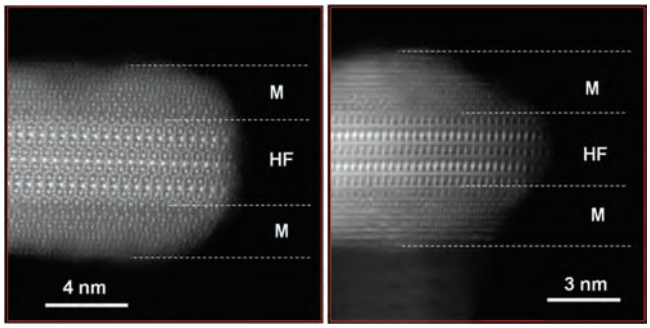


Figure 4: HAADF images of composite nanoplatelets. An individual nanoplatelet is composed of a hexaferrite core (HF) in between of two maghemite layers (M). The hexaferrite core on the left-hand image contains three layers of the Ba^{2+} ions (orientation of the core is $[10\text{-}10]_{HF}$), the hexaferrite core on the right-hand image contains two layers of the Ba^{2+} ions (orientation of the core is $[11\text{-}20]_{HF}$).

on the level of few atomic layers. The layer thickness also varies minimally when comparing different composite nanoplatelets in the sample.

We also continued the research devoted to applications of hexaferrite nanoplatelets and their incorporation into liquid crystals (in cooperation with the Department of Condensed Matter, JSI). Our studies were focused on modification of the nanoplatelets' surface chemistry. The aim was to increase the concentration of the nanoplatelets in liquid crystals by hydrophobization of their surfaces. This should intensify the magnetic response of the ferromagnetic liquid crystals. In parallel we were involved (with the Department of Condensed Matter, JSI and University of Colorado) in the development of isotropic ferromagnetic liquids, which showed similar behaviour to ferromagnetic liquid crystals. Moreover, the isotropic ferromagnetic liquids showed very high sensitivity to a magnetic field, as they responded to the Earth's magnetic field.

We also participate in the development of novel magnetic-field sensors (in cooperation with Faculty of Electrical Engineering and Computer Science, University of Maribor) through the optimization of nanoplatelet suspensions.

We continued with the research of fluorescent optical materials. Fluorescent nanoparticles with upconversion emission can be applied in various optical elements and are also proposed as alternative bio-markers in imaging diagnostic techniques for medicine. We continued with the studies of the chemical stability of fluoride nanoparticles doped with lanthanides and the development of protective coatings. Namely, the nanoparticles for biomedicine should be chemically and colloidally stable in aqueous media. We showed that fluoride nanoparticles with different compositions (binary and ternary) partly dissolve in water, which limits their applicability in biomedicine. The dissolution studies conducted in cooperation with the Department for Inorganic Synthesis and Technology, JSI, suggested the dissolution mechanism of exemplary AYF_4 nanoparticles (A = Na or K), co-doped with Yb^{3+} in Tm^{3+} (Figure 5). A partial dissolution of these nanoparticles in water was attributed to the surface dissociation, which proceeds in a few minutes. The subsequent dissolution in water is slow. In contrast to this, fluoride nanoparticles dissolve rapidly in a phosphate buffer. The driving force of the process is the simultaneous formation of poorly soluble lanthanide phosphates. Considering the presence of phosphates in the cells (nucleic acids, ATP, cell membrane) the fluoride fluorescent nanoparticles as such are not suitable for in-vivo applications. For applications of the fluorescent nanoparticles in medicine we tested different coatings for the protection of the nanoparticles against dissolution. The most efficient protective coating was made with cross-linking poly(maleic anhydride-alt-1-octadecen) (PMAO) with bis(hexamethylene)triamine (BHMT). We showed that the cross-linking between the two polymers in the coating is crucial for the purpose. At the same time, the PMAO-BHMT coatings also enabled excellent colloidal stability of the studied nanoparticles in the water and phosphate buffer, and it showed a beneficial effect on the fluorescence intensity of the nanoparticles.

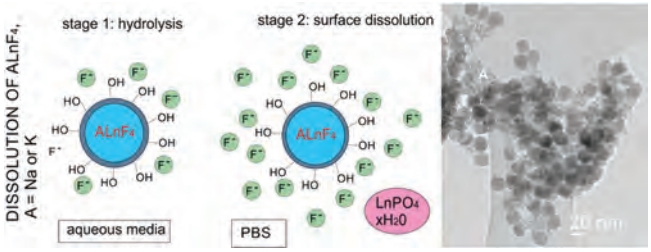


Figure 5: Schematic representation of the dissolution mechanism for fluoride fluorescent nanoparticles (left) and TEM image (right) of nanoparticles in an amorphous phosphate matrix (marked with A), which represents the side product of the dissolution.

A study of the effect of the dissolution of fluoride fluorescent upconverting nanoparticles on their optical properties was accomplished in cooperation with Bundesanstalt für Materialforschung und prüfung (BAM), Berlin, Germany, and with the Department for Surface Engineering and Optoelectronics, JSI. We showed that changes of the nanoparticles' surface chemistry induced by their partial dissolution significantly reduced the Tm^{3+} fluorescence lifetime. Our results represent a basis for the development of a new, non-destructive analytic method for screening the changes of the surface composition of upconverting fluorescent nanoparticles. Namely, surface chemistry has a significant effect on the optical properties of the upconverting nanoparticles due their large surface-to-volume ratio.

The basic research of semiconducting ceramics was devoted to the origin of a positive temperature coefficient of resistivity (PTCR) in $BaTiO_3$ ceramics. We have shown that it is possible to prepare PTC thermistors on the basis of $BaTiO_3$ ceramics without donor-doping when a composite containing the mixture of conducting phase and non-conducting phase is formed. Due to dimensional changes in the non-conducting phase at its Curie temperature, disconnections occur in the conductive phase that leads to the PTCR anomaly. In this way, we have succeeded in preparing PTC thermistors with a Curie temperature of 180 °C and a low, room-temperature resistivity of the ferroelectric ceramics based on the system of $BaTiO_3$–$Na_{0,5}Bi_{0,5}TiO_3$. The newly developed material, unlike the materials available in the market, contains no toxic lead.

An extremely steep temperature dependence of the electrical resistivity, i.e., a jump-like form of the dependence, was measured in the composite composed of conducting metal and nonconducting ferroelectric $BaTiO_3$. To the best of our knowledge such a sharp temperature characteristic has not been reported in the literature yet.

Some outstanding publications in the past year

1. Pušnik, Klementina, Peterlin, Mojca, Kralj Cigić, Irena, Marolt, Gregor, Kogej, Ksenija, Mertelj, Alenka, Gyergyek, Sašo, Makovec, Darko. Adsorption of amino acids, aspartic acid, and lysine onto iron-oxide nanoparticles. The journal of physical chemistry. C, Nanomaterials and interfaces, 2016, 120, 14372-14381.
2. Gyergyek, Sašo, Makovec, Darko, Jagodič, Marko, Drofenik, Mihael, Schenk, Kurt, Jordan, Olivier, Kovač, Janez, Dražić, Goran, Hofmann, Heinrich. Hydrothermal growth of iron oxide NPs with a uniform size distribution for magnetically induced hyperthermia : structural, colloidal and magnetic properties. Journal of alloys and compounds, 2017, 694, 261-271.
3. Lisjak, Darja, Plohl, Olivija, Vidmar, Janja, Majaron, Boris, Ponikvar-Svet, Maja. Dissolution mechanism of upconverting AYF_4:Yb,Tm (A = Na or K) nanoparticles in aqueous media. Langmuir, 2016, 32, 8222-8229.

Awards and appointments

1. Blaž Belec: 3rd award for presentation at the 8. Conference of Jožef Stefan International Postgraduate School, Ljubljana, Jožef Stefan International Postgraduate School.
2. Blaž Belec: Best contribution at the 8. Conference of Jožef Stefan International Postgraduate School, Ljubljana, Jožef Stefan International Postgraduate School.
3. Tanja Goršak: Best presentation at the 8. Conference of Jožef Stefan International Postgraduate School, Ljubljana, Jožef Stefan International Postgraduate School.

Patent granted

1. Peter Dušak, Marin Berovič, Darko Makovec, Process for regulation of lactic acid fermentation in wine production by magnetic elimination of bacteria, SI24998 (A), Slovenian Intellectual Property Office, 30. 11. 2016

INTERNATIONAL PROJECTS

1. COST IC1208; Integrating Devices and Materials: A Challenge for New Instrumentation in ICT
   Prof. Darko Makovec
   Cost Office
2. COST TD1402 - RADIOMAG; Multifunctional Nanoparticles for Magnetic Hyperthermia and Indirect Radiation Therapy
   Prof. Darko Makovec
   Cost Office
3. The European Upconversion Network - From the Design of Photon-Upconverting Nanomaterials to Biomedical Applications
   Prof. Darja Lisjak
   Cost Office

R&D GRANTS AND CONTRACTS

1. Nanotheranostics based on magneto-responsive materials
   Dr. Slavko Kralj
2. Tunneling nanotubes for innovative urinary bladder cancer treatments
   Dr. Slavko Kralj

NEW CONTRACTS

1. Development and validation of the TEM method for analysis of an inorganic-core size in final ferric carboxymaltose product
   Prof. Darko Makovec
   Lek d. d.

RESEARCH PROGRAM

1. Advanced inorganic magnetic and semiconducting materials
   Prof. Darko Makovec

VISITOR FROM ABROAD

1. Jan Kotouček, Brno University of Technology, Češka, 1. 8. -9. 9. 2016

STAFF

Researchers
1. Dr. Sašo Gyergyek
2. Prof. Darja Lisjak
3. **Prof. Darko Makovec, Head**
4. Dr. Igor Zajc

Postdoctoral associates
5. Dr. Slavko Kralj

Postgraduates
6. Blaž Belec, B. Sc.
7. Tanja Goršak, B. Sc.
8. *Dr. Olivija Plohl, left 20.06.16*
9. *Dr. Klementina Pušnik, left 19.05.16*

Technical and administrative staff
10. Bernarda Anželak, B. Sc.

BIBLIOGRAPHY

Original Article

1. Branka Babić-Stojić, Vukoman Jokanović, Dušan Milivojević, Miroslav Požek, Zvonko Jagličić, Darko Makovec, Katarina Arsikin, Verica Paunović, "Gd_2O_3 nanoparticles stabilized by hydrothermally modified dextrose for positive contrast magnetic resonance imaging", *J. magn. magn. mater.*, vol. 403, pp. 118-126, 2016.
2. Alenka Bunderšek, Boštjan Japelj, Branka Mušič, Nevenka Rajnar, Sašo Gyergyek, Rok Kostanjšek, Peter Krajnc, "Influence of Al(OH)3 nanoparticles on the mechanical and fire resistance properties of poly(methyl methacrylate) nanocomposites", *Polym. compos.*, vol. 37, iss. 6, pp. 1659-1666, June 2016.
3. George Cordoyiannis, Sašo Gyergyek, Brigita Rožič, Samo Kralj, Zdravko Kutnjak, George Nounesis, "The effect of magnetic nanoparticles upon the smectic-A to smectic-C* phase transition", *Liq. cryst.*, vol. 43, no. 3, pp. 314-319, 2016.
4. Peter Dušak, Mojca Benčina, Martina Turk, Dejan Bavčar, Tatjana Košmerl, Marin Berovič, Darko Makovec, "Application of magneto-responsive Oenococcus oeni for the malolactic fermentation in wine", *Biochem. eng. j.*, vol. 110, pp. 134-142, 15 June 2016.
5. T. B. Ivetić, Marin Tadić, Marko Jagodič, Sašo Gyergyek, G. R. Štrbac, S. R. Lukić -Petrović, "Structure and magnetic properties of Co_3O_4/SiO_2 nanocomposite synthesized using combustion assisted sol-gel method", *Ceram. int.*, vol. 42, no. 16, pp. 18312-18317, 2016.
6. Lazar Kopanja, Slavko Kralj, Dragiša Žunić, Boris Lončar, Marin Tadić, "Core-shell superparamagnetic iron oxide nanoparticle (SPION) clusters: TEM micrograph analysis, particle design and shape analysis", *Ceram. int.*, vol. 42, no. 9, pp. 10976-10984, 2016.
7. Lazar Kopanja, Dragiša Žunić, Boris Lončar, Sašo Gyergyek, Marin Tadić, "Quantifying shapes of nanoparticles using modified circularity and ellipticity measures", *Measurement (Lond.)*, vol. 92, pp. 252-263, 2016.
8. Matjaž Kristl, Sašo Gyergyek, Nataša Srt, Irena Ban, "Mechanochemical route for the preparation of nanosized aluminium and gallium sulfide and selenide", *Mater. manuf. process.*, vol. 31, iss. 12, pp. 1608-1612, 2016.
9. Mukta Vishwanath Kulkarni, Anca Mazare, Jung Park, Ekaterina Gongadze, Manuela Sonja Killian, Slavko Kralj, Klaus von der Mark, Aleš Iglič, Patrik Schmuki, "Protein interactions with layers of TiO_2 nanotube and nanopore arrays: morphology and surface charge influence", *Acta biomaterialia*, vol. 45, pp. 357-366, Nov. 2016.
10. Darja Lisjak, Mitja Bukovec, Klementina Zupan, "Suppression of the exaggerated growth of barium ferrite nanoparticles from solution using a partial substitution of Sc_{3+} for Fe_{3+}", *J. nanopart. res.*, vol. 18, no. 2, pp. 44-1-44-11, 2016.
11. Darja Lisjak, Olivija Plohl, Janja Vidmar, Boris Majaron, Maja Ponikvar-Svet, "Dissolution mechanism of upconverting AYF_4: Yb, Tm (A = Na or K) nanoparticles in aqueous media", *Langmuir*, vol. 32, no. 32, pp. 8222-8229, 2016.
12. Darinka Primc, Blaž Belec, Darko Makovec, "Synthesis of composite nanoparticles using co-precipitation of a magnetic iron-oxide shell onto core nanoparticles", *J. nanopart. res.*, vol. 18, no. 3, pp. 64-1-64-13, 2016.
13. Klementina Pušnik, Tanja Goršak, Mihael Drofenik, Darko Makovec, "Synthesis of aqueous suspensions of magnetic nanoparticles with the co-precipitation of iron ions in the presence of aspartic acid", *J. magn. magn. mater.*, vol. 413, pp. 65-75, 2016.
14. Klementina Pušnik, Mojca Peterlin, Irena Kralj Cigić, Gregor Marolt, Ksenija Kogej, Alenka Mertelj, Sašo Gyergyek, Darko Makovec, "Adsorption of amino acids, aspartic acid, and lysine onto iron-oxide nanoparticles", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, iss. 26, pp. 14372-14381, 2016.
15. Katarina Rajapakse, Damjana Drobne, Damijana Kastelec, Ksenija Kogej, Darko Makovec, C. Gallampois, Hanna Amelina, Gabriela Danielsson, Lijana Fanedl, Romana Marinšek-Logar, Susana Cristobal, "Proteomic analyses of early response of unicellular eukaryotic microorganism Tetrahymena thermophila exposed to TiO^2 particles", *Nanotoxicology*, vol. 10, no. 5, pp. 542-556, 2016.
16. Tea Romih, Anita Jemec, Monika Kos, Samo B. Hočevar, Slavko Kralj, Darko Makovec, Damjana Drobne, "The role of PVP in the bioavailability of Ag from the PVP-stabilized Ag nanoparticle suspension", *Environ. pollut. (1987)*, vol. 218, pp. 957-964, Nov. 2016.
17. M. Shuai, Alenka Mertelj, Darja Lisjak, Martin Čopič, et al., "Spontaneous liquid crystal and ferromagnetic ordering of colloidal magnetic nanoplate", *Nature communications*, vol. 7, pp. 10394-1- 10394-8, 2016.

Review Article

1. Slavko Kralj, Tanja Potrč, Petra Kocbek, Silvia Marchesan, Darko Makovec, "Design and fabrication of magnetically responsive nanocarriers for drug delivery", *Curr. med. chem.*, vol. 23, pp. 1-16, 2016.

Published Conference Contribution

1. Blaž Belec, Darko Makovec, "Building thick spinel iron oxide layer onto the hexaferrite core nanoparticles using multiple co-precipitation of iron ions", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 215-226.
2. Tanja Goršak, Slavko Kralj, Darko Makovec, Darja Lisjak, "The formation of silica coatings on barium hexaferrite nanoparticles and funct ionalization with 3-aminopropyl silane", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 227-238.

Patent

1. Peter Dušak, Marin Berovič, Darko Makovec, *Process for regulation of lactic acid fermentation in wine production by magnetic elimination of bacteria,* SI24998 (A), Urad RS za intelektualno lastnino, 30. 11. 2016.

Mentoring

1. Olivija Plohl, *Dissolution of fluoride upconverting nanoparticles in aqueous suspensions and their protection with amphiphilic coatings:* doctoral dissertation, Ljubljana, 2016 (mentor Darja Lisjak).
2. Klementina Pušnik, *Engineering properties of aqueous suspensions of iron-oxide nanoparticles using amino acids:* doctoral dissertation, Ljubljana, 2016 (mentor Darko Makovec).
3. Mojca Peterlin, *Določanje aminokislin adsorbiranih na površini nanodelcev železovega oksida (γ-Fe_2O_3):* master's thesis, Ljubljana, 2016 (mentor Irena Kralj Cigić; co-mentor Darko Makovec).

DEPARTMENT FOR ADVANCED MATERIALS K-9

In the Department for Advanced Materials we investigate novel materials through an understanding of the mutual dependence of their structural, microstructural and functional characteristics. Modern technologies that enable the synthesis of materials with atomic and microscale precision are used to prepare pre-designed structural 3D materials, thin films and nanoparticles with the desired crystal structure, chemical composition, microstructure and morphology. Among our important objectives is the development of: i) novel functional oxide materials for various electronic applications, ii) new materials with improved antibacterial and photocatalytic effects and iii) new materials for efficient energy conversion.

Head:
Prof. Danilo Suvorov

Functionalized oxides for electronic applications

In our study of the mechanisms for controlling the size of ferroelectric perovskite particles with an anisotropic shape of the plates there were two main directions. In the first part, the main emphasis was on control of the morphology of $Bi_4Ti_3O_{12}$ and $Bi_{3.8}Nd_{0.2}Ti_3O_{12}$ nanoplates (side length ~100nm, thickness ~10 nm) under hydrothermal conditions. The former types of plates were used as the template for a topochemical conversion into perovskite ($BaTiO_3$, $SrTiO_3$) nanoparticles with the shape of blocks and plates, while the latter composition was prepared mainly due to a study of their behaviour in a liquid crystal. In the second part, we studied the mechanisms of the topochemical conversion from μm- and nm-sized $Bi_4Ti_3O_{12}$ plates into $BaTiO_3$ and $SrTiO_3$ in a molten salt or under hydrothermal conditions.

A study of the topochemical conversion of $Bi_4Ti_3O_{12}$ nanoplates into $BaTiO_3$ in a molten salt was focused on the preservation of the nanodimensions of $BaTiO_3$ during heating to high temperature, which is needed for the increase of tetragonality, and consequently the ferroelectricity. For the growth of $BaTiO_3$ nano-plates, nano-blocks due to Ostwald ripening were retarded based on the fact that the rate of the dissolution and growth of the particles with flat and smooth faces is slower than those with an irregular shape and high curvature.

The topochemical conversion of layered Aurivillius $Bi_4Ti_3O_{12}$ into $BaTiO_3$ or $SrTiO_3$ perovskite under hydrothermal conditions has not been reported yet. Previous results imply that it is possible to affect the prevailing growth mechanism and thus tune the reaction towards the target morphology by controlling the synthesis conditions (Figure 1). In order to preserve the anisotropic shape of the $Bi_4Ti_3O_{12}$ plates, the growth of the perovskite on these plates should be layer-by-layer (Frank-van der Merwe). Additionally, it is assumed that control over the reaction conditions for the layer-by-layer growth will also be crucial for the preparation of the composite plates of $BaTiO_3/SrTiO_3$, which are expected to exhibit enhanced ferroelectric properties due to the lattice strains, which result from the lattice mismatch. Consequently, the ferroelectric polarization of $BaTiO_3$ grown on (100) oriented $SrTiO_3$ plates is assumed to point perpendicular to the plate surface, which is required in several applications. Ferroelectricity is also expected to be preserved down to smaller dimensions of the $BaTiO_3/SrTiO_3$ nanocomposite plates, which makes them very useful building blocks for the fabrication of nanometric electromechanical devices.

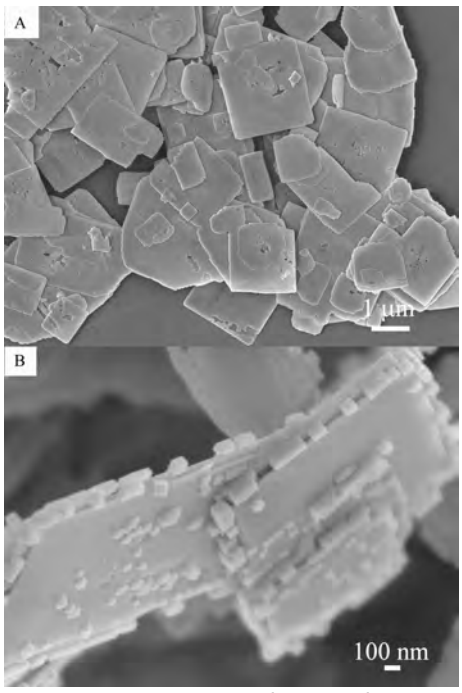


Figure 1: Topochemical transformation from $Bi_4Ti_3O_{12}$ plate-like particles into $SrTiO_3$ under alkaline hydrothermal conditions with the dominance of the growth similar to a) Frank-van der Merwe (layer-by-layer) and b) Volmer-Weber (island formation).

The integration of epitaxial complex oxides with Si represents an invaluable opportunity for the creation of novel devices with logic and sensing capabilities, both implemented in the same chip. Using PLD we grew epitaxial ultra-thin (3–4-nm) $SrTiO_3$ (STO) layers on Si(001), showcasing the possibilities of this technique for the growth of templates for the integration of complex oxides with Si. Our procedure involves the growth of a 1/2 monolayer (ML) of Sr buffer layer on the reconstructed Si(001) surface by PLD, the deposition of STO in an inert Ar atmosphere, and latter oxidation and crystallization phases (Figure 2). The optimization of STO deposition, oxidation, and crystallization parameters proves to be essential for the improvement of the layer's quality. It has been found that the minimization of the thermal budget during the crystallization phase increases the interface sharpness, but a minimum temperature is needed for a proper densification of the STO layer. A coverage of 2 ML before every crystallization and oxidation phases was determined as the best balance between the critical thickness, minimization of the thermal budget, and a proper coverage of the buffer layer, which prevents its reactions with the Sr/Si surface. These results improve the general knowledge and understanding of metal oxide/silicon heterojunctions,

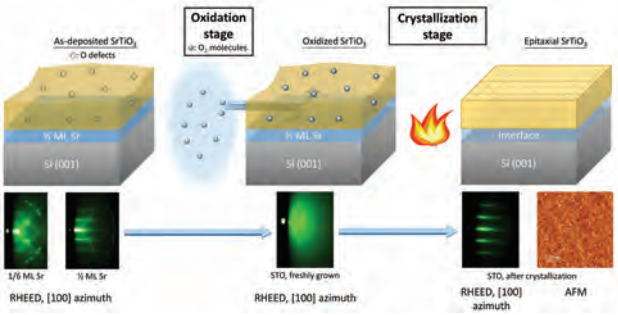


Figure 2: Graphical scheme of the STO growth process. The STO is grown on the 1/2 ML Sr/Si surface, and it consists of STO deposition, oxidation and crystallization phases, which are adjusted to minimize interface reactions and to obtain the most optimal crystalline quality. Below the scheme, RHEED patterns can be seen for the deposition of the Sr buffer layer (left), the freshly grown STO (center) and the crystallized STO (right), along with an AFM image after the final stage of the growth process.

and represent a solid stepping stone for the growth of high-quality, thin STO templates on Si by PLD.

In our work we have studied the structural properties of a strontium buffer layer on silicon grown by the PLD technique. The samples were prepared in a vacuum chamber with a base pressure of 2×10^{-9} by first removing the native SiO_2 layer by flash annealing at 1200 °C, followed by the deposition of half a monolayer of strontium. *In-situ* characterization by reflection high-energy diffraction showed a typical two-domain (2×1)+(1×2) reconstruction. In order to ensure an adsorbate-free surface the samples were transferred using an ultra-high vacuum suitcase. The samples were analysed by low-energy electron diffraction (LEED) and scanning tunnelling microscopy (STM). LEED analysis confirmed that the surface reconstruction was preserved during the transfer. High-resolution STM images revealed a highly ordered surface, which has a quality comparable to a surface prepared using a more established molecular beam epitaxy technique (Figure 3). This study presents the first local structural analysis on of the Sr/Si surface prepared by PLD on the atomic scale.

We used PLD technique to prepare $Pb[Mg_{1/3}Nb_{2/3}]O_3$-$PbTiO_3$ (PMN-PT) thin films on single-crystal $SrTiO_3$ substrates as well. PMN-PT exhibits excellent piezoelectrical properties, however, only in the absence of the pyrochlore phase, which can form due to lead-loss during the synthesis. We prepared single-phase PMN-PT films by optimizing the deposition conditions and by using PbO-excess targets. The (00l)-peak splitting in the X-ray diffraction spectra revealed a strong influence of the process pressure on the domain structure of the films, which was confirmed by high-resolution transmission electron microscopy. In the next stage we deposited thin-film electrodes ($SrRuO_3$ or $LaNiO_3$) between the STO and the PMN-PT. We found that the electrode layer (especially $LaNiO_3$) has a pronounced influence on the further growth of PMN-PT by stabilizing the formation of the perovskite phase.

Antibacterial and photocatalytic materials

The group for biomaterials has been working on fields including the development of innovative antimicrobial coatings, the development of new antimicrobial biomaterials and innovative techniques for cryopreservation.

We have developed an innovative composite coating system consisting of 1D nanostructured MgO incorporated within the PLGA matrix. We detected the presence of a strong interphase interaction between MgO and PLGA, which resulted in the retention of MgO nanoparticles at the surface of MgO/PLGA coatings. As a consequence, the MgO/PLGA coating was able to prevent *S. epidermdiis* colonization without exhibiting any change to the attached red blood cells. We concluded that the stabilization of MgO within PLGA matrix widened the "therapeutic window" of magnesium oxide particles.

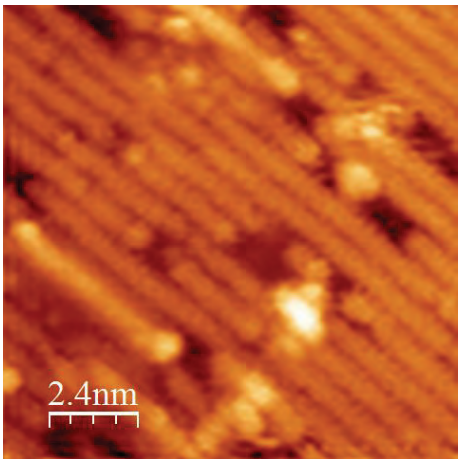


Figure 3: Filled electron state STM image of the Sr/Si(001) surface exhibiting a (2×1) reconstruction. In the filled electron state image, the tunneling current is related to the Si dangling bonds of the Si dimer chains participating in bonding with Sr atoms sitting in-between the dimer chains (T=60 K, U=-3V, I=200 pA).

We continued our research on nanocomposite materials based on gallium, gold and hydroxyapatite. A nanocomposite of Ga and hydroxyapatite was compared to a nanocomposite of Ag nanoparticles and hydroxyapatite. The new gallium-based nanocomposite was more effective against *Pseudomonas aeruginosa* and less toxic to L929 as well as IMR-90 fibroblasts (Figure 4 and 5). We also investigated the influence of the size and size distribution of the Ga nanoparticle and Ga content on the antibacterial activity and cytotoxicity of the nanocomposite and optimised its synthesis. We could obtain a very narrow size distribution by using oleic acid as a surfactant and thermal decomposition to create Ga nanoparticles. Nanocomposites with such Ga nanoparticles exhibited a stronger antibacterial effect, but also an increased toxicity in comparison with the nanocomposites prepared by ultrasonic emulsification without any surfactant. Based on our discoveries on the incorporation of Ga^{3+} ions into hydroxyapatite, we have developed an optimum nanocomposite of functionalised Au nanoparticles and Ga(III)-containing hydroxyapatite, which effectively stops the growth of *P. aeruginosa, E. coli* and *S. epidermidis* bacteria and has low toxicity for L929 fibroblasts. Apart from these achievements we have also made very interesting findings about the mechanism and optimisation of the formation of functionalised Ga/Au core-shell nanoparticles and discovered possibilities for their stabilisation. The results of this research, which were published in three research articles, have been selected for an illustration of the Journal of Materials Science: Materials in Medicine.

The research in the field of new biomaterials that combine antimicrobial and magnetic properties was initiated in 2016 in the framework of a bilateral project with Serbia. In this field, we have developed new processes for the synthesis of composites that combine the functionalized nanoparticles of gold (Au-arginine) and ferrite nanoparti-

cles (MFe_2O_4, M = Zn^{2+}, Co^{3+}, Cu^{2+}). We have shown that the new composites possess a strong antimicrobial activity (against *E. coli* and *S. epidermis*), enabled by functionalized gold, and magnetic properties, which were enabled by ferrite nanoparticles. In spite of the nano-size (20-nm Au particles having 5-nm particles on their surfaces), we showed that the composite particles do not cause damage to blood cells and have shown to be very promising for further research in biomedical applications.

In the field of innovative techniques for cryopreservation we started research on the development of biomimetic inorganic calcium hydroxyapatite (HAp) nanoparticles for the delivery of bioactive payloads in cells. Our research was focused on cell cryopreservation for blood-transfusion applications and the developed HAp nanoparticles were used for the delivery of natural cryoprotectant trehalose in erythrocytes, which lack the endocytosis machinery. The work involved studies of the relationship between nanoparticle properties and their efficiency for trehalose delivery in cells and on the mechanism of interactions between nanoparticles and the cell membrane. The studies have shown that HAp nanoparticles are efficient agents for the delivery of trehalose in erythrocytes and strongly enhance the cryo-survival of erythrocytes after freeze-thawing. From this area we applied for a Marie Curie research project that was awarded with a "Seal of Excellence" from the European Commission.

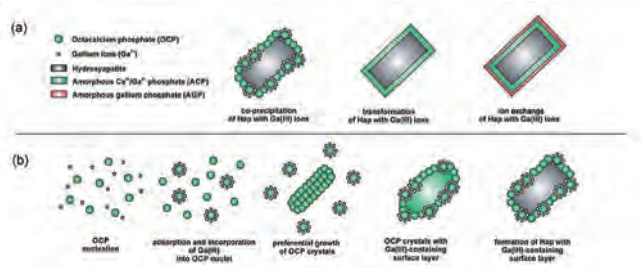


Figure 4: a) Illustration of the structure of HAp(Ga) obtained by co-precipitation, transformation and ion exchange with Ga3+ ions and b) the mechanism of formation of HAp(Ga) co-precipitated nanocrystals.

New materials for efficient energy conversion

In the scope on the research on new materials for energy conversion we investigated compounds with a layered crystal structure that comply with the "phonon-glass, electron-crystal" concept and are thus interesting for the development of new thermoelectric materials. In the case of materials based on layered titanium disulphide we developed a process that allows the synthesis of a highly stoichiometric compound, which leads to a wide range of possibilities regarding the formation of intercalated bulk materials with improved electrical and thermal transport properties. Furthermore, we optimized a high-pressure pulsed electric current sintering process that resulted in highly textured, twinned bulk materials based on titanium disulphide with an order of magnitude lower thermal conductivity.

In the case of bulk materials based on layered cobaltates we found that crystal structure changes within individual grains can be triggered by changing the atmosphere in the predicted operating temperature range. The findings contribute to a new understanding of the crystal chemistry of layered compounds as candidate materials for thermoelectric energy conversion.

Within the research field of energy-conversion materials we also studied crystal-structure and domain-texture changes induced by external mechanical stresses and electrical fields. For the studies, we applied *in-situ* X-ray diffraction and *in-situ* transmission electron microscopy to the lead-free piezoceramics. We found that induced changes depend on the initial state of the material. The study contributed to an understanding of the coupling between structural changes, which is crucial for development of new environmentally friendly piezomaterials.

Materials for heat-insulation applications

Our research focused on the development of insulation materials with improved insulation capacity, temperature stability, and/or improved sustainability. We investigated foaming mechanisms for various glass cullets and identified additives that enable the tuning of the foaming process in the preparation of foam glasses. Selected additives facilitate the preparation of foam glass from cullets of cathode-ray-tube (CRT) panel glass, flat glass, container glass as well as their mixtures under very similar process conditions (Figure 6). A decreased dependence of the foaming process on the composition of the glass is an important scientific and industrial contribution. Foam-glass products with a high content of container glass were open porous, suitable for use in sound insulation. Closed-porous foams are suitable for load-bearing, age-resistant thermal insulation within the whole lifespan of the building. The thermal conductivity of the foams with a higher content of the CRT panel glass (Figure 7) was lower than that of the foams with the container or bottle glass. The lowest achieved thermal insulation values are 39–40 mW/(m·K). We also measured the thermal conductivity of the solid structure in an evacuated open-porous sample, which revealed the approximately 50 % contribution of the solid conductivity to the effective thermal conductivity.

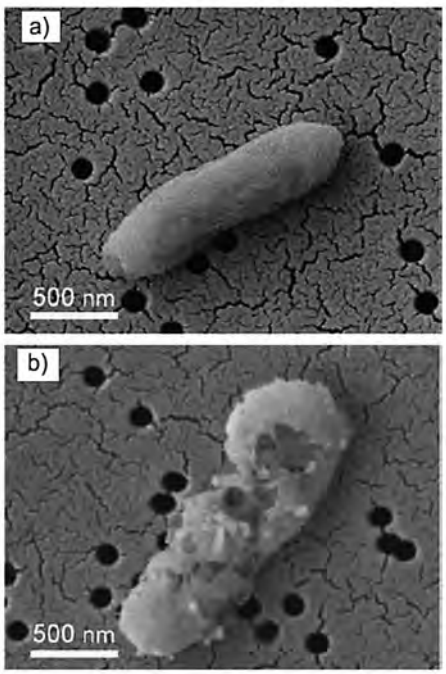


Figure 5: Bacterial morphology: a) SEM image of P. aeruginosa MW1 after 24-h incubation in growth medium with 0.5 mg/mL hydroxyapatite and b) SEM image of P. aeruginosa MW1 after 24-h incubation in growth medium with 0.1 mg/mL of Ga@HAp.

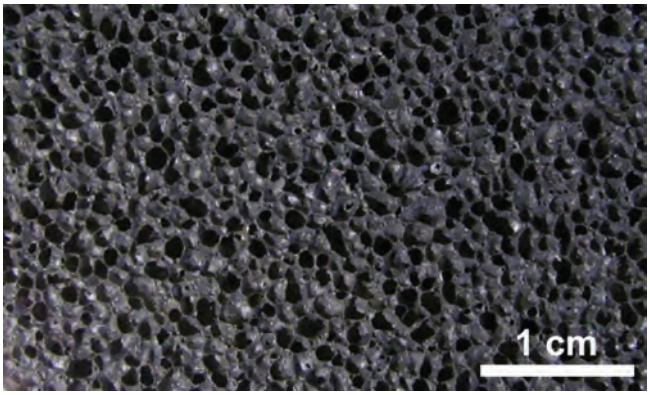


Figure 6: Microstructure of a foam glass with 95 % porosity prepared from waste window glass.

ENPIEZO

In the scope of the M-ERA.NET project ENPIEZO we are developing piezoelectric-based energy-harvesting (EH) devices to provide a remote source of electricity from waste vibrations. We are investigating the fabrication-friendly pulsed-laser deposition of high-quality epitaxial $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (PMN-PT) thin films on Si, based on the delicate engineering of silicon-oxide interfaces. The study, joining laboratory- and industrial-scale systems, is the first of its kind. On our laboratory system we thoroughly studied the Sr-reconstructed Si surface and optimized the crucial growth parameters of $SrTiO_3$ (STO) on Si. Separately, we optimized the growth on PMN-PT thin films on single-crystal STO substrates, whereupon we started integrating the two systems. Within this project we are also studying the preparation of polycrystalline PMN-PT films by aerosol-deposition on stainless-steel substrates. In the past year mathematical modelling of the piezoelectric transducers was also completed. Simultaneously, we investigated various potential applications for these transducers.

EPCOS

For our industrial partner EPCOS OHG, Deutschlandsberg, Austria, in the past year we have carried out the project: "Devices for energy storage based on PLZT thin films and Cu electrodes". We grew PLZT thin films using a laboratory and industrial system for pulsed-laser deposition. On Si substrates with a diameter of 150 mm we successfully controlled the chemical homogeneity of all the present elements, as well as the layer thickness along the substrate. Further development of advanced devices for energy storage in electronic applications will be based on the results of this project.

SCOPES

Within the SCOPES project, which is trilateral cooperation between Serbia, Slovenia and Switzerland, we have developed new methods for forming porous structures which are suitable as carriers of stem cells and are useful in tissue engineering. Such structures include a polymer matrix (made up of a series of new biocompatible and biodegradable polymers, which we developed together with the TMF partner in Serbia) and the inorganic particles are based on doped apatite (which includes ions such as Mg^{2+}, Zn^{2+}, Ga^{3+} and Sr^{2+}). In the first phase of materials testing (which was made in the ETH within a cooperation with a partner in Switzerland), we have shown that the presence of ions has a strong influence on the different stages of the cell life cycle of stem cells and stimulates their differentiation and growth.

Figure 7: Cross-section images of the foam glasses prepared from panel glass powders with different particle sizes. The density of the foam glass prepared from 13-μm powders is 120 kg/m³.

CleanTechBlock II

Project CleanTechBlock II – energy-saving facade building component develops and demonstrates a new building block with improved foam glass insulation core and clay brick shells. The goal of the project is to demonstrate the new foam-glass preparation process on a larger scale (size 1:1) and preparation and thermal insulation property testing of a wall segment from the new building blocks.

Some outstanding publications in the past year

1. Jakob Koenig, Rasmus R. Petersen, Yuanzheng Yue, "Influence of the glass particle size on the foaming process and physical characteristics of foam glasses", J. non-cryst. solids, vol. 447, str. 190-197, 2016, doi: 10.1016/j.jnoncrysol.2016.05.021.
2. Lei Li, Matjaž Spreitzer, Danilo Suvorov, "The microstructure, dielectric abnormalities, polar order and microwave dielectric properties of $Ag(Nb_{(1-x)}Ta_x)O_3$ (x = 0-0.8) ceramics", J. Eur. Ceram. Soc., vol. 36, no. 14, str. 3347-3354, 2016, doi: 10.1016/j.jeurceramsoc.2016.05.017.
3. Vojka Žunič, Mario Kurtjak, Danilo Suvorov, "Bifunctional bridging linker-assisted synthesis and characterization of TiO_2/Au nanocomposites", J. nanopart. res., vol. 18, no. 11, str. 336-1-336-11, 2016.
4. Zoran Jovanović, Matjaž Spreitzer, Urška Gabor, Danilo Suvorov, "Control of SrO buffer-layer formation on Si(001) using the pulsed-laser deposition technique", RSC advances, vol. 6, issue 85, str. 82150-82156, 2016, doi: 10.1039/c6ra16311d.

5. Mario Kurtjak, Marija Vukomanović, Andraž Krajnc, Lovro Kramer, Boris Turk, Danilo Suvorov, "Designing Ga(III)-containing hydroxyapatite with antibacterial activity", RSC advances, vol. 6, iss. 114, str. 112839-112852, 2016, http://pubs.rsc.org/en/content/articlepdf/2016/ra/c6ra23424k, doi: 10.1039/C6RA23424K.
6. Nemanja Aničić, Marija Vukomanović, Danilo Suvorov, "The nano-texturing of MgO microrods for antibacterial applications", RSC advances, 6(104), str. 102657-102664, 2016, doi: 10.1039/C6RA23058J.

Awards and Appointments

1. Urška Gabor: Award for best oral presentation in young researchers section at the 24th International Conference on Materials and Technology, Portorož, Metals and Technology (IMT), "Different approaches to avoiding lead deficiency in PMN-PT thin films"
2. Martin Štefanič: Seal of Excellence, Brussels, Belgium, European Commission, project proposal NanoDryCell: Nanoparticle-assisted desiccation of mesenchymal stem cells for the "off-the-shelf" allogeneic cell therapy

Organization of conferences, congresses and meetings

1. Workshop on M.ERA-NET project "ENPIEZO: Enabling technology for high-quality piezoMEMS", Taipei, Taiwan, 21. – 28. 2. 2016 (co-organizers)
2. Workshop on "EUDP Clean TechBlock II" project, Aalborg, Denmark, 29. 2. - 4. 3. 2016 (co-organizers)
3. Workshop on M.ERA-NET project "HarvEnPiez: Innovative nano-materials and architectures for integrated piezoelectric energy harvesting application", Ljubljana, 25. – 26. 8. 2016
4. Workshop on M.ERA-NET project "ENPIEZO: Enabling technology for high-quality piezoMEMS", Oslo, Norway, 31. 8. – 3. 9. 2016 (co-organizers)
5. COST TO-BE (Towards Oxide - Based Electronics) Fall Meeting 2016, Ljubljana, 28. – 30. 9. 2016
6. 24. International Conference on Materials and Technology, Portorož, 28. – 30. 9. 2016 (co-organizers)

INTERNATIONAL PROJECTS

1. Thin-Film-Energy-Storage Device on the basis of PLZT and Cu-Electrodes
   Prof. Danilo Suvorov, doc. dr. Matjaž Spreitzer
   Epcos Ohg
2. Investigation of Rare Earth Alloys and Related Compounds
   Prof. Danilo Suvorov, doc. dr. Srečo Škapin
   Urban Mining Company
3. Investigation of Rare Earth Alloys and Related Compounds
   Prof. Danilo Suvorov, doc. dr. Srečo Škapin
   Urban Mining Company
4. COST MP1308; Towards Oxide Based Electronics (TO-BE)
   Asst. Prof. Matjaž Spreitzer
   Cost Office
5. COST 1308 TO BE Workshop, Ljubljana, Slovenia, 28.-30.9.2016
   Asst. Prof. Matjaž Spreitzer
   Cost Office
6. Gold/Ferrite Nanocomposites: Antimicrobial and Magnetic Properties for Biomedical Applications
   Marija Vukomanović
   Slovenian Research Agency
7. Thermoelectric Materials based on Layered Crystal Structures
   Asst. Prof. Boštjan Jančar
   Slovenian Research Agency

RESEARCH PROGRAM

1. Contemporary Inorganic Materials and Nanotechnologies
   Prof. dr. Danilo Suvorov

R & D GRANTS AND CONTRACTS

1. Engineering of structural and microstructural characteristics in contemporary dielectrics and ferroelectrics with perovskite and perovskite-like crystal structures
   Prof. Danilo Suvorov
2. Growth of high quality piezoelectric thin films on silicon using pulsed laser deposition
   Asst. Prof. Matjaž Spreitzer
3. Development of heterogeneous catalysts for oxidative dehydrogenation of propane with CO
   Asst. Prof. Matjaž Spreitzer
4. SCOPES; Intelligent Scaffolds as a Tool for Advanced Tissue Regeneration
   Marija Vukomanović
   Snf- Swiss National Science Foundation
5. Cleantech Block II - Energy Saving Cladding
   Dr. Jakob König
   Eddp (eudp) Energy Technology Development
6. Enabling technology for high-quality piezoMEMS
   Asst. Prof. Matjaž Spreitzer
   MIZŠ

NEW CONTRACTS

1. Development and characterisation of mineral wool fibres
   Prof. Danilo Suvorov, dr. Jakob König
   Knauf Insulation, d. o. o., Škofja Loka
2. PBE Silent and PBE Varioface
   Prof. Danilo Suvorov, dr. Jakob König
   Knauf Insulation, d. o. o., Škofja Loka

VISITORS FROM ABROAD

1. Jelena Mitrić, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 21.11. - 25.12.2016
2. Dr. Zoran Jovanović, Dr. Sonja Jovanović, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 18.11. - 23.12.2016
3. Prof. Xiang Ming Chen, Institute of Materials Physics, School of Materials Science and Engineering, Zhejiang University, Hangzhou, China, 26. - 31. 8. 2016
4. Dr. Ioana Vlaicu, Dr. Raluca Negrea, National Institute of Materials Physics, Bucharest, Romania, 25. – 26. 8. 2016
5. Dr. Olga Plopa, Intelectro Iasi SRL, Romania, 25. – 26. 8. 2016
6. Dr. Eugene Kotomin, University of Latvia, Riga, Latvia, 25. – 26. 8. 2016
7. Dr. Sonja Jovanović, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 24. 7. - 21. 8. 2016
8. Dr. Jyoti Prosad Guha, Missoury University of Science and Technology, Rolla, USA, 26.6. – 23. 9. 2016
9. Dr. Manfred Schweinzger, Dr. Kerstin Schmoltner, TDK EPCOS, Deutschlandsberg, Austria, 24.6.2016.
10. Dr. Maja Đekić, Amra Salčinović, University of Sarajevo, Sarajevo, Bosnia and Herzegovina, 19. - 29.6.2016
11. Prof. Yuanzheng Yue, Dr. Rasmus R. Petersen, Martin B. Østergaard, Aalborg University & Jacob H. Bendtsen, Peter Matzen, Gråsten Brickwork, Denmark, 15.6.2016
12. Dr. Kerstin Schmoltner, TDK EPCOS, Deutschlandsberg, Austria, 1.- 2.6.2016
13. Dr. Bratislav Antić, Vinča Institute of Nuclear Sciences, Belgrade, Serbia, 20. - 23. 4. 2016

14. Dr. Sonja Jovanović, Vinča Institute of Nuclear Sciences, Belgrade, Serbia 12. – 25. 4. 2016
15. Dr. Chao-Ting Chen, National Taiwan University, Taipei City, Taiwan, 20. – 27. 3. 2016

Visiting Researchers

1. Dr. Jyoti Prosad Guha, Missoury University of Science and Technology, Rolla, USA, 26.6. – 23. 9. 2016
2. Dr. Daniel Diaz Fernandez, Universidad Autónoma de Madrid, Spain, 1. 10. 2015 – 30. 9. 2017

STAFF

Researchers

1. Asst. Prof. Boštjan Jančar
2. Dr. Jakob König
3. Dr. Špela Kunej
4. Dr. Marjeta Maček Kržmanc
5. Dr. Matjaž Spreitzer
6. **Prof. Danilo Suvorov, Head**
7. Asst. Prof. Srečo Davor Škapin
8. Dr. Marija Vukomanović

Postdoctoral associates

9. *Dr. Mojca Otoničar, 01.05.16, transferred to Department K5*
10. Dr. Martin Štefanič
11. *Dr. Vojka Žunič, left 01.04.16*

Postgraduates

12. Nemanja Aničić, B. Sc.
13. Alja Čontala, B. Sc.
14. Urška Gabor, B. Sc.
15. *Mario Kurtjak, B. Sc., left 01.09.16*
16. Tjaša Parkelj, B. Sc.
17. Tilen Sever, B. Sc.

Technical officers

18. David Fabijan, B. Sc.
19. *Dr. Jana Ferčič, left 01.07.16*
20. Damjan Vengust, B. Sc.

Technical and administrative staff

21. Vesna Butinar, B. Sc.
22. *Maja Šimaga, M. Sc., 01.12.16, transferred to Department B3*
23. Silvo Zupančič

BIBLIOGRAPHY

Original Article

1. Nemanja Aničić, Marija Vukomanović, Danilo Suvorov, "The nano-texturing of MgO microrods for antibacterial applications", *RSC advances,* vol. 6, iss. 104, pp. 102657-102664, 2016.
2. Marja Jerič, Johannes de Boor, Boštjan Jančar, Miran Čeh, "An enhanced thermoelectric figure of merit for $Sr(Ti_{0.8}Nb_{0.2})O_3$ based on a Ruddlesden-Popper-polytype-induced microstructure", *J. Eur. Ceram. Soc.*, vol. 36, nol. 5, pp. 1177-1182, 2016.
3. Zoran Jovanović, Matjaž Spreitzer, Urška Gabor, Danilo Suvorov, "Control of SrO buffer-layer formation on Si(001) using the pulsed-laser deposition technique", *RSC advances*, vol. 6, issue 85, pp. 82150-82156, 2016.
4. Luka Kelhar, Jana Bezjak, Pascal Boulet, Marjeta Maček, Sašo Šturm, Martin Lamut, Boštjan Markoli, Spomenka Kobe, Jean-Marie Dubois, "Stabilisation of Ce-Cu-Fe amorphous alloys by addition of Al", *Philos. mag. (2003)*, vol. 96, iss. 30, pp. 3143-3185, 2016.
5. Andraž Kocjan, Marko Češnovar, Damjan Vengust, Tomaž Kosmač, Aleš Dakskobler, "Translucent yttria- and silica-doped mullite ceramics with anisotropic grains produced by spark plasma sintering", *J. Am. Ceram. Soc.*, vol. 99, iss. 9, pp. 3090-3069, 2016.
6. Jakob Koenig, Rasmus R. Petersen, Yuanzheng Yue, "Influence of the glass particle size on the foaming process and physical characteristics of foam glasses", *J. non-cryst. solids*, vol. 447, pp. 190-197, 2016.
7. Mario Kurtjak, Marija Vukomanović, Andraž Krajnc, Lovro Kramer, Boris Turk, Danilo Suvorov, "Designing Ga(III)-containing hydroxyapatite with antibacterial activity", *RSC advances*, vol. 6, iss. 114, pp. 112839-112852, 2016.
8. Mario Kurtjak, Marija Vukomanović, Lovro Kramer, Danilo Suvorov, "Biocompatible nano-gallium/hydroxyapatite nanocomposite with antimicrobial activity", *J. mater. sci., Mater. med.*, vol. 27, iss. 11, art. 170, 2016.
9. Lei Li, Matjaž Spreitzer, Danilo Suvorov, "The microstructure, dielectric abnormalities, polar order and microwave dielectric properties of $Ag(Nb_{1-x}Ta_x)O_3$ (x = 0-0.8) ceramics", *J. Eur. Ceram. Soc.*, vol. 36, no. 14, pp. 3347-3354, 2016.
10. Lei Li, Matjaž Spreitzer, Danilo Suvorov, Xiang Ming Chen, "Unique dielectric tunability of $Pb_{0.99}[(Zr_{0.6}Sn_{0.4})_{0.94}Ti_{0.06}]_{0.98}Nb_{0.02}O_3$ antiferroelectric ceramics", *J. appl. phys.*, vol. 120, no. 7, pp. 074109-1-074109-5, 2016.
11. Smilja Marković, Vladimir Rajić, Ana Stanković, Ljiljana Veselinović, Jelena Belošević Čavor, Katarina Batalović, Nadica Abazović, Srečo D. Škapin, Dragan Uskoković, "Effect of PEO molecular weight on sunlight induced photocatalytic activity of ZnO/PEO composites", *Sol. energy*, vol. 127, pp. 124-135, 2016.
12. Sami Myllymäki, Marjeta Maček, Marcin Sloma, J. Juuti, M. Nelo, Merja Teirikangas, Małgorzata Jakubowska, Danilo Suvorov, Heli Jantunen, "Microwave properties of sphere-, flake-, and disc-shaped $BaFe_{12}O_{19}$ nanoparticle inks for high-frequency applications on printed electronics", *J. magn. magn. mater.*, vol. 419, pp. 218-224, 2016.
13. Mojca Otoničar, Angelika Reichmann, Klaus Reichmann, "Electric field-induced changes of domain structure and properties in La-doped PZT-from ferroelectrics towards relaxors", *J. Eur. Ceram. Soc.*, vol. 36, iss. 10, pp. 2495-2504, 2016.
14. Rasmus R. Petersen, Jakob Koenig, Yuanzheng Yue, "Evaluation of foaming behavior of glass melts by high-temperature microscopy", *Int. j. appl. glass sci.*, vol. 7, no. 4, pp. 524-531, 2016.
15. Zoran Stojanović, Nenad Ignjatović, Victoria Wu, Vojka Žunič, Ljiljana Veselinović, Srečo D. Škapin, Miroslav Miljković, Vuk Uskoković, Dragan Uskoković, "Hydrothermally processed 1D hydroxyapatite: mechanism of formation and biocompatibility studies", *Mater. sci. eng., C, Biomim. mater., sens. syst.*, vol. 68, pp. 746-757, 2016.
16. Martin Štefanič, Xiang Zhang, "Novel method for fabrication of samples for cell testing of bioceramics in granular form", *J. Appl. Biomater. Functional Mater.*, vol. 14, iss. 4, pp. e395-e501, 2016.
17. Erika Švara Fabjan, Mojca Otoničar, Miran Gaberščček, Andrijana Sever Škapin, "Surface protection of an organic pigment based on a modification using a mixed-micelle system", *Dyes pigm.*, vol. 127, pp. 100-109, Apr. 2016.
18. M. Tuhkala, Marjeta Maček, T. Siponkoski, J. Juuti, Merja Teirikangas, Danilo Suvorov, Heli Jantunen, "The effect of $BaTiO_3$ particle shape on complex permittivity of $0.98MgTiO_3 - 0.02BaTiO_3$ composite powders at GHz frequencies", *Mater. res. bull.*, vol. 76, pp. 300-304, 2016.
19. Ana Varlec, Denis Arčon, Srečo D. Škapin, Maja Remškar, "Oxygen deficiency in MoO_3 polycrystalline nanowires and nanotubes", *Mater. chem. phys.*, vol. 170, pp. 154-161, 2016.
20. Damjan Vengust, Jan Ravnik, Aleš Mrzel, Mojca Vilfan, "Molybdenum carbide nanowires: facile synthesis, a new hybrid phase and their use as transparent electrodes", *RSC advances*, vol. 6, no. 93, pp. 90806-90812, 2016.
21. Vojka Žunič, Mario Kurtjak, Danilo Suvorov, "Bifunctional bridging linker-assisted synthesis and characterization of TiO_2/Au nanocomposites", *J. nanopart. res.*, vol. 18, no. 11, pp. 336-1-336-11, 2016.

Published Conference Contribution

1. Aysen Kaya, Matejka Podlogar, Damjan Vengust, Damjan Svetin, Süleyman Kahraman, Aleksander Rečnik, Slavko Bernik, "Hydrothermal growth of doped ZnO films on amorphous substrates", In: *Conference proceedings 2016*, 52nd International Conference on Microelectronics, Devices and Materials and the Workshop on Biosensors and Microfluidics, September 28 - 30 2016, Ankaran, Slovenia, pp. 37-42

DEPARTMENT OF BIOCHEMISTRY, MOLECULAR AND STRUCTURAL BIOLOGY B-1

The research activities of the members of the department are largely focused on studies of the physiological role of proteases in normal and pathological conditions, the mechanism of their action and regulation, as well as their properties and structure. Part of the activities is devoted to the development of tools that allow us to understand the properties of proteases and other enzymes, as well as to enable their monitoring and manipulation in in vivo conditions.

Head:
Prof. Boris Turk

Protease research has undergone a major expansion in the past decade, largely due to the extremely rapid development of new technologies, such as quantitative proteomics and *in vivo* imaging, as well as an extensive use of *in vivo* models. These have led to the identification of physiological substrates and resulted in a paradigm shift from the concept of proteases as protein-degrading enzymes to proteases as key signalling molecules. Their catalytic activities are precisely regulated, the most important ways being zymogen activation and inhibition by their endogenous protein inhibitors. Any imbalance in this regulation can lead to pathologies such as autoimmune, neurological and cardiovascular disorders, cancer and osteoporosis. However, protease-signalling pathways are only partially understood. Currently, only a minor subset of physiological substrates for a limited number of proteases has been identified, and their physiological regulation is still not well understood.

We have continued with proteomic approaches devoted to the identification of protease specificities and the identification of physiological protease substrates. We have thus developed a novel, in-gel-based method that allows a very rapid determination of protease specificities and was already successfully tested on a few proteases, including trypsin and several cysteine cathepsins. In addition, we have in collaboration with dr. O. Schilling (University of Freiburg) developed an improved gel-based approach for the identification of protease substrates. In this approach peptide libraries are generated by the endoproteolytic digestion of proteomes without chemical modification of the primary amines before exposure to a protease under investigation. After incubation with a test protease, treated and control libraries are differentially isotope-labelled and analysed by liquid chromatography-tandem mass spectrometry. We validated the workflow with trypsin and caspase-3, and additionally provided specificity profiles of a protease encoded by a human endogenous retrovirus and for chlamydial protease-like activity factor, as well as for a disintegrin and metalloproteinases with thrombospondin motifs (ADAMTS) -4, -5, and -15, where we showed a canonical profile, including glutamate in P1 and glycine in P3' positions.

Figure 1: Quantum FX micro CT apparatus (Perkin Elmer) enables CT imaging of small rodents in preclinical investigations

We have previously demonstrated that cysteine cathepsins can facilitate the proteolytic release of the extracellular domains of several transmembrane proteins (ectodomain shedding), which is one of the major mechanism in regulating cellular signalling. In collaboration with dr. Dennis Thiele (Duke University), we identified Ctr1, a high-affinity Cu (+) transporter on the plasma membrane and endosomes that exists as a full-length protein and a truncated form of Ctr1 lacking the methionine- and histidine-rich metal-binding ectodomain with reduced Cu (+) transport activity, as a substrate of cathepsins L and B in vivo. We were also invited to write an overview on current proteomic and degradomic approaches and challenges in identifying protease substrates and specificities with a special focus on terminomic strategies, which combine peptide labelling and enrichment.

In addition to proteomic approaches, we also worked on small-molecule substrates and probes. The major enzyme we focused on was legumain (AEP), which is linked to a number of diseases including inflammation, arteriosclerosis, and tumorigenesis. In collaboration with dr. M. Drag (University of Wroclaw), we used a hybrid combinatorial substrate library (HyCoSuL) approach to obtain P1-Asp fluorogenic substrates and biotin-labelled inhibitors that targeted legumain. Since this approach led to probes that were also recognized by caspases, we introduced a Counter Selection Substrate Library (CoSeSuL) approach that biases the peptidic scaffold against caspases, thus delivering highly selective legumain probes, which were successfully validated in cells. This approach offers several advantages in the design of selective probes for proteases where the selectivity is difficult to achieve using conventional profiling approaches.

We also continued to work on targeted drug-delivery systems and developed several cathepsin B-specific DARPins that have the potential for non-invasive diagnostic imaging and theranostic applications. We also collaborated with dr. G. Blum (Hebrew University, Jerusalem) on the development of reactive drug carriers with a focus on self-assembled tetra-peptides that include the diphenylalanine motif, thereby serving as substrates of the cathepsins. The degradation of such tetrapeptide substrate nanofibers by cathepsin B led to the release of the majority of the incorporated anti-cancerous drug Doxorubicin from the nanofibers. Moreover, we also demonstrated that tumour lysates fully degraded such nanofibers, suggesting that tetrapeptide substrates that form nanostructures could serve as a promising platform for targeted drug delivery to pathologies in which the protease activity is highly elevated.

Another protease that we focused on was cathepsin K, which is a major target in the osteoporosis treatment. We characterized its allosteric fine-tuning via a recently identified allosteric site. We showed that one of the compounds investigated bound to this site and acted as a specific partial inhibitor of the collagenolytic activity of cathepsin K. The allosteric site was further characterized by site-directed mutagenesis and shown that it is involved in specific regulation of the collagenolytic activity of cathepsin K.

Part of the work was also focused on cathepsin L. Insight into the specificity of this protease is important for elucidating its physiological roles and drug discovery. To study interactions with synthetic ligands, we prepared a presumably inactive mutant and crystallized it. Unexpectedly, the crystal structure determined at 1.4 revealed that the cathepsin L molecule is cleaved, with the cleaved region trapped in the active site cleft of the neighbouring molecule. Hence, the catalytic mutant demonstrated low levels of catalytic activity, which is unusual for the cathepsins.

Part of the work was also devoted to inhibitors. One of these is the p41 splice variant of the MHC class II-associated chaperone, called the invariant chain p41 Ii, which contains an amino acid sequence, the p41 fragment, which is a thyropin-type inhibitor of proteolytic enzymes. We found that the exogenous p41 fragment can enter the endocytic pathway of targeted human immature DC, where it could inhibit the enzymatic activity of cysteine proteases. In addition, the p41 fragment was shown to reduce the secretion of interleukin-12 during the subsequent maturation of the treated DC. These findings thus support the immunomodulatory potential of the inhibitor. In addition, we have shown that the deletion of the cystatin C gene has an impact on the development of mammary gland carcinomas in vivo in a mouse model.

A special honour was given to V. Turk, who was invited together with J. Neefjes and E. Unanue, to write an overview about the MHC class II (MHC-II) molecules, which are critical in the control of many immune responses, including in most autoimmune diseases and other pathologies, and the associated proteolysis. This process ultimately determines the MHC-II-presented peptidome, including cryptic peptides, modified peptides, and other peptides that are relevant in autoimmune responses. The authors illustrated that MHC-II is variable not only in amino acids (polymorphic) but also in its biology, with important consequences for both health and disease. The work was published in Annu Rev Immunol, the premier journal in the field.

An important overview about the cathepsins and their regulation in neuronal system was also written by V. Stoka and colleagues, and was published in a special issue of one of the leading journals in neurology, Aging Res Rev, which was devoted to the lysosomal system.

Part of the activities was also devoted to other enzymes or associated with our expertise in the field of mass spectrometry and structural biology. In collaboration with colleagues from the National Institute of Chemistry (dr. M. Novič) we used in-silico prediction tools to study the substrate or ligand (inhibitor) binding regions of autolysin E, a bacteriolytic enzyme that plays an important role in the division and growth of bacterial cells and therefore represents a promising potential drug target. Combining several approaches, specific amino acid residues were predicted as ligand binding residues. Therefore, the molecules that would bind with inhibitory potency to these residues could represent potential new antibacterial agents. In another collaboration with colleagues from AciesBio (dr. G. Kosec) and the National Institute of Biology (dr. K. Gruden), we have undertaken an integrated study of the genomic, transcriptomic, and proteomic differences between the wild type strain and the industrial high-producing strain of S. erythraea to reveal the mechanisms related to increased yield of production of erythromycin. A total of 165 observed mutations led to differences in gene expression profiles and protein abundance between the two strains, which were most prominent in the initial stages of erythromycin production. Enzymes involved in erythromycin biosynthesis, metabolism of branched chain amino acids and proteolysis were most strongly upregulated in the HP strain. Interestingly, genes related to the TCA cycle and DNA-repair were downregulated. Additionally, comprehensive data analysis uncovered significant correlations in the expression profiles of the erythromycin-biosynthetic genes, other biosynthetic gene clusters and previously unidentified putative regulatory genes. Based on this information, we demonstrated that the overexpression of several genes involved in an amino acid metabolism can contribute to an increased yield of erythromycin, confirming the validity of our systems biology approach. Our comprehensive omics approach, carried out in industrially relevant conditions, thus enabled the identification of key pathways affecting the erythromycin yield, suggesting strategies for a rapid increase in the production of secondary metabolites in an industrial environment.

It is worth mentioning that our department has, partially through the help of Center of Excellence Center for Integrative approaches for Chemistry and Biology of Proteins (CIPKEBIP), established several technological platforms that are all unique in Slovenia and include a structural biology platform, a proteomics platform and a whole-body imaging platform, based on an IVIS Spectrum imaging system and a Quantum FX micro CT, which was installed in 2016. All three platforms are open for external collaborations and several works resulting from these collaborations have already been published.

We participated in the FP7 project Alexander and were involved in the Slovenian Center of Excellence CIPKEBIP that we coordinate. In addition, there are numerous other international collaborations with excellent research teams from different countries including Belgium (a joint project through FWO), France, Germany, Sweden, Switzerland, UK, USA, Australia, Hungary and Japan, which resulted in joint publications.

In addition, B. Turk co-organized together with dr. F.X. Aviles (University Autonomous Barcelona) a B-debate series symposium "Imaging for Life: From Molecules to Diagnostics and Therapy", and several members of the department were invited to give lectures at international symposia and foreign universities.

Some outstanding publications in the past year

1. Stoka V, Turk V, Turk B. (2016) Lysosomal cathepsins and their regulation in aging and neurodegeneration. Ageing Res Rev. 32, 22-37. doi: 10.1016/j.arr.2016.04.010.
2. Unanue ER, Turk V, Neefjes J. (2016) Variations in MHC Class II Antigen Processing and Presentation in Health and Disease. Annu Rev Immunol. 34, 265-297. doi: 10.1146/annurev-immunol-041015-055420.
3. Sosnowski P, Turk D. (2016) Caught in the act: the crystal structure of cleaved cathepsin L bound to the active site of Cathepsin L. FEBS Lett. 590, 1253-1261. doi: 10.1002/1873-3468.12140.
4. Novinec M, Rebernik M, Lenarčič B. (2016) An allosteric site enables fine-tuning of cathepsin K by diverse effectors. FEBS Lett. 590, 4507-4518. doi: 10.1002/1873-3468.12495.

Organisation of conferences, congresses and meetings

1. 32nd Winter School on Proteases and their Inhibitors, Tiers, Italy, 24 – 28 Februar 2016, coorganisers
2. IUBMB Symposium on Proteinases, Inhibitors and Biological Control, Portorož, Slovenija, 17 – 21 September 2016

INTERNATIONAL PROJECTS

1. Supply of DPPI Enzyme and the Non-exclusive License Rights
   Prof. Dušan Turk
   Prozymex A/s
2. 7FP - ALEXANDER; Mucus Permeating Nanoparticulate Drug Delivery Systems
   Asst. Prof. Olga Vasiljeva
   European Commission
3. COST BM1307; European Network to integrate Research on Intracellular Proteolysis Pathways in Health and Disease (PROTEOSTASIS)
   Boris Turk
   Cost Office
4. COST OC-2015; TRANSAUTOPHAGY: European Network of Multidisciplinary Research and Translation of Autophagy Knowledge
   Prof. Eva Žerovnik
   Cost Office
5. COST CA 15203; Mitochondrial Mapping: Evolution-Age-Gender-Lifestyle-Environment
   Asst. Prof. Nataša Kopitar – Jerala
   Cost Office
6. COST CA15124; NEUBIAS - A New Network of European Bioimage Analysts to Advance Life Science Imaging
   Asst. Prof. Tina Zavašnik Bergant
   Cost Office
7. COST CA15214; An Integrative Action for Multidisciplinary Studies on Cellular Structural Networks
   Asst. Prof. Nataša Kopitar – Jerala
   Cost Office
8. MD Simulations of the Initial Steps in Oligomerization of an Amyloidogenic Protein Human Stefin B; Complex of Stefin B Oligomers with A-beta
   Prof. Eva Žerovnik
   Slovenian Research Agency
9. Building Interface between Crystallographic Software MAIN and Integrative Modeling Platform IMP
   Prof. Dušan Turk
   Slovenian Research Agency
10. Effect of Anti-oxidants on Protein Aggregation; In Vitro Study of Amyloid Fibrillation on the Model of Stefin B and Beta2-microglobulin
    Prof. Eva Žerovnik
    Slovenian Research Agency

RESEARCH PROGRAMS

1. Structural biology
   Prof. Dušan Turk
2. Proteolysis and its regulation
   Prof. Boris Turk

R & D GRANTS AND CONTRACTS

1. Nitroxoline and its derivatives as new antitumour drugs
   Asst. Prof. Olga Vasiljeva
2. Role of cysteine cathepsins in inflammation-associated diseases
   Prof. Boris Turk
3. Structural insight into iodine metabolism
   Dr. Ajda Taler-verčič
4. „Insights into the protein interactions involved in the Potato virus Y potatorelation"
   Prof. Dušan Turk
5. Role of cysteine proteases in the process of cancerogenesis
   Prof. Marko Fonović
6. Proteases in inflammation and cell death
   Prof. Boris Turk
7. The role of micro RNA-21 and cathepsins in delayed preconditioning to acute kidney injury
   Prof. Boris Turk
8. XVth International Symposium on Proteinases, Inhibitors and Biological Control, Portorož, Slovenia, 17.9.-21.9.2016
   Boris Turk
9. In Vivo Studies of Antitumor Activity and Toxicity of Low-Dimensional Al-Hydroxide based Nanostructures
   Boris Turk
   National Research Tomsk

NEW CONTRACT

1. Mass spectromety analysis
   Prof. Boris Turk
   Krka, Tovarna Zdravil, d. d.

VISITORS FROM ABROAD

1. Andrey Kadin, Shemyakin and Ovchinnikov Institute of Bioorganic Chemistry, Russian Academy of Science, Moscow, Russia, 1 January –31 July 2016 (IJS fellowship holder)
2. Prof. dr. Igor Weber, Ruder Bošković Institute, Zagreb, Croatia, 28 February – 12 March 2016
3. Prof. dr. Peter Hamar, Semmelweis University, Department of Pathophysiology, Budapest, Hungary,16 – 18 April 2016
4. Dr. Vitalie Rotari, Chisinau, Moldova, 1 – 4 Jun 2016
5. Samra Hasanbašić, Univerzitet Tuzla, Bosnia and Herzegovina, 4 July – 3 August 2016
6. Alma Jahić, Univerzitet Tuzla, Bosnia and Herzegovina, 5 September – 4 October 2016
7. Prof. dr. Selma Berbić, Univerzitet Tuzla, Bosnia and Herzegovina, 10 – 14 October 2016
8. Prof. dr. Carlos Lopez Otin, Departamento de Bioquimica y Biologia molecular, IUOPA, Universidad de Oviedo, Spain, 16 September 2016
9. Prof. dr. Hiroshi Nakanishi in prof.dr. Wu Zhou, Department of Pharmacology and Aging Science, Faculty of Dental Science, Kyushu University, Fukuoka, Japan, 21 –22 September 2016
10. Prof. dr. Ozaki Yasuhiko, Department of Obstetrics and Ginecology, Nagoya City University, Graduate School of Medical Sciences, Nagoya, Japan, 22 September 2016
11. prof. dr. Goto Shinobu, Nagoya City Hospital, Department of Obstetrics and Ginecology, Nagoya, Japan, 22 September . 2016
12. prof. dr. Dieter Bromme in Panwar Preety,The University of British Columbia, Vancouver, Canada, 22 September 2016
13. Prof. dr. Henry Chapman, Universitat Hamburg, Germany, 25 – 27 October 2016
14. Prof. dr. Kazuo Umezawa, Department of Molecular Target Medicine Screening, School of Medicine, Aichi Medical University, Nagakute, Japan, 16 – 18 November 2016

STAFF

Researchers

1. Dr. Iztok Dolenc
2. Prof. Marko Fonović
3. Asst. Prof. Nataša Kopitar - Jerala
4. Prof. Brigita Lenarčič*
5. *Asst. Prof. Urška Repnik, left 14.10.16*
6. Prof. Veronika Stoka
7. Andrej Šali, B. Sc.
8. **Prof. Boris Turk, Head**
9. Prof. Dušan Turk
10. Asst. Prof. Livija Tušar
11. Asst. Prof. Olga Vasiljeva
12. Asst. Prof. Tina Zavašnik Bergant
13. Prof. Eva Žerovnik

Postdoctoral associates

14. Dr. Miha Butinar
15. Dr. Maruša Hafner Česen
16. Dr. Nataša Lindič
17. *Dr. Katarina Pegan, left 01.05.16*
18. Dr. Jure Pražnikar*
19. Dr. Vida Puizdar
20. *Dr. Jelena Rajković, on leave 01.06.16*
21. Dr. Barbara Sobotič
22. Dr. Ajda Taler-Verčič
23. Dr. Aleksandra Usenik
24. Dr. Matej Vizovišek

Postgraduates

25. Monika Biasizzo, B. Sc.
26. *Katja Bidovec, B. Sc., left 09.06.16*
27. Janja Božič, B. Sc.
28. Andreja Bratovš, B. Sc.
29. Marija Grozdanić, B. Sc.
30. Katarina Hočevar, B. Sc.
31. Aleksander Krajnc, B. Sc.
32. Lovro Kramer, B. Sc.
33. Jure Loboda, B. Sc.
34. *Sabina Ott, B. Sc., 01.05.16, transferred to Department B2*
35. Sara Pintar, B. Sc.
36. Mojca Trstenjak Prebanda, B. Sc.
37. Dr. Robert Vidmar
38. Janja Završnik, B. Sc.

Technical officers

39. Marjeta Arnolj, B. Sc.
40. Andreja Sekirnik, B. Sc.
41. Ivica Štefe, B. Sc.

Technical and administrative staff

42. Maja Orehek, B. Sc.
43. Dejan Pelko
44. Polonca Pirš Kovačič
45. *Gregor Pretnar, left 01.05.16*
46. Barbara Vrtačnik

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Martin L. Biniossek *et al.* (13 authors), "Identification of protease specificity by combining proteome-derived peptide libraries and quantitative proteomics", *Molecular & cellular proteomics*, vol. 15, pp. 2515-2524, 2016.
2. Lachlan W. Casey *et al.* (13 authors), "The CC domain structure from the wheat stem rust resistance protein Sr33 challenges paradigms for dimerization in plant NLR proteins", *Proc. Natl. Acad. Sci. U. S. A.*, vol. 113, no. 45, pp. 12856-12861, 2016.
3. Sara Drmota Prebil, Urška Slapšak, Miha Pavšič, Gregor Ilc, Vid Puž, Euripedes de Almeida Ribeiro, Dorothea Anrather, Markus Hartl, Lars Backman, Janez Plavec, Brigita Lenarčič, Kristina Djinović Carugo, "Structure and calcium-binding studies of calmodulin-like domain of human non-muscle α-actinin-1", *Scientific reports*, vol. 6, pp. 1-13, 2016.
4. Javier Fernandez-Martinez *et al.* (17 authors), "Structure and function of the nuclear pore complex cytoplasmic mRNA export platform", *Cell (Cambridge)*, issue 5, vol. 167, pp. 1215-1228, 2016.
5. Katarina Karničar, Igor Drobnak, Marko Petek, Vasilka Magdevska, Jaka Horvat, Robert Vidmar, Špela Baebler, Ana Rotter, Polona Jamnik, Štefan Fujs, Boris Turk, Marko Fonović, Kristina Gruden, Gregor Kosec, Hrvoje Petković, "Integrated omics approaches provide strategies for rapid erythromycin yield increase in Saccharopolyspora erythraea", *Microb Cell Fact*, vol. 15, no. 93, pp. 1/17-17/17, 2016.
6. Mario Kurtjak, Marija Vukomanović, Andraž Krajnc, Lovro Kramer, Boris Turk, Danilo Suvorov, "Designing Ga(III)-containing hydroxyapatite with antibacterial activity", *RSC advances*, vol. 6, iss. 114, pp. 112839-112852, 2016.
7. Mario Kurtjak, Marija Vukomanović, Lovro Kramer, Danilo Suvorov, "Biocompatible nano-gallium/hydroxyapatite nanocomposite with

antimicrobial activity", *J. mater. sci., Mater. med.*, vol. 27, iss. 11, art. 170, 2016.
8. Melanie Niemer, Urlich Mehofer, Maria Verdianz, Andreas Porodko, Philipp Schähs, Daniel Kracher, Brigita Lenarčič, Marko Novinec, Lukas Mach, "Nicotiana benthamiana cathepsin B displays distinct enzymatic features which differ from its human relative and aleurain-like protease", *Biochimie (Paris)*, vol. 122, pp. 119-125, 2016.
9. Marko Novinec, Mateja Rebernik, Brigita Lenarčič, "An allosteric site enables fine-tuning of cathepsin K by diverse effectors", *FEBS lett.*, vol. 590, iss. 24, pp. 4507-4518, 2016.
10. Helena Ohrvik, Brandon Logeman, Boris Turk, Thomas Reinheckel, Dennis J. Thiele, "Cathepsin protease controls copper and cisplatin accumulation via cleavage of the Ctr1 metal-binding ectodomain", *J Biol Chem*, vol. 291, pp. 13905-13916, 2016.
11. Melanie Paireder, Urlich Mehofer, Stefan Tholen, Andreas Porodko, Philipp Schähs, Daniel Maresch, Martin L. Biniossek, Ranier van der Hoorn Hoorn, Brigita Lenarčič, Marko Novinec, Oliver Schilling, Lukas Mach, "The death enzyme CP14 is a unique papain-like cysteine proteinase with a pronounced S2 subsite selectivity", *Arch. biochem. biophys.*, vol. 603, pp. 110-117, 2016.
12. Marcin Poreba *et al.* (11 authors), "Counter selection substrate library strategy for developing specific protease substrates and probes", *Chemistry & Biology*, vol. 23, issue 8, pp. 1023-1035, 2016.
13. Urška Potočar, Samo Hudoklin, Mateja Erdani-Kreft, Janja Završnik, Krešimir Božikov, Mirjam Fröhlich, "Adipose-derived stem cells respond to increased osmolarities", *PloS one*, vol. 11, iss. 10, pp. 1-18, Oct. 2016.
14. Urška Repnik, Maruša Hafner Česen, Boris Turk, "The use of lysosomotropic dyes to exclude lysosomal membrane permeabilization", *Cold Spring Harb. protoc.*, 2016, iss. 5, prot087106.
15. Urška Repnik, Maruša Hafner Česen, Boris Turk, "Measuring cysteine cathepsin activity to detect lysosomal membrane permeabilization", *Cold Spring Harb. protoc.*, 2016, iss. 5, prot087114.
16. Urška Repnik, Maruša Hafner Česen, Boris Turk, "Strategies for assaying lysosomal membrane permeabilization", *Cold Spring Harb. protoc.*, 2016, iss. 6, top077479.
17. Urška Repnik, Maruša Hafner Česen, Boris Turk, " Studying lysosomal membrane permeabilization by analyzing the release of preloaded BSA-gold particles into the cytosol", *Cold Spring Harb. protoc.*, 2016, iss. 6, prot087122.
18. Piotr Sosnowski, Dušan Turk, "Caught in the act: the crystal structure of cleaved cathepsin L bound to the active site of Cathepsin L", *FEBS lett.*, vol. 590, no. 8, pp. 1253-1261, 2016.
19. Tanja Špec, Sebastijan Peljhan, Jana Vidič, Nika Lendero Krajnc, Marko Fonović, Črtomir Tavzes, Polonca Ropret, "CIM [registered sign] monolith chromatography-enhanced ELISA Detection of proteins in Artists' paints: Ovalbumin as a case study", *Mirochem. j.*, vol.127, pp. 102-112, 2016.
20. Tjaša Tibaut, Jure Borišek, Marjana Novič, Dušan Turk, "Comparison of in silico tools for binding site prediction applied for structure-based design of autolysin inhibitors", *SAR QSAR environ. res.*, vol. 27, iss. 7, pp. 573-587, 2016.
21. Livija Tušar, Irena Leonida Kropf, Avrelija Cencič, "Impact of salt reduction on the number of microorganisms and a sensory analysis for Kranjska sausages during their shelf-life", *Agricultura*, vol. 13, no. 1-2, str. 33-47, 2016.
22. Kenneth R. Wong, Elizabeth Memendez, Charles S. Craik, Michael C. Kavanaugh, Olga Vasiljeva, "In vivo imaging of protease activity by Probody therapeutic activation", *Biochimie (Paris)*, vol. 122, pp. 62-67, 2016.
23. Tina Zavašnik-Bergant, Martina Bergant Marušič, "Exogenous Thyropin from p41 Invariant chain diminishes cysteine protease activity and affects IL-12 secretion during maturation of human dendritic cells", *PloS one*, vol. 11, no. 3, pp. 0150815-1-0150815-26, 2016.
24. Janez Žibert, Jure Cedilnik, Jure Pražnikar, "Particulate matter (PM10) patterns in Europe: an exploratoy data analysis using non-negative matrix factorization", *Atmos. environ. (1994)*, vol. 132, pp. 217-228, 2016.

Review Article

1. Daniel J. Klionsky *et al.* (1998 authors), "Guidelines for the use and interpretation of assays for monitoring autophagy", *Autophagy*, vol. 12, no. 1, pp. 1-240, 2016.
2. Veronika Stoka, Vito Turk, Boris Turk, "Lysosomal cathepsins and their regulation in aging and neurodegeneration", *Ageing research reviews*, vol. 32, pp. 22-37, 2016.
3. Matej Vizovišek, Robert Vidmar, Marko Fonović, Boris Turk, "Current trends and challenges in proteomic identification of protease substrates", *Biochimie (Paris)*, vol. 122, pp. 77-87, 2016.
4. Eva Žerovnik, Nataša Kopitar-Jerala, R. Layfield, "Recent revelopments in treating Alzheimer's disease", *Journal of Alzheimer's disease & Parkinsonism*, vol. 6, no. 2, art. 1000220, 2016.

Published Conference Contribution

1. Maša Bošnjak, Urška Kamenšek, Aleš Sedlar, Maja Čemažar, Janja Završnik, Boris Turk, Céline Bouquet, Gregor Serša, "Antimetastatic potential in mice after gene therapy with plasmid AMEP", In: *1st World Congress on Electroporation and Pulsed Electric Fields in Biology, Medicine and Food & Environmental Technologies (WC 2015): Portorož, Slovenia, September 6-10, 2015*, (IFMBE proceedings, vol. 53), pp. 219-222.

Independent Component Part or a Chapter in a Monograph

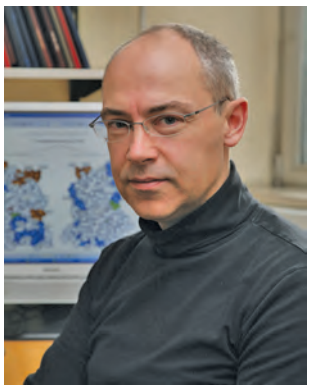
1. Maruša Hafner Česen, Veronika Stoka, Boris Turk, "Role of lysosomes in intracellular degradation", In: *Encyclopedia of cell biology*, (Molecular cell biology, volume 1), San Diego, Elsevier, 2016, pp. 612-620.

Mentoring

1. Nina Frančič, *Sol-gel based layer containing enzyme His_6-OPH for organophosphate detection:* doctoral dissertation, Ljubljana, 2016 (mentor Aleksandra Lobnik; co-mentor Brigita Lenarčič).
2. Piotr Sosnowski, *Structural insight in the substrate specificity of cathepsins:* doctoral dissertation, Ljubljana, 2016 (mentor Dušan Turk).
3. Robert Vidmar, *Proteomic characterization of legumain and its physiological substrates:* doctoral dissertation, Ljubljana, 2016 (mentor Marko Fonović).
4. Monika Biasizzo, *Vpliv cistatina C na aktivacijo inflamasoma v mišjih makrofagih, pridobljenih iz kostnega mozga:* master's thesis, Ljubljana, 2016 (mentor Boris Turk).
5. Klara Brusar, *Influence of culinary processing on the nitrate levels in potatoes:* master's thesis, Maribor, 2016 (mentor Tomaž Langerholc; co-mentor Livija Tušar).
6. Griša Prinčič, *Načrtovanje in sinteza za EpCAM specifičnih malih molekul:* master's thesis, Ljubljana, 2016 (mentor Brigita Lenarčič; co-mentor Jurij Svete).
7. Nina Strah, *The effect of butylated hydroxyanisole on signaling pathways triggered by TNF-alpha in a human colorectal adenocarcinoma cell line:* master's thesis, Ljubljana, 2016 (mentor Bojan Doljak; co-mentor Boris Turk).

DEPARTMENT OF MOLECULAR AND BIOMEDICAL SCIENCES B-2

The research program of the Department of Molecular and Biomedical Sciences is focused mainly on basic research in protein biochemistry, molecular and cellular biology, and genetics. The primary goal of our investigations is the acquisition of a new understanding of mammalian pathophysiology with the aim of improving human and animal health.



Head:
Prof. Igor Križaj

Toxinology

One of our most important research topics in the field of toxinology is the study of molecular mechanisms for the toxic action of secreted phospholipases A_2 ($sPLA_2$) from animal venoms. In particular, we are interested in their presynaptic neurotoxicity. The knowledge that we gather by studying toxic $sPLA_2$s represents valuable assistance in understanding the pathophysiological roles of orthologous mammalian $sPLA_2$s, for example, their role in the development of neurodegenerative diseases such as Alzheimer's disease.

Ammodytoxin A (AtxA) is a neurotoxic $sPLA_2$ from the venom of the nose-horned viper (*Vipera ammodytes ammodytes*). In 2016 we continued with the study of the role of the phospholipase activity of this molecule in neurotoxicity. We produced a large amount of a recombinant, enzymatically inactive form of AtxA, AtxA(D49S), and characterized it.

We studied the process of AtxA neurotoxicity using the PC12 model cell line. Mitochondria are the organelles that are the most severely affected by AtxA in nerve cells. We discovered that AtxA binds specifically to cytochrome c oxidase (CCOX) in mitochondria, more precisely, to its catalytic subunit II. We succeeded in demonstrating the interaction between these two proteins also *in vivo* in these cells. Moreover, we showed that AtxA, also as its enzymatically inactive mutant AtxA(D49S), inhibited the oxidation of cytochrome c in mitochondria isolated from PC12 cells and thus pointed to the physiological effect of AtxA on CCOX. We also checked the influence of both $sPLA_2$ variants on the mitochondrial membrane potential. While AtxA induced its collapse, AtxA(D49S) did not have any effect. The influence on the mitochondrial membrane potential is therefore, contrary to the influence on CCOX, dependent on phospholipase activity. The endogenous $sPLA_2$, of the same structural type (group IIA) as AtxA, has been found in mitochondria. Its physiological role in this organelle is still unknown. Our results suggest that this enzyme, through its interaction with CCOX, may be involved in the regulation of cellular respiration. Consequently, deregulation of its function may result in different neurodegenerative diseases, characterized by the malfunction of mitochondria.

Animal venoms are a rich source of new substances and molecular tools to improve human and animal health.

In 2016 we continued with the venom proteomics or venomics, the systematic analysis of the components of the nose-horned viper (*Vipera ammodytes ammodytes*) and the common adder (*Vipera berus berus*) venoms. The first comprehensive proteomic results of the common adder venom, very important for the preparation of optimal therapeutic strategy upon envenomation (Figure 1), we succeeded to publish in the respected *Journal of Proteomics* (Z. Latinović et al., *J. Proteomics*, 146 (2016), 34–47). In the past year we also worked intensively on the preparation of a report on the most, to date, inclusive analysis of the nose-horned viper venom that is scheduled for publication in 2017. In the scope of a systematic analysis of the *Vipera a. ammodytes* venom also goes the identification of the cardiotoxic component of this venom. In collaboration with colleagues from the Clinical Department of Infectious Diseases, University Hospital Centre Split, Croatia, and the Department of Pharmacology, Mostar University School of Medicine, Bosnia and Herzegovina, we performed and published an analysis of the effects of all venom fractions on the isolated rat heart (S. Karabuva et al., *Toxicon*, 121 (2016), 98–104). The most prominent effect on the heart was obtained with the venom fraction containing $sPLA_2$. We will prepare all the components of this venom fraction in a pure form to define those that are cardiotoxic and describe details of their interference with heart rate.

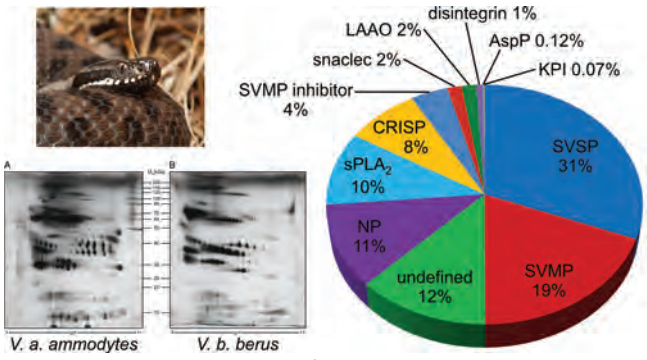


Figure 1: Comparative venomics of the two medically most important European vipers. We have analysed the venom proteome of Vipera berus berus (V.b.berus) (right-hand part of the figure), the most widely distributed venomous snake in Europe (upper-left part of the figure), and compared it with the venom proteome of the most venomous viper in Europe, Vipera ammodytes ammodytes (V.a.ammodytes) also using two-dimensional gel electrophoresis (lower-left part of the figure). Obtained results provided an explanation for the effectiveness of treatment of V.b.berus envenomation by V.a.ammodytes antiserum and explained why full protection of V.a.ammodytes venom poisoning by V.b.berus antiserum should not always be expected.

With intensity we studied the nose-horned viper venom proteins that affect the blood coagulation process—haemostasis, in particular two such proteins, a homologue of serine protease with anticoagulant activity (VaaSPH-1) and a serine protease with procoagulant, FVIIa-like activity (SP-10). In the past year both molecules were extensively characterized. We determined the complete cDNA sequence of VaaSPH-1. Consequently, we also know its complete amino acid sequence. We started to develop a procedure to produce this protein in mammalian cells. In the case of SP-10, we still do not know its complete cDNA and protein structures. In collaboration with the group of Dr. Manjunatha R. Kini, the renowned expert for haemostasis from the National University of Singapore, in 2016 we made a major step forward in analysing the molecular mechanisms of VaaSPH-1 and SP-10. Both molecules have special properties and are therefore very interesting for further developments in the direction of medical usage: VaaSPH-1, as a strong inhibitor of blood coagulation without an enzymatic activity, and SP-10, as the first snake venom serine protease that specifically activates FX.

Figure 2: Science on the Street on animal venoms. Prof. Igor Križaj during the presentation of a public lecture entitled "Animal Venoms: from Deadly to the Healthy" in Kavarna Union in Ljubljana. The event, attended by more than 200 people, was organized in the scope of the "Science on the Street" project by the Slovenian Academic Society for Science and Engineering (SATENA).

We wrote the first article about disintegrins from the nose-horned viper, which is now in the revision process. Disintegrins are polypeptides that bind to integrin molecules and impair in this way their function. The nose-horned viper disintegrins efficiently prevent migration and thus the spreading of cancer cells. They thus express an anti-metastatic potential, which gives a good prospective for their development in the direction of a new anti-cancer drug.

Following a break, in 2016 we continued the study of snake venom cysteine-rich secretory proteins (CRISPs). Snake venom CRISP molecules can cause the paralysis of peripheral smooth muscles and hypothermia by inhibiting certain types of ion channels. The physiological effect of the nose-horned viper CRISPs is still unknown and we intend to describe it.

In 2016 we initiated a Slovenian-Croatian bilateral research project. The result of a common work with colleague immunologists from the University of Zagreb and medical doctors from the Centre for Clinical Toxicology and Pharmacology, University Medical Centre Ljubljana (UMC) is the publication of two papers. In the first, we described the efficiency of a commercial anti-venom directed towards European viperids (Viperfav™) on a real patient. The key conclusion of this work is that the dose of Viperfav™, recommended for the treatment of persons envenomed by the venom of *Vipera aspis* or *Vipera berus berus*, is probably not enough in the case of a serious envenomation by the venom of *Vipera ammodytes ammodytes* (T. Kurtović et al., *Toxins*, 8 (2016), 244). For this reason, we recommended constant monitoring of such patients during anti-venom treatment. In the second paper, which is accepted for publication (M. Brvar et al., *Clinical Toxicology*, in press), we describe the treatment of patients, envenomed by the nose-horned viper venom, using anti-venom directed towards the common adder venom (ViperaTAb®). We found that the treatment using paraspecific anti-venom alleviated the swelling and temporarily improved the systemic effects of envenomation, by lowering the concentration of toxic components in the patients' blood, but it did not eliminate the neurotoxic effects.

In the past year we also invested a lot of energy in the popularization of our scientific activity by presenting our work to the broader community. Invited by the SATENA society, I. Križaj presented a public lecture in the scope of the action "Science on Street". The lecture entitled "Animal Venoms: from Deadly to the Healthy" was very well attended and received an excellent response (Figure 2). The lecture was recorded and is available at Videolectures.net (http://videolectures.net/znanostnacesti_krizaj_zivalski_strupi/). Furthermore, we participated at the preparation and presentation of a popular scientific TV broadcast "Bite the Science" entitled "Animal Venoms – Deadly and Useful" (http://4d.rtvslo.si/arhiv/ugriznimo-znanost/174441881). As well, we presented toxinology and our achievements in this field of science in two interviews: for the national radio in an emission "Frequency X" on animal venoms (http://4d.rtvslo.si/arhiv/frekvenca-x/174442156) and for the Slovenian Press Agency (http://znanost.sta.si/2318140/z-zivalskimi-strupi-do-zdravljenja-bolezni-pri-ljudeh).

Lipid metabolism and signalization

Tumours display changes in metabolism that maximize their ability to proliferate and survive during times of stress. Apart from the dependence of many cancer types on glucose and glutamine, lipid metabolism is also altered in cancer. An increased availability of fatty acids (FAs), either through *de novo* synthesis in tumour cells or from exogenous sources, is needed for the synthesis of membranes and signalling molecules that are indispensable for tumour growth, and limiting FA supply may prevent cell proliferation in

Lipid droplets are antioxidant organelles that increase the resistance of cancer cells to stress.

tumours. The transformed properties of cancer cells depend on the changes in lipolysis, FA oxidation, membrane phospholipid hydrolysis and reacylation pathways, and the provision of FAs from the circulation. Additionally, the accumulation of neutral lipids in cytosolic lipid droplets has been confirmed in several cancers. Discovering the critical links between cancer-cell survival and lipid metabolism has a strong therapeutic potential.

Lipid droplets are newly recognized organelles composed of a core of neutral lipids, including triacylglycerol and cholesterol esters, and are covered with a phospholipid monolayer and lipid droplet-associated proteins. They are not passive repositories of energy, but act as platforms integrating cellular lipid metabolism and signalling, FA trafficking, protein management and quality control, viral replication and immunity. However, relatively little is known about the role of lipid accumulation and lipid droplets in cancer. $sPLA_2$s are lipolytic enzymes that hydrolyse membrane phospholipids and release free FAs and lysophospholipids. $sPLA_2$ activity leads to the release of a mixture of mono- and polyunsaturated FAs (PUFAs), including omega-6 and omega-3 PUFAs. We have recently reported a novel mechanism of action of $sPLA_2$ in cancer, describing for the first time a relationship between membrane hydrolysis, lipid droplet formation and breast cancer cell survival. We have found that by inducing lipid droplet formation the $sPLA_2$ enzyme augments cell proliferation and prevents cell death in breast-cancer cells exposed to nutrient deprivation-induced stress. Our recent, soon to be published, data show that lipid droplets help in reducing oxidative stress as well, particularly in cancer cells exposed to starvation or high levels of oxidation-prone PUFAs in the environment. Furthermore, blocking lipid droplets breakdown by depleting cells of a crucial lipase (Figure 3) led to a reduction in PUFA-induced oxidative stress, suggesting that lipid droplets serve as antioxidant storage depots preventing the damage induced by the easily oxidisable PUFAs. Clearly, lipid droplets are emerging as critical regulators of cancer-cell survival during stress induced by nutrient deprivation and lipotoxic insults, properties which can be exploited to specifically target cancer cells that are known for their high resilience to oxidative and metabolic stress.

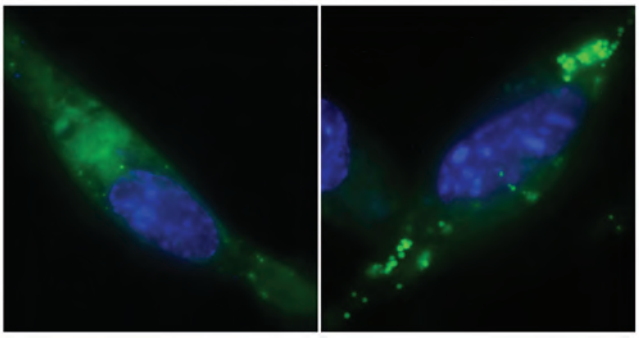


Figure 3: Depleting cells of a lipase involved in lipid droplet breakdown leads to a reduction in lipolysis and a significant increase in the size and number of lipid droplets. Control cells are on the left-hand side and lipase-depleted cells on the right. Lipid droplets were visualized using neutral-lipid specific staining with the BODIPY 493/503 fluorescence dye and nuclei with DAPI. The photographs were acquired using a Zeiss AxioObserver Z1 microscope.

High-throughput genetics and functional genomics in yeast *Saccharomyces cerevisiae*

Polygenic trait analysis is one of the fastest-developing fields in genetics. The identification of causal alleles for such traits, which cover the vast majority of all, has almost become routine in model organisms like yeast. The application of this knowledge holds great promise for biomedicine and for biotechnology in the development of new cell factories (J.P. Meijnen et al., *Biotechnol. Biofuels*, 9 (2016), 5). Methods for accurate genome editing that enable the insertion of causal alleles are necessary for the efficient application of such knowledge. To this end, we developed our own protocol of the CRISPR/Cas9 method for genome editing in yeast. This enables us fast and efficient assembly of new combinations of alleles and the generation of strains with the desired traits. We have been using this approach in the development of yeast strains with varying amounts of neutral lipids.

Polygenic trait analysis in yeast for the development of biomedicine and biotechnology.

Figure 4: Microorganisms' colony morphology analysis for the Scan-o-matic method. (A) Transmission scanning of a colony. (B) Side-view portrait of the colony. (C) Computational reconstruction of the colony's morphology.

In 2016 we also made important progress in the field of promoter development for the tight regulation of the expression of genes – endogenous and heterologous alike – in yeast cells. Promoters are a key element of the synthetic biology toolbox. We therefore optimized methods for an accurate determination of the strength and variability for the expression of promoter libraries.

A paper was published in 2016 describing the most sophisticated method for large-scale microorganism phenotyping (M. Zackrisson et al., *G3*, 6 (2016), 3003–3014). The core of the method, which is based on unprecedently fast and accurate analysis of microorganisms' colony morphology (Figure 4), has been developed at the Jožef Stefan Institute and developed, in collaboration with a group from Sweden, into a key method for polygenic trait analysis.

Analysis of genomes

The S1 family of serine peptidases is the largest family of peptidases. Its members are specifically inhibited by Kunitz/BPTI inhibitors. The Kunitz domain is characterized by a compact 3D structure with the most important inhibitory loops for the inhibition of S1 peptidases. In the present study we analysed the action of site-specific positive selection and its impact on the structurally and functionally important parts of the snake venom Kunitz/BPTI family of proteins (V. Župunski & D. Kordiš**,** *Sci. Rep.*, 6 (2016), 37054). By using numerous models we demonstrated the

Positive selection changes the electrostatic potential on the surface of Kunitz/BPTI proteins that may play an important role in the precise targeting of these inhibitors into the active site of the S1 family of serine peptidases.

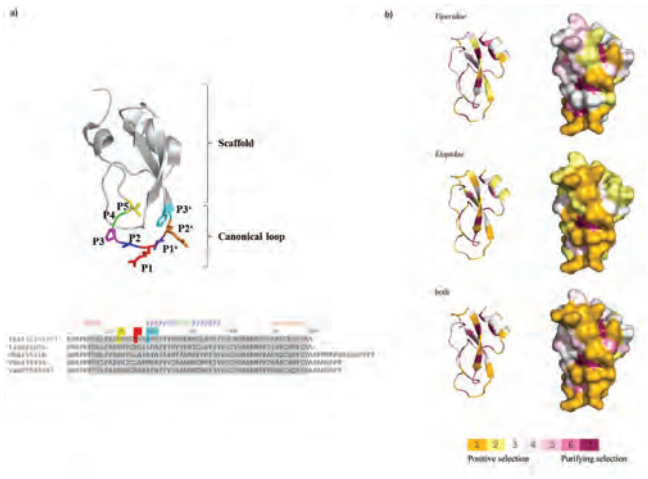


Figure 5: Positively selected amino acids on a three-dimensional model of textilinin-1. a) Structure of textilinin-1 (3BYB) showing the canonical inhibitory loop and protein scaffold. b) Positively selected amino acids in the structure of textilinin-1 (3BYB) are coloured in orange (PP=0.99) and yellow (PP>0.95). The figure is reproduced from V. Župunski & D. Kordiš, Sci. Rep., 6 (2016), 37054.

presence of large numbers of site-specific, positively selected sites that can reach between 30–50% of the Kunitz domain. Mapping of the positively selected sites on a 3D model of Kunitz/BPTI inhibitors has shown that these sites are located in the structurally most important part of the molecule, in the inhibitory loops 1 and 2, and also in the Kunitz scaffold (Figure 5). Amino acid replacements are localized exclusively on the surface, with the vast majority of replacements causing the change of charge. The consequence of these substitutions is the change in electrostatic potential on the surface of Kunitz/BPTI proteins that may play an important role in the precise targeting of these inhibitors into the active site of the S1 family of serine peptidases. The presence of the multigene families of Kunitz/BPTIs in venomous snakes can be explained by the target-oriented arms race, since the number of S1 peptidases in vertebrate preys can reach up to hundreds of representatives. As Kunitz/BPTIs are broad-spectrum inhibitors, they can be functionally diversified to target numerous and diverse S1 peptidases in their prey. A comparison of the Kunitz/BPTI inhibitors from venomous snakes with those from ticks and vampire bats has demonstrated that they experienced strong and widespread action of site-specific positive selection only in venomous snakes.

Antimicrobial peptides (AMPs) are one of the oldest defence components of the innate immune system. Although numerous AMP families are present in prokaryotes and eukaryotes, the greatest diversity can be seen in vertebrates. Since AMPs can inhibit the growth of bacteria, fungi and viruses, they are used in the development of novel antibiotics and immuno-regulatory compounds. The evolution of antimicrobial peptides in vertebrates is still not well explained, mostly because of the confusion in genomic and proteomic databases. A genomic and transcriptomic analysis of all AMP families in vertebrates has been made. In numerous databases we analysed the distribution of AMP families in vertebrates, from the oldest cyclostomes to the land vertebrates. We demonstrated that besides the numerous lineage-specific AMP families vertebrates also possess a number of common AMP families. We have found that the vertebrate ancestor possessed diverse AMP families that survived hundreds of millions years and that evolutionary younger, lineage-specific AMP families originated several times independently. We have obtained a new insight into the origin, evolution and functional diversification of numerous AMP families in vertebrates.

Other subjects

In 2016 we also participated at several research projects out of the thematic scope of our department.

Together with our programme group colleagues from the Biotechnical Faculty of the University of Ljubljana (BF UL) we have been analysing the toxin Cdt (cytolethal distending toxin) from the bacteria *Aggregatibacter actinomycetemcomitans* associated with a severe form of periodontal disease. We also confirmed the existence of a shorter form of the B subunit of this trimeric toxin (CdtB) on the protein level in patients with periodontal disease. This finding may result in new insights into this disease and its treatment (D. Obradović et al., *PLoS One*, 11 (2016), e0159231).

With them, we also analysed the influence of OlyA-mCherry, a fluorescent derivative of ostreolysin A from the mushroom *Pleurotus ostreatus*, on Madin-Darby canine kidney cells. We discovered that by binding on cholesterol- and sphingomyelin-enriched membrane nano-domains the derivative induced formation of vesicles into the extracellular space. At detail characterization of the formed vesicles, potentially interesting model for biophysical and biochemical studies of cell membranes and as a system for non-invasive sampling of cytosol from cells, our task was to analyse their protein composition (M. Skočaj et al., *Biochim. Biophys. Acta – Biomembranes*, 1858 (2016), 2882–2893).

We are partners in the targeted research project (CRP) "Definition of molecular parameters for protection of Carniolan honeybee" that is coordinated by the Zootechnical Department at BF UL. In 2016, we continued a comparative proteomic analysis of haemolymph, royal jelly and venom of the local populations of carniolan honeybee (*Apis mellifera carnica*). In this project we also contributed with a bio-informatic analysis of the collected data. Our results so far have been preliminarily presented (J. Božič et al., *Acta Agricult. Slov.*, Suppl. 5 (2016), 18–27).

For our colleagues from the Medical Faculty of the UL we provided knowledge of the preparation of fluorescently labelled ligands for applications in cell biology. The work describes the internalization of the S100B protein from

the extracellular space into cultured astrocytes and suggests a new way of removing this toxic protein also *in vivo* (E. Lasič et al., *J. Neurochem.*, 139 (2016), 309–323).

For our colleagues from the Department of Nanostructured Materials – K7 at the Jožef Stefan Institute we provided a mass spectrometric analysis of the protein composition of their preparation of fibroin from natural silk, one of the most promising natural materials as a support material in tissue regeneration. A prerequisite for a safe application in human medicine is the preparation of fibroin without a trace of another silk protein sericin due to its high immunogenicity. We succeeded in confirming the perfection of the developed procedure to prepare medically compatible fibroin from the raw silk (N. Drnovšek et al., *J. Mater. Chem. B*, 4 (2016), 6597–6608).

Researchers from the Department of Physical and Organic Chemistry – K3 at the IJS are also interested in the synthesis of new antimalarial substances. Together with them we prepared a review paper about malarial toxins in which we suggested several original strategies directed against this group of toxins (K. Starkl Renar et al., Toxicon, 119 (2016), 319–329).

As partners in a project led by colleagues from the Faculty of Electrical Engineering of the UL we accomplished a structural identification analysis of the protein corona composition of nanoparticles prepared in different dispersion media. As the protein corona of nanoparticles primarily determines the pathophysiological characteristics of nanoparticles in biological systems, knowledge about its controlled formation is vitally important for the safe use of nanoparticles in medicine. Our publication reporting about the dependency of the protein corona composition of nanoparticles on the procedure of nanoparticles preparation is in press (K. Strojan et al., *PLoS One*, in press).

Some outstanding publications in the past year

1. Župunski, V. and Kordiš, D.: Strong and widespread action of site-specific positive selection in the snake venom Kunitz/BPTI protein family. Sci. Rep., 6 (2016), 37054
2. Latinović, Z., Leonardi, A., Šribar, J., Sajevic, T., Žužek, M.C., Frangež, R., Halassy, B., Trampuš-Bakija, A., Pungerčar, J. and Križaj, I.: Venomics of *Vipera berus berus* to explain differences in pathology elicited by *Vipera ammodytes ammodytes* envenomation: Therapeutic implications. J. Proteomics, 146 (2016), 34–47
3. Kurtović, T., Brvar, M., Grenc, D., Lang Balija, M., Križaj, I. and Halassy, B.: A single dose of Viperfav™ may be inadequate for *Vipera ammodytes* snake bite: A case report and pharmacokinetic evaluation. Toxins, 8 (8) (2016), 244
4. Skočaj, M., Yu, Y., Grundner, M., Resnik, N., Bedina Zavec, A., Leonardi, A., Križaj, I., Guella, G., Maček, P., Erdani-Kreft, M., Frangež, R., Veranič, P. and Sepčić, K.: Characterisation of plasmalemmal shedding of vesicles induced by the cholesterol sphingomyelin binding protein, ostreolysin A-mCherry. Biochim. Biophys. Acta – Biomembranes, 1858 (2016), 2882–2893
5. Obradović, D., Gašperšič, R., Caserman, S., Leonardi, A., Jamnik, M., Podlesek, Z., Seme, K., Anderluh, G., Križaj, I., Maček, P. and Butala, M.: A cytolethal distending toxin variant from *Aggregatibacter actinomycetemcomitans* with an aberrant CdtB that lacks the conserved catalytic histidine 160. PLoS One, 11 (2016), e0159231

Organization of conferences and meetings

1. Annual meeting of co-workers of the research programme Toxins and Biomembrans from the Department of Molecular and Biomedical Sciences at the Jožef Stefan Institute and the Department of Biology, Biotechnical Faculty, University of Ljubljana, Ljubljana, 22–23 November 2016
2. 10th Young Researchers' Day (Chemistry, Materials, Biochemistry, Environment), Jožef Stefan Institute, Ljubljana, 31 March 2016

INTERNATIONAL PROJECTS

1. 7FP - YeSVitE; Yeasts for the Sustainability in Viticulture and Oneology
   Prof. Uroš Petrovič
   European Commission
2. Antivenomics as a Tool to increase Efficacy of Specific and Paraspecific Serotherapy against Envenomation with Viperidae Venoms
   Prof. Igor Križaj
   Slovenian Research Agency

RESEARCH PROGRAM

1. Toxins and biomembranes
   Prof. Igor Križaj

R&D GRANTS AND CONTRACTS

1. Thermophoretic guidance, accumulation and sorting of biomolecules in microfluidic devices
   Prof. Igor Križaj
2. Integrative research of sexual dimorphism evolution
   Prof. Dušan Kordiš
3. Applications of aegerolysin-like proteins for detection and eradication of pests
   Prof. Igor Križaj
4. Genetic background of mastitis resistance
   Prof. Igor Križaj
5. Evaluation of possible harmful effects of nanoparticles and underlying mechanisms – from physico-chemical and in vitro toxicity characterisation to innate immune system activation
   Prof. Igor Križaj
6. Crosstalk betwen lipid and central carbon metabolism
   Prof. Uroš Petrovič

7. Bisphenol A alternatives: transfer from food contact material, fate and human exposure
   Asst. Prof. Toni Petan
8. Improved treatment and monitoring of Water Framework Directive priority pollutants
   Prof. Igor Križaj
9. Definition of molecular parameters for protection of Carniolan honeybee
   Prof. Igor Križaj

VISITORS FROM ABROAD

1. Federica Valdetara, University of Milan, Milan, Italy, 16 January – 18 March 2016 and 1–16 July 2016
2. Dr Beata Halassy, Centre for Research and Knowledge Transfer in Biotechnology, University of Zagreb, Zagreb, Croatia, 8 June 2016
3. Dr Tihana Kurtović, Centre for Research and Knowledge Transfer in Biotechnology, University of Zagreb, Zagreb, Croatia, 8 June 2016
4. Dr Maja Lang Balija, Centre for Research and Knowledge Transfer in Biotechnology, University of Zagreb, Zagreb, Croatia, 8 June 2016
5. Merve Yilmazer, University of Istanbul, Istanbul, Turkey, 19 October 2016 – 17 February 2017

STAFF

Researchers
1. Prof. Dušan Kordiš
2. **Prof. Igor Križaj, Head**
3. Dr. Adrijana Leonardi
4. Prof. Uroš Petrovič*
5. Prof. Jože Pungerčar

Postdoctoral associates
6. Asst. Prof. Toni Petan
7. Dr. Jernej Šribar

Postgraduates
8. Eva Jarc, B. Sc.
9. *Minca Klobčar, B. Sc., left 15.08.16*
10. Mojca Ogrizović, B. Sc.
11. Sabina Ott, B. Sc.

Technical officers
12. *Miha Škalič, B. Sc., left 07.06.16*

Technical and administrative staff
13. Igor Koprivec
14. Maja Šimaga, M. Sc.
15. *Darja Žunič Kotar, retired 01.06.16*

Note:

* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Nataša Drnovšek, Rok Kocen, Ana Gantar, Marinka Drobnič-Košorok, Adrijana Leonardi, Igor Križaj, Aleksander Rečnik, Saša Novak, "Size of silk fibroin β-sheet domains affected by Ca^{2+}", *J. mater. chem. B* , vol. 4, iss. 40, pp. 6597-6608, 2016.
2. Svjetlana Karabuva, Ivica Brizić, Zorica Latinović, Adrijana Leonardi, Igor Križaj, Boris Lukšić, "Cardiotoxic effects of the *Vipera ammodytes ammodytes* venom fractions in the isolated perfused rat heart", *Toxicon (Oxford)*, vol. 121, pp. 98-104, 2016.
3. Tihana Kurtović, Miran Brvar, Damjan Grenc, Maja Lang Balija, Igor Križaj, Beata Halassy, "A single dose of Viperfav™ may be inadequate for *Vipera ammodytes* snake bite: a case report and pharmacokinetic evaluation", *Toxins (Basel)*, vol. 8, no. 8, pp. 244-1-244-7, 2016.
4. Eva Lasič, Fabiana Galland, Nina Vardjan, Jernej Šribar, Igor Križaj, Marina Concli Leite, Robert Zorec, Matjaž Stenovec, "Time-dependent uptake and trafficking of vesicles capturing extracellular S100B in cultured rat astrocyte", *J. neurochem.*, vol. 139, iss. 2, pp. 309-323, Oct. 2016.
5. Zorica Latinović, Adrijana Leonardi, Jernej Šribar, Tamara Sajevic, Monika C. Žužek, Robert Frangež, Beata Halassy, Alenka Trampuš-Bakija, Jože Pungerčar, Igor Križaj, "Venomics of *Vipera berus berus* to explain differences in pathology elicited by *Vipera ammodytes ammodytes* envenomation: Therapeutic implications", *Journal of proteomics*, vol. 146, pp. 34-47, 2016.
6. Jean-Paul Meijnen, Paola Randazzo, María R. Foulquié-Moreno, Joost van den Brink, Paul Vandecruys, Marija Stojiljkovic, Françoise Dumortier, Polona Zalar, Teun Boekhout, Nina Gunde-Cimerman, Janez Kokošar, Miha Štajdohar, Tomaž Curk, Uroš Petrovič, Johan M. Thevelein, "Polygenic analysis and targeted improvement of the complex trait of high acetic acid tolerance in the yeast *Saccharomyces cerevisiae*", *Biotechnol. biofuels*, vol. 9, pp. 1-18, 2016.
7. Davor Obradović, Rok Gašperšič, Simon Caserman, Adrijana Leonardi, Maja Jamnik, Zdravko Podlesek, Katja Seme, Gregor Anderluh, Igor Križaj, Peter Maček, Matej Butala, "A cytolethal distending toxin variant from *Aggregatibacter actinomycetemcomitans* with an aberrant CdtB that lacks the conserved catalytic histidine 160", *PloS one*, vol. 11, iss. 7, pp. 1-16, 2016.
8. Matej Skočaj, Yang Yu, Maja Grundner, Nataša Resnik, Apolonija Bedina Zavec, Adrijana Leonardi, Igor Križaj, Graziano Guella, Peter Maček, Mateja Erdani-Kreft, Robert Frangež, Peter Veranič, Kristina Sepčić, "Characterisation of plasmalemmal shedding of vesicles induced by the cholesterol/ sphingomyelin binding protein, ostreolysin A-mCherry", *Biochim. biophys. acta, Biomembr.*, vol. 1858, no. 11, pp. 2882-2893, 2016.
9. Martin Zackrisson *et al.* (14 authors), "Scan-o-matic: High-resolution microbial phenomics at a massive scale", *G3 (Bethesda Md.)*, vol. 6, no. 9, pp. 3003-3014, 2016.
10. Vera Župunski, Dušan Kordiš, "Strong and widespread action of site-specific positive selection in the snake venom Kunitz/BPTI protein family", *Scientific reports*, vol. 6, pp. 37054-1-37054-12, 2016.

Review Article

1. Katarina Starkl, Jernej Iskra, Igor Križaj, "Understanding malarial toxins", *Toxicon (Oxford)*, vol. 119, pp. 319-329, 2016.

Published Conference Contribution (invited lecture)

1. Janko Božič, Dušan Kordiš, Igor Križaj, Adrijana Leonardi, Robert Močnik, Mitja Nakrst, Peter Podgoršek, Janez Prešern, Simona Sušnik Bajec, Minja Zorc, Jelena Zurc, Peter Dovč, "Novel aspects in characterisation of Carniolan honey bee (*Apis mellifera carnica*, Pollmann 1879)", In: *Technology driven animal production*, (Acta agriculturae slovenica, Supplement, 2016, 5), 24th International Symposium Animal Science Days, Ptuj, September 21st-23rd, 2016, pp. 18-25.

University, Higher Education or Higher Vocational Education Textbook

1. Nataša Debeljak, Simon Horvat, Peter Juvan, Rok Košir, Tanja Kunej, Uroš Petrovič, Tadeja Režen, Damjana Rozman, Jure Ačimovič (urednik), *Funkcijska genomika: praktikum*, 2. izd., Ljubljana, Medicinska fakulteta, 2016.

Mentoring

1. Urša Kresal, *Metabolism and transport of fatty acids in the action of secreted phospholipases A_2 in breast cancer cells:* master's thesis, Ljubljana, 2016 (mentor Jože Pungerčar; co-mentor Toni Petan).
2. Petra Malavašič, *Phospholipases A_2 and changes in the synthesis, storage and use of lipids in cancer cells:* master's thesis, Ljubljana, 2016 (mentor Igor Križaj).

DEPARTMENT OF BIOTECHNOLOGY
B-3

At the Department of Biotechnology we investigate the biological molecules of microbiological, fungal, plant and animal origin using modern biotechnological methods. We would like to apply them for diagnostic and therapeutic purposes in human and veterinary medicine, for plant protection, the preparation of quality and safe food and for the protection of the environment, contributing to an improvement of peoples' health and of the environment in which we live. Our research work is focused on the processes of cancer progression and immune response, neurodegenerative processes, the biology of fungi, plant stress response and in the search for new biotechnological approaches and products.

Head:
Prof. Janko Kos

As in previous years, also in 2016, we studied the structure and function of various fungal enzymes, inhibitors and lectins. Mushrooms represent a promising source of bioactive proteins and biopesticides based on their own arsenal of various compounds used against pests, parasites and pathogens. Among them, defense proteins are very important and include lectins and protease inhibitors with strong and specific insecticidal and/or nematicidal activity. Phylogenetic analyses revealed that these proteins are widely present among higher fungi, ascomycetes and basidiomycetes. These protein toxins have potential applications in veterinary and human medicine and in crop protection. We have also described the medicinal properties of mushrooms belonging to the genus of funnel mushrooms (Clitocybe sp.) and of lectins from clouded funnel (Clitocybe nebularis), which show antitumor, immunomodulatory, antioxidative and antimicrobial (antiviral, antibacterial, and antifungal) activities.

- **New genes associated with amyotrophic lateral sclerosis were discovered**
- **The aggregation of TDP-4-3 leads to the loss of its function**
- **The current understanding of the role of nuclear transport in ALS and FTD was critically reviewed**

The search for novel antibacterial compounds from mushrooms in cooperation with the National Institute of Biology using the plant pathogenic bacterium Ralstonia solanacearum as the model led to isolation and characterization of the protein complex with L-amino acid oxidase activity. Interestingly, these enzymes with antibacterial activity that were previously described mainly as major components of snake venoms, are also present in poisonous mushrooms such as the death cap (Amanita phalloides) and surprisingly also in edible mushrooms such as the trooping funnel (Clitocybe geotropa).

The continuing study on the involvement of proteases in plant response to drought showed a new level of complexity demonstrating that different stages of water deficit correlate to different levels of peptidase activities in leaves of different ages in common bean plants.

The studies in the field of glycobiology in 2016 focused on lectins from different mushrooms and their effects on different cell lines, with emphasis on immune cells. We confirmed the exclusive cytotoxicity of CNL lectin from clouded funnel against leukemic T cells Jurkat causing programmed cell death through binding a receptor in a plasma membrane.

Investigating the role of proteolytic enzymes in the regulation of cell cytotoxicity we focused our work on cathepsins C and H, two main convertases of progranzyme B, the molecule which triggers the processes of cell death. The activity of cathepsins C and H in secretory vesicles is controlled by the endogenous inhibitor cystatin F. Using different cystatin F mutants we analyzed the mechanism of its secretion, activation and cell uptake on different cell lines. With different cystatin F mutants we identified its target proteases involved in the regulation of the cytotoxicity of natural killer cells (NK cells) and confirmed its involvement in the reduced cytotoxicity of anergized NK cells. To study the involvement of cystatin F in the regulation of cytotoxic T lymphocyte function we established a model of cytotoxic T lymphocytes with reduced cytotoxicity. Using this model we can further study mechanisms leading to lower cytotoxicity after the interaction of cytotoxic cells with tumor cells. We found increased cystatin F levels in cells with lower cytotoxicity. Furthermore, using antibodies against LAMP1 and flow cytometric analysis we confirmed that exocytosis is not blocked in these cells.

Figure 1: Death cap is a source of various bioactive compounds including antibiotics and trypsin inhibitors.

In the field of neurobiology we published three articles in reputable journals on the topic of molecular processes underlying frontotemporal dementia (FTD) and amyotrophic lateral sclerosis (ALS). In our most acclaimed publication and in collaboration with a large international consortium

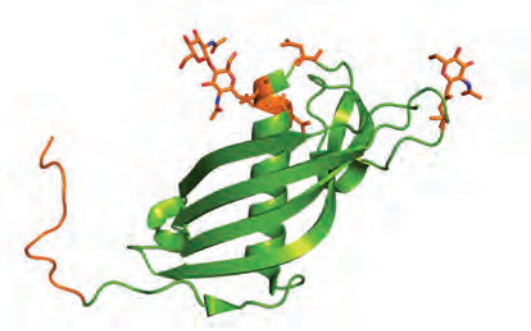


Figure 2: Ribbon diagram of human cystatin F with mutants indicated in orange.

- **L-amino-acid oxidases from Amanita phalloides and Clitocybe geotropa induce caspase-dependent apoptosis**
- **The functional recombinant B subunit of shiga toxin, Stx1B was produced and expressed on the surface of lactic acid bacterium Lactococcus lactis**

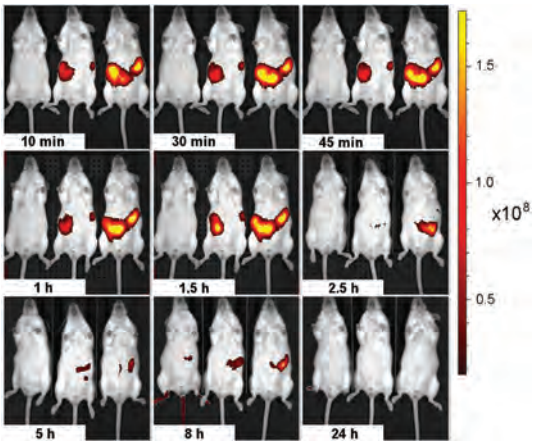


Figure 3: Representative example of 24h time-course imaging of mice administered with no bacteria (left; control), 2.5×1010 cells of IRFP713-expressing L. lactis (middle) and 5.0×1010 cells of IRFP713-expressing L. lactis (right). Colour bar indicates radiant efficiency.

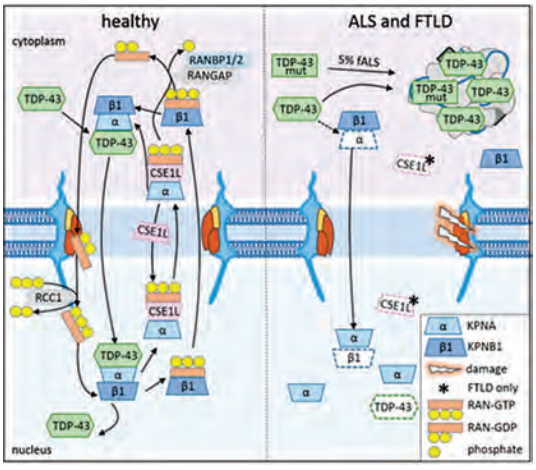


Figure 4. Model of nuclear transport of TDP-43 in healthy individuals, and in cases of ALS-TDP and FTLD-TDP. TDP-43 is translocated into the nucleus by the classical import pathway. In cases of ALS-TDP and FTLD-TDP TDP-43 is mislocalized to cytoplasmic inclusions. Reduced levels of CSE1L in FTLD-TDP and loss of nuclear KPNB1 in ALS-TDP imply that this is due to nuclear transport defect. Proteins with reduced levels are in dashed brackets. From Prpar Mihevc et al., Brain 2016).

we reported new genes and gene regions that are associated with the development of ALS. The study was published in the journal Nature Genetics and has received a substantial response in foreign and domestic media. Upon publication, we had several television, radio and newspaper interviews and reports. In the second article, we focused on the impact of the lack of protein TDP-43 on cell proteome (Prpar Mihevc et al., Scientific Reports). In cooperation with a group of ICGEB, Trieste, we found that the aggregation of TDP-43 leads to a similar lack of specific proteins as silencing or loss of TDP-43. We also published a review article in the prestigious journal Brain, on the nuclear transport in ALS (Prpar Mihevc et al., Brain).

Infections with shiga toxin-producing bacteria, like enterohemorrhagic Escherichia coli and Shigella dysenteriae, represent a serious medical problem. No specific and effective treatment is available for patients with these infections, creating a need for the development of new therapies. We have produced functional recombinant B subunit of shiga toxin, Stx1B, in Escherichia coli and used it as a target for the selection of ABD variants from the ABD scaffold-derived high-complex combinatorial library in collaboration with our Czech partners. We have selected 17 different ABD variants (named S1B) with a five-round ribosome display. The two most promising S1Bs (S1B22 and S1B26) were characterized into more details by ELISA, surface plasmon resonance and microscale thermophoresis. The binding affinity to Stx1B was determined to be in the 1-μM range with both methods. The addition of S1Bs changed the subcellular distribution of Stx1B in HeLa cells, completely eliminating it from Golgi apparatus, most likely by interfering with its retrograde transport. All S1Bs were successfully displayed on the surface of safe lactic acid bacterium Lactococcus lactis by fusing to the Usp45 secretion signal and to the peptidoglycan-binding C terminus of AcmA. Binding of Stx1B by engineered lactococcal cells was confirmed using flow cytometry and whole-cell ELISA. Engineered lactic acid bacteria are potentially useful for the removal of Shiga toxin from human intestine. Additionally, novel ABD scaffold-derived Stx1B binders are useful for basic research on Shiga toxin-related infections and could be further improved for in-vitro diagnostics.

The results of the research work at the Department of Biotechnology in the year 2016 were published in 24 scientific papers in journals with an impact factor and in one book chapter. Also, three patent applications were filed. We received two research grants and Ph.D. grant from the Slovenian Research Agency, two bilateral international grants and as partners EU project 'Carbohydrate Metrology', CSA - Coordination & Support Action, Horizon 2020. Two Ph.D. students defended their doctoral theses. Ph.D. Young researcher Ana Bajc Česnik ended a one-year visit to the laboratory of Prof. dr. Cleveland, UCSD, USA. Head of department prof. Janko Kos was elected as a member of European Academy of Sciences and Arts. The members of the department were also very active in pedagogical work as lecturers and mentors to students preparing diploma and doctoral thesis at universities in Slovenia and abroad.

Some outstanding publications in the past year

1. Prpar Mihevc, Sonja, Darovic, Simona, Kovanda, Anja, Bajc Česnik, Ana, Župunski, Vera, Rogelj, Boris. Nuclear trafficking in amyotrophic lateral sclerosis and frontotemporal lobar degeneration. Brain, ISSN 0006-8950, [in press] 2016, 14 str., doi: 10.1093/brain/aww197. COBISS.SI-ID 29663527, IF 10,1.
2. Rheenen, Wouter Van, Shatunov, Aleksey, Dekker, Annelot M., Mclaughlin, Russell L., Diekstra, Frank P., Pulit, Sara L., Van Der Spek, Rick A. A., Võsa, Urmo, De Jong, Simone, Robinson, Matthew R., Rogelj, Boris, Vrabec, Katarina, Ravnik-Glavač, Metka, Koritnik, Blaž, Zidar, Janez, Leonardis, Lea, Dolenc-Grošelj, Leja, et al. Genome-wide association analyses identify new risk variants and the genetic architecture of amyotrophic lateral sclerosis. Nature genetics, , vol. 48, no. 9, str. 1043-1048. [COBISS.SI-ID 3106220], IF 31,6

3. McKinnon, Brett D., Kocbek, Vida, Nirgianakis, Kostantinos, Bersinger, Nick A., Mueller, Michael D. Kinase signalling pathways in endometriosis : potential targets for non-hormonal therapeutics. Human reproduction update, ISSN 1355-4786, [in press] 2016, 22 str., doi: 10.1093/humupd/dmv060. [COBISS. SI-ID 29436455], IF 11,2

Organization of conferences and meetings

1. 10th Young researchers' day (Chemistry, Materials, Biochemistry, Environment), Jožef Stefan Institute, Ljubljana, 31 March 2016
2. Day of Biomolecular Sciences – Biomolekularec 2016, Faculty of Medicine, University of Ljubljana, Ljubljana, 22 September 2016
3. Annual meeting of co-workers of the research programme Pharmaceutical Biotechnology: Knowledge for Health, from the Department of Biotechnology at the Jožef Stefan Institute and the, Chair of Pharmaceutical Biology, Faculty of Pharmacy, University of Ljubljana, 1 December 2016

Patent granted

1. Tadej Rejc, Uroš Petrič, Jana Debeljak, Toni Bremec, Polonca Ferk, Mojca Lunder, Irena Roškar, Borut Štrukelj, Samo Kreft, Mixture of natural polyphenols from white fir wood for reducing postprandial glucose concentration, SI24984 (A), Slovenian Intellectual Property Office , 30. 11. 2016.

INTERNATIONAL PROJECTS

1. Functional and Structural Studies of Lectins from Mushrooms
   Dr. Jerica Sabotič
   Slovenian Research Agency
2. The Role of C/EBP Alpha in Regulation of Cystatin F Expression
   Prof. Janko Kos
   Slovenian Research Agency

RESEARCH PROGRAM

1. Pharmaceutical Biotechnology: Knowledge for Health
   Prof. Janko Kos

R & D GRANTS AND CONTRACTS

1. Dysregulation of TDP-43 expression in amyotrophic lateral sclerosis and frontotermoral lobar degeneration
   Prof. Boris Rogelj
2. Nitroxoline and its derivatives as new antitumour drugs
   Dr. Janko Kos
3. Post-transcriptional regulatory networks in neurodegenerative diseases
   Prof. Boris Rogelj
4. Genetics and pharmacogenomics of inflammatory bowel diseases and genetically related chronic immune diseases
   Prof. Boris Rogelj
5. Pathogenic mechanism of the C9orf72 expanded hexanucleotide repeat mutation in neurodegeneration
   Prof. Boris Rogelj
6. The role of cysteine protease inhibitors in NK cell mediated lysis of tumour cells
   Prof. Janko Kos
7. Protein engineering of recombinant probiotic lactic acid bacteria for treatment of irritative bowel disease
   Prof. Borut Štrukelj

VISITORS FROM ABROAD

1. Dr. Tibor Hortobagy, University of Debrecen, Debrecen, Hungary, 24 May – 25 May 2016
2. Prof. Daniel H. Wreschner, University of Tel Aviv, Tel Aviv, Israel, 4 July 2016
3. Dr. Adeleta Softić, Faculty of Pharmacy, University of Tuzla, Tuzla, Bosnia and Herzegovina, 21 August – 31 August 2016
4. Esmeralda Dautović, M.Sc., Faculty of Pharmacy, University of Tuzla, Tuzla, Bosnia and Herzegovina, 21 August – 22 November 2016

STAFF

Researchers
1. Asst. Prof. Aleš Berlec
2. **Prof. Janko Kos*, Head**
3. Prof. Boris Rogelj
4. Dr. Jerica Sabotič
5. Prof. Borut Štrukelj*

Postdoctoral associates
6. Dr. Vida Kocbek
7. Dr. Špela Konjar
8. Dr. Anja Kovanda
9. Dr. Milica Perišić Nanut
10. Dr. Sonja Prpar Mihevc
11. Dr. Anja Pucer Janež
12. *Dr. Petra Zadravec, left 01.08.16*

Postgraduates
13. Ana Bajc Česnik, B. Sc.
14. *Dr. Simona Darovic, left 01.06.16*
15. Mirjana Malnar, B. Sc.
16. Mateja Prunk, B. Sc.
17. Katja Škrlec, B. Sc.

Technical and administrative staff
18. Maja Šimaga, M. Sc.
19. *Darja Žunič Kotar, retired 01.06.16*

Note:

* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Maruška Budič, Blaž Cigić, Maja Šoštarič, Jerica Sabotič, Vladimir Meglič, Janko Kos, Marjetka Kidrič, "The response of aminopeptidases of Phaseolus vulgaris to drought depends on the developmental stage of the leaves", *Plant physiol. biochem. (Paris)*, vol. 109, pp. 326-336, 2016.
2. Jana Debeljak, Polonca Ferk, Miro Čokolič, Andrej Zavratnik, Eva Tavčar Benković, Samo Kreft, Borut Štrukelj, "Randomised, double blind, cross-over, placebo and active controlled human pharmacodynamic study on the influence of silver fir wood extract (Belinal) on post-prandial glycemic response", *Pharmazie*, vol. 71, no. 10, pp. 566-569, 2016, .
3. Gorazd Drevenšek, Mojca Lunder, Eva Tavčar Benković, Borut Štrukelj, Samo Kreft, "Cardioprotective effects of silver fir (Abies alba) extract in ischemic-reperfused isolated rat hearts", *Food & nutrition research*, vol. 60, pp. 1-7, oct. 2016.
4. Jana Erjavec, Maja Ravnikar, Jože Brzin, Tine Grebenc, Andrej Blejec, Mateja Želko-Gosak, Jerica Sabotič, Janko Kos, Tanja Dreo, "Antibacterial activity of wild mushroom extracts on bacterial wilt pathogen Ralstonia solanacearum", *Plant dis.*, vol. 100, iss. 2, pp. 453-464, 2016.
5. Giovanni Grandi, Michael D. Mueller, Andrea Papadia, Vida Kocbek, Nick A. Bersinger, Felice Petraglia, Angelo Cagnacci, Brett D. McKinnon, "Inflammation influences steroid hormone receptors targeted by progestins in endometrial stromal cells from women with endometriosis", *J. reprod. immunol.*, vol. 117, pp. 30-38, 2016.
6. Vida Kocbek, Giovanni Grandi, Fabian Blank, Carlos Wotzkow, Nick A. Bersinger, Michael D. Mueller, Satoru Kyo, Brett D. McKinnon, "TNFα-induced IKKβ complex activation influences epithelial, but not stromal cell survival in endometriosis", *Mol. hum. reprod.*, vol. 22, no. 11, pp. 768-777, 2016.
7. Urban Košak, Boris Brus, Damijan Knez, Roman Šink, Simon Žakelj, Jurij Trontelj, Anja Pišlar, Jasna Šlenc, Martina Gobec, Marko Živin, Larisa Tratnjek, Martina Perše, Kinga Sałat, Adrian Podkowa, Barbara Filipek, Florian Nachon, Xavier Brazzolotto, Anna Więckowska, Barbara Malawska, Jure Stojan, Irena Mlinarič-Raščan, Janko Kos, Nicolas Coquelle, Jacques-Philippe Colletier, Stanislav Gobec, "Development of an in-vivo active reversible butyrylcholinesterase inhibitor", *Scientific reports*, vol. 6, pp. 1-16, Dec. 2016.
8. Jernej Luzar, Peter Molek, Mira Šilar, Peter Korošec, Mitja Košnik, Borut Štrukelj, Mojca Lunder, "Identification and characterization of major cat allergen Fel d 1 mimotopes on filamentous phage carriers", *Mol. immunol.*, vol. 71, pp. 176-183, Mar. 2016.
9. Brett D. McKinnon, Vida Kocbek, Kostantinos Nirgianakis, Nick A. Bersinger, Michael D. Mueller, "Kinase signalling pathways in endometriosis: potential targets for non-hormonal therapeutics", *Hum. reprod. updat.*, vol. 22, no. 3, pp. 382-403, 2016.
10. Ana Mitrović, Jakob Kljun, Izidor Sosič, Stanislav Gobec, Iztok Turel, Janko Kos, "Clioquinol-ruthenium complex impairs tumour cell invasion by inhibiting cathepsin B activity", *Dalton trans. (2003)*, vol. 45, iss. 42, pp. 16913-16921, 2016.
11. Ana Mitrović, Bojana Mirković, Izidor Sosič, Stanislav Gobec, Janko Kos, "Inhibition of endopeptidase and exopeptidase activity of cathepsin B impairs extracellular matrix degradation and tumour invasion", *Biol Chem*, vol. 397, issue 2, pp.165-174, 2016.
12. Anja Pišlar, Jerica Sabotič, Jasna Šlenc, Jože Brzin, Janko Kos, "Cytotoxic L-amino-acid oxidases from Amanita phalloides and Clitocybe geotropa induce caspase-dependent apoptosis", *Cell death discovery*, vol. 7, iss. 2, 2016.
13. Sonja Prpar Mihevc, Marco Baralle, Emanuele Buratti, Boris Rogelj, "TDP-43 aggregation mirrors TDP-43 knockdown, affecting the expression levels of a common set of proteins", *Scientific reports*, vol. 6, pp. 33996 -1-33996 -9, 2016.
14. Wouter van Rheenen *et al.* (177 authors), "Genome-wide association analyses identify new risk variants and the genetic architecture of amyotrophic lateral sclerosis", *Nat Genet*, vol. 48, no. 9, pp. 1043-1048, Sept. 2016.
15. Petra Zadravec, Lucie Marečková, Hana Petroková, Vesna Hodnik, Milica Perišić, Gregor Anderluh, Borut Štrukelj, Petr Malý, Aleš Berlec, "Development of recombinant Lactococcus lactis displaying albumin-binding domain variants against Shiga toxin 1 B subunit", *PloS one*, vol. 11, no. 9, pp. 0162625-1-0162625-21, 2016.

Review Article

1. Jernej Luzar, Borut Štrukelj, Mojca Lunder, "Phage display peptide libraries in molecular allergology: from epitope mapping to mimotope-based immunotherapy", *Allergy (Cph.)*, vol. 71, iss. 11, pp. 1526-1532, 2016, .
2. Jure Pohleven, Janko Kos, Jerica Sabotič, "Medicinal properties of the genus Clitocybe and of lectins from the clouded funnel cap mushroom, C. nebularis (Agaricomycetes): a review", *Int. j. medic. mushrooms*, vol. 18, no. 11, pp. 965-975, 2106.
3. Sonja Prpar Mihevc, Simona Darovic, Anja Kovanda, Ana Bajc Česnik, Vera Župunski, Boris Rogelj, "Nuclear trafficking in amyotrophic lateral sclerosis and frontotemporal lobar degeneration", *Brain*, vol. 140, issue 1, pp. 13-26, 2016.
4. Jerica Sabotič, Robin Ohm, Markus Künzler, "Entomotoxic and nematotoxic lectins and protease inhibitors from fungal fruiting bodies", *Appl. microbiol. biotechnol.*, vol. 100, nol. 1, pp. 91-111, 2016.
5. Borut Štrukelj, "Potencialni učinki kanabinoidov", *Farm. vestn. (Tisk. izd.)*, vol. 67, no. 2-3, pp. 69-73, 2016.
6. Miha Vodnik, Borut Štrukelj, Mojca Lunder, "Ghrelin receptor ligands reaching clinical trials: from peptides to peptidomimetics; from agonists to antagonists", *Horm. Metab. Res.*, vol. 48, no. 1, pp. 1-15, 2016.

Short Article

1. Irena Roškar, Borut Štrukelj, Mojca Lunder, "Screening of phenolic compounds reveals inhibitory activity of nordihydroguaiaretic acid against three enzymes involved in the regulation of blood glucose level", *Plant foods hum. nutr. (Dordrecht)*, vol. 71, iss. 1, pp. 88-89, 2016.

Published Conference Contribution

1. Jelena M. Janjic, Aleš Berlec, Christina Bagia, Lu S. Liu, Irenej Jerič, Michael Gach, Bratislav M. Janjic, Borut Štrukelj, "NIR and MR imaging supported hydrogel based delivery system for anti-TNF alpha probiotic therapy of IBD", In: *Reporters, Markers, Dyes, Nanoparticles, and Molecular Probes for Biomedical Applications VIII: 15-16 February 2016, San Francisco, California, United States*, (Proceedings of SPIE, vol. 9723), (Progress in biomedical optics and imagins, vol. 17, no. 35), pp. 972309-1-972309-10.
2. Maja Zakošek, Janko Mrkun, Breda Jakovac-Strajn, Katarina Pavšič Vrtač, Janko Kos, Anja Pišlar, Alenka Nemec Svete, Petra Zrimšek, "Biomarkerji v semenski plazmi kot faktorji napovedi kakovosti kratkotrajno hranjenega merjaščevega semena", In: *6. Slovenski veterinarski kongres 2016: Portorož, 2. -3. December 2016*, (Slovenian veterinary research, Vol. 53, suppl. 17, 2016), pp. 106-109.

Independent Component Part or a Chapter in a Monograph

1. Jerica Sabotič, Janko Kos, "Fungal protease inhibitors", In: *Fungal metabolites*, (Reference Series in Phytochemistry), J. M. Merillon, ed., K. G. Ramawat, ed., Berlin, Springer, 2016, 33 pp..

Patent

1. Tadej Rejc, Uroš Petrič, Jana Debeljak, Toni Bremec, Polonca Ferk, Mojca Lunder, Irena Roškar, Borut Štrukelj, Samo Kreft, *Mixture of natural polyphenols from white fir wood for reducing postprandial glucose concentration,* SI24984 (A), Urad RS za intelektualno lastnino, 30. 11. 2016.

Mentoring

1. Simona Darovic, *Modifications of FUS and implications in pathological changes in neurodegenerative diseases:* doctoral dissertation, Ljubljana, 2016 (mentor Boris Rogelj).
2. Petra Zadravec, *Development of genetically modified lactic acid bacteria with shiga toxin binding ability:* doctoral dissertation, Ljubljana, 2016 (mentor Aleš Berlec).

3. Valter Bergant, *Characterization of heterogeneous nuclear ribonucleoprotein H in cytoplasmic stress granules:* master's thesis, Ljubljana, 2016 (mentor Boris Rogelj).
4. Melisa Fazlić, *The function and localization of gamma-enolase in colon cancer Caco-2 cell line:* master's thesis, Ljubljana, 2016 (mentor Janko Kos; co-mentor Tjaša Vižin).
5. Tanja Jakoš, *Novel inhibitors of cysteine peptidase cathepsin X:* master's thesis, Ljubljana, 2016 (mentor Janko Kos; co-mentor Urša Pečar Fonović).
6. Božena Kesić, *Isolation and characterization of cystatin F mutants:* master's thesis, Ljubljana, 2016 (mentor Janko Kos; co-mentor Milica Perišić Nanut).
7. Sabina Kolar, *Differentiation of human pluripotent stem cells is accompanied with LIN28A protein nuclear accumulation:* master's thesis, Ljubljana, 2016 (mentor Boris Rogelj).
8. Jure Loboda, *Protein and morphological analysis of vesicles secreted by human microglia:* master's thesis, Ljubljana, 2016 (mentor Janko Kos; co-mentor Metka Lenassi).
9. Mirjana Malnar, *Characterisation of L1 ORF1p in mammalian cells:* master's thesis, Ljubljana, 2016 (mentor Boris Rogelj).
10. Polona Megušar, *Characterisation of antimicrobial and antiadhesive activity of mushrooms aqueous extracts:* master's thesis, Ljubljana, 2016 (mentor Anja Klančnik; co-mentor Jerica Sabotič).
11. Klara Tereza Novoselc, *Expression changes in selected proteins after muscle inactivity:* master's thesis, Ljubljana, 2016 (mentor Boris Rogelj; co-mentor Anja Kovanda).
12. Maja Oven, *Evaluation of L-amino acid oxidases as inducers of apoptosis:* master's thesis, Ljubljana, 2016 (mentor Janko Kos; co-mentor Anja Pišlar).

DEPARTMENT OF ENVIRONMENTAL SCIENCES O-2

The research of the Department of Environmental Sciences deals with fundamental scientific questions about natural environmental systems and processes at various scales, their interactions and responses to human activities, and with the development of technical solutions for environmental problems and environmental management issues. Our research is inter- and multidisciplinary: Environmental analytical chemistry, Biogeochemical cycles, Microbial ecology, Environment and health, Environmental technologies, Risk and environmental assessment, and Environmental monitoring.

The department hosts the "ISO-FOOD" ERA Chair for isotope techniques in food safety, quality and traceability, the infrastructure Centre of Mass Spectrometry (CMS) and the Mobile Ecological Laboratory Unit (ELMU).

Head:
Prof. Milena Horvat

Environmental analytical chemistry

In the field of elemental speciation, a review of monolithic chromatography in the speciation analysis of metal-containing biomolecules has been published, highlighting the great potential of monolithic columns for applications in metallomics. A book chapter was also written on analytical procedures for the speciation of chromium, aluminium and tin in environmental and biological samples.

A procedure has been developed for the quantification of **tributyltin** (TBT) in natural waters at the environmental quality standard level required by the water framework directive. An inter-laboratory comparison of data on TBT determination in whole water samples has also been performed.

A simple analytical method with minimal sample preparation steps was developed for sensitive and reliable determinations of the six PBDEs in sewage sludge by the use of gas chromatography coupled to inductively coupled plasma mass spectrometry (GC-ICP-MS).

In the vast majority of the sample digestion methods the solid residue (silicates, zirconium, etc.) remains undissolved, yielding possible errors in radionuclide determination. A novel methodology for fast sample digestion using lithium borate fusion was developed and applied for the determination of actinides in solid samples. The methodology allows for the complete digestion of solid samples with no residues left, which ensures reliable determinations of the actinides in sample matrices that are difficult to digest.

Following the acquisition of Nu Plasma II multicollector inductively coupled plasma mass spectrometer (MC-ICP-MS), methodologies for the determination of Hg, Pb, Sr and U isotope ratios in various environmental and biological matrices were developed. The application of isotope ratio analysis to environmental studies complements the information on the concentration and speciation of specific elements in the environment and represents a powerful tool in different applications such as tracing the fate of the contaminant in the environment, its biogeochemical transformations or for tracing the origin of food samples.

In the field of the analysis of organic compounds, the group has continued with its research into the fate of pharmaceutical and personal care products and industrial compounds with an endocrine-disrupting effect in environmental and wastewater samples with an emphasis on advanced sampling/extraction. We have developed and published a series of analytical procedures for determining cytostatics (Cyclophosphamide, Ifosfamide, Methotrexate, Imatinib, Vincristin and Etoposide) and their commercially available metabolites in waste and environmental water samples. We showed the presence of detectable quantities of these compounds in wastewaters from hospitals, where cancer therapies are being conducted, in wastewater treatment plant (WWTP) influents and in some effluents. None of the studied cytostatics were detected in receiving waters. Using a newly developed and validated analytical method, we determined the cytostatic bleomycine in serum and tumour tissue in mice and oncologic patients, which were provided by the Institute of Oncology in Ljubljana. The results of these studies were published in international journals with a high impact factor.

Besides cytostatic drugs, also analytical methods for **sertraline** and its metabolites/transformation products norsertraline, sertraline ketone and sertraline imine were developed. To improve the performance of sertraline analysis, we have been developing and testing **molecularly imprinted polymers** (MIPs) with sertraline as the target compound (in collaboration with the Faculty of Chemistry and Chemical Engineering at the University of Maribor). We focused on the problem of sertraline leeching out of the template used during synthesis and choosing the MIP with the highest MIP effect for norsertraline. In the area of industrial chemicals, we developed and

validated analytical methods for the presence of BPA and its alternatives in potable and waste waters and food and food-contact material (FCM) samples (honey). In the case of honey and wastewaters, the analytical method was also applied to a series of honey, FCM and wastewater samples. In addition, we developed an analytical method for determining **diclofenac and other estrogens** listed on the WFD watch list using disk-based solid-phase extraction and GC-MS with the aim of achieving WFD required LOQs and developing a multiresidual analytical method for the simultaneous determination of 48 various compounds of emerging concern (pharmaceuticals, UV filters, preservatives, industrial chemicals etc.). Both validated analytical methods were applied to a series of environmental and wastewater samples.

In the area of **non-target analysis**, we continued with the identification of transformation products of cytostatics (Cyclophosphamide, Ifosfamide, Methotrexate) and identified numerous transformation products for the first time using advanced instrumentation like the LTQ Orbitrap XL mass spectrometer (Curtin University, Perth, Australia; CSIC, Barcelona, Spain). In addition, batch biotransformation experiments of the **antidepressants sertraline and bupropion**, **antimitotic ketoconazole and three bisphenols (bisphenol Z, S and C2)** was carried out and non-target analyses of their transformation products are currently being evaluated in collaboration with the University of Antwerp, Belgium and EAWAG, Switzerland. In collaboration with the Faculty of Chemistry and Chemical Engineering at the University of Ljubljana, several of the identified transformation products were also synthesised and applied as standards in our research.

Within the Empire project Metra we developed a method for the quantitative determination of elemental mercury in broken fluorescent lamps. We have also developed a method for the determination of MeHg based on derivatization using dithizone and their separation on a chromatographic column and final quantification by using cold vapour atomic fluorescence spectrophotometry.

In the context of the key intercomparison K-127 "Contaminants and other lements in the soil" organized in collaboration with CENAM from Mexico, data were collected and processed in the final report prepared. We participate in the key comparison (KC) CCQM-K140: Carbon Stable Isotope Ratio Delta Values in Honey and in inter-laboratory comparison in food: FIT-PTS, which is organized three times per year by EUROFINS. A group training entitled: "**Metrology in isotope ratio measurements: traceability, uncertainty and comparability**", was organized within the MASSTWIN project in collaboration with Fondazione Edmund Mach (FEM). In total, 44 participants attended the training, representing nine different countries. In the field of metrology the new PRO-METROFOOD project was accepted in order to provide catalytic and leveraging support for the preparatory phase and the early phase of the ESFRI project METROFOOD, leading to the construction of new research infrastructures in the field of food quality, safety and traceability. We also participated in several interlaboratory comparisons organised by WEPAL, IAEA, NPL, BfS, GEOTRACES and MRI.

Biogeochemical cycles

In the field of **water cycle** investigations, a new Slovenian–Hungarian research project started on the spatial distribution of water isotopes in precipitation on the transect from the Adriatic to the Pannonian Plain. A gap analysis was performed on existing data, to improve the monitoring in the frame of Slovenian Network of Isotopes in Precipitation (SLONIP). The observation network was extended with 6 new stations in the framework of the common research project with the Faculty of Civil and Geodetic Engineering of the University of Ljubljana on the modelling of the hydrologic response of the non-homogeneous Ljubljanica river catchment. The SLONIP observation sites will provide input data for on-going and future research of water resources and their management, food authentication, etc.

In the frame of several national and international research projects we continued **isotopic hydrogeochemical research of Slovenian rivers** (Sava, Krka, Pesnica, Radovna and Savica) and groundwater in carbonate fractured aquifers in central Slovenia. Stable isotopes were used as tracers to assess the biogeochemical cycling of nutrients, groundwater recharge and the relation between land use and the quality of ground/surface water. In collaboration with researchers from the Ruđer Bošković Institute (Croatia) we participated in studies of the hydrological dynamics of karst springs in Trabaque valley (Spain) from isotopic records of the river and recent and ancient tufa. A hydrological model of overflow springs was generated and a tufa $\delta^{18}O$ record under constrained parameters was simulated. The authigenic precipitation of carbonate and pyrite was studied in the lake Kuti, a karstic crypto depression in the Neretva river delta (Croatia) using isotopic methods and field-emission scanning electron microscopy, where the environmental conditions and early diagenetic processes were correlated with the habitus of precipitated phases.

An interpolation model of the spatial distribution of coalbed gas in relation to the structure of the Velenje coal basin was developed, based on data on coalbed gas (CO_2, CH_4) concentrations, their isotopic composition and the Carbon Dioxide Index (CDMI) collected from a 500-m-deep excavation field in collaboration with the Velenje Coalmine d.d. since 2000

A method was developed for **Hg isotope ratio analysis** using MC-ICP-MS, Hg isotopic compositions and evaluation of Hg the isotopic fractionation of soil cores and different ores from the Idrija mercury mine, processed (retorted) ore, native elemental $Hg^0_{(L)}$ present in the mine and appearing in the near-by Idrijca river, and elemental Hg^0, produced in Idrija smelting plant. Preliminary results showed a very variable Hg isotopic composition among the analysed samples, indicating a rich history of biogeochemical transformations of Hg in Idrija.

Figure 1: Sampling at the Sava River, Serbia, September 2016.

The research performed within the **GLOBAQUA** project is focused on the Sava River basin (SRB) and comprised: (1) a determination of the sources and mean residence time in the groundwater of Ljubljansko polje aquifer, which represents the main drinking-water supply for Ljubljana and its surroundings using δ^2H, $\delta^{18}O$ and ^3H and $^3H/^3He$, respectively; (2) a determination of the sources of nitrate pollution in the Sava River; and (3) modelling the surface-groundwater interactions in the Ljubljansko Polje aquifer. The important upper boundary conditions of the hydrogeological model were determined, describing the spatio-temporal variability of infiltration pathways from the two main groundwater sources: the Sava River and spatial percolation from precipitation and snowmelt. The MIKE 11 and WaSiM software were applied for these purposes and combined with the FEFLOW software for groundwater flow modelling. The use of stable isotopes in hydrological and climate studies was also the subject of the GLOBAQUA training programme organized at the JSI in October 2017.

Further investigations of the **CO_2 fluxes above the subterranean cave** were carried out. Results indicate that the main parameter affecting the ventilation in the investigated cave is the difference between the cave and outside-air temperatures, causing summer stagnation with CO_2 build-up and winter ventilation. The results of stable isotope analysis indicate that the cave CO_2 is a mixture of atmospheric air CO_2 and CO_2 originating from organic matter produced by C3 vegetation. During the cold season, we were able to detect the cave CO_2 influence in soil and estimate its contribution to be up to 80% of soil air CO_2.

The use of stable isotopes in carbon and CO_2 also has an applied value in other fields of research, for example, for **detecting CO_2 leakage** from proposed subsea carbon capture and storage (CCS) sites, i.e., usually depleted gas and oil reservoirs or saline formations, which lie below the seabed. CCS is regarded as one of the most important long-term measures for reducing carbon globally. In collaboration with the Institute Nazionale di Oceanografia e Geofisica Sperimentale – OGS Trieste, Italy, a mesocosmos experiment was performed in order to decode how different sources (natural, anthropogenic) of CO_2 influence biological systems (phytoplankton) using stable carbon isotopes. The results are in progress.

Stable isotopes of C and N were also used in the research of **palaeoclimatic changes** at the Ljubljana Marshes. Research is conducted in collaboration with ZRC-SAZU. Our results were compared with results from other sites in different regions of Slovenia and Europe, to better understand the intensity, timing and spatial framework of environmental processes over the last 15,000 years and the emergence of today's cultural landscape.

Microbial ecology

The microbial system ecology is focused on the interaction of microbes with surfaces, particularly the colonisation and tripartite bio-physico-chemical processes occurring on surfaces. The human biomonitoring is focused on elucidation of the biological and chemical processes that put in the increasing risk of particular human subpopulations. In both research activities we use molecular biology, chemical analytics and nanotechnology-based methods.

Under the microbial system ecology activities, in 2016 we successfully started a national basic research project involving partners from Medical Faculty (MFUM) Faculty of Mechanical Engineering (FMEUM), both from the University of Maribor, in addition to Faculty of Pharmacy (FP) from the University of Ljubljana aiming to determine the electrostatic interaction of bacteria with surfaces as well as their biological responses. Supporting this research through the establishment of a cooperation with the Saratov State University (SSU) from Russian Federation and Queen Mary University of London, UK, via a governmentally supported bilateral project, enabled us to elucidate the effects of polyelectrolytes on the bacterial division at the single-cell level.

The **electrostatic attachment of alive bacterial cells**, developed under the ongoing project, has been applied within a few national projects: in cooperation with MFUM and FMEUM we developed special patches that incorporate beneficial bacteria and in cooperation with FP and University Clinical Centre from Ljubljana we have been developing the active polymeric sol-gel structure incorporating beneficial bacteria preventing either ulcers on diabetic feet or the development of periodontal disease, respectively. Using electrostatic attachment and in cooperation with researchers from Belgium, Netherlands and Denmark we also developed the strategy to clean 2,6-dichlorobenzamide (BAM)

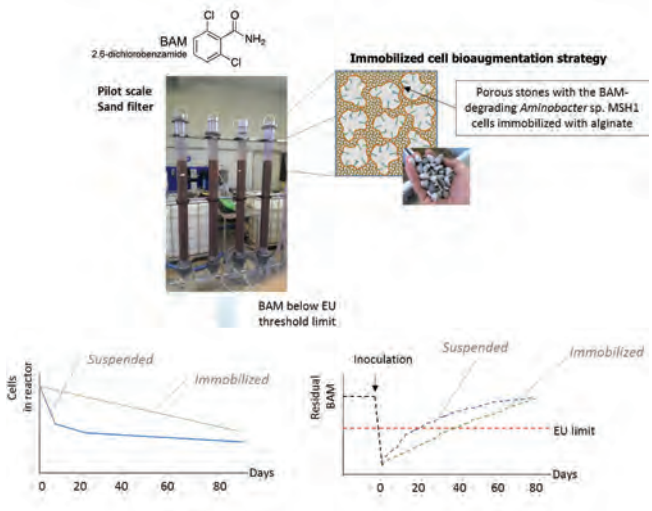


Figure 2: Applicative solution for the use of immobilized bacterial cells for the degradation of xenobiotics, as presented for the case study of a pesticide residual BAM.

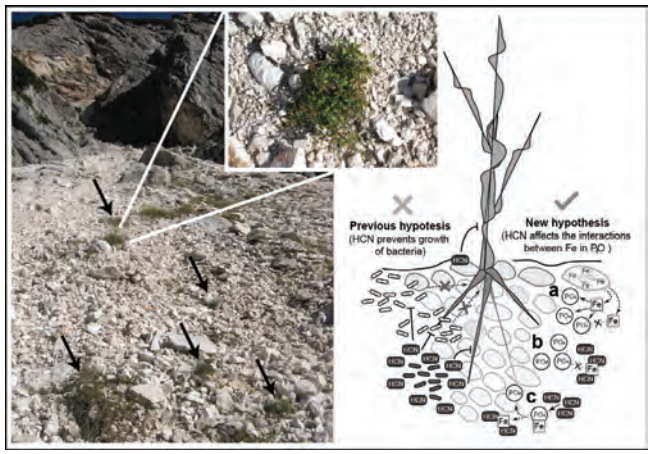


Figure 3: In oligotrophic environments, where the nutrients are stored in the raw bedrock, bacteria producing HCN interfere with processes of co-precipitation of iron with phosphate, which indirectly increase the availability of phosphorous.

polluted drinking water by applying BAM degrading bacteria (Fig. 2). Using this approach we were able to increase the durability of the filter and decrease the operating costs. The manuscript based on the insights of this approach has been accepted in the Environmental Science and Technology journal. This year, on the same principle of electrostatic attachment of bacteria, we also applied the first stage of the H2020 call under topic "Architectured/ Advanced Material Concepts for Intelligent Bulk Material Structures" to develop a self-healing concrete mixture.

In 2016 we achieved a major breakthrough in the research of the physiology of attached microbes on plants roots. We were able to determine the involvement of HCN producing bacteria in the processes of the P uptake by plants. Based on our analysis we disregarded the decades-long hypothesis that HCN producing bacteria present in this ecosystem act against plant pathogenic bacteria, but we gave alternative one where HCN produced by bacteria sequester Fe by formation of complexes. In return, plants can obtain more P due to its increased bioavailability. We published these insights in the prominent journal Frontiers in Microbiology (Fig. 3).

Environment and health

The human biomonitoring activities **LIFE+ project CROME** (Cross-Mediterranean Environment and Health Network), coordinated by the University in Thessaloniki (AUTH), finished at the end of December 2016. In this project, an advanced methodology was applied for identifying associations between environmental stressors (mainly pollutants from the environment), metabolism, genetic background, and subclinical or clinical health effects. Re-sampling of birth cohort established within the PHIME project was successfully finished with the collaboration of the Children's Hospital in Ljubljana. Children, now 7-8 years old, were re-assessed for internal exposure to metal(loid)s and cognitive performance by psychologists using standard intelligence tests. Data analysis performed so far, indicated the importance of a genetic component in the response to environmental stress, particularly, negative association between mercury prenatal exposure and cognitive function at 18 months of age was observed, which was dependent on the apolipoprotein E gene polymorphism.

Based on the existing data from the **national HBM**, we showed the importance of using appropriate biomarkers of exposure in such studies, particularly for cadmium. We also critically evaluated biomarkers of kidney damage, which are also assessed at low levels of exposure, the levels that are typical for general, not occupationally exposed populations. In addition to this, we investigated associations between concentrations of metals in samples, either essential or potentially toxic, and birth weight, taking into account potential life-style and numerous other factors that could influence birth weight.

Following similar aims and using the same methods, in the frame of the FP7 project **HEALS** we have harmonized and prepared a protocol for a study that is including the recruitment of twins and singletons, to investigate a role of genetic, epigenetic, metabolic and other factors in response to environmental stress in the most vulnerable period of life. Recruitment of this new study population is foreseen to be conducted at the beginning of 2017.

In the framework of the **Minamata convention** we have conducted a methodological workshop (*Monitoring exposure to and environmental concentrations of mercury*) under the World Health Organization (WHO), which was intended for national coordinators and laboratory analysts from participating countries.

We were also actively involved in the preparation of a proposal for **European HBM** (HBM4EU), starting on the 1st of January 2017, in which we are taking the leading part in the workpackage focused on cadmium and chromium.

At the beginning of October we started with activities in the frame of **CRP project** (*Exposure of children and teenagers to selected chemicals in the living environment*), which is also coordinated by our department. We prepared a criteria-based review of chemicals, based on which the most relevant will be selected for monitoring in specific population groups.

In a dwelling with elevated air **radon concentration** (in winter up to 16 kBq m^{-3}), situated in the Slovene Karst, the temporal and spatial distribution of radon has been studied and its main source sought. Extremely high radon levels in summer (during a weeklong absence of residents it reached 20 kBq m^{-3}), led us to the conclude

that the strong radon source is not the basement with earthen floor, but rather a hidden karst cave near or even under the house in the part without the basement. Due to the prevailing karst in our country, more such cases could be expected.

Determinations of the number concentration of **nanoparticles** (10–1100 nm) and their size distribution have been performed (within a bilateral cooperation with Serbia) in wintertime in several dwellings, whose heating is based on burning wood in a stove. *This process* emitted particles mostly smaller than100 nm, with an average particle generation rate from 1.1×10^{10} to 1.5×10^{11} min^{-1}. Similarly, smoking a cigarette released up to 2.4×10^{11} particles min^{-1}, only they were larger, i.e., 200 nm.

In biomedical research, in collaboration with other departments from JSI, pH and **metal concentration of synovial fluid of osteoarthritic joints** and joints with metal replacements have also been studied.

In cooperation with Oncology Institute from Ljubljana, magnetic field was applied, enhancing the cellular uptake for effective therapy with magnetofection, using plasmid DNA encoding against Mcam in B16F10 melanoma in vivo. Cytotoxic trans-platinum(II) complex with 3-hydroxymethylpyridine was synthesised and its structure characterised by x-ray spectrometry. The complex was evaluated regarding its biological activity. The study was also performed on electrochemotherapy by pulsed electromagnetic field treatment in mouse melanoma B16F10 in vivo.

In a collaboration with University Medical Centre Ljubljana we continued with a study of **arsenic metabolism in acute promyelocytic leukaemia** patients treated with arsenic trioxide. Our results suggest the possibility of unpredictable exceptions in the metabolism of individual patients, which are important in terms of individual dose adjustment. We assume that the causes lie mainly in the interaction of additional disease states and/or additional drugs and to a lesser extent in genetics. We also followed metabolites of arsenic and polymorphisms of selected genes (*ASMT, SELP,* etc.) in the general population with a nutritional intake of arsenic - pregnant women, sea food.

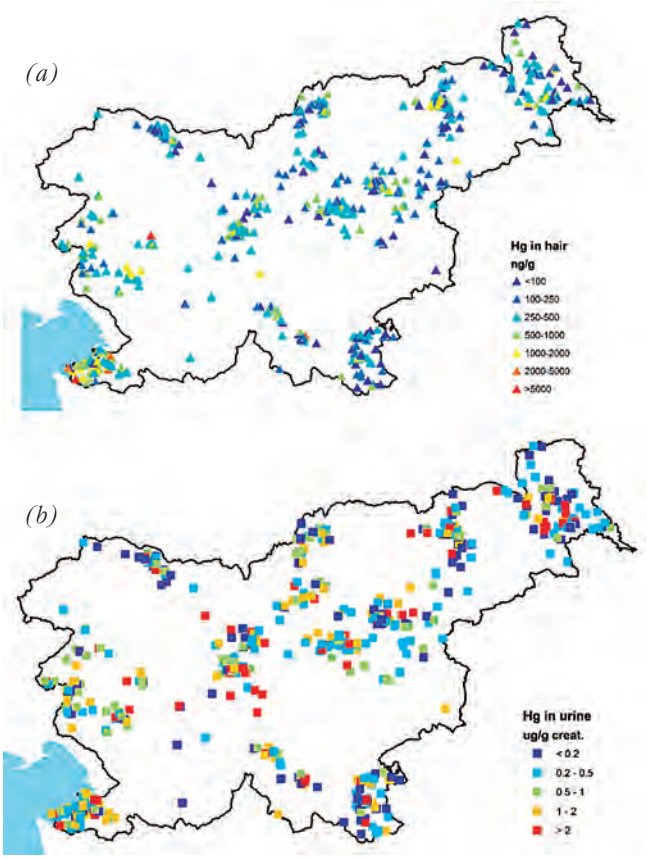


Figure 4. Distribution of Hg in Slovenian population (a) hair values reflect Hg uptake from frequent consumption of fish (b) urine Hg values reflect Hg uptake from amalgams.

In the arsenic speciation field, we also studied the metabolism of **arsenic in plants** and were involved in the development of new methods for the determination of the total arsenic in solid samples using laser ablation and atomic fluorescence spectrometry.

Cr(III)-EDTA, **Cr(VI) and Cr(III)-nitrate cytotoxic and genotoxic activity was studied in the human hepatoma** (HepG2) cell line and the influence of non-cytotoxic concentrations of contaminants on DNA damage was determined with the comet assay. Cell viability was decreased only by Cr(VI) at concentrations above 1.0 mg mL^{-1}. Cr(VI) at 0.2 mg mL^{-1} and Cr(III) at 1.0 mg mL^{-1} induced DNA damage, while Cr(III)-EDTA exposure did not form DNA strand breaks.

Food research and activities of the ERAChair ISO-FOOD

The ISO-FOOD - ERA Chair for isotope techniques in food safety, quality and traceability was established in 2014. Work is ongoing on the studies of potential robust indicators for determining the geographical origin and discriminating amongst various types of production regimes for vegetables (lettuce, sweet pepper, tomato, potato, garlic). Stable isotopes of carbon, nitrogen, oxygen and sulphur, as well as elemental composition (P, S, Cl, K, Ca, Si, Ti, Zn, Br, Rb and Sr) were analysed in order to determine the geographical origin of vegetables at the scale of Slovenia and also Southern and Central Europe and the Mediterranean. Additionally, rare-earth elements (La, Pr, Nd, Dy), other macro and micro elements (Na, Mg, Cr, Mn, Fe, Co, Ni, Cu, Zn, Mo, Cd, Cs, Pb) and chemical-physical parameters (antioxidant potential, total phenolics, vitamin C, carotenoids, ammonium, nitrites and nitrates) were also used in some cases. The preliminary results show good potential for the discrimination according to the geographical origin. The influence of different fertilizing regimes on nitrogen isotopic fingerprints in vegetables in combination with morphological characteristics was evaluated in pot experiments with garlic, sweet pepper and carrots. Results show differences among different types of production regimes.

Furthermore, we investigated the possibility of determining the **geographical origin of milk** and milk products. Our study contains a combination of multi-elemental composition and the analysis of stable isotopes of light elements for genuine samples of milk and cheeses from different geographical areas of Slovenia. Using linear discriminant analysis discrimination and specification of goat, cow and sheep milk and cheese was possible. Based

on a database of genuine Slovenian milk, which was supplemented from 2012, we have developed a statistical model based on which it is possible to verify whether the milk is really produced in Slovenia. The model was tested on 30 samples of milk available on the Slovenian market arising from different European countries. Slovenian milk was statistically distinguishable from all other milk, where the most important parameters were: $\delta^{18}O$, Sr, K and Ca.

Furthermore, our research performed **in the smart-specialization program "Food for Future"** started with method optimization for active components detection with GC-MS-SPME and preliminary testing of selected analytical systems and methods. Commercially available distillate of apples were analysed to obtain the best analytical conditions that could be further used for stable isotope analysis. This research is performed in collaboration with Frutarom Etol company.

In cooperation with the Institute for Hop Research and Brewing, we examined the usefulness of stable isotopes of light elements (C, H, N and S) in the **differentiation of hops from different geographical areas.** The first studies have not given encouraging results, so we decided to expand our research into the determination of the isotopic composition of H and O in hops.

In laboratory-based conditions, the **soil-to-plant transfer of uranium, thorium, radium and lead** for radish, savoy and rocket was investigated on soils contaminated with uranium-mill tailings. Different levels of soil contamination under various growing conditions were applied in a pot experiment to simulate different contamination scenarios. The results obtained indicate a significant linear correlation between the content of the radionuclides in the soil and plants as well as between content of the radionuclides in plants and pedological parameters, while contamination has no effect on the photochemical efficiency and the content of photosynthetic pigments in the selected plants.

In the research field of nanoparticles, we cooperated with the Department of Nanostructured Materials and the Department of Physics of Complex Matter. We have investigated the **properties of nanoparticles** that can be found in the food, the interactions between the organic substance and the nanoparticles activated by light, and the potential for transfer of substances contained in nanoparticles in food and their transfer to human tissues.

Also, this year ISO-FOOD organized Exploratory Workshop entitled "Isotopic techniques in food characterization" with seven invited speakers from different topics, including metrology and preparation of reference materials, the use of different instruments for stable isotope analysis, statistical evaluation and modelling and formation of "isoscapes" in food traceability. In total, the workshop attracted 46 participants from nine different countries.

Environmental technologies

We performed a series of **photo and bio-degradations of sertraline**, where photodegradation experiments with pH-related experiments were carried out and an experiment where sensitizers such as riboflavin, rose bengal and anthraquinone-2-sulfonic acid were applied. In the case of bisphenol alternatives, we have begun the incubation of suspended and attached growth biomass reactors with a mixture of 18 BPA alternatives.

A work was performed on the chemical characterisation of dredged sediments from Luka Koper. The data indicated that due to the large amounts of sediment available, civil engineering applications such as the construction of embankments is the most beneficial recycling solution at present.

The **leaching protocols** available for the evaluation of the long-term environmental impacts of building composites containing waste materials were critically assessed. New leaching tests based on the diffusion and dissolution of contaminants were proposed using synthetic surface and seawater as the leaching solutions.

For an accurate determination of **TiO_2 nanoparticles** (NPs), sample treatments, which maintain NPs dispersed and stabilized in solution, enabling quantitative transfer of TiO_2NPs during the analytical procedure, are of crucial importance. Dispersion approaches using different mechanical and ultrasonication procedures in combination with various dispersing agents were examined. Results demonstrated that different environmental conditions (natural organic matter, ionic strength) have a significant influence on the efficiency of dispersion and the stability of TiO_2NPs, revealing that for each environmental matrix, different dispersion approach needs to be applied.

Iron nanoparticles (FeNPs) are frequently applied in the remediation of contaminated environmental waters. If FeNPs remain in these waters after the treatment, they can cause hazardous effects to the environment. A time-dependent size distribution of FeNPs was investigated in Milli-Q water, forest spring water and landfill leachate after the different FeNPs treatments. The data revealed that settling and removal of FeNPs after the treatment of waters was related to the sample characteristics and the ways of NPs dispersion. When mixing was used for the dispersion the FeNPs quickly settled. Dispersion with TMAH resulted in a slower settling of iron aggregates, and thus may represent a potential threat in environmental waters with low ionic strength.

In collaboration with other departments from the JSI, dissolution mechanism of upconverting AYF_4:Yb,Tm (A = Na or K) nanoparticles in aqueous media was investigated.

Environmental management, environmental impact assessment and risk assessment

In September the **CITI-SENSE** project ended, an EU project aimed to test and develop air-quality related *Citizens' observatories* (CO) in nine cities across the Europe, Ljubljana being one of pilot cities. The general public, schools and other interested were involved in the project through hosting some of the AQ sensor devices, as well as providing feedback on developed tools and applications. As part of awareness raising campaigns on air quality issues and novel sensor technologies, workshops, information days, activities in the nature as well as in the city centre were organised throughout the lifetime of the project.

In 2016 the work on a 4 year **H2020 ICARUS** project started (ICARUS stands for Integrated Climate forcing and Air Pollution Reduction in Urban Systems).

We commenced a 2-year national research project "Potential substances of very high concern in the context of REACH regulation" in the framework of the Targeted research programme 2016.

Additionally, second phase of the site suitability evaluation for the new LPG storage facilility at Steklarna Hrastnik d.o.o. has been made, and an opinion for the NPP Krško regarding obligations associated with Environmental Impact Assessment procedure for its lifetime extension by 2043 has been provided.

Environmental monitoring

In collaboration with the Environmental Agency from Croatia monitoring of organotin compounds and polybrominated diphenyl ethers in surface and sea water started in 2016. The monitoring of natural radionuclides within the influential area of the former uranium mine and mill at Žirovski vrh was performed. We also participated in off-site monitoring of Krško Nuclear Power Plant (NPP) with a determination of strontium and tritium in environmental samples. The monitoring of tritium and radiocarbon in gas effluents from the NPP was also performed. With analyses of strontium and tritium we also participated in the monitoring of radioactivity in drinking water in Slovenia, as well as in the monitoring of the living environment in Slovenia. Methods used for the determination of strontium, tritium and radiocarbon for the monitoring purposes are accredited by the Slovenian accreditation body (SA LP-090).

Infrastructural Centre for Mass Spectrometry (CMC)

The mass spectrometric measurements are involved in many research programs and projects in the field of environmental chemistry, chemistry for sustainable development, synthesis and medicinal chemistry, biochemistry, medicine and other natural sciences with research groups at JSI, the National institute of Chemistry, National institute of Biology, University of Ljubljana, Maribor and Nova Gorica, Centers of excellence: One-fist, CIPKeBiP, Namaste et al.

With a high-resolution tandem mass spectrometer QTof Premier, LC-MS and GC-MS analyses were identified and determined the structure of many organic compounds, organic-metallic complexes, biopolymers and similar compounds. We studied the new synthesized organic compounds, the bioactive substances, proteins, lipids and similar organic molecules, ceramic materials, food supplements and food additives, monitoring pollutants in the environment, etc.

An example of such research, in collaboration with the Faculty of Pharmacy at University of Ljubljana and the National institute of Chemistry, was a publication in the prestigious scientific journal Angewandte Chemie, where we explained the function of a new type of potential target drugs to selective inhibition on immunoproteasome. This would improve the treatment of autoimmune disease and cancer. The coupling of liquid chromatography and mass spectrometry were also used for the characterization of organic acids in the complex compounds of nickel in plants for the bioremediation of the degraded environment, chemical analysis of a mixture of fatty acid derivatives, lipids, cholesterol in biological membranes, cytostatic bleomycin in the blood serum and tumour tissue, quantitative determination of cannabinoids in preparations of medical hemp and many other MS applications.

The Department of Environmental Sciences also operates a mobile chemical laboratory ELMU (Ecological Laboratory with a Mobile Unit) which is organized in the system of Slovenian Civil Protection as a unit for the intervention in ecological accidents with hazardous substances and materials. The chemical mobile unit had four interventions in 2016, mainly due to chemical accidents and environmental pollution of toxic compounds. A new vehicle mobile chemical laboratory ELMU is on standby to provide ecological accidents with hazardous substances, and also serves for the sampling of water, air and soil from the environment.

Some outstanding achievements

1. A study of the fate of iron nanoparticles (FeNPs) in contaminated environmental waters treated with nanoscale zero-valent iron, FeONPs and Fe_3O_4NPs. The investigation significantly contributed to understanding the mechanisms and kinetics of FeNPs settlings and their removal from remediated waters, which is essential to prevent nano-threat to living organisms.

2. Mathematical model for determination of origin of precipitation based on linear combination of $\delta^{2}H$ and $\delta^{18}O$ values and quantity of precipitation connected to air circulation, developed in 2015, was selected as excellent achievement in hydrogeology field by the ARRS in 2016.
3. Involvement in the new smart specialization program: Food for Future and active participation in SRIP – Food.
4. Based on our analysis we disregarded the decades-long hypothesis that HCN producing bacteria present in this ecosystem act against plant pathogenic bacteria, but we gave alternative one where HCN produced by bacteria sequester Fe by the formation of complexes. In return, plants can obtain more P due to its increased bioavailability.
5. We developed the strategy to clean 2,6-dichlorobenzamide (BAM) polluted drinking water applying electrostaticaly attached BAM degrading bacteria. Using this approach we were able to increase the durability of the filter and decrease the operating costs.
6. We have demonstrated the importance of apolipoprotein E genetic variability in association between low-level mercury exposure, typical for the Slovenian population, and the cognitive performance of children.
7. Contribution to the extended operation of Nuclear Power Plant Krško until 2043.
8. In the framework of the MAASTWIN project capacity building in novel mass spectrometry techniques have commenced.

Some outstanding publications in the past year

1. K. Peeters, G. Lespes, T. Zuliani, J. Ščančar, R. Milačič. The fate of iron nanoparticles in environmental waters treated with nanoscale zero-valent iron, FeONPs and Fe_3O_4NPs. *Water Research*, 2016, 94, 315-327.
2. P. Novak, T. Zuliani, R. Milačič, J. Ščančar. Development of an analytical method for the determination of polybrominated diphenyl ethers in sewage sludge by the use of gas chromatography coupled to inductively coupled plasma mass spectrometry. *Analytica Chimica Acta*, 2016, 915, 27-35.
3. T. Kosjek, A. Krajnc, T. Gornik, D. Žigon, A. Grošelj, G. Serša, M. Čemažar. Identification and quantification of bleomycin in serum and tumor tissue by liquid chromatography coupled to high resolution mass spectrometry. *Talanta*, 2016, 160, 164-171.
4. M. Zdanowicz, E.M. Krümmel, A.J. Poulain, E. Yumivhoze, J. Chen, M. Štrok, M. Scheer, H. Hintelmann. Historical variations of mercury stable isotope ratios in Arctic glacier firn and ice cores. *Global biogeochemical cycles,* 2016, 30, 1324-1347.
5. A.Bratkič, M. Vahčič, J. Kotnik, K. Obu, E. Begu, M.E. Woodward, M. Horvat. Mercury presence and speciation in the South Atlantic Ocean along the 40°S transect. *Global biogeochemical cycles*, ISSN 1944-9224, 2016, 30, 105-119.
6. A B. Kobal J. Snoj Tratnik, D. Maze, V. Fajon, D. Gibičar, A. Miklavčič, d. Kocman, J. Kotnik, A.Briški, J. Osredkar, M. Krsnik, M. prezelj, Č. Knap, B. Križaj, L. Liang, M. Horvat, Exposure to mercury in susceptible population groups living in the former mercury mining town of Idrija, Slovenia, Environmental Research, 2016, in press.
7. K. Bat, K. Eler, D. Mazej, B. Mozetič Vodopivec, I. Mulič, P. Kump, N. Ogrinc. Isotopic and elemental characterisation of Slovenian apple juice according to geographical origin: preliminary results. *Food chemistry*, 2016, 203, 86-94
8. B. Horemans, B. Raes, J. Vandermaesen, Y. Simanjuntak, H. Brocatus, J. T'Syen, J. Degryse, J. Boonen, J. Wittebol, A. Lapanje, S.R. Sørensen. D. Springael. Biocarriers improve bioaugmentation efficiency of a rapid sand filter for the treatment of 2, 6-dichlorobenzamide (BAM)-contaminated drinking water. *Environmental science & technology*, in press 2016, 28p.
9. T. Rijavec, A. Lapanje. Hydrogen cyanide in the rhizosphere: not suppressing plant pathogens, but rather regulating availability of phosphate. *Frontiers in microbiology*, in press 2016, 45p.
10. B. Kontić, M. Bohanec, D. Kontić, N. Trdin, M. Matko. Improving appraisal of sustainability of energy options - a view from Slovenia, *Energy Policy*, 2016, 90, 154-171.

Organization of conferences, congresses and meetings

1. Milena Horvat: WHO Training workshop for national coordinators and laboratory analysts in the frame of the UNEP/WHO project "Development of a Plan for Global, Monitoring of Human Exposure to and Environmental Concentrations of Mercury", Reaktorski center Podgorica, Ljubljana, Slovenia, 8–12 February 2016
2. MASSTWIN Kick-off meeting; Reactor Centre Podgorica Podgorica, Ljubljana, Slovenia, 29–30 March 2016
3. Iso-Food Workshop on speciation of trace elements: Mercury speciation in food and the global mercury cycle; Reactor Centre Podgorica, Ljubljana, Slovenia, 46 April 2016

4. ISO-FOOD Summer School: Radionuclides in food; Reactor Centre Podgorica, Ljubljana, Slovenia, 6–10 June 2016
5. GLOBAQUA training course "The use of stable isotopes in investigations of hydrological processes and climate change", Reactor Centre Podgorica Podgorica, Ljubljana, 10–13 October 2016
6. CROME-LIFE Inter-regional Workshop, Reactor Centre Podgorica, Ljubljana, Slovenia, 24–25 November 2016
7. MASSTWIN Group training "Metrology in measurements of stable isotopes of light elements: traceability, uncertainty and comparability", Reactor Centre Podgorica, Ljubljana, Slovenia, 7 December 2016
8. ERA-Chair ISO-FOOD Exploratory Workshop »Isotopic Techniques in food characterisation«, Reactor Centre Podgorica, Ljubljana, Slovenia, 8–9 December 2016
9. 14RPT-03-ENVCRM Project Midterm Meeting, "EMPIR; ENVCRM–Matrix reference materials for environmental analysis", Reactor Centre Podgorica, Ljubljana, Slovenia, 13–14 December 2016

Patent granted

1. Aleš Lapanje, The impregnation process and attachment of microorganisms in porous materials, SI24910 (A), Slovenian Intellectual Property Office , 29. 07. 2016.

INTERNATIONAL PROJECTS

1. Analyses of Metals, TBT and DBT in Sediments, Mussels and Fish
   Prof. Janez Ščančar
   Analyses of the Swiss Moss Samples in the Framework of the UNECE ICP Vegetation Programme
   Asst. Prof. Zvonka Jeran
   Fub Ag
2. 7FP - CITI-SENSE; Development of Sensor-based Citizens' Observatory Community for Improving Quality of Life in Cities
   Prof. Milena Horvat
   European Commission
3. 7FP - HEALS; Health and Environment-wide Associations Based on Large Population Surveys
   Prof. Milena Horvat
   European Commission
4. 7FP - GLOBAQUA; Managing the Effects of Multiple Stressors on Aquatic Ecosystems Under Water Scarcity
   Prof. Radmila Milačič
   European Commission
5. 7 FP; ERA CHAIR ISO-FOOD - Era Chairs for Isotope Techniques in Food Quality, Safety and Traceability
   Prof. Milena Horvat
   European Commission
6. LIFE12 ENV/ - CROME-LIFE; Cross-Mediterranean Environment and Health Network
   Prof. Milena Horvat
   European Commission
7. MeTra; EMRP - Traceability for Mercury Measurements
   Prof. Milena Horvat
   Euramet E.v.
8. EMPIR; ENVCRM - Matrix Reference Materialls for Environmental Analysis
   Prof. Milena Horvat
   Euramet E.v.
9. STAWA; Towards the Assessment of Ecological Status of Water Bodies in the Sava River Basin
   Prof. Radmila Milačič
   Eurovienna - Eu-consulting & -management Gmbh
10. COST ES1403 - New and Emerging Challenges and Opportunities in Wastewater Reuse (NEREUS)
    Prof. Ester Heath
    Cost Office
11. LIFE RusaLCA-Nanoremediation of water from small waste water tretment plants and reuse of water and solid remains for local needs
    Prof. Janez Ščančar
    European Commission
12. The Use of Stable Isotopes and Elemental Composition for Determination of Authenticity and Geographical Origin of Milk and Dairy Products; Accessible Technologies for the Verification of Origin of Dairy Products as an Example Control System...
    Prof. Nives Ogrinc
    IAEA - International Atomic Energy Agency
13. Stability Monitoring of ERM-EF411, ERM-EF412 & ERM-EF413
    Dr. Radojko Jaćimović
    Institute For Reference Materials And Measurements
14. Training Fees for Ms Delali Tulasi, (Ghana), 01.01. - 31.07.2016
    Prof. Milena Horvat
    International Centre for Theoretical Physics
15. Stability Monitoring of the Certified Reference Material ERM-CZ120
    Asst. Prof. Tea Zuliani
    Institute For Reference Materials And Measurements
16. Stability Monitoring of ERM-EC590 and ERM-EC591
    Dr. Radojko Jaćimović
    Institute For Reference Materials And Measurements
17. Develop Training Modules as a Component of a Training Course Mercury and Implementation of the Minamata Convention in the Health Sector
    Prof. Milena Horvat
    World Health Organization
18. BCR-679 White Cabbage and ERM-CD281 Rye Grass
    Prof. Milena Horvat
    Institute For Reference Materials And Measurements
19. Stability Monitoring of Certified Reference Material BCR-185R (Bovine Liver)
    Asst. Prof. Tea Zuliani
    Institute For Reference Materials And Measurements
20. Development of a Plan for Global Monitoring of Human Exposure to and Enviromental Concentrations of Mercury
    Prof. Milena Horvat
    World Health Organization
21. Training Fees for Mr Dalerjon Khojiboev (Tajikistan), 25.4.2016 - 27.7.2016
    Prof. Ljudmila Benedik
    International Centre for Theoretical Physics
22. Stability Monitoring of ERM-EC680m and ERM-EC681m
    Dr. Radojko Jaćimović
    European Commission
23. Training Fees for Mr Kyrylo Korychenskyi (Ukraine), 10.9.2016 - 9.12.2016
    Prof. Borut Smodiš
    International Centre for Theoretical Physics
24. Training Fees for Mrs Delali Tulasi (Ghana), 17.9.2016 - 16.1.2017
    Prof. Milena Horvat
    International Centre for Theoretical Physics
25. IAEA Fellowship for Mr Faisal J H H A Alabasey (KUW/16016), 17.10.2016-16.11.2016, IAEA Project: Upgrading National Nuclear Analytical Capabilities for Environmental and Foodstuff Radioactivity
    Prof. Janja Vaupotič
    IAEA - International Atomic Energy Agency
26. H2020 - ERA-PLANET; The European Network for Observing Our Changing Planet
    Prof. Milena Horvat
    European Commission
27. H2020 - ICARUS; Integrated Climate Forcing and Air Pollution Reduction in Urban Systems
    Prof. Milena Horvat
    European Commission
28. H2020 - MASSTWIN; Spreading Excellence and Widening Participation in Support of Mass Spectrometry and Related Techniques in Health, Environment, and Food Analysis
    Prof. Milena Horvat
    European Commission
29. Exposure-response Asessment of Ambient Air Pollution (AAP) and Hg Contamination in Affected Cities of India and Slovenia: A Comparative Study

Prof. Milena Horvat
Slovenian Research Agency
30. The Use of New Methods for Dating Young Groundwater in Slovenia
Prof. Nives Ogrinc
Slovenian Research Agency
31. Screening of Organic Pollutants and their Effects in Water
Prof. Ester Heath
Slovenian Research Agency
32. Anthropogenic Radionuclides in the Sava River and their Transboundary Effects
Dr. Marko Štrok
Slovenian Research Agency
33. Air Pollution Monitoring, Maps and Tools for Assessment of Exposure to Selected Pollutants in Slovenia and Serbia
Dr. David Kocman
Slovenian Research Agency
34. Trace Metals Partitioning between Water Column, Suspended Particulate Matter and Sediments of the Sava River
Prof. Janez Ščančar
Slovenian Research Agency
35. Assessment of Emerging Contaminants in the Sava River
Prof. Ester Heath
Slovenian Research Agency
36. Effects of Electrostatic Modifications of Bacterial Cells on their Physiology: Growth, Division, Expression
Dr. Aleš Lapanje
Slovenian Research Agency
37. Promotion of Slovenian Science and Slovenia in the Framework of "Division of Chemistry and Environment" within "European Association for Chemical and Molecular Sciences"
Prof. Milena Horvat
Slovenian Research Agency

RESEARCH PROGRAMS

1. Modelling and environmental impact assessment of processes and energy technologies
Prof. Borut Smodiš
2. Cycling of substances in the environment, mass balances, modelling of environmental processes and risk assessment
Prof. Milena Horvat

R&D GRANTS AND CONTRACTS

1. Development of Molecularly Imprinted Polymers and their application in environmental and bio-analysis
Asst. Prof. Tina Kosjek
2. Vegetation and hydrology of Ljubljansko barje in the past, present and future a consequence of succession, human impact or climatic fluctuations?
Prof. Nives Ogrinc
3. Modelling hydrologic response of nonhomogeneous catchments
Prof. Sonja Lojen
4. Electrostatic immobilisation of bacterial cells and effects on their physiology
Prof. Milena Horvat
5. The effect of iodine and selenium on growth and quality of crops
Prof. Vekoslava Stibilj
6. Bisphenol A alternatives: transfer from food contact material, fate and human exposure
Prof. Ester Heath
7. Spatial distribution of water isotopes in precipitation in Europe with special fokus on the transect from the Adriatic Coast to the Pannonian Plain
Dr. Polona Vreča
8. Comparative study of ecosystem management and services in contrasting Slovenian freshwater systems
Dr. David Kocman
9. In-situ remediacija onesnažene zemljine na področju stare Cinkarne In-situ remediation of polluted grouns in the area of the Zink-works at Celje
Prof. Janez Ščančar
10. Improved treatment and monitoring of Water Framework Directive priority pollutants
Prof. Ester Heath
11. Optimization and validation of new indicator systems in complex environmental matrices
Prof. Milena Horvat
12. Evaluating geological sequestration of CO2 in low rank coals; Velenje basin, Slovenia as a natural analogue
Dr. Tjaša Kanduč
13. Pharmaceutical and personal care product residues in the environment: Occurence, sources, treatment and effects
Prof. Ester Heath
14. Evaluation of quality and safety parameters of vegetables produced on different systems in Slovenia and abroad with aim to establish national quality scheme for vegetables
Prof. Nives Ogrinc
15. Evaluation of quality and safety parameters of vegetables produced on different systems in Slovenia and abroad with aim to establish national quality scheme for vegetables
Prof. Nives Ogrinc
16. Exposure of children and adolescents to selected chemicals through their habitat environment
Prof. Milena Horvat
17. Potential substances of very high concern in the context of REACH regulation
Dr. Davor Kontić
18. In situ immobilization of contaminated soil using innovative nanotechnology, for processingand use as urban soils
Prof. Radmila Milačič
19. In situ immobilization of contaminated soil using innovative nanotechnology, for processingand use as urban soils
Prof. Radmila Milačič
20. Slovenian National Implementation Plan for the Minamata Convention on Mercury
Dr. David Kocman
21. EMRP; MeTRA - Traceability for Mercury Measurements
Prof. Milena Horvat
22. Services; Determination of the Isotopic Composition of Carbon in Sugar Samples
Prof. Nives Ogrinc
23. Different Analyses
Prof. Sonja Lojen
24. Provision of Testing Services for Filter Media used in IMS Radionuclide Stations
Prof. Ljudmila Benedik
The Preparatory Commission For The Comprehensive
25. Small Services in the Years from 2007 to 2016
Prof. Milena Horvat
26. Determining Elemental Content in Environmental Samples Using k0-INAA
Dr. Radojko Jaćimović
27. Irradiation and Analysis of Nano SiC Samples
Dr. Radojko Jaćimović
National Nuclear Research Center
28. The Use of Stable Isotopes in Investigations of Hydrological Processes and Climate Change
Prof. Nives Ogrinc
29. Food for future - F4F
Prof. Nives Ogrinc

NEW CONTRACTS

1. Evaluating gelogical sequestration of CO2 in low rank coals; Velenje basin, Slovenia as a natural analogue
Dr. Tjaša Kanduč
Velenje Coal Mine
2. Analyses of atmospheric releases in 2015, 2016 and 2017
Dr. Marko Štrok
Krško Nuclear Power Plant (NEK)
3. Environmental radioactivity monitoring of living environment in Slovenia in 2015
Dr. Marko Štrok
Ministry of the Environment and Spatial Planning
4. Off-site radiological monitoring of the Krško Nuclear Power Plant in2016 and 2017
Dr. Marko Štrok
Krško Nuclear Power Plant (NEK)
5. Environmental radioactivity monitoring of living environment in Republic Slovenia in 2016
Dr. Marko Štrok
Ministry of the Environment and Spatial Planning
6. Monitoring of radiaoactivity in drinking water in Republic of Slovenia in 2016 and 2017
Dr. Marko Štrok
Ministry of Health of the Republic of Slovenia

VISITORS FROM ABROAD

1. Dr Sergio Ribeiro Guevara, Centro Atomico Bariloche, Comision Nacional de Energia Atomica, Bariloche, Argentina, 17 January to 6 February 2016
2. Jarmila Makovinska, Emilia Elexova Miškova, Water research Institute, Bratislava, Slovakia, 9–12 February 2016
3. Stefan Andus, Marija Ilić, Nikola Marinković, Đurad Milošević, Miroslava Mitrović, Boris Novaković, Miroslav Očadilnik, Momir Paunivić, Marina Piria, Nataša Popović, Predrag Simonović, Jelena Đuknić, Jelena Vićanović, University of Belgrade, Institute for Biological Research "Sinisa Stankovic", Belgrade, Serbia, 9–12 February 2016

4. Dr Dominika Saniewska, Department of Marine Chemistry and Environmental Protection, Institute of Oceanography, University of Gdańsk, Gdańsk, Poland, 29 February to 25 March 2016
5. Diana Babi, Tekran® Instruments Corporation, Totonto, Canada, 10–14 March 2016
6. Dr Bourquin Maurice Henri Césa Eric, Elžibeta Marta Nowak, CERN, Geneva, Switzerland, 21–23 March 2016
7. Prof. Akagi Hirokatsu, International Mercury Laboratory Inc., Minamata, Kumamoto, Japan, 15 April to 12 May 2016
8. Dr Arne Jernelöv, ex-director International Institute of Applied Systems Analysis in Vienna, Vienna, Austria, 28 April to 1 May 2016
9. Dalerjon Khojiboev, Department of Ecology, Faculty of Metallurgy, Mining-Metallurgical Institute of Tajikistan, Sogd region, Chkalovsk, Tadzhikistan, 25 April to 30 July 2016
10. Theo Bulteau, Université François Rabelais – Département Géosciences-Environnement – Faculté des Sciences et Techniques, Tours, France, 27 April to 31 August 2016
11. Elisa Petranich, Department of Mathematics & Geosciences (DMG), Trieste, Italy, 15 May to 10 June 2016
12. Dr Dimitra Lambropoulou, University of Thessaloniki, Greece, 25 May 2016
13. Dr Miren Lopez deAlda, CSIC, Barcelona, Spain, 20 April 2016
14. Tolongutov Baigabyl, State Regulation Center on Environment Protection and Ecosafety of the SAEPF of Kyrgyz Republic, Bishkek, Kirgizistan, Mademinov Muradyl, Dzhogorku Kenesh of Kyrgyz Republic, Bishkek, Kirgizistan, Zhutanov Almaz, Dzhogorku Kenesh of Kyrgyz Republic, Bishkek, Kirgizistan, Kozhogulov Bakytbek, Project Research Organization Ken-Too, Kyrgyz Republic, Bishkek, Kirgizistan, Isakov Ilias, Khaidarkan Mercury Plant, Kyrgyz Republic, Batken region, Aidarken, Razakov Zhenish, Representative of Government in Batken region, Kyrgyz Republic, Batken, Kirgizistan, Saitov Azamat, Sharapov Zakir, Aidarken city hall, Kyrgyz Republic, Batken region, Aidarken, Kirgizistan, Timur Dosmambetov, State Regulation Center on Environment Protection and Ecosafety of the SAEPF of Kyrgyz Republic, Kirgizistan, Satyvaldiev Asylbek, Government Office of Kyrgyz Republic, Bishkek, Kirgizistan, Dzhuraev Saidolimzhon, Dzhogorku Kenesh of Kyrgyz Republic, Bishkek, Kirgizistan, Davis Kenneth, United Nations Environment Programme, Chemicals and Waste Branch, Geneva, Switzerland, 4 May 2016
15. Prof. Ivana Ivančev Tumbas, Aleksandra Tubić, University of Novi Sad, Novi Sad, Serbia, 2–3 June 2016
16. Mauro Paolini, Fondazione Edmund Mach Research and Innovation Centre - Department Food Quality and Nutrition Stable Isotope and Traceability, S.Michele all'Adige, Italy, 1–30 September 2016
17. Kyrylo Korychenskyi, Ukrainian Hydrometeorological Institute (UHMI), Kiev, Ukraine, 9–12 September 2016
18. Nataša Sarap, Vinča Institute of Nuclear Sciences, Laboratorija za zaštitu od zračenja i zaštitu životne sredine Vinča, Serbia, 5–15 September 2016
19. Dr Maria Bonsignore, Istituto per l'Ambiente Marino Costiero (IAMC-CNR), (Institute for Coastal Marine Environment), Fraz. Campobello di Mazara, Tp, Italy, 16 September to 5 October 2016
20. Dr Neda Vdović, Nevenka Mikac, Irena Jurina Tokić, Maja Ivanić, Mavro Lučić, Niko Bačić, Ruđer Bošković Institute, Zagreb, Croatia, 23 September 2016
21. Prof. Ivana Ivančev Tumbas, University of Novi Sad, Novi Sad, Serbia, 23 September to 2 October 2016
22. Minja Bogunović, University of Novi Sad, Novi Sad, Serbia, 26 September to 7 October 2016
23. Yelizaveta Melnik, Department of Rare, Scattered and Radioactive Element Technology, Tomsk Polytechnic University, Tomsk, Russian Federation, 7–30 October 2016
24. Prof. Gabriel J Bowen, Geology & Geophysics Department, University of Utah, Salt Lake City, United States of America, 10–13 October 2016
25. Zoltán Kern, István Fórizs, György Czuppon, Tamás Mona, Hungarian Academy of Sciences, Budapest, Hungary, 10–11 October 2016
26. Dr Maria Ângela Menezes, CDTN/CNEN, Belo Horizonte, Brazil, 15–31 October 2016
27. Faisal J H H A Alabasey, Radiation Protection Department, Ministry of Health, Kuwait, Kuwait, 17 October to 16 November 2016
28. Delali Tulasi, University of Ghana, School of Nuclear and Allied Sciences, Legon, Accra, Ghana, 17 October to 31 December 2016
29. Dr Lata Gawade, CSIR-National Institute of Oceanography, Dona Paula-Goa, India, 2–4 November 2016
30. Prof. Arndt Schimmelmann, Indiana University, Department of Geological Sciences, USA, 5–11 December 2016
31. Dr Lesley Chesson, IsoForensics Inc., USA, 6–11 December 2016
32. Prof. Milena Jovaševič Stojanović, Ivan Lazović, M.Sc., 12–15 December 2016,
33. Dr Miloš Davidović, Dušan Topalović, M.Sc., Vinča Institute of Nuclear Sciences, 12.–16. 12. 2016

STAFF

Researchers

1. Prof. Ljudmila Benedik
2. Asst. Prof. Ingrid Falnoga
3. Dr. David John Heath
4. Prof. Ester Heath
5. **Prof. Milena Horvat, Head**
6. Dr. Radojko Jaćimović
7. Asst. Prof. Zvonka Jeran
8. Dr. David Kocman
9. Asst. Prof. Branko Kontić
10. Asst. Prof. Tina Kosjek
11. Dr. Jože Kotnik
12. Dr. Aleš Lapanje
13. Prof. Sonja Lojen
14. Dr. Darja Mazej
15. Prof. Radmila Milačič
16. Prof. Nives Ogrinc
17. Prof. Borut Smodiš
18. Prof. Janez Ščančar
19. Asst. Prof. Zdenka Šlejkovec
20. Dr. Marko Štrok
21. Prof. Janja Vaupotič
22. Dr. Polona Vreča
23. Asst. Prof. Tea Zuliani
24. Dr. Dušan Žigon

Postdoctoral associates

25. Dr. Marjeta Česen
26. Dr. Tjaša Kanduč
27. Dr. Davor Kontić
28. Dr. Kelly Peeters
29. Dr. Tomaž Rijavec
30. Dr. Miha Trdin

Postgraduates

31. Lojze Gačnik, B. Sc.
32. Ana Jerše, B. Sc.
33. Ana Kovačič, B. Sc.
34. Ana Kroflič, B. Sc.
35. Petra Novak, B. Sc.
36. Majda Pavlin, B. Sc.
37. *Dr. Petra Planinšek, left 05.01.16*
38. Doris Potočnik, B. Sc.
39. Johanna Amalia Robinson, B. Sc.
40. Janja Snoj Tratnik, B. Sc.
41. Anja Stajnko, B. Sc.
42. Vanja Usenik, B. Sc.
43. Janja Vidmar, B. Sc.
44. Igor Živković, B. Sc.

Technical officers

45. Vesna Fajon, B. Sc.

Technical and administrative staff

46. Damjana Nikovski, B. Sc.
47. *Janja Smrke, retired 19.12.16*
48. Barbara Svetek, B. Sc.
49. Zdenka Trkov, B. Sc.
50. Stojan Žigon

BIBLIOGRAPHY

Original Article

1. Enrica Alasonati *et al.* (11 authors), "Towards tributyltin quantification in natural water at the environmental quality standard level required by the water framework directive", *Talanta (Oxford)*, vol. 160, pp. 499-511, 2016.
2. Marina Arcagni, Andrea Rizzo, Romina Juncos, Majda Pavlin, Linda Campbell, Maria Arribére, Milena Horvat, Sergio Ribeiro Guevara, "Mercury and selenium in the food web of Lake Nahuel Huapi, Patagonia, Argentina", *Chemosphere (Oxford)*, vol. 166, pp. 163-173, 2016.
3. Karmen Bat, Klemen Eler, Darja Mazej, Branka Mozetič Vodopivec, Ines Mulič, Peter Kump, Nives Ogrinc, "Isotopic and elemental

characterisation of Slovenian apple juice according to geographical origin: preliminary results", *Food chem.*, vol. 203, pp. 86-94, 2016.
4. Ermira Begu, Yaroslav Shlyapnikov, Andrej Stergaršek, Peter Frkal, Jože Kotnik, Milena Horvat, "A method for semi-continuous measurement of dissolved elemental mercury in industrial and natural waters", *Int. j. environ. anal. chem.*, vol. 96, iss. 7, pp. 609-626, 2016.
5. Ljudmila Benedik, "Evaluation of procedures for Ra-226 determination in samples with high barium concentration by alpha-particle spectrometry", *Appl. radiat. isotopes*, vol. 109, pp. 210-213, 2016.
6. Arne Bratkič, Mitja Vahčič, Jože Kotnik, Kristina Obu, Ermira Begu, E. Malcolm S. Woodward, Milena Horvat, "Mercury presence and speciation in the South Atlantic Ocean along the 4023S transect", *Glob. biogeochem. cycles*, vol. 30, iss. 2, pp. 105-119, 2016.
7. Mihael Brenčič, Polona Vreča, "Hydrogeological and isotope mapping of the karstic River Savica in NW Slovenia", *Environmental earth sciences*, vol. 75, nol. 8, pp. 651-1-651-13, 2016.
8. Ivana Capan, Ž. Pastuović, R. Siegele, Radojko Jaćimović, "Vacancy-related defects in n -type Si implanted with a rarefied microbeam of accelerated heavy ions in the MeV range", *Nucl. instrum. methods phys. res., B Beam interact. mater. atoms*, vol. 372, pp. 156-160, 2016.
9. Marjeta Česen, Tina Eleršek, Matjaž Novak, Bojana Žegura, Tina Kosjek, Metka Filipič, Ester Heath, "Ecotoxicity and genotoxicity of cyclophospamide, ifosfamide, their metabolites/transformation products and their mixtures", *Environ. pollut. (1987)*, vol. 210, pp. 192-201, 2016.
10. Marjeta Česen, Tina Kosjek, Francesco Busetti, Boris Kompare, Ester Heath, "Human metabolites and transformation products of cyclophosphamide and ifosfamide: analysis, occurrence and formation during abiotic treatments", *Environ. sci. pollut. res. int.*, vol. 23, iss. 11, pp. 11209-11223, 2016.
11. Marjeta Česen, Dimitra A. Lambropoulou, Maria Laimou-Geraniou, Tina Kosjek, Urška Blaznik, David John Heath, Ester Heath, "Determination of bisphenols and related compounds in honey and their migration from selected food contact materials", *J. agric. food chem.*, vol. 664, iss. 46, pp. 8866-8875, 2016.
12. Romina Daga, Sergio Ribeiro Guevara, Majda Pavlin, Andrea Rizzo, Sonja Lojen, Polona Vreča, Milena Horvat, Maria Arribére, "Historical records of mercury in southern latitudes over 1600 years: Lake Futalaufquen, Northern Patagonia", *Sci. total environ.*, vol. 553, pp. 541-550, 2016.
13. Tadej Dolenec, Todor Serafimovski, Sonja Lojen, Matej Dolenec, Goran Tasev, Sabina Kramar, Nastja Rogan Šmuc, Petra Vrhovnik, "Environmental characterization of lake ecosystems located in Serbo Macedonian massif (FYRM)", In: *Biomineralization: from fundamentals to biomaterials & environmental issues,* (Key Engineering Materials, Vol. 672), Frédéric Marin, ed., Pfaffikon, Trans Tech Publications, 2016, vol. 672, pp. 295-311, 2016.
14. Matevž Dular, Tjaša Griessler Bulc, Ion Gutiérrez-Aguirre, Ester Heath, Tina Kosjek, Aleksandra Krivograd-Klemenčič, Martina Oder, Martin Petkovšek, Nejc Rački, Maja Ravnikar, Andrej Šarc, Brane Širok, Mojca Zupanc, Miha Žitnik, Boris Kompare, "Use of hydrodynamic cavitation in (waste)water treatment", *Ultrason. sonochem.*, vol. 29, pp. 577-588, 2016.
15. Tina Eleršek, Sara Milavec, Maša Korošec, Polona Brezovšek, Noelia Negreira, Božo Žonja, Miren Lopez de Alda, Damià Barceló, Ester Heath, Janez Ščančar, Metka Filipič, "Toxicity of the mixture of selected antineoplastic drugs against aquatic primary producers", *Environ. sci. pollut. res. int.*, vol. 23, iss. 15, 14780-14790, 2016. [COBISS.SI-ID 3722063]
16. Jadran Faganeli, Ingrid Falnoga, Ljudmila Benedik, Zvonka Jeran, Katja Klun, "Accumulation of 210Po in coastal waters (Gulf of Trieste, northern Adriatic Sea)", *J. environ. radioact.*, pp. 1-7, jul. 2016.
17. Sabina Grabner, Barbara Modec, Nataša Bukovec, Peter Bukovec, Maja Čemažar, Simona Kranjc, Gregor Serša, Janez Ščančar, "Cytotoxic trans-platinum(II) complex with 3-hydroxymethylpyridine: synthesis, x-ray structure and biological activity evaluation", *J. inorg. biochem.*, pp. 1-44.
18. Aleš Grošelj, Mojca Kržan, Tina Kosjek, Maša Bošnjak, Gregor Serša, Maja Čemažar, "Bleomycin pharmacokinetics of bolus bleomycin dose in elderly cancer patients treated with electrochemotherapy", *Cancer Chemother Pharmacol*, vol. 77, no. 5, pp. 939-947, 2016.
19. Mae Sexauer Gustin *et al.* (15 avtorjev), "Importance of integration and implementation of emerging and future mercury research into the Minamata convention", *Environ. sci. technol.*, vol. 50, iss. 6, pp. 2767-2770, 2016.
20. Ester Heath, Marjeta Česen, Janez Ščančar, Srdjan Novaković, Vesna Mislej, Marjetka Stražar, Tina Kosjek, et al., "First inter-laboratory comparison exercise for the determination of anticancer drugs in aqueous samples", *Environ. sci. pollut. res. int.*, vol. 23, no. 15, pp. 14692-14704, 2016.
21. Benjamin Horemans *et al.* (12 authors), "Biocarriers improve bioaugmentation efficiency of a rapid sand filter for the treatment of 2,6-dichlorobenzamide (BAM)-contaminated drinking water", *Environ. sci. technol.*, vol. 51, issue 3, pp. 1616-1625, 2016.
22. Marina Isidori, Margherita Lavorgna, Chiara Russo, Michael Kundi, Bojana Žegura, Matjaž Novak, Metka Filipič, Miroslav Mišík, Siegfried Knasmueller, Miren Lopez de Alda, Damià Barceló, Božo Žonja, Marjeta Česen, Janez Ščančar, Tina Kosjek, Ester Heath, "Chemical and toxicological characterisation of anticancer drugs in hospital and municipal wastewaters from Slovenia and Spain", *Environ. pollut. (1987)*, vol. 219, pp. 275-287, 2016.
23. Jácint Jónás, Zoltán Sas, Janja Vaupotič, Erika Kocsis, János Somlai, Tibor Kovács, "Thoron emanation and exhalation of Slovenian soils determined by a PIC detector-equipped radon monitor", *Nukleonika (Wyd. pol.)*, vol. 61, no. 3, pp. 379-384, 2016.
24. Tjaša Kanduč, Nataša Mori, Ajda Koceli, Timotej Verbovšek, "Hydrogeochemistry and isotope geochemistry of Velenje Basin groundwater", *Geologija*, 59, no. 1, pp. 7-21, 2016.
25. Tjaša Kanduč, Zoran Samardžija, Nataša Mori, Andreja Jerebic, Ines Levačić, Miha Kračun, Johanna A. Robinson, Stojan Žigon, Željko Blažeka, David Kocman, "Hydrogeochemical and isotopic characterization of Pesnica River, Slovenia", *Geologija*, vol. 59, no. 2, pp. 179-192, 2016.
26. Tjaša Kanduč, Simon Zavšek, Sergej Jamnikar, Timotej Verbovšek, "Spatial distribution and origin of coalbed gases at the working faces of the Velenje Coal Basin, Slovenia, since the year 2000", *RMZ-mater. geoenviron.*, vol. 63, pp. 213-225, 2016.
27. Dafina Kikaj, Zvonka Jeran, Meleq Bahtijari, Peter Stegnar, "Radon in soil gas in Kosovo", *J. environ. radioact.*, vol. 164, pp. 245-252, 2016.
28. Anja Klančnik, Nataša Toplak, Minka Kovač, Nives Ogrinc, Barbara Jeršek, "Robust PCR-based method for quantification of bovine milk in cheeses made of caprine and ovine milk", *Int. j. dairy technol.*, vol. 69, iss. 4, pp. 540-549, Nov. 2016.
29. Stoimir Kolarević *et al.* (17 authors), "Evaluation of genotoxic pressure along the Sava river", *PloS one*, vol. 11, no. 9, pp. 0162450-1-0162450-23, 2016.
30. Predrag Kolarž, Janja Vaupotič, Ivan Kobal, Predrag Ujić, Zora S. Žunić, "Air ion and aerosol study in rural dwellings", *J. aerosol sci.*, vol. 95, pp. 118-134, 2016.
31. Branko Kontić, "Effects of the revised EIA Directive on practice in Slovenia", *UVP-Rep.*, vol. 30, no. 2, pp. 101-105, 2016.
32. Branko Kontić, Marko Bohanec, Davor Kontić, Nejc Trdin, Maruša Matko, "Improving appraisal of sustainability of energy options - a view from Slovenia", *Energy policy*, vol. 90, pp. 154-171, 2016.
33. Tina Kosjek, Anja Krajnc, Tjaša Gornik, Dušan Žigon, Aleš Grošelj, Gregor Serša, Maja Čemažar, "Identification and quantification of bleomycin in serum and tumor tissue by liquid chromatography coupled to high resolution mass spectrometry", *Talanta (Oxford)*, vol. 160, pp. 164-171.
34. Tina Kosjek, Noelia Negreira, Ester Heath, Miren Lopez de Alda, Damià Barceló, "Biodegradability of the anticancer drug etoposide and identification of the transformation products", *Environ. sci. pollut. res. int.*, vol. 23, iss. 15, pp. 14706-14717, 2016.
35. Kristina Kotnik, Tina Kosjek, Bojana Žegura, Metka Filipič, Ester Heath, "Photolytic fate and genotoxicity of benzophenone-derived compounds and their photodegradation mixtures in the aqueous environmen", *Chemosphere (Oxford)*, vol. 147, pp. 114-123, 2016.
36. Bor Krajnc, Ryoko Fujiyoshi, Janja Vaupotič, Hikaru Amano, Yosuke Sakuta, Asta Gregorič, Nives Ogrinc, "Using ^{222}Rn and carbon isotopes ^{12}C, ^{13}C and ^{14}C to determine CO_2 sources in forest soils developed on contrasting geology in Slovenia", *Environmental earth sciences*, vol. 75, no. 3, pp. 1068-1-1068-10, 2016.
37. Simona Kranjc, Matej Kranjc, Janez Ščančar, Jure Jelenc, Gregor Serša, Damijan Miklavčič, "Electrochemotherapy by pulsed electromagnetic field treatment (PEMF) in mouse melanoma B16F10 in vivo", *Radiol. oncol. (Ljubl.)*, vol. 50, no. 1, pp. 39-48, III, Mar. 2016.
38. Ana Kroflič, Mateja Germ, Špela Mechora, Vekoslava Stibilj, "Selenium and its compounds in aquatic plant Veronica anagallis-aquatica", *Chemosphere (Oxford)*, vol. 151, pp. 296-302, 2016.
39. Davor Kubalek, Gregor Serša, Marko Štrok, Ljudmila Benedik, Zvonka Jeran, "Radioactivity of cigarettes and the importance of ^{210}Po and thorium isotopes for radiation dose assessment due to smoking", *J. environ. radioact.*, vol. 155/156, pp. 97-104, 2016.
40. A.S. Leal, Ivana Marques Marzano, E. C. Pereira Maia, Radojko Jaćimović, "Investigation of the potential antitumor radioactive complex of

platinum(II) with tetracycline", *J. radioanal. nucl. chem.*, vol. 309, pp. 85-89, 2016.
41. Ekaterina Lengert, Alexey Yashchenok, Vsevolod Atkin, Aleš Lapanje, Dmitry A. Gorin, Gleb B. Sukhorukov, Bogdan V. Parakhonskiy, "Hollow silver alginate microspheres for drug delivery and surface enhanced Raman scattering detection", *RSC advances*, vol. 6, iss. 24, pp. 20447-20452, 2016.
42. Gaëtane Lespes, Tea Zuliani, Dirk Schaumlöffel, "Need for revisiting the terminology about speciation", *Environ. sci. pollut. res. int.*, vol. 23, no. 15, pp. 15767-15770, 2016.
43. Darja Lisjak, Olivija Plohl, Janja Vidmar, Boris Majaron, Maja Ponikvar-Svet, "Dissolution mechanism of upconverting AYF_4: Yb, Tm (A = Na or K) nanoparticles in aqueous media", *Langmuir*, vol. 32, no. 32, pp. 8222-8229, 2016.
44. Maruša Matko, Mojca Golobič, Branko Kontić, "Integration of extreme weather event risk assessment into spatial planning of electric power infrastructure", *Urbani izziv (Tisk. izd.)*, let.27, no. 1, pp. 95-112, 2016.
45. Maruša Matko, Mojca Golobič, Branko Kontić, "Vključevanje rezultatov ocene tveganja zaradi izrednih vremenskih dogodkov v prostorsko načrtovanje elektroenergetske infrastrukture", *Urbani izziv (Tisk. izd.)*, vol. 27, no. 1, pp. 9-26, 95-112, jun. 2016.
46. Ilona Matveyeva, Radojko Jaćimović, Petra Planinšek, Borut Smodiš, Mukhambetkali Burkitbayev, "Uptake of uranium, thorium and radium isotopes by plants growing in dam impoundment Tasotkel and the Lower Shu region (Kazakhstan)", *Radiochim. Acta*, vol. 104, iss. 1, pp. 51-57, 2016.
47. Špela Mechora, Tjaša Kanduč, "Environmental assessment of freshwater ecosystems of the Sava River watershed and Cerkniško Lake, Slovenia, using the bioindicator species Fontinalis antipyretica: insights from stable isotopes and selected elements", *Isot. environ. health stud.*, vol. 52, iss. 3, pp. 239-257, 2016.
48. Mirjana Mihailović *et al.* (16 authors), "Biochemical indicators and biomarkers in chub (Squalius cephalus L.) from the Sava River", *Sci. total environ.*, vol. 540, pp. 368-376, 2016.
49. Gazmend Nafezi, Janja Vaupotič, Margarita Kuqali, Asta Gregorič, Gëzim Hodolli, Dafina Kikaj, Zenun Mulaj, Meleq Bahtijari, "Exposure to radon in dwellings in the Pristina region in the vicinity of two lignite-fired power plants", *J. chem. biol. phys. sci.*, vol. 6, no. 1, pp. 71-79, 2016.
50. Marijan Nečemer, Doris Potočnik, Nives Ogrinc, "Discrimination between Slovenian cow, goat and sheep milk and cheese according to geographical origin using a combination of elemental content and stable isotope data", *J. food compos. anal.*, vol. 52, pp. 16-23, 2016.
51. Petra Novak, Tea Zuliani, Radmila Milačič, Janez Ščančar, "Development of an analytical method for the determination of polybrominated diphenyl ethers in sewage sludge by the use of gas chromatography coupled to inductively coupled plasma mass spectrometry", *Anal. chim. acta*, vol. 915, pp. 27-35, 2016.
52. Saša Novak, Martina Lorenzetti, Anja Drame, Janja Vidmar, Janez Ščančar, Metka Filipič, "Diversity of TiO_2 nanopowders' characteristics relevant to toxicity testing", *J. nanopart. res.*, vol. 18, pp. 130-1-130-13, 2016.
53. Breda Novotnik, Janez Ščančar, Radmila Milačič, Metka Filipič, Bojana Žegura, "Cytotoxic and genotoxic potential of Cr(VI), Cr(III)-nitrate and Cr(III)-EDTA complex in human hepatoma (HepG2) cells", *Chemosphere (Oxford)*, vol. 154, pp. 124-131, 2016.
54. Nives Ogrinc, Tjaša Kanduč, Bor Krajnc, Urša Vilhar, Primož Simončič, Lixin Jin, "Inorganic and organic carbon dynamics in forested soils developed on contrasting geology in Slovenia - a stable isotope approach", *Journal of soils and sediments*, vol. 16, no. 2, pp. 382-395, 2016.
55. Momir Paunović *et al.* (12 authors), "Steps towards integrated water management in the Sava River basin", *Water Res. Manag.*, vol. 6, no. 1, pp. 3-10, 2016.
56. Dijana Pavičić Hamer, Delko Barišić, Brigita Šimunac, Branko Petrinec, Marko Štrok, "^{137}Cs distribution in the northern Adriatic Sea", *J. radioanal. nucl. chem.*, vol. 309, iss. 3, pp. 997-998, 2016.
57. Kelly Peeters, Gaëtane Lespes, Tea Zuliani, Janez Ščančar, Radmila Milačič, "The fate of iron nanoparticles in environmental waters treated with nanoscale zero-valent iron, FeONPs and Fe_3O_4(NPs)", *Water res. (Oxford)*, vol. 94, pp. 315-327, 2016.
58. Petra Planinšek, Borut Smodiš, Ljudmila Benedik, "Simultaneous determination and uptake assessment of selected radionuclides in plants grown in substrate contaminated with U-mill tailings", *J. radioanal. nucl. chem.*, vol. 309, no. 1, pp. 351-365, 2016.
59. Stefaan Pommé, Ljudmila Benedik, "On the ^{209}Po half-life error and its confirmation: an answer to the critique", *J. radioanal. nucl. chem.*, vol. 309, no. 2, pp. 931-940, 2016.
60. Doris Potočnik, Marijan Nečemer, Darja Mazej, Radojko Jaćimović, Nives Ogrinc, "Multi-elemental-composition of Slovenian milk: analytical approach and geographical origin determination", *Acta IMEKO*, vol. 5, no. 1, pp. 15-21, 2016.
61. Tanja Potočnik, Nives Ogrinc, Doris Potočnik, Iztok Jože Košir, "Fatty acid composition and δ^{13}C isotopic ratio characterisation of pumpkin seed oil", *J. food compos. anal.*, vol. 53, pp. 85-90, 2016.
62. E. S. Prikhozhdenko, Vsevolod Atkin, Bogdan V. Parakhonskiy, I. A. Rybkin, Aleš Lapanje, Gleb B. Sukhorukov, Dmitry A. Gorin, Alexey Yashchenok, "New post-processing method of preparing nanofibrous SERS substrates with a high density of silver nanoparticles", *RSC advances*, vol. 6, no. 87, pp. 84505-84511, 2016.
63. Lara Prosen, Samo Hudoklin, Maja Čemažar, Monika Štimac, Urša Lampreht Tratar, Maja Ota, Janez Ščančar, Rok Romih, Gregor Serša, "Magnetic field contributes to the cellular uptake for effective therapy with magnetofection using plasmid DNA encoding against Mcam in B16F10 melanoma in vivo", *Nanomedicine (Lond.)*, vol. 11, no. 6, pp. 627-641, 2016.
64. Vladimir Radulović, Andrej Trkov, Radojko Jaćimović, G. Gregoire, Christophe Destouches, "Use of boron nitride for neutron spectrum characterization and cross-section validation in the epithermal range through integral activation measurements", *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 840, pp. 5-14, 2016.
65. Sebastijan Rep, Marko Hočevar, Janja Vaupotič, Luka Ležaič, "Ocena SPECT/CT in odštevne scintigrafije pri bolnikih s primarnim hiperparatiroidizmom", *Bilten*, vol. 33, no. 1, pp. 10-15, 2016.
66. Janine Richter *et al.* (19 authors), "An interlaboratory comparison on whole water samples", *Accredit. qual. assur.*, vol. 21, no. 2, pp. 121-129, 2016.
67. Tomaž Rijavec, Aleš Lapanje, "Hydrogen cyanide in the rhizosphere: not suppressing plant pathogens, but rather regulating availability of phosphate", *Front. microbiol.*, vol. 7, art. 1785, 2016.
68. Angelo Rubino *et al.* (13 authors), "Biogeochemical, isotopic and bacterial distributions trace oceanic abyssal circulation", *PloS one*, vol. 11, no. 1, pp. 0145299-1-0145299-12, 2016.
69. Paula M. B. Salles, Maria Angela Menezes, Radojko Jaćimović, Tarcisio P. R. Campos, "Inorganic elements in sugar samples consumed in several countries", *J. radioanal. nucl. chem.*, vol. 308, pp. 485-493, 2016.
70. Winfried Schröder *et al.* (36 authors), "Spatially valid data of atmospheric deposition of heavy metals and nitrogen derived by moss surveys for pollution risk assessments of ecosystems", *Environ. sci. pollut. res. int.*, vol. 23, iss. 11, pp. 10457-10476, 2016.
71. A. N. Severyukhina *et al.* (12 authors), "Light-induced antibacterial activity of electrospun chitosan-based material containing photosensitizer", *Mater. sci. eng., C, Biomim. mater., sens. syst.*, vol. 70, part 1, pp. 311-316, 2016.
72. Predrag Simonović, Maria Piria, Tea Zuliani, Marina Ilić, Nikola Marinković, Margareta Kračun-Kolarević, Momir Paunović, "Characterization of sections of the Sava River based on fish community structure", *Sci. total environ.*, vol. 574, pp. 264-271, 2016.
73. Mitja Skudnik, Zvonka Jeran, Franc Batič, Damijana Kastelec, "Spatial interpolation of N concentrations and [delta]15N values in the moss Hypnum cupressiforme collected in the forests of Slovenia", *Ecological indicators*, vol. 61, iss. 2, pp. 366-377, 2016.
74. Borut Smodiš, "Automation of a TRIGA-type pneumatic transfer system", *J. radioanal. nucl. chem.*, vol. 309, iss. 1, pp. 107-113, 2016.
75. Izidor Sosič, Martina Gobec, Boris Brus, Damijan Knez, Matej Živec, Janez Konc, Samo Lešnik, Mitja Ogrizek, Aleš Obreza, Dušan Žigon, Dušanka Janežič, Irena Mlinarič-Raščan, Stanislav Gobec, "Nonpeptidic selective inhibitors of the chymotrypsin-like (ß5i) subunit of the immunoproteasome: Elektronski vir", *Angew. Chem. (Int. ed.)*, vol. 55, iss. 19, pp. 5745-5748, 2016.
76. Francesca Sprovieri *et al.* (41 authors), "Atmospheric mercury concentrations observed at the ground-based monitoring sites globally distributed in the framework of the GMOS network", *Atmos. chem. phys.*, vol. 16, no. 18, pp. 11915-11935, 2016.
77. Zdenka Šlejkovec, Helena Podgornik, Peter Černelč, Ingrid Falnoga, "Exceptions in patterns of arsenic compounds in urine of acute promyelocytic leukaemia patients treated with As[sub]2O[sub]3", *Biometals*, iss. 1, vol. 29, pp. 107-118, 2016.
78. Anja Torkar, Mihael Brenčič, Polona Vreča, "Chemical and isotopic characteristics of groundwater-dominated Radovna River (NW Slovenia)", *Environmental earth sciences*, vol. 75, iss. 18, pp. 1-18, 2016.
79. Timotej Verbovšek, Tjaša Kanduč, "Isotope geochemistry of groundwater from fractured Dolomite aquifers in Central Slovenia", *Aquat. geochem.*, vol. 22, no. 2, pp. 131-151, 2016.
80. Janja Vidmar, Radmila Milačič, Viviana Golja, Saša Novak, Janez Ščančar, "Optimization of the procedure for efficient dispersion of titanium

dioxide nanoparticles in aqueous samples", *Analytical methods*, vol. 8, no. 5, pp. 1194-1201, 2016.
81. D. Vromman, I. Lefevre, Zdenka Šlejkovec, Juan-Pablo Martinez, N. Vanhecke, M. Briceño, Mahendra Kumar, Stanley Lutts, "Salinity influences arsenic resistance in the xerohalophyte Atriplex atacamensis Phil.", *Environ. exp. bot.*, vol. 126, pp. 32-43, 2016.
82. Janja Vrzel *et al.* (12 authors), "Determination of the sources of nitrate and the microbiological sources of pollution in the Sava River Basin", *Sci. total environ.*, vol. 573, pp. 1460-1471, 2016.
83. C. M. Zdanowicz, E. M. Krümmel, A. J. Poulain, E. Yumvihoze, J. Chen, Marko Štrok, M. Scheer, Holger Hintelmann, "Historical variations of mercury stable isotope ratios in Arctic glacier firn and ice cores", *Glob. biogeochem. cycles*, vol. 30, iss. 9, pp. 1324-1347, 2016.
84. Tea Zuliani, Ana Mladenovič, Janez Ščančar, Radmila Milačič, "Chemical characterisation of dredged sediments in relation to their potential use in civil engineering", *Environ. monit. assess.*, vol. 188, no. 4, pp. 234-1-234-12, 2016.

Review Article

1. Joel E. Creswell, Annie Carter, Bin Chen, John DeWild, Vesna Fajon, Anthony Rattonetti, Mark Saffari, Martin Tsz-Ki Tsui, Igor Živković, Hans Fedrik Veiteberg Braaten, "Assessing bias in total mercury results after removing a subsample from the bottle", *Int. j. environ. anal. chem.*, vol. 96, iss. 11, pp. 1038-1047, 2016.
2. Radmila Milačič, Tea Zuliani, Janja Vidmar, Janez Ščančar, "Monolithic chromatography in speciation analysis of metal-containing biomolecules: a review", *J. anal. at. spectrom.*, vol. 31, no. 9, pp. 1766-1779, 2016.
3. Janja Mirtič, Ksenija Kogej, Mirjana Gašperlin, Aleš Lapanje, Julijana Kristl, "Polielektrolitni kompleksi kot osnova za načrtovanje novih nanodelcev in nanooblog", *Farm. vestn. (Tisk. izd.)*, vol. 67, no. 4, pp. 310-317, 2016.
4. Polona Vreča, Neža Malenšek, "Slovenian Network of Isotopes in Precipitation (SLONIP) - a review of activities in the period 1981-2015", *Geologija*, 59, no. 1, pp. 67-83, 2016.

Short Article

1. Ester Heath, Metka Filipič, Tina Kosjek, Marina Isidori, "Fate and effects of the residues of anticancer drugs in the environment: editorial", *Environ. sci. pollut. res. int.*, vol. 23, no. 15, pp. 14687-14691, 2016.

Published Conference Contribution (invited lecture)

1. Mateja Germ, Nina Kacjan-Maršić, Helena Šircelj, Ana Kroflič, Ana Jerše, Aleksandra Golob, Janja Turk, Alenka Gaberščik, Vekoslava Stibilj, Ivan Kreft, "Impact of selenium and iodine on buckwheat plant characteristics", In: *The 13th international symposium on buckwheat (ISB): 2016. 9. 9. (Fri.) - 9. 11. (Sun.), [Korea]*, pp. 749-755.

Published Conference Contribution

1. Mihael Brenčič, Polona Vreča, Nina Kononova, "Application of elementary circulation mechanisms according to Dzerdzeevskii in studies of stable isotopic composition of precipitation", In: *Issledovaniye izmeneniy klimata s ispol'zovaniyem metodov klassifikacii rezhimov cirkuljacii atmosfery: trudy mežđunarodnoy naučnoy konferencii, 16-18 maya 2016 g.*, pp. 162-166.
2. Marjeta Česen, Tina Kosjek, Boris Kompare, Metka Filipič, Tina Eleršek, Matjaž Novak, Bojana Žegura, Francesco Busetti, Ester Heath, "Occurrence, fate and effects of cytostatic residues in the aqueous environment", In: *Zbornik referatov in povzetkov*, 22. Slovenski kemijski dnevi, Portorož, 28.-30. september 2016, 6. pp.
3. Ana Drinčić, Irena Nikolić, Tea Zuliani, Radmila Milačič, Janez Ščančar, "Building composites from flay ash, cement and electric arc furnace dust: environmental impacts", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 20-30.
4. Ana Drinčić, Irena Nikolić, Tea Zuliani, Radmila Milačič, Janez Ščančar, "Ocena dolgoročnih okoljskih vplivov gradbenih materialov, ki vsebujejo odpadne snovi, z uporabo različnih izlužitvenih testov", In: *Zbornik 17. posvetovanja z mednarodno udeležbo Gospodarjenje z odpadki - GzO'16 Zeleno urbano rudarjenje*, pp. 69-75.
5. Lojze Gačnik, Radojko Jaćimović, "HPGe gamma detector effective solid angle calculation", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 31-38.
6. Tjaša Gornik, Anja Krajnc, Amadeja Koler, Marko Turnšek, Ester Heath, Jernej Iskra, Peter Krajnc, Karel Jeřábek, Tina Kosjek, "Implementing molecularly imprinted polymer (MIP) in the analytical method for determining sertraline residues in aqueous environment", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 39-45.
7. Marta Jagodic, Janja Snoj Tratnik, Darja Mazej, Anja Stajnko, Majda Pavlin, Mladen Krsnik, Alfred Bogomir Kobal, Lijana Kononenko, Milena Horvat, "Maternal blood levels of selected elements and birth weight of mother - child pairs living in Slovenia", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 46-51.
8. Ana Jerše, Ana Kroflič, Mateja Germ, Nina Kacjan-Maršić, Helena Šircelj, Vekoslava Stibilj, "Iodine and selenium content in buckwheat seeds after foliar spraying of plants with I and Se solution", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 52-55.
9. Bor Krajnc, Mitja Ferlan, Nives Ogrinc, "Evidence of cave ventilation and its contribution to soil CO_2 flux", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 56-64.
10. Ana Kroflič, Ana Jerše, Nina Kacjan-Maršić, Mateja Germ, Helena Šircelj, Vekoslava Stibilj, "Does iodine affect selenium content in buckwheat sprouts?", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 65-68.
11. Anja Mahne Opatić, Marijan Nečemer, Sonja Lojen, "Determination of the geographical origin of Slovenian potato and garlic, based on stabel isotope and elemental analylsis: preliminary results", In: *Proceedings of the 2nd IMEKO FOODS "Metrology Promoting Objective and Measurable Food Quality and Safety", October 2nd - 5th, 2016, Benevento*, pp. 119-122.
12. Maruška Mole, Longlong Wang, Asta Gregorič, Klemen Bergant, Luka Drinovec, Griša Močnik, Samo Stanič, Janja Vaupotič, Marko Vučković, "Študij atmosferskih procesov v Vipavski dolini na podlagi razširjanja aerosolov", In: *Raziskave s področja geodezije in geofizike 2015: zbornik del*, 21. srečanje Slovenskega združenja za geodezijo in geofiziko, Ljubljana, 28. januar 2016, pp. 35-49.
13. Marijan Nečemer, Karmen Bat, Nives Ogrinc, "Capabilities of the combination of isotope ratio mass spectrometry and total reflection X-ray fluorescence spectrometry in foodstuffs analysis", In: *Proceedings of the 2nd IMEKO FOODS "Metrology Promoting Objective and Measurable Food Quality and Safety", October 2nd - 5th, 2016, Benevento*, 4 pp.
14. Petra Novak, Tea Zuliani, Radmila Milačič, Janez Ščančar, "Determination of polybrominated diphenyl ethers in sewage sludge with GC-ICP-MS", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 76-80.
15. Majda Pavlin, Arkadije Popović, Radojko Jaćimović, Milena Horvat, "A study of the thermal release of mercury compounds in FGD gypsum from the Šoštanj Thermal Power Plant using mass spectrometry", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 91-95.
16. Doris Potočnik, Marijan Nečemer, Nives Ogrinc, "Stable isotope composition and elemental profile as a tool for determination of cheese species and geographical origin", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 96-105.
17. Nina Rman, Andrej Lapanje, Tjaša Kanduč, Kim Mezga, "Razvoj podzemne vode v regionalnih geotermalnih vodonosnikih vzhodne Slovenije", In: *Zbornik radova*, XV Srpski simpozijum o hidrogeologiji sa međunarodnim učešćem, Kopaonik, 14-17. septembar 2016. godine, pp. 315-319.
18. Johanna A. Robinson, David Kocman, Davor Kontić, "Building a wireless sensor network to capture air pollution trends in Ljubljana: pilots, demos and experimental case", In: *Smart cities in smart region conference, Lahti 2016, Finland: conference proceedings*, (The publication series of Lahti University of applied sciences, part 27), pp. 183-189.
19. Anja Stajnko, Janja Snoj Tratnik, Darja Mazej, Marta Jagodic, Mladen Krsnik, Lijana Kononenko, Milena Horvat, Ingrid Falnoga, "Cadmium exposure biomarkers and their associations with renal function biomarkers at low level of exposure", In: *Zbornik*, 8. študentska

konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 106-112.
20. Marko Štrok, Borut Smodiš, Darja Mazej, " ^{210}Bi - from interference to advantage in ^{210}Pb determination with liquid scintillation counter", In: *Proceedings of the 20th International Conference on Radionuclide Metrology and its Applications, 8-11 June 2015, Vienna, Austria*, (Applied radiation and isotopes, vol. 109, 2016), pp. 296-300.
21. Janja Vidmar, Primož Oprčkal, Ana Mladenovič, Radmila Milačič, Janez Ščančar, "The fate of zero valent iron nanoparticles after their use in wastewater remediation by single particle ICP-MS", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 113-121.
22. Dušan Žigon, David Neubauer, "Mass spectrometric characterization of cannabinoids in industrial hemp in relation to health risk assessment", In: *Zbornik referatov in povzetkov*, 22. Slovenski kemijski dnevi, Portorož, 28.-30. september 2016, 6 pp.
23. Igor Živković, Milena Horvat, Mladen Šolić, Vesna Fajon, Jože Kotnik, "Speciation of mercury and microbial communities in the seawater of the Central Adriatic Sea", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 122-128.

Independent Component Part or a Chapter in a Monograph

1. Jernej Jerman, Andrej Lešnjak, Luka Snoj, Borut Smodiš, "Inspection of the TRIGA reactor tank", In: *History, development and future of TRIGA research reactors*, (Technical report series, no. 482), Vienna, IAEA = International Atomic Energy Agency, 2016, 10 pp.
2. Radmila Milačič, Tea Zuliani, Janja Vidmar, Janez Ščančar, "Analytical procedures for speciation of chromium, aluminum, and tin in environmental and biological samples", In: *Metallomics: analytical techniques and speciation methods*, Bernhard Michalke, ed., Weinheim, Wiley-VCH, 2016, pp. 237-275.
3. Borut Smodiš, Luka Snoj, "The JSI TRIGA Mark II reactor, Slovenia", In: *History, development and future of TRIGA research reactors*, (Technical report series, no. 482), Vienna, IAEA = International Atomic Energy Agency, 2016, pp. 76-89.

Patent

1. Aleš Lapanje, *The impregnation process and attachment of microorganisms in porous materials,* SI24910 (A), Urad RS za intelektualno lastnino, 29. 07. 2016.

Mentoring

1. Ermira Begu, *Determination of dissolved elemental mercury in surface and industrial waters:* doctoral dissertation, Ljubljana, 2016 (mentor Milena Horvat).
2. Marjeta Česen, *Occurrence, fate and effects of cytostatic residues in the aqueous environment:* doctoral dissertation, Ljubljana, 2016 (mentor Ester Heath; co-mentor Tina Kosjek).
3. Kristina Kotnik, *Occurrence, fate and toxicity of benzophenone derived compounds in the aqueous environment:* doctoral dissertation, Ljubljana, 2016 (mentor Ester Heath; co-mentor Tina Kosjek).
4. Petra Planinšek, *Plant uptake of selected natural radionuclides from contaminated environment:* doctoral dissertation, Ljubljana, 2016 (mentor Borut Smodiš; co-mentor Ljudmila Benedik).
5. Karmen Bizjak Bat, *Characterization of Slovenian apple juice with respect to its geographical origin and agricultural production practice:* doctoral dissertation, Nova Gorica, 2016 (mentors Nives Ogrinc, Branka Mozetič Vodopivec).
6. Katja Klun, *Composition and complexation of colloidal organic matter in coastal sea (Gulf of Trieste):* doctoral dissertation, Ljubljana, 2016 (mentor Jadran Faganeli; co-mentor Ingrid Falnoga).
7. Sabina Berisha, *Mosses as bioindicators of trace elements and nitrogen in Ljubljana forest:* master's thesis, Ljubljana, 2016 (mentor Zvonka Jeran).
8. Dafina Kikaj, *Radon in soil gas in Kosovo:* master's thesis, Ljubljana, 2016 (mentor Peter Stegnar; co-mentors Zvonka Jeran, Meleq Bahtijari).
9. Hiacinta Klemenčič, *Priprava merilnih virov za spektrometrijo alfa s poudarkom na homogenosti nanosa:* master's thesis, Ljubljana, 2016 (mentor Helena Prosen; co-mentor Ljudmila Benedik).
10. Sebastijan Rep, *The role of spect/ct scintigraphy in localization of parathyroid adenomas:* master's thesis, Nova Gorica, 2016 (mentors Marko Hočevar, Janja Vaupotič).
11. Nataša Smrekar, *Assessment of effective doses based on various radon measuring techniques:* master's thesis, Nova Gorica, 2016 (mentor Janja Vaupotič).
12. Katja Valek, *Comparision analysis of formal air impact assessment in the procedure of environmental impact assessment with similar informal analysis performed by experts:* master's thesis, Ljubljana, 2016 (mentor Branko Kontić).
13. Andraž Lovšin, *Optimization of continuous measurment of biologically available fraction of mercury in water sample:* master's thesis, Ljubljana, 2016 (mentor Romana Marinšek Logar; co-mentor Aleš Lapanje).

DEPARTMENT OF AUTOMATION, BIOCYBERNETICS AND ROBOTICS E-1

The research strategy within our department is unique, as it supports a variety of multi- and interdisciplinary research projects. Specifically, our research combines the fields of robotics (including intelligent control, humanoids, cognitive robotics, robot learning, and robot vision), automation, biocybernetics, ergonomics and environmental physiology. The common theme of our research endeavours to date has been optimising "the behaviour of man and machine", accounting for interactions with the environment. Recently, we have added "human-robot partnership" as an additional goal of our research programme. By combining engineering and life sciences, we have been able to make significant contributions to the development of new methods for sensorimotor learning by imitation and coaching, a planetary habitat simulation facility, humanoid vision systems, manikins enabling the evaluation of protective garments for industry and recreation, kinematic models of the human body that serve as a basis for the design of anthropomorphic systems, reconfigurable robotic systems, and a medical treatment for frostbite.

The department maintains the programme group "Automation, robotics and biocybernetics" in the field of Production Technologies (leader prof. dr. Igor B. Mekjavic). Members of the department participate in numerous EU projects in the area of robotics and artificial intelligence, health, and space technologies. We are also active in transferring our research results into various applications through direct collaborations with industry. By maintaining a critical mass of researchers in all areas within one programme group, we have managed to foster exciting multidisciplinary projects.

Research in the area of humanoid and cognitive robotics as well as robot learning is primarily conducted within the Humanoid and Cognitive Robotics Lab (leader dr. Bojan Nemec), which operates within the department. The aim of this laboratory is to create robots capable of helping people and interacting with them in natural environments.

Head:
Prof. Aleš Ude

Historical note: Since its inception the department has maintained an inter- and multidisciplinary research focus. The scientific inheritance of its founders includes pioneering research culminating in the first demonstration of how functional electrical stimulation can assist paraplegics to walk and the development of the first industrial robots in our region. The common denominator in the robotics and biomedical research is improving the quality of life.

During the past year, our research focused on the development of cognitive robotic systems, new robot-learning methodologies, including imitation learning and autonomous exploration, contact modelling, humanoid robot vision, robotic assistive devices, reconfigurable robotic workcells, the automation of industrial manufacturing, studies of human physiology in extreme environments, an evaluation of protective equipment, and the development of biomedical methods. In the past year we acquired two new H2020 projects, AnDy (http://www.andy-project.eu/) and AUTOWARE (http://www.autoware-eu.org), and the programme GOSTOP, which is part of the smart specialization strategy of Slovenia and is coordinated by our department. Through these projects we will widen our research programme in the area of humanoid robotics and factories of the future.

Robotics

In 2016 we continued our successful collaboration in the H2020 project **ReconCell** (A **Recon**figurable robot work**Cell** for the rapid set-up of automated assembly processes in SMEs, http://www.reconcell.eu/), where we developed new reconfiguration technologies that enable the rapid setup of robotic workcells in industrial production. The proposed workcell is based on a number of novel technologies including 1. robot programming by kinesthetic guiding, 2. sensor-based feedback control, 3. robot-aided reconfiguration, 4. object localization using 3-D vision, 5. visual quality control, 6. robot simulation, and 7. integration with business intelligence. Our software implementation is based on ROS (Robot Operating System), which provides tools for effective communications between all workcell elements. The main result in the past year was the development of new passive fixtures that can be automatically reconfigured by robotic manipulation. We developed new control techniques for automatic reconfiguration. Integration with robot-learning approaches based on kinesthetic guiding was also achieved.

Another important topic in the past year was the development of new methodologies for programming by the demonstration for bimanual tasks. This research was performed in the scope of the ARRS project "Learning and autonomous adaptation of dual arm assembly and service tasks". We studied new representations for bimanual tasks based on a task decomposition into absolute and relative coordinates. A new approach where the human co-worker can modify both the spatial course of motion as well as the speed of execution in an intuitive way was developed. It allows a human co-worker to be less precise in the parts of the task that require high precision, as the precision aspect can be provided by the robot. The required dynamic capabilities of the robot were obtained by decoupling the bimanual robot dynamics in path operational space, which is attached to the desired trajectory.

In EU project ACAT we developed a new methodology that enables statistical learning of compliant robot movements. For this purpose we applied a new movement representation called compliant movement primitives.

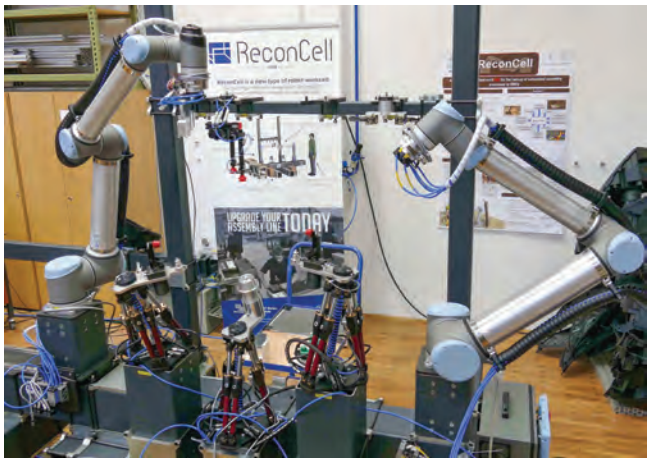


Figure 1: Reconfigurable robotic workcell

Using a biologically plausible control method of an arm exoskeleton we extended the usable arm workspace where humans can efficiently perform manual operations.

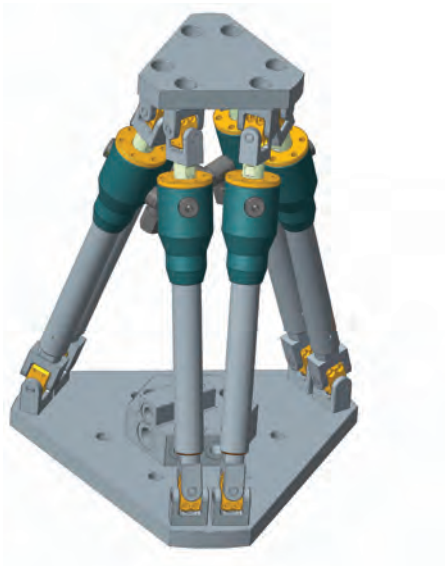


Figure 2: Reconfigurable fixture

Cognitive robots operating in natural environments should be able to quickly acquire new skills without extensive programming and mathematical modelling. In 2016 we successfully concluded the FP7 project **ACAT** (Learning and execution of action categories, http://www.acat-project.eu/). We showed that robot movements in contact with the environment can be effectively represented by position and orientation trajectories supplemented with the associated force-torque profiles. Statistical learning can be used for adaptation. To implement compliant robot movements when mathematical task models are not available, we extended the framework of **dynamic movement primitives** with **torque primitives**. The applicability of the proposed approaches was shown on several problems from automated assembly. Besides publications in high-quality international journals, we also presented the results of the ACAT project at the largest industrial fair in the world, Hannover Messe 2016.

In the scope of the Horizon 2020 project SPEXOR (http://www.spexor.eu/) we developed **a novel control approach** for **robots that are physically coupled with humans**, such as exoskeletons and assisting devices. In contrast with the conventional controllers, where assistance is usually provided indifferently of the configuration of the arm and direction of the motion, we propose a control method that compensates the **anisotropic property of the manipulability** related to the human arm. Consequently, the assistive behaviour of the proposed method allows the user to perform tasks in arm configurations that are otherwise unsuitable due to the lack of manipulability. In effect, the proposed method transforms the elliptical shape of the force manipulability ellipse to a circular shape in the whole space of human arm configurations. We evaluated the proposed approach by an experimental study where a group of subjects wearing a 2 DOF arm-exoskeleton had to move a 4 kg weight between several locations. The results of our study demonstrate that the proposed approach **effectively augments the ability of human motor control** to perform tasks equally well in the whole arm workspace that include configurations with a low intrinsic manipulability.

Many studies on human motor control have examined how humans move their arms. A well-known phenomenon called Fitts' law describes the trade-off between the speed of motion and its accuracy. In robotics, many studies were performed and different control methods were proposed for robots working in well-structured environments. Nevertheless, the cooperation between humans and robots remains a challenging task that is highly relevant for **robots aiming to work together with humans in non-structured environments**. We developed a novel method for the on-line adaptation of robotic trajectories, where humans and robots are autonomous agents coupled through physical interaction, for example, through a manipulated object. Within the proposed framework, the robot adapts to the human motion through the sensory feedback by taking into account the Fitts' law where the user-specific behaviour is estimated using a recursive least-square update. The movement trajectories are represented by the **dynamic movement primitives**, where the adaptation relies on the **iterative learning control** framework. The proposed approach was evaluated by a cooperative human-robot arm reaching task on a plane. We tested the accuracy and efficiency of the proposed method, showed its relevance and demonstrated that the proposed approach fully adapts to the human motor control and maintains the desired accuracy of the movement.

Automation and industrial robotics

An important mission of our department is to transfer our research results to industrial applications. In the past year we prepared and launched a new program in the scope of **Slovenia's smart-specialization strategy** GOSTOP: Building blocks, tools and systems for factories of the future. The aim of the proposed GOSTOP program is to accelerate the development of the factories of the future concept in Slovenia and to provide solutions to the current needs of Slovenian industry, where some companies have already started to introduce this concept into their production facilities. In GOSTOP, 13 companies and 6 research organizations with compatible R&D programs in the factories of the future area joined forces to advance the concept. We identified 4 areas in which decisive breakthroughs can be achieved in Slovenia in the near future: **control technologies, tooling, robotics, and photonics**. In the area of robotics we collaborate with companies such as Kolektor, Domel, Yaskawa, and Podkrižnik.

We prepared and launched a new program in the scope of Slovenia's smart-specialization strategy GOSTOP: Building blocks, tools and systems for factories of the future.

Figure 3: Robot programming by kinesthetic guiding

Our main topics in GOSTOP program are: 1. **intelligent sensors and actuators**, 2. **adaptive robotic workcell for visual quality control**, and 3. **platform of the virtual factory**. Research in the area of intelligent sensors and actuators is directed towards the development of intelligent drive systems with torque-control algorithms and a built-in monitoring system and the possibility for predictive maintenance for each drive system. The second research theme, adaptive robotic workcell, will concentrate on new flexible grasping and manipulation processes, machine-vision, and machine-learning solutions. A specific objective of this activity is to develop an adaptive robotic workcell for the quality control of industrial parts. This will open new opportunities for robots in various tasks that are nowadays still done manually. The main goal of the platform of the virtual factory development is to design and produce an intelligent, competitive, sustainable information system in a smart factory that includes the elements of robotics. This will include research in the field of intelligent control algorithms, discrete event simulation in real time, and Plug & Produce interfaces with the principles of IoT.

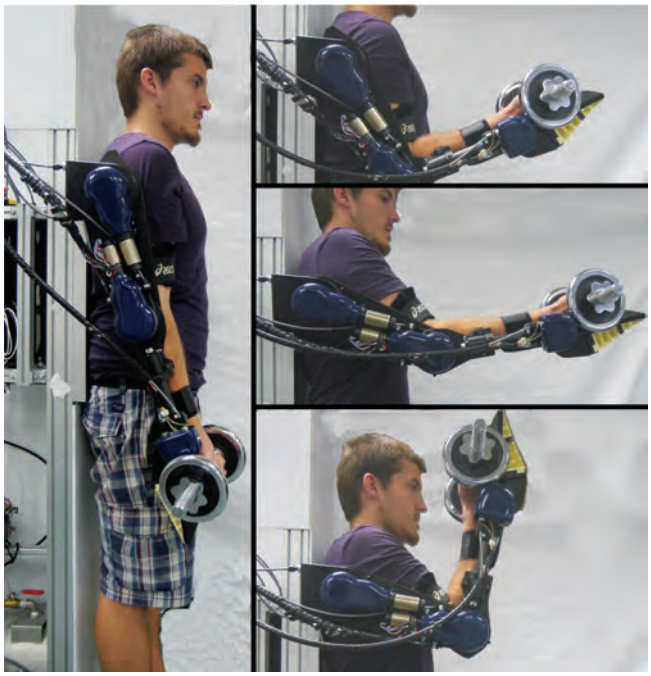


Figure 4: Weight manipulation supported by an exoskeleton

Environmental physiology and ergonomics

The **Biocybernetics group** in our department focuses primarily on research concerning the influence of extreme environmental factors on humans as well as on the development and evaluation of technology, and strategies to maintain safety and unhindered performance in such environments.

We maintain a research facility at the Nordic Centre Planica, where we conduct studies investigating the **effect of inactivity and unloading of the weight-bearing limbs** on physiological function. The effects of inactivity/unloading, as experienced by astronauts during microgravity exposure in space, is simulated with the bed-rest experimental model. Prolonged exposure to microgravity results in musculoskeletal atrophy and deconditioning of the cardiovascular system, which constitute a threat to the health and well-being of astronauts. Given that various space agencies are aiming to pursue long-term space mission in the near future, novel issues connected to space habitation are highly important. In particular, due to technical reasons, the environment within future Lunar and Mars habitats will be **hypobaric and hypoxic**. The continued aim of our research programme in space life sciences is to assess the effect of hypoxia on the processes of adaptation to microgravity which have been observed in a normoxic environment. We achieve this by comparing the adaptation of physiological systems to inactivity/unloading in a normoxic environment, with the changes observed in a hypoxic environment. Our current research in this area mostly focusses on novel strategies to counter the effects of inactivity and/or hypoxia on musculoskeletal system deconditioning.

We have initiated a research programme investigating the concept of physiological cross-tolerance. Specifically, we are investigating how prolonged exposure to one environmental stressor will influence the same responses to another stressor. We are currently most interested in the interactions between heat and hypoxia, their respective effects on human performance, and on the characteristics of autonomic temperature regulation. Another focus of our research is the effect of ambient humidity on thermal balance, physical performance, and cognitive function.

Figure 5: Investigating the effect of hypoxic acclimation on exercise performance in a hot enviroment

In this regard, we continue to assess the available technologies and various strategies in maintaining unhindered performance in hot environments.

With the industrial partner Kimberly-Clark (USA) we investigate novel strategies in the development of **optimal personal protective garments**. A significant step in our human manikin programme was the development of a **sweating thermal head manikin**, with both visual and breathing functionality. Visual images obtained from cameras situated in the eye sockets of the manikin can be analysed with dedicated software to provide an index of the magnitude of fogging in say goggles and/or face masks/visors. Furthermore, the mouth of the manikin is connected to a breathing simulator that monitors the pressure and volume during inspiration and expiration, and calculates the work of breathing imposed by a breathing apparatus. The sweating thermal head manikin is currently being used for evaluating helmets, hoods and breathing apparatus. Additionally, utilising our **sweating thermal hand manikin** we evaluated the thermal and evaporative resistances of new concepts in hand protection for the industrial partner W.L. Gore and Associates (USA & Germany).

Figure 6: Sweating thermal head manikin

Compression socks are now widely used in recreation, sport and rehabilitation. Standards have been established governing their classification and use, yet there is a paucity of data concerning their efficacy. In collaboration with industrial partner Intersocks d.o.o., we studied the **effect of applying compression socks** during recovery following a variety of activities in laboratory and field conditions. The results indicate that, though the magnitude of the exercise-induced delayed onset muscle soreness is reduced by the application of compression socks, the use of the socks does not exert any significant effect on subsequent muscle function.

Our hypoxic exercise and confinement studies investigate the potential additive effects of exercise training during intermittent or continuous exposure to hypoxia on appetite regulation, oxidative stress and sleep modulation. The impetus for these studies is recent evidence that **hypoxia per se can modify appetite** and thereby modulate body mass, and could thus provide a strategy for inducing weight loss and treating metabolic syndrome. This is one of the key priorities of modern research in the field of non-communicable disease prevention, given the fact that the prevalence of obesity is escalating in Europe, particularly among children and adolescents.

Physical disabilities are no longer a hindrance to participation in recreation and outdoor activities. Paraplegic individuals, for example, now practice diving with self-contained underwater breathing apparatus. In cooperation with personnel from the University Clinical Centre Maribor we investigated the effect of cold-water immersion on the physiological responses of paraplegic divers. In particular, we studied their ability to maintain their core temperature during a simulated dive protocol in cold water.

Figure 7: Testing of compression socks

With the support of the Slovenian Sport Foundation we investigated the **effect of simulated altitude conditions on factors** that can affect alpine skiing ability in children. Whereas in the past recreational skiing was limited to low altitudes, present day development of high-altitude ski resorts allows individuals of all ages and abilities to ascend to such high-altitude ski slopes (> 3000m). The altitude of such EU ski resorts is at a level where the prevailing hypoxia may have **detrimental effects** on a variety of physiological and psychological systems. We assessed the effect of hypoxia on: i) cardiorespiratory responses to exercise on a cycle and ski ergometer, ii) muscle strength, iii) orthostatic tolerance, iv) visual function, v) sleep, vi) pulmonary function, and vii) cognitive function. The study was conducted at our research facility at the Olympic Sport Centre Planica. There does not appear to be a significant difference between adults and children, in the manner and magnitude of the effect of hypoxia on physiological factors important for downhill skiing.

Hypoxia associated with high-altitude exposure triggers numerous **cardiovascular adjustments** and can lead to life-threatening conditions. Nowadays a vast number of high altitude visitors are potentially more susceptible to the detrimental effects of **hypobaric hypoxia**. In particular, individuals born prematurely might be especially vulnerable due to prematurity induced cardiorespiratory control alternations resulting in **blunted ventilator and cerebrovascular responses to hypoxia**. Within the ARRS-funded project we compared the effect of normobaric and hypobaric hypoxic exercise-

induced cardiorespiratory responses in adults that had been born prematurely with results observed in normal-birth individuals. Preliminary data indicates that individuals born prematurely might exhibit reduced ventilatory response at rest, but not during physical activity.

Climate change is the biggest global health threat of the 21st century, with enormous consequences for humanity. Rising temperatures have been observed in Europe considerably more than in other areas, and have become a growing challenge for our community. Problems are already experienced by millions of Europeans during summer months, particularly in occupational settings. In addition to the well-known effects of heat exposure, a number of studies have confirmed a 2% reduction in productivity for each degree centigrade above 25°C. Given this productivity loss, **reducing the impacts of rising workplace temperatures** will produce two strategic benefits for EU: i) it will ensure the wellbeing of the EU's workforce, and ii) it will improve the EU's competitiveness and secure its future economy. In the framework of the Horizon 2020 project "Heat Shield" we are collaborating with the industrial partner Odelo to mitigate the detrimental effects of heat waves on the workforce in their manufacturing plant.

Some outstanding publications in the past years

1. J. Babič, E. Oztop, and M. Kawato (2016) Human motor adaptation in whole body motion. Scientific Reports, vol. 6, pp. 32868-1-32868-12.
2. M. Deniša, A. Gams, A. Ude, and T. Petrič (2016) Learning compliant movement primitives through demonstration and statistical generalization. IEEE/ASME Transactions on Mechatronics, vol. 21, no. 5, pp. 2581-2594
3. E. Rueckert, J. Čamernik, J. Peters, and J. Babič (2016) Probabilistic movement models show that postural control precedes and predicts volitional motor control. Scientific Reports, vol. 6, pp. 28455-1- 28455-12.
4. A. Gams, T. Petrič, M. Do, B. Nemec, J. Morimoto, T. Asfour, and A. Ude (2016) Adaptation and coaching of periodic motion primitives through physical and visual interaction, Robotics and Autonomous Systems, vol. 75, pp. 340-351.
5. L. Peternel, T. Petrič, T. Noda, A. Ude, J. Morimoto, and J. Babič (2016) Adaptive control of exoskeleton robots for periodic assistive behaviours based on EMG feedback minimisation, PLoS ONE, vol. 11, no. 2, e0148942.
6. T. Debevec, E. J. Simpson, I. B. Mekjavić, O. Eiken, and I. A. Macdonald (2016) Effects of prolonged hypoxia and bed rest on appetite and appetite-related hormones. Appetite, vol. 107, pp. 28-37.
7. B. Mekjavić, M. Amon, R. Kölegård, S. N. Kounalakis, L. Simpson, O. Eiken, M. E. Keramidas, and I. A. Macdonald (2016) The effect of normobaric hypoxic confinementon metabolism, gut hormones, and body composition: promised and limitations. Frontiers in Physiology, vol. 7, pp. 202-1-202-13.
8. T. Debevec, V. Pialoux, S. Ehrström, A. Ribon, O. Eiken, I. B. Mekjavić, and G. P. Millet (2016) Femhab: the effects of bed rest and hypoxia on oxidative stress in healthy females. Journal of Applied Physiology, vol. 120, no. 8, pp. 930-938.

Organization of conferences, congresses and meetings

1. 6th International Conference on the Physiology and Pharmacology of Temperature Regulation (PPTR), Ljubljana, 5. – 9. 12. 2016.
2. Workshop at European Robotics Forum (ERF 2016): Efficient Robot Programming, Force Control and Passive Reconfiguration Technologies for Fast Set-Up of Robotic Workcells, Ljubljana, 23. 3. 2016.
3. Workshop at a major robotics conference IROS 2016: Human-Robot Collaboration: Towards Co-Adaptive Learning Through Semi-Autonomy and Shared Control, Daejeon, Korea, 10. 10. 2016.
4. Kick-off meeting of Horizon 2020 project SPEXOR, Ljubljana, 28. – 29. 1. 2016.
5. General meeting of Horizon 2020 project ReconCell, Ljubljana, 10. – 20. 9. 2016.

INTERNATIONAL PROJECTS

1. Stimulators and Parts
   Prof. Aleš Ude
2. Yaskawa: Polishing and Grinding by Programming by Demonstration and Autonomous Adaptation
   Prof. Aleš Ude
   Yaskawa Electric Corporation
3. Kimberly-Clark - Development of LCD Shutter in the Year 2016
   Asst. Prof. Leon Žlajpah
   Kimberly-clark
4. Kimberly Clark: Stetson and Pillars of Comfort
   Prof. Igor Mekjavić
   Kimberly-clark
5. Yaskawa: Polishing and Grinding by Programming by Demonstration
   Prof. Aleš Ude
   Yaskawa Electric Corporation
6. 7FP - ACAT; Learning and Execution of Action Categories
   Prof. Aleš Ude
   European Commission
7. 7FP - CoDyCo; Whole-body Compliant Dynamical Contacts in Cognitive Humanoids
   Asst. Prof. Jan Babič
   European Commission
8. COST CA16116 - 20786; Wearable Robots for Augmentation, Assistance or Substitution of Human Motor Functions
   Asst. Prof. Jan Babič
   Cost Office
9. H2020 - HEAT-SHIELD; Integrated Inter-Sector Framework to increase the Thermal Resilience of European Workers in the Context of Global Warming
   Prof. Igor Mekjavić
   European Commission
10. H2020 - AUTOWARE; Wireless Autonomous, Reliable and Resilient Production Operation Architecture for Cognitive Manufacturing

Prof. Aleš Ude
European Commission
11. H2020 - ReconCell; A Reconfigurable Robot Workcell for Fast Set-up of Automated Assembly Processes in SME-s
Prof. Aleš Ude
European Commission
12. H2020 - SPEXOR; Spinal Exoskeletal Robot for Low Back Pain Prevention and Vocational Reintegration
Asst. Prof. Jan Babič
European Commission
13. Control of Bimanual Physical Human-Robot Interaction for Rehabilitation and Industrial Services
Asst. Prof. Andrej Gams
Slovenian Research Agency
14. Improving Prediction of Optimization Based Model-Predictive Control for High-Performance Bipedal Robotic Plaftorms with Learning of Initial Approximations
Asst. Prof. Andrej Gams
Slovenian Research Agency
15. Discovery of the Optimality Criteria for Full Body Human Movements Using Inverse Reinforcement Learning
Asst. Prof. Jan Babič
Slovenian Research Agency

RESEARCH PROGRAM

1. Avtomation, robotics and biocybernetics
Prof. Igor Mekjavić

R & D GRANTS AND CONTRACTS

1. Learning and autonomous adaptation of dual arm assembly and service tasks
Prof. Aleš Ude
2. Cardiorespiratory responses during hypoxic exercise in individuals born prematurely
Asst. Prof. Tadej Debevec
3. Methods of algebra and functional analysis in theory and practice of financial mathematics
Prof. Igor Klep
4. Building blocks, tools and systems for the Factories of the Future – GOSTOP
Asst. Prof. Igor Kovač
5. Customer Service – Abroad
Prof. Igor Mekjavić

NEW CONTRACTS

1. Specification of requirements and development of solutions for an automatic MES, supervision and plant control system
Dr. Anton Ružić
Žito Prehrambena Industrija, d. d.
2. Prevention of delayed onset muscle soreness using compression socks
Prof. Igor Mekjavić
Intersocks d. o. o., Kočevje

VISITORS FROM ABROAD

1. dr. Han Houdijk, Heliomare, Amsterdam, Netherlands 28 – 30 January 2016
2. dr. Coen van Bannek, Heliomare, Amsterdam, Netherlands 28 – 30 January 2016
3. Idsart Kingma, Vrije Universiteit, Amsterdam, Netherlands 28 – 30 January 2016
4. Jacob Hendrik Van Dieen, Amsterdam, Netherlands, 28. – 30 January 2016
5. prof. Ludovic Righetti, Max Planck Institute, Germany, 30 March – 2 April 2016
6. dr. Diane Cooper, DLR, Köln, Germany 14 – 28 February 2016
7. Prof. Egon Muller, Technische Universitat Chemnitz, Chemintz, Germany, 21–24 March 2016
8. Michael Koehle, University of British Columbia, Canada, 7 – 9 March 2016
9. Mathias Poussel, Centre Hospitalier Regional Universitaire de NANCY, Lausanne, Switzerland, 9 – 12. May 2016
10. prof. Mikael Grönkvist, KTH, Stockholm, Sweden, 29 March – 8 April 2016
11. prof. dr. Ola Eiken, KTH, Stockholm, Sweden, 29 March – 8 April 2016
12. dr. Mirko Raković, University of Novi Sad, Novi Sad, Serbia, 10 – 12 May 2016
13. dr. Srđan Savić, University of Novi Sad, Novi Sad, Serbia, 10 – 12 May 2016
14. dr. Milutin Nikolić, University of Novi Sad, Novi Sad, Serbia, 10 – 12 May 2016
15. Aleksandar Batinica, University of Novi Sad, Novi Sad, Serbia, 10 – 12 May 2016
16. prof. dr. Craig Asmundson, Univerza Simon Frazer, Vancouver, Canada, 12 –13May 2016
17. Franck Buret, Kimberly Clark, Roswell, USA, 6 – 10 June 2016
18. Manish Raval, Kimberly Clark, Roswell, USA, 6 – 10 June 2016
19. Damon Larkin, Kimberly Clark, Roswell, USA, 6 – 10 June 2016
20. Lenox Wilson, Kimberly Clark, Roswell, USA, 6 – 10 June 2016
21. Pam Mayberry, Kimberly Clark, Roswell, USA, 3 – 11 June 2016
22. Stephanie Teat, Kimberly Clark, Roswell, USA, 3 – 11 June 2016
23. Roberto Greselin, Kimberly Clark, Roswell, USA, 8 – 9. June 2016
24. dr. Kai Salminen, Hermia Group New Factory Ltd, Tampere, Finland, 23 – 28 July 2016
25. Michael Kaplin, Eberhard Karls University Tuebingen, Dettingen, Germany, 3 October – 4 November 2016
26. Marc Piggemeyer, Institute for Man-Machine Interaction, RWTH Aachen University, Aachen, Germany, 28 August – 3. September 2016
27. Anders Prier Lindvig, University of Southern Denmark, Odense, Denmark, 12 – 20 September 2016
28. Prof. Ken Parsons, Loughborough University, Leicestershire, United Kingdom, 4.– 10. 12. 2016
29. Alex Buoite Stella, University of Udine, Udine, Italy, 4 – 9 December 2016
30. dr. Jessica Mee, Bangor University, Bangor, Gwynedd, United Kingdom, 4 – 9 December 2016
31. dr. Oliver Gibson, Brunel University, London, United Kingdom, 4 – 9 December 2016
32. dr. Yungbin Kim, Seoul National University, Seoul, South Korea, 4 – 10 December 2016
33. Sora Shin, Seoul National University, Seoul, South Korea, 3 – 9 December 2016
34. Panagiotis Miliotis, National and Kapodistrian University of Athens, Athens, Greece 4 – 10 December 2016

STAFF

Researchers
1. Asst. Prof. Jan Babič
2. Asst. Prof. Tadej Debevec
3. Asst. Prof. Andrej Gams
4. Asst. Prof. Igor Kovač
5. Prof. Igor Mekjavić
6. Asst. Prof. Bojan Nemec
7. Dr. Matjaž Omladič
8. Dr. Tadej Petrič
9. Asst. Prof. Dušan Ponikvar*
10. Dr. Anton Ružić
11. **Prof. Aleš Ude, Head**
12. Asst. Prof. Leon Žlajpah

Postdoctoral associates
13. Dr. Urša Ciuha
14. Prof. Igor Klep
15. Prof. Tomaž Košir*
16. Asst. Prof. Marjeta Kramar Fijavž*
17. Dr. Nejc Likar
18. Dr. Adam Mc Donnell
19. Dr. Zrinka Potočanac
20. Dr. Barry Martin Ridge
21. Asst. Prof. Klemen Šivic*
22. *Dr. Rok Vuga, left 01.06.16*

Postgraduates
23. Robert Bevec, B. Sc.
24. Jernej Čamernik, B. Sc.
25. Miha Deniša, B. Sc.
26. Miha Dežman, B. Sc.
27. Timotej Gašpar, B. Sc.
28. Rok Goljat, B. Sc.
29. Aljaž Kramberger, B. Sc.
30. Rok Pahič, B. Sc.
31. Martin Pečar, B. Sc.
32. Alexandros Sotiridis, B. Sc.

Technical officers
33. Martin Bem, B. Sc.
34. Mišel Cevzar, B. Sc.
35. Damjan Fink
36. Simon Reberšek, B. Sc.
37. Bogomir Vrhovec, B. Sc.

Technical and administrative staff
38. Tanja Dragojević, B. Sc.
39. *Anja Gosar, 01.12.16, transferred to Department U1*
40. Marija Kavčič, B. Sc.
41. Jana Stanič
42. Danijela Zeljković Anžiček, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Jan Babič, Erhan Oztop, Mitsuo Kawato, "Human motor adaptation in whole body motion", *Scientific reports*, vol. 6, pp. 32868-1-32868-12, 2016.
2. Urška Ciuha, Mikael Grönkvist, Igor B. Mekjavić, Ola Eiken, "Strategies for increasing evaporative cooling during simulated desert patrol mission", *Ergonomics*, vol. 59, no. 2, pp. 298-309, 2016.
3. Urška Ciuha, Igor B. Mekjavić, "Regional thermal comfort zone in males and females", *Physiol. behav.*, vol. 161, pp. 123-129, 2016.
4. Jernej Čamernik, Zrinka Potočanac, Luka Peternel, Jan Babič, "Holding a handle for balance during continuous postural perturbations: immediate and transitionary effects on whole body posture", *Front. hum. neurosci.*, vol. 10, pp. 486-1-486-8, 2016.
5. Tadej Debevec, Vincent Pialoux, Sabine Ehrström, Alexandra Ribon, Ola Eiken, Igor B. Mekjavić, Grégoire P. Millet, "FemHab: the effects of bed rest and hypoxia on oxidative stress in healthy females", *J Appl Physiol*, vol. 120, no. 8, pp. 930-938, 2016.
6. Tadej Debevec, Elizabeth J. Simpson, Igor B. Mekjavić, Ola Eiken, Ian A. Macdonald, "Effects of prolonged hypoxia and bed rest on appetite and appetite-related hormones", *Appetite,* vol. 107, pp. 28-37, 2016.
7. Miha Deniša, Andrej Gams, Aleš Ude, Tadej Petrič, "Learning compliant movement primitives through demonstration and statistical generalization", *IEEE/ASME trans. mechatron.*, vol. 21, no. 5, pp. 2581-2594, 2016.
8. Ola Eiken, Igor B. Mekjavić, Stylianos N. Kounalakis, Roger Kölegård, "Pressure distension in leg vessels as influenced by prolonged bedrest and a pressure habituation regimen", *J Appl Physiol*, vol. 120, no. 12, pp. 1458-1465, 2016.
9. Helio Fernandez Tellez, Shawnda A. Morrison, X Neyt, O. Mairesse, Maria Francesca Piacentini, E Macdonald-Nethercott, Andrej Pangerc, Leja Dolenc-Grošelj, Ola Eiken, Nathalie Pattyn, Igor B. Mekjavić, Romain Meeusen, "Exercise during short-term and long-term continuous exposure to hypoxia exacerbates sleep-related periodic breathing", *Sleep (New York)*, vol. 39, iss. 4, pp. 773-783, 2016.
10. Andrej Gams, Tadej Petrič, Martin Do, Bojan Nemec, Jun Morimoto, Tamim Asfour, Aleš Ude, "Adaptation and coaching of periodic motion primitives through physical and visual interaction", *Robot. auton. syst.*, vol. 75, part B, pp. 340-351, 2016.
11. Polona Jaki, Eva Lenassi, Ola Eiken, Igor B. Mekjavić, "Effect of acute hypercapnia during 10-d hypoxic bed rest on posterior eye structures", *J Appl Physiol*, vol. 120, no. 10, pp. 1241-1248, 2016.
12. Michail E. Keramidas, Roger Kölegård, Igor B. Mekjavić, Ola Eiken, "PlanHab: hypoxia exaggerates the bed-rest-induced reduction in peak oxygen uptake during upright cycle ergometry", *Am J Physiol Heart Circ Physiol*, vol. 311, no. 2, pp. H453-H464, 2016.
13. Michail E. Keramidas, Igor B. Mekjavić, Roger Kölegård, Alexander Choukèr, Claudia Strewe, Ola Eiken, "PlanHab: hypoxia counteracts the erythropoietin suppression, but seems to exaggerate the plasma volume reduction induced by 3 weeks of bed rest", *Physiol. reports*, vol. 4, no. 7, pp. e12760-1-e12760-10, 2016.
14. Michail E. Keramidas, Nektarios Stavrou, Stylianos N. Kounalakis, Ola Eiken, Igor B. Mekjavić, "Severe hypoxia during incremental exercise to exhaustion provokes negative post-exercise affects", *Physiol. behav.*, vol. 156, pp. 171-176, 2016.
15. Igor Klep, Scott McCullough, Christopher Nelson, "On trace-convex noncommutative polynomials", *Mich. math. j.*, vol. 65, iss. 1, pp. 131-146, 2016.
16. Aljaž Kramberger, Rok Piltaver, Bojan Nemec, Matjaž Gams, Aleš Ude, "Learning of assembly constraints by demonstration and active exploration", *Ind. rob.*, vol. 43, no. 5, pp. 524-534, 2016.
17. Polona Kraner Zrim, Igor B. Mekjavić, Tatjana Rijavec, "Properties of laminated silica aerogel fibrous matting composites for footwear applications", *Tex. res. j.*, vol. 86, no. 10, pp. 1063-1073, 2016.
18. Tijs Louwies, Polona Jaki, Bianca Cox, Ola Eiken, Igor B. Mekjavić, Stylianos N. Kounalakis, Patrick De Boever, "Separate and combined effects of hypoxia and horizontal bed rest on retinal blood vessel diameters", *Invest. ophthalmol. visual sci.*, vol. 57, no. 11, pp. 4927-4932, Sep. 2016.
19. Igor B. Mekjavić, Mojca Amon, Roger Kölegård, Stylianos N. Kounalakis, Liz Simpson, Ola Eiken, Michail E. Keramidas, Ian A. Macdonald, "The effect of normobaric hypoxic confinementon metabolism, gut hormones, and body composition: promised and limitations", *Front. physiol.*, vol. 7, pp. 202-1-202-13, 2016.
20. Grégoire P. Millet, Tadej Debevec, Franck Brocherie, Davide Malatesta, Oliver Girard, "Therapeutic use of exercising in hypoxia: promises and limitations", *Front. physiol.*, vol. 7, art. 224, 2016.
21. Shawnda A. Morrison, Andrej Pangerc, Ola Eiken, Igor B. Mekjavić, Leja Dolenc-Grošelj, "Effect of exercise on night periodic breathing and loop gain during hypoxic confinement", *Respirology*, vol. 21, iss. 4, pp. 746-753, May 2016.
22. Luka Peternel, Tomoyuki Noda, Tadej Petrič, Aleš Ude, Jun Morimoto, Jan Babič, "Adaptive control of exoskeleton robots for periodic assistive behaviours based on EMG feedback minimisation", *PloS one*, vol. 11, no. 2, pp. 0148942-1-0148942-26, 2016.
23. Tim Podlogar, Tadej Debevec, "Effects of 14-day high-carbohydrate diet on exercise performance of a low-carbohydrate adaptive athlete - case study", *Kinesiol. Slov.,* lLetn. 22, no. 1, pp. 37-46, 2016.
24. Zrinka Potočanac, Mirjam Pijnappels, Sabine Verschueren, Jaap van Dieën, Jacques Duysens, "Two stage muscle activity responses in decisions about leg movement adjustments during trip recovery", *Journal of neurophysiology*, vol. 115, no. 1, pp. 143-156, 2016.
25. Alexandra Ribon, Vincent Pialoux, Jonas J. Saugy, Thomas Rupp, Raphael Faiss, Tadej Debevec, Grégoire P. Millet, "Exposure to hypobaric hypoxia results in higher oxidative stress compared to normobaric hypoxia", *Respiratory physiology & neurobiology*, vol. 233, pp. 23-27, 2016.
26. Joern Rittweger *et al.* (11 authors), "On the combined effects of normobaric hypoxia and bed rest upon bone and mineral metabolism: results from the PlanHab study", *Bone*, vol. 91, pp. 130-138, 2016.
27. Elmar Rueckert, Jernej Čamernik, Jan Peters, Jan Babič, "Probabilistic movement models show that postural control precedes and predicts volitional motor control", *Scientific reports*, vol. 6, pp. 28455-1- 28455-12, 2016.
28. Erik Rullman, Igor B. Mekjavić, Helene Fischer, Ola Eiken, "PlanHab PlanHab (Planetary Habitat Simulation): the combined and separate effects of 21 days bed rest and hypoxic confinement on human skeletal muscle miRNA expression", *Physiol. reports*, vol. 4, no. 8, pp. e12753-1-e12753-12, 2016.
29. Elizabeth J. Simpson, Tadej Debevec, Ola Eiken, Igor B. Mekjavić, Ian A. Macdonald, "PlanHab: the combined and separate effects of 16 days bed rest and normobaric hypoxic confinement on circulating lipids and indices of insulin sensitivity in healthy men", *J Appl Physiol*, vol. 120, no. 8, pp. 947-955, 2016.
30. Pablo Ramon Soria, Robert Bevec, Begoña C. Arrue, Aleš Ude, Anibal Ollero, "Extracting objects for aerial manipulation on UAVs using low cost stereo sensors", *Sensors*, vol. 16, no. 5, pp. 700-1-700-19, 2016.
31. Rok Vuga, Bojan Nemec, Aleš Ude, "Speed adaptation for self-improvement of skills learned from user demonstrations", *Robotica (Camb.)*, vol. 34, no. 12, pp. 2806-2822, 2016.

Published Conference Contribution

1. Miha Deniša, Aleš Ude, "Movement recognition and cooperative task synthesis through hierarchical database search", In: *Papers*, 25th International Workshop on Robotics in Alpe-Adria-Danube Region RAAD 2016, June 30th - July 2nd 2016, Belgrade, 7 pp.
2. Miha Deniša, Aleš Ude, Andrej Gams, "Adaptation of motor primitives to the environment through learning and statistical generalization", In: *Advances in robot design and intelligent control: proceedings of the 24th International Conference on Robotics in Alpe-Adria-Danube Region, (RAAD), [27-29 May 2015, Bucharest, Romania]*, (Advances in intelligent systems and computing, volume 371), pp. 449-457.
3. Miha Dežman, Tadej Debevec, Jan Babič, Andrej Gams, "Effects of passive ankle exoskeleton on human energy expenditure: pilot evaluation", In: *Papers*, 25th International Workshop on Robotics in Alpe-Adria-Danube Region RAAD 2016, June 30th - July 2nd 2016, Belgrade, 8 pp.
4. Miha Dežman, Tadej Debevec, Jan Babič, Andrej Gams, "Passive ankle exoskeleton: design and practical evaluation", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 140-148.
5. Andrej Gams, Tadej Petrič, "On-line modifications of robotic trajectories: learning, coaching and force vs. position feedback", In:

Papers, 25th International Workshop on Robotics in Alpe-Adria-Danube Region RAAD 2016, June 30th - July 2nd 2016, Belgrade, 8 pp.
6. Andrej Gams, Aleš Ude, "On-line coaching of robots through visual and physical interaction: analysis of effectiveness of human-robot interaction strategies", In: *ICRA 2016*, 2016 IEEE International Conference on Robotics and Automation, May 16-21, 2016, Stockholm, Sweden, pp. 3028-3034.
7. Aljaž Kramberger, Andrej Gams, Bojan Nemec, Casper Schou, Dmimitros Chrysostomou, Ole Madsen, Aleš Ude, "Transfer of contact skills to new environmental conditions", In: *HUMANOIDS 2016*, IEEE-RAS 16th International Conference on Humanoid Robots, November 15-17, 2016, Cancun, Mexico, pp. 668-675.
8. Aljaž Kramberger, Andrej Gams, Bojan Nemec, Aleš Ude, "Generalization of orientational motion in unit quaternion space", In: *HUMANOIDS 2016*, IEEE-RAS 16th International Conference on Humanoid Robots, November 15-17, 2016, Cancun, Mexico, pp. 808-813.
9. Aljaž Kramberger, Casper Schou, Dmimitros Chrysostomou, Andrej Gams, Ole Madsen, Aleš Ude, "Fast setup and adaptation of industrial assembly tasks with force-based exception strategies: pilot evaluation", In: *Papers*, 25th International Workshop on Robotics in Alpe-Adria-Danube Region RAAD 2016, June 30th - July 2nd 2016, Belgrade, 8 pp.
10. Igor B. Mekjavić, "Kampus Planica: predstavitev raziskovalnih del in dobre prakse: research and best practices", In: *Zbornik*, IX. konferenca slovenskih znanstvenikov in gospodarstvenikov iz sveta in Slovenije, Ljubljana, 27.-28. oktober 2016, pp. 134-136.
11. Bojan Nemec, Nejc Likar, Andrej Gams, Aleš Ude, "Bimanual human robot cooperation with adaptive stiffness control", In: *HUMANOIDS 2016*, IEEE-RAS 16th International Conference on Humanoid Robots, November 15-17, 2016, Cancun, Mexico, pp. 607-613.
12. Luka Peternel, Erhan Oztop, Jan Babič, "A shared control method for online human-in-the-loop robot learning based on locally weighted regression", In: *IROS 2016*, 2016/IEEE/RSJ International Conference on Inteligent Robots and Systems, September 28 - October 9-14, 2016, Daejeon, Korea, pp. 3900-3906.
13. Tadej Petrič, Andrej Gams, "Effect of sequence order on autonomous robotic database expansion", In: *Papers*, 25th International Workshop on Robotics in Alpe-Adria-Danube Region RAAD 2016, June 30th - July 2nd 2016, Belgrade, 8 pp.
14. Tadej Petrič, Rok Goljat, Jan Babič, "Augmentation of human arm motor control by isotropic force manipulability", In: *IROS 2016*, 2016/IEEE/RSJ International Conference on Inteligent Robots and Systems, September 28 - October 9-14, 2016, Daejeon, Korea, pp. 696-701.
15. Tadej Petrič, Rok Goljat, Jan Babič, "Cooperative human-robot control based on Fitts' law", In: *HUMANOIDS 2016*, IEEE-RAS 16th International Conference on Humanoid Robots, November 15-17, 2016, Cancun, Mexico, pp. 345-350.
16. Tadej Petrič, Aleš Ude, Auke Jan Ijspeert, "Autonomous learning of internal dynamic models for reaching tasks", In: *Advances in robot design and intelligent control: proceedings of the 24th International Conference on Robotics in Alpe-Adria-Danube Region, (RAAD), [27-29 May 2015, Bucharest, Romania]*, (Advances in intelligent systems and computing, volume 371), pp. 439-447.
17. Barry Ridge, Aleš Ude, "Action-grounded surface geometry and volumetric shape feature representations for object affordance prediction", In: *HUMANOIDS 2016*, IEEE-RAS 16th International Conference on Humanoid Robots, November 15-17, 2016, Cancun, Mexico, pp. 1022-1028.
18. Aleš Ude, Rok Vuga, Bojan Nemec, Jun Morimoto, "Trajectory representation by nonlinear scaling of dynamic movement primitives", In: *IROS 2016*, 2016/IEEE/RSJ International Conference on Inteligent Robots and Systems, September 28 - October 9-14, 2016, Daejeon, Korea, pp. 4728-4735.
19. Adam Wolniakowski *et al.* (13 authors), "Optimizing grippers for compensating pose uncertainties by dynamic simulation", In: *SIMPAR proceedings*, 2016 IEEE International Conference on Simulation, Modeling, and Programming for Autonomous Robots, Dec. 13-16, San Francisco, USA, 8 pp.
20. Tomaž Zavrl, Žiga Gosar, Igor Kovač, Aleš Ude, "Robotsko nalaganje kosov na plošče za planete za vakuumsko oslojevanje", In: *Vir znanja in izkušenj za stroko: zbornik foruma*, [8.] industrijski forum IRT, Portorož, 6. in 7. junij 2016, pp. 51-55.
21. Leon Žlajpah, "Kinematic control of redundant robots in changing task space", In: *Papers*, 25th International Workshop on Robotics in Alpe-Adria-Danube Region RAAD 2016, June 30th - July 2nd 2016, Belgrade, 8 pp.

Independent Component Part or a Chapter in a Monograph

1. Miha Deniša, Tadej Petrič, Andrej Gams, Aleš Ude, "A review of compliant movement primitives", In: *Robot control*, Efren Gorrostieta Hurtado, ed., Rijeka, InTech, 2016, pp. 1-17.

DEPARTMENT OF SYSTEMS AND CONTROL E-2

The department is engaged in the analysis, control and optimization of systems and processes. The activities of the department are focused on the research of new methods and algorithms for automatic control, the development of procedures and tools to support the design of control systems, the development of specific measurement and control modules, and the development and construction of complete systems for the control and supervision of machines, devices and industrial processes.

Head:
Dr. Vladimir Jovan

Basic and applied research

Basic and applied research in 2016 was devoted to three sub-areas: methodologies for analysis and control systems design; tools and building blocks for implementation; and applied research in the priority problem domains.

The first topic addressed the modelling and identification of nonlinear and complex dynamical systems. The research on methods for the dynamical systems' modelling was pursued in two directions: the development of Gaussian-process models and the development of model-tree ensembles. The research of modelling methods for environmental systems continued in the first track. In addition, a scientific monograph on modelling and control with Gaussian process models, authored by a member of department, was published by the Springer publishing house in 2016. The research of methods based on model-tree ensembles was focused on multivariable systems and on a comparison with other modelling methods.

The second topic was *advanced control.* We have continued the research and development of model predictive control (MPC) by using fast, online, first-order quadratic programming optimization techniques. Using singular value decomposition we have implemented an advanced MPC controller for the ITER plasma current and shape controller for the plasma magnetic control of the Iter fusion tokamak reactor, evaluated its simulation performance, and tested its numerical implementation in a low-latency Linux environment. Using an active-set approach, a new theoretical result on tight local convergence estimates was found for the dual gradient method, which explains different convergence rates observed in numerical simulations (Figure 1).

In the field of *fault detection and condition monitoring* our work included research dealing with robust fault detection in model-based approaches. In order to facilitate robust fault detection, we proposed a novel approach that combines elements of Gaussian process models and Jensen-Reny divergence. A Gaussian process model is employed in order to correct modelling errors due to a mismatch between measurements and a physical model employed for residual generation. Then, the residuals generated by employing physical and Gaussian models, are evaluated via Jensen-Reny divergence. The proposed approach was applied for SOFC fault detection and the results were presented at the *SysTOL* conference in Barcelona, Spain. The accurate anticipation of the remaining useful life (RUL) of a machine is also becoming mandatory in Industry 4.0 for efficient exploitation of the assets and avoiding unplanned downtimes. A novel, three-stage, data-driven approach to the RUL prediction has been developed and demonstrated on an industrial sand-blasting machine.

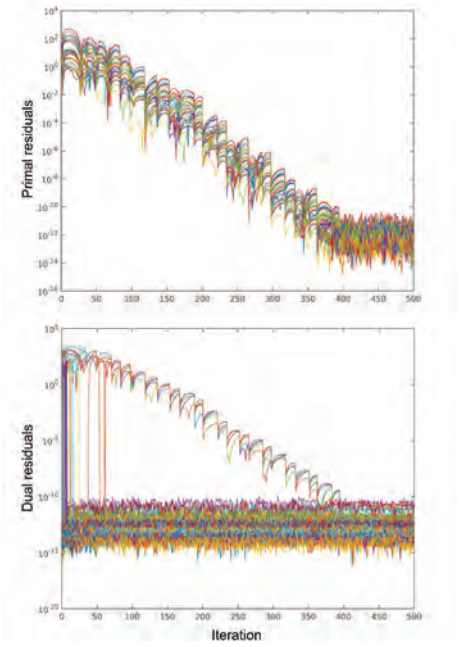


Figure 1: Convergence courses of primal (top) and dual (bottom) residuals through iterations of the dual fast gradient method with restarting at the optimization of a sample quadratic program of the plasma current and shape controller in one time-step. Validation of ozone-model predictions with measurements of maximum daily values

In 2016 we continued working on the diagnostics of PEM fuel cells with the use of its own developed fast electrochemical impedance spectroscopy. During the past 5 years we have achieved a considerable number of research and applied results in the area of PEM fuel-cell diagnostics. In 2016, all these results have been presented in a book, which is currently in the publishing process with the Springer publishing company.

In the area of **tools and building blocks for implementation** we have started the activities to upgrade the tool for analysis and optimisation of the production performance – ProOpter. We have overviewed current global initiatives and trends in the field of smart manufacturing. The main focus was to review functional and integrational aspects of the tool within the smart manufacturing ecosystem. Furthermore, architectural aspects were reviewed in order to be in line with the trends of Industry 4.0 (IoT, cloud, etc.) (Figure 2).

In the past year, a number of members of the department in collaboration with colleagues from other partner organisations, worked intensively on preparing a proposal for the public call entitled "Promoting the implementation of research and development programs (TRL 3-6)." We proposed

a program entitled "Building Blocks, tools and systems for factories of the future", with the acronym GOSTOP, in the frame of the priority area Factories of the Future. The application was successful and the work on the program started in November. The program will last 42 months, until end of April 2020. The program involves 19 partners, of which there are 6 institutions and 13 companies. The program is structured in two ways, first of which is based on the content, and second on the technology readiness level (TRL). In terms of content, the program is divided into four pillars, namely Control technologies, Tooling technology, Robotics, and Photonics. According to TRL, each of the four pillars is divided into two research and development projects, of which first aims to achieve TRL 3-4 (industrial research), and second TRL 5-6 (experimental development). Hence, the program contains eight R&D projects. Members of our department are involved in the research and development activities of the program (in the Control technologies pillar), as well as in the program-management activities (deputy coordinator, member of the executive committee, chairman of the committee for the dissemination and exploitation of results, assistant of the program coordinator for R&D coordination, management of the Control technologies pillar, management of two activities of the Control technologies pillar).

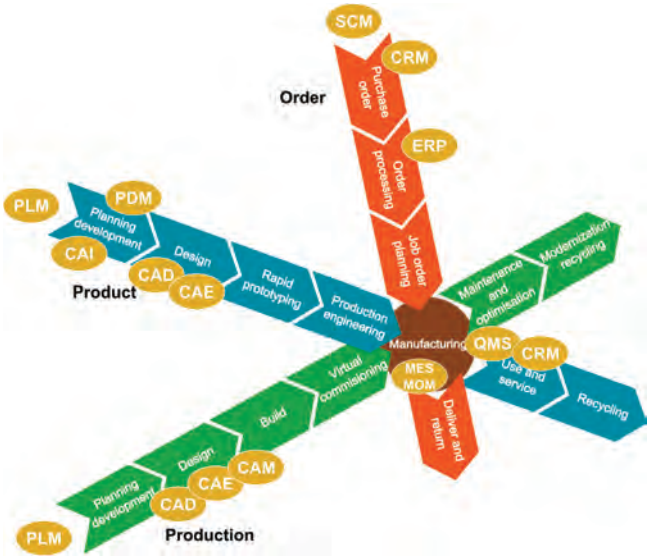


Figure 2: Smart Manufacturing Ecosystem

Applied research in the priority problem domains was the third sub-area of our interest. In collaboration with SME Entia d.o.o. we completed Slovenian Research Agency project "Cost optimization of energy consumption for refrigeration in shopping malls," where we have developed a control system for freezers, which implicitly takes into account the prescribed temperature constraints according to the HACCP standard. The system simultaneously allows an adjustment of the total power consumption to the desired consumption profile.

For another on-going Slovenian Research Agency project named Development and implementation of a method for on-line modelling and forecasting of air pollution research on algorithms for modelling and prediction based on Gaussian process that can be used with a mobile station were pursued. Moreover, the research was also pursued on empirical modelling methods for improved modelling and forecasting pollution with ozone over Slovenia as a case study of complex terrain.

In the past year a new test rig for electronically commutated motors has been set up in Domel d.o.o. For this purpose a new graphical user interface for the control and monitoring of motor parameters has been developed. The test system has been connected to the information system in Domel d.o.o. in line with Industry 4.0 trends. In addition, a new instrument has been prepared for monitoring the vibrations of motors with MEMS accelerometers. The purpose of the instrument is to explore possible ways of mounting MEMS accelerometers on existing electronically commutated motors and determine whether the installation of the MEMS sensors is economically justified.

Within the new project L2-7663 “State-of-health estimation of electrochemical energy systems”, funded by Slovenian Research Agency, we were studying various models that describe the degradation phenomena in PEM fuel cells. For that purpose we have built a test-bench for run-to-failure testing of PEM fuel cells under various operating conditions.

International R&D projects

Since April 2014 we have participated in the third EU FW7 project “Diamond - Diagnosis-aided control for SOFC power systems”. A simple, model-free supervisory optimizer for SOFC (solid-oxide fuel cell) power systems was designed. The optimizer adjusts set-points for the low-level controllers in such a way as to maximize the electrical efficiency of the system and prevent stack voltage drops. The optimization problem is solved by using the extremum-seeking approach where the optimum is sought directly on the process. The optimizer shows encouraging performance and exceeds the weakness of model-based optimizers, which assume nominal process conditions all the time and do not take into account the degradation process.

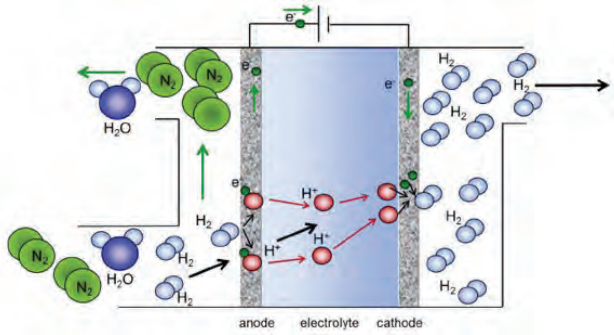


Figure 3: The principle of electro-chemical hydrogen compression and purification

In the framework of the 3-year project "Fast Model Predictive Control for Magnetic Plasma Control - FMPCFMPC", "Enabling Research" activity of the EUROfusion Work Programme 2015 (part of Horizon 2020 / Euratom), we have been collaborating with the consortium ENEA/CREATE from Naples, Italy. The aim of the project is to apply novel fast MPC approaches to plasma magnetic control, where MPC is currently not applicable due to the large-scale multivariable nature of the problem and sub-second sampling rates.

At the beginning of 2017 a new H2020 hydrogen technology related project has been started where the Department of Systems and Control acts as a partner. The scope of the project is the development of an electro-chemical system for hydrogen compression and cleaning using membranes, similar to the ones used in PEM fuel cells. The compression system reaches pressure up to 1000 bar, it is driven by the electricity and it has higher energy efficiency than mechanical compressors. During decompression a part of the electrical energy utilized during compression is recuperated. The system can also be used for hydrogen cleaning since the membrane only conducts hydrogen protons (Figure 3).

Recent accomplishments in the health monitoring of solid-oxide fuel cells have given a boost to extending the methodology to a perspective technology of solid-oxide electrolyzers. The first step within a bilateral project with a French research institution CEA and our department, initiated in July 2016, was oriented towards a detailed feasibility study.

Within the COST Water_2020 project we have participated in the preparation of the book chapter "Model-based comparative assessment of innovative processes". The objective of the chapter is to compare the simulation results of three different wastewater-treatment-plant configurations using dynamic modelling. The chapter is part of the book "Innovative Wastewater Treatment & Resource Recovery Technologies: Impacts on Energy, Economy and Environment" which is prepared by the partners of the COST Action. The book, which has more than 160 contributors, will be released by the IWA Publishing in May 2017.

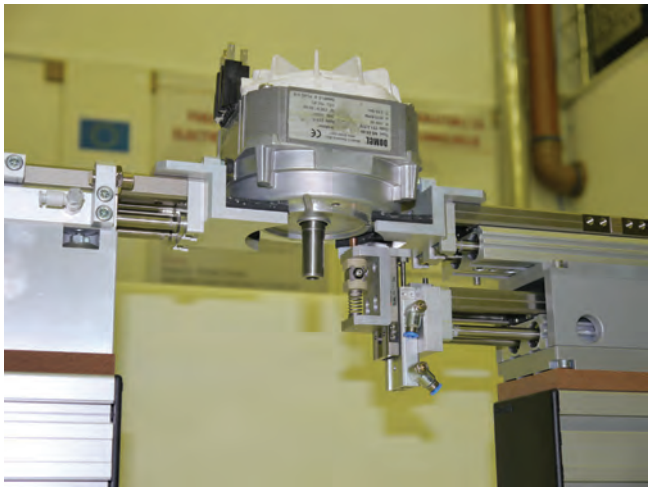


Figure 4: Gripper of the new system for the motor final quality control in Domel d.o.o.

Applied work

In the context of a long-term partnership with Danfoss Trata d.o.o in 2016 we started with the activities on the development of hardware and software for three new families of valve drives. There are various types and sizes of drives with a variety of functionalities to be used by both the HVAC systems as well as in district heating systems.

In Domel d.o.o. in 2016 the partial installation of a new diagnostic system for the end control of electronically commutated motors (type 771) has been completed. The system is based upon diagnostic systems on older production lines. Nevertheless, many innovations were introduced during the implementation on the electro-mechanical part as well as on the software part. The new system supports the diagnostics of two different motors, wherein one type of motor has a built-in controller, which further increases the complexity of manipulators and electronic components of the line (Figure 4). Next, on the software side the focus was on informatization of the production line in accordance with the current trend Industry 4.0 (iIOT – Industrial Internet Of Things). Thus, the majority of components and sensors has its own IP address and can communicate with the ERP system. The production line is scheduled to start operating in the first quarter of 2017.

Another project in Domel d.o.o was installed in their unit PE ECS. We have developed and installed a configurable end-quality control line for electronically commutated blowers. The line is capable of self-reconfiguration, thus enabling total end-quality control of all the produced blower families. The line's design and implementation is completely in line with Industry 4.0 guidelines.

Figure 5: Bowling tournament to celebrate the department's 30th anniversary

Educational and training activities

Some members of the department are giving lectures and practical courses at different faculties and universities: the Faculty of Electrical Engineering, University of Ljubljana, the Faculty of Logistics, University of Maribor, the University of Nova Gorica and the "Jožef Stefan" International Postgraduate School. They also act as supervisors of four Ph.D. students.

Some outstanding publications in the past year

1. Dolanc, Gregor, Pregelj, Boštjan, Petrovčič, Janko, Pasel, Joachim, Kolb, Günter. Control of autothermal reforming reactor of diesel fuel. *Journal of power sources*, ISSN 0378-7753, may 2016, vol. 313, pp. 223-232

2. Nerat, Marko, Vrančić, Damir. A novel fast-filtering method for rotational speed of the BLDC motor drive applied to valve actuator. *IEEE/ASME transactions on mechatronics*, ISSN 1083-4435, 2016, vol. 21, no. 3, pp. 1479-1486
3. Dolenc, Boštjan, Vrečko, Darko, Juričić, Đani, Pohjoranta, Antti, Pianese, Cesare. Online estimation of internal stack temperatures in solid oxide fuel cell power generating units. *Journal of power sources*, ISSN 0378-7753, 2016, vol. 336, pp. 251-260
4. Pregelj, Boštjan, Micor, Michał, Dolanc, Gregor, Petrovčič, Janko, Jovan, Vladimir. Impact of fuel cell and battery size to overall system performance - a diesel fuel-cell APU case study. *Applied energy*, ISSN 0306-2619, 2016, vol. 182, pp. 365-375
5. Boškoski, Pavle, Juričić, Đani. Inverse Gaussian mixtures models of bearing vibrations under local faults. *Mechanical systems and signal processing*, ISSN 0888-3270, 2016, vol. 66/67, pp. 546-556

Some outstanding achievements in the past year

1. The Department of Systems and Control celebrates its 30th anniversary. On 22th of June, 2016 we celebrated this event with a barbecue and a bowling tournament (Figure 5)
2. The book entitled "Modelling and Control of Dynamic Systems Using Gaussian Process Models", authored by our Department member Prof. Dr. Juš Kocijan, has appeared in the Springer series "Advances in Industrial Control"
3. The "2016 Prešeren award" at the Faculty of Electrical Engineering, Ljubljana was awarded to our department member Tomaž Kos for his research project entitled Measurement system for automated low-frequency and high-temperature characterization of dielectric materials
4. "Jozef Stefan" Institute and the Ministry of Education, Science and Sport have signed an agreement on co-financing operation no. C3330-16-529000, **"Building Blocks, Tools and Systems for Factories of the Future" (GOSTOP).** Our department plays one of the main roles in this programme
5. Two new projects in the field of the development of hydrogen technologies (Memphys, Insight) were approved for financing within the scope of Horizon 2020 programme (Fuel Cells and Hydrogen Joint Undertaking)

Awards and appointments

1. Tomaž Kos: The 2016 Prešeren award at the University of Ljubljana, Faculty of Electrical Engineering for his research project entitled Measurement system for automated low-frequency and high-temperature characterization of dielectric materials
2. Stanislav Strmčnik: received the Professor Emeritus of the University of Nova Gorica award for his significant contribution to the development of scientific activities and his remarkable performance as professor and mentor

Patent granted

1. Janko Petrovčič, Damir Vrančić, Reducing oscillations in a control system, EP2356522 (B1), European Patent Office, 06. 01. 2016.

INTERNATIONAL PROJECTS

1. 7FP - DIAMOND; Diagnosis-aided Control for SOFC Power System
   Prof. Đani Juričić
   European Commission
2. COST ES1202; Water_2020: Conceiving Wastewater Treatment in 2020 - Energetic, Environmental and Economic Challenges
   Dr. Darko Vrečko
   Cost Office
3. ER-3-FU; Enabling Research; EUROFUSION
   Dr. Samo Gerkšič
   European Commission
4. Non-invasive Condition Monitoring of High Temperature Steam Electrolyser
   Prof. Đani Juričić
   Slovenian Research Agency

RESEARCH PROGRAM

1. Program systems and control
   Prof. Đani Juričić

R & D GRANTS AND CONTRACTS

1. State-of-health prognostics of electrochemical energy systems
   Dr. Pavle Boškoski
2. E-maintenance of electro-mechanical drives: prognostics and health management solutions under non-stationary operating conditions
   Prof. Đani Juričić
3. Development and implementation of a method for on-line modelling and forecasting of air pollution
   Prof. Juš Kocijan
4. Optimisation of energy cost for refrigeration systems in shopping malls
   Asst. Prof. Damir Vrančić
5. Building blocks, tools and systems for the Factories of the Future – GOSTOP
   Dr. Vladimir Jovan

NEW CONTRACTS

1. Design and assembly of diagnostic system for quality assessment of the 771 family of brushless motors
   Dr. Janko Petrovčič
   Domel, d. o. o.

2. Optimisation of energy cost for refrigeration systems in shopping malls
   Asst. Prof. Damir Vrančić
   Danfoss Trata, d. o. o.
3. Functional upgrades on existing diagnostics systems for on-line analysis of operating characteristics and vibration measurement of motors
   Dr. Janko Petrovčič
   Domel, d. o. o.

VISITOR FROM ABROAD

1. prof. dr. Marco Ariola, Parthenope University of Naples, Naples, Italy, 25–26 February 2016
2. prof. dr. Gianmaria de Tomassi, University of Naples Federico II, Naples, Italy, 25–26 February 2016
3. prof. dr. Alfredo Pironti, University of Naples Federico II, Naples, Italy, 25–26 February 2016
4. dr. Denis Kalupin, EUROfusion, Garching, Germany, 25–26 February 2016
5. assoc. prof. Alexandra Grancharova, University of Chemical Technology and Metallurgy, Sofija, Bulgaria, 19 May 2016
6. prof. dr. Aneta Stefanovska, Department of Physics, Lancaster University, Lancaster, United Kingdom, 6 September 2016
7. dr. Attila Göllei, University of Pannonia, Veszprém, Hungary, 12–14 October 2016
8. dr. Attila Magyar, University of Pannonia, Veszprém, Hungary, 12–14 October 2016
9. Roland Bálint, University of Pannonia, Veszprém, Hungary, 12–14 October 2016

STAFF

Researchers
1. Dr. Pavle Boškoski
2. Dr. Gregor Dolanc
3. Dr. Samo Gerkšič
4. Dr. Giovanni Godena
5. Dr. Dejan Gradišar
6. Dr. Nadja Hvala
7. **Dr. Vladimir Jovan, Head**
8. Prof. Đani Juričić
9. Prof. Juš Kocijan
10. Dr. Bojan Musizza
11. Dr. Matija Perne
12. Dr. Janko Petrovčič
13. Dr. Boštjan Pregelj
14. Prof. Stanislav Strmčnik
15. Asst. Prof. Damir Vrančić
16. Dr. Darko Vrečko

Postdoctoral associates
17. Dr. Andrej Debenjak
18. Dr. Miha Glavan
19. Dr. Marko Nerat

Postgraduates
20. Boštjan Dolenc, B. Sc.
21. Tomaž Kos, B. Sc.
22. Gjorgji Nusev, B. Sc.
23. Martin Stepančič, B. Sc.

Technical officers
24. Stanislav Černe, B. Sc.
25. Primož Fajdiga, B. Sc.

Technical and administrative staff
26. Maja Janežič, B. Sc.
27. Miroslav Štrubelj

BIBLIOGRAPHY

Original Article

1. Darko Aleksovski, Juš Kocijan, Sašo Džeroski, "Ensembles of fuzzy linear model trees for the identification of multi-output systems", *IEEE trans. fuzzy syst.*, vol. 24, no. 4, pp. 916-929, 2016.
2. Pavle Boškoski, Đani Juričić, "Inverse Gaussian mixtures models of bearing vibrations under local faults", *Mech. syst. signal process.*, vol. 66/67, pp. 546-556, 2016.
3. Andraž Bradeško, Đani Juričić, Marina Santo-Zarnik, Barbara Malič, Zdravko Kutnjak, Tadej Rojac, "Coupling of the electrocaloric and electromechanical effects for solid-state refrigeration", *Appl. phys. lett.*, vol. 109, no. 14, pp. 143508-1-143508-7, 2016.
4. Nadja Damij, Pavle Boškoski, Marko Bohanec, Biljana Mileva-Boshkoska, "Ranking of business process simulation software tools with DEX/QQ hierarchical decision model", *PloS one*, vol. 11, no. 2, pp. 0148391-1-0148391-16, 2016.
5. Gregor Dolanc, Boštjan Pregelj, Janko Petrovčič, Joachim Pasel, Günter Kolb, "Control of autothermal reforming reactor of diesel fuel", *J. power sources*, vol. 313, pp. 223-232, maj 2016.
6. Boštjan Dolenc, Pavle Boškoski, Đani Juričić, "Distributed bearing fault diagnosis based on vibration analysis", *Mech. syst. signal process.*, vol. 66/67, pp. 521-532, 2016.
7. Boštjan Dolenc, Darko Vrečko, Đani Juričić, Antti Pohjoranta, Cesare Pianese, "Online estimation of internal stack temperatures in solid oxide fuel cell power generating units", *J. power sources*, vol. 336, pp. 251-260, 2016.
8. Miha Glavan, Dejan Gradišar, Serena Invitto, Iztok Humar, Đani Juričić, Cesare Pianese, Damir Vrančić, "Cost optimisation of supermarket refrigeration system with hybrid model", *Appl. therm. eng.*, vol. 103, pp. 56-66, 2016.
9. Miha Glavan, Dejan Gradišar, Damir Vrančić, "Modeliranje hladilnih elementov v nakupovalnih središčih za namene optimizacije energijskih stroškov", *Avtomatika*, vol. 2016, no. 149, pp. 42-49, 2016.
10. Dejan Gradišar, Boštjan Grašič, Marija Božnar, Primož Mlakar, Juš Kocijan, "Improving of local ozone forecasting by integrated models", *Environ. sci. pollut. res. int.*, vol. 23, no. 18, pp. 18439-18450, 2016.
11. Juš Kocijan, Dejan Gradišar, Marija Božnar, Boštjan Grašič, Primož Mlakar, "On-line algorithm for ground-level ozone prediction with a mobile station", *Atmos. environ. (1994)*, vol. 131, pp. 326-333, 2016.
12. Marko Nerat, Đani Juričić, "A comprehensive 3-D modeling of a single planar solid oxide fuel cell", *Int. j. hydrogen energy*, vol. 41, no. 5, pp. 3613-2627, 2016.
13. Marko Nerat, Damir Vrančić, "A novel fast-filtering method for rotational speed of the bldc motor drive applied to valve actuator", *IEEE/ASME trans. mechatron.*, vol. 21, no. 3, pp. 1479-1486, 2016.
14. Boštjan Pregelj, Gregor Dolanc, Janko Petrovčič, "FCGEN - razvoj in izvedba sistema vodenja za pomožni agregat z gorivnimi celicami na dizelsko gorivo", *Avtomatika*, vol. 2016, no. 145, pp. 42-49, 2016.
15. Boštjan Pregelj, Michał Micor, Gregor Dolanc, Janko Petrovčič, Vladimir Jovan, "Impact of fuel cell and battery size to overall system performance - a diesel fuel-cell APU case study", *Appl. energy*, vol. 182, pp. 365-375, 2016.
16. Tadej Rojac, Maja Makarovič, Julian Walker, Hana Uršič, Dragan Damjanović, Tomaž Kos, "Piezoelectric response of $BiFeO_3$ ceramics at elevated temperatures", *Appl. phys. lett.*, vol. 109, no. 4, pp. 042904-1-042904-4, 2016.

Published Conference Contribution

1. Darko Aleksovski, Dejan Dovžan, Sašo Džeroski, Juš Kocijan, "A comparison of fuzzy identification methods on benchmark datasets", In: *Proceedings of the 4th IFAC Conference on Intelligent Control and Automation, ICONS 2016, 1-3 June 2016, Reims, France*, *IFAC-PapersOnline*, vol. 49, no. 5, pp. 31-36, 2016.
2. Matjaž Bostič, Alexander Marinšek, Miha Glavan, Damir Vrančić, Iztok Humar, "Agent za upravljanje hladilnih sistemov z vidika zniževanja stroškov porabe", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož,*

Slovenija, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. A, pp. 121-124.

3. Marija Božnar, Boštjan Grašič, Primož Mlakar, Dejan Gradišar, Juš Kocijan, "Analysis of the daily cycles in the data on air pollution through the use of advanced analytical tools", In: *Proceedings*, fHARMO-17, 17th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 9-12 May 2016, Budapest, Hungary, pp. 171-176.
4. Boštjan Dolenc, Pavle Boškoski, Đani Juričić, "Ocenjevanje stopnje degradacije skladov gorivnih celic", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. A, pp. 155-158.
5. Boštjan Dolenc, Martin Stepančič, Đani Juričić, Juš Kocijan, Dario Marra, Cesare Pianese, "Accounting for modelling errors in model-based diagnosis by using Gaussian process models", In: *3rd International Conference on Control and Fault-Tolerant Systems, SysTOL 2016, Barcelona, September 7-9, 2016*, pp. 510-515.
6. Xavier Flores-Alsina, Christian Kazadi Mbamba, Emma Thomson-Brewster, Kimberly Solon, Darko Vrečko, Stephan Tait, Ulf Jeppsson, Krist V. Gernaey, Damien J. Batstone, "The use of an advanced aqueous phase chemistry approach with IWA biological process models in a plant-wide context", In: *5th IWA/WEF Wastewater Treatment Modelling Seminar, 2-6 April 2016, Annecy, France*, 4 pp..
7. I. Ganchev, Damir Vrančić, "Automatic control aspects of the Czochralski crystal growth process", In: *Proceedings: John Atanasoff celebration days*, International Conference Automatics and Informatics '2016, Bulgaria, Sofia, October 4-5, 2016, Sofia, pp. 223-225.
8. Samo Gerkšič, "ITER plasma current and shape control using MPC", In: *2016 IEEE Multiconference on Systems and Control, MSC 2016, September 19-22, 2016, Buenos Aires*, pp. 599-604.
9. Miha Glavan, Dejan Gradišar, Iztok Humar, Damir Vrančić, "Vodenje električne moči v trgovskih centrih", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. A, pp. 159-162.
10. Dejan Gradišar, Boštjan Grašič, Marija Božnar, Primož Mlakar, Juš Kocijan, "Local ozone prediction with hybrid model", In: *SIMULTECH: proceedings of the 6th International Conference on Simulation and Modeling Methodologies, Technologies and Applications, July 29 - 31, 201, Lisbon, Portugal*, pp. 262-269.
11. José Marín-Medina, Dejan Gradišar, Juan Carlos Seck-Tuoh-Mora, Norberto Hernandez-Romero, Federico Nuñez-Piña, "A Petri net model to obtain the makespan in the flow shop scheduling problem", In: *Proceedings of the World Congress on Engineering and Computer Science 2016, WCECS 2016, October 19-21, 2016, San Francisco, USA*, 5 pp..
12. Primož Mlakar, Dragana Kokal, Boštjan Grašič, Marija Božnar, Dejan Gradišar, Juš Kocijan, "Validation of the performance of meteorological forecasts in fine spatial and temporal resolution designed as an input for dispersion models", In: *Proceedings*, fHARMO-17, 17th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, 9-12 May 2016, Budapest, Hungary, pp. 30-35.
13. Boštjan Pregelj, Samo Gerkšič, Matic Knap, Matija Perne, "Koraki za zmanjšanje računske zahtevnosti prediktivnega regulatorja za vodenje plazme v IRT fuzijskem reaktorju", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. A, pp. 139-142.
14. Martin Stepančič, Boštjan Dolenc, Đani Juričić, "Model-based fault diagnosis with Gaussian process regression of nominal model residuals", In: *Zbornik*, 8. Študentska konferenca Mednarodne podiplomske Šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 180-192.
15. Emma Thomson-Brewster, Stephan Tait, Darko Vrečko, Xavier Flores-Alsina, Christian Kazadi Mbamba, Kimberly Solon, Ulf Jeppsson, Krist V. Gernaey, Damien J. Batstone, "Modelling physico-chemistry in extreme conditions", In: *5th IWA/WEF Wastewater Treatment Modelling Seminar, 2-6 April 2016, Annecy, France*, 3 pp..
16. Damir Vrančić, "Izboljšanje regulacijskih lastnosti zanke s pomočjo kompenzacijskega člena", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. A, pp. 147-150.
17. Darko Vrečko, Marko Nerat, Damir Vrančić, Gregor Dolanc, Boštjan Dolenc, Boštjan Pregelj, Fabien Meyer, Siu Fai Au, Robert Makkus, Đani Juričić, "Control design for a 2.5kW solid oxide fuel cell power system", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. A, pp. 135-138.

Independent Component Part or a Chapter in a Monograph

1. Franci Gabrovšek, Martin Knez, Janja Kogovšek, Andrej Mihevc, Bojan Otoničar, Janez Mulec, Matija Perne, Metka Petrič, Tanja Pipan, Mitja Prelovšek, Tadej Slabe, Stanka Šebela, Nataša Ravbar, Nadja Zupan Hajna, "Development challenges in karst regions: sustainable land use planning in the karst of Slovenia", In: *Preserving karst environments and karst caves: karst dynamics, environments, usage and restauration: towards an international karst preservation system*, (Zeitschrift für Geomorphologie, Supplementband, N. F., vol. 60, suppl. issue 2), Elena Trofimova, ed., Jean-Nöel Salomon, ed., Stuttgart, Gebrüder Borntraeger, 2016, pp. 293-318.
2. Juš Kocijan, Dejan Petelin, "Closed-loop control with evolving Gaussian process models", In: *Complex systems: relationships between control, communicatins and computing*, (Studies in systems, decision and control, vol. 55), Georgi M. Dimirovski, ed., [S. l.], Springer, 2016, pp. 505-521.

Scientific Monograph

1. Martin Knez, Tadej Slabe, Franci Gabrovšek, Janja Kogovšek, Andrej Kranjc, Andrej Mihevc, Janez Mulec, Bojan Otoničar, Matija Perne, Metka Petrič, Tanja Pipan, Mitja Prelovšek, Nataša Ravbar, Stanka Šebela, Nadja Zupan Hajna, Pavel Bosák, Petr Pruner, Hong Liu, Martin Knez (urednik), Tadej Slabe (urednik), *Cave exploration in Slovenia: discovering over 350 new caves during motorway construction on classical karst*, (Cave and karst systems of the world), Cham [etc.], Springer, cop. 2016.
2. Juš Kocijan, *Modelling and control of dynamic systems using Gaussian process models*, (Advances in industrial control), Cham [etc.], Springer, cop. 2016.

University, Higher Education or Higher Vocational Education Textbook

1. Juš Kocijan, Stanko Strmčnik, *Osnove avtomatskega vodenja*, V Novi Gorici, Založba Univerze, 2016.

Patent

1. Janko Petrovčič, Damir Vrančić, *Reducing oscillations in a control system,* EP2356522 (B1), European Patent Office, 06. 01. 2016.

Mentoring

1. Giovanni Godena, *Models of batch process control software:* doctoral dissertation, Ljubljana, 2016 (mentor Stanko Strmčnik).
2. Matej Gabrijelčič, *Closed-loop control of multi-zone furnace for heat treatment of steel ropes:* master's thesis, Nova Gorica, 2016 (mentor Juš Kocijan).
3. Tomaž Kos, *Measurement system for automated low-frequency and high-temperature characterization of dielectric materials:* master's thesis, Ljubljana, 2016 (mentor Gregor Klančar; co-mentor Tadej Rojac).

ARTIFICIAL INTELLIGENCE LABORATORY

E-3

Head:
Prof. Dunja Mladenić

The Artificial Intelligence Laboratory (http://ailab.ijs.si/) is mainly concerned with the research and development of information technologies, with an emphasis on artificial intelligence. Our main areas of research are: data analysis with an emphasis on text, web and cross-modal data, scalable real-time data analysis, machine learning, analysis and modelling of large networks, visualization of complex data, semantic technologies, language technologies, reasoning methods and knowledge management. The Artificial Intelligence Laboratory has employees and students with an international background and expertise in different areas of artificial intelligence. In addition to publishing their research results in international publications and presenting their work at international events, our researchers have also developed numerous software tools for multimodal data analysis. These tools include: Text-Garden, a suite of text mining tools; OntoGen (http://ontogen.ijs.si/), a tool for ontology learning; Document-Atlas (http://docatlas.ijs.si/), a tool for complex visualization; Atlas of Slovenian Science (http://scienceatlas.ijs.si/), a web portal for analysing the scientific community; Enrycher (http://enrycher.ijs.si/), a system for the semantic enrichment of textual data; SearchPoint (http://searchpoint.ijs.si/), a portal for visual and contextualized web browsing; OntoPlus, a methodology for semi-automatic ontology extension; Contextify (http://contextify.net/), a tool for contextualized e-mail and contact management; Qminer (http://qminer.ijs.si/), a data analytics platform for processing large-scale real-time streams containing structured and unstructured data; NewsFeed (http://newsfeed.ijs.si/), a clean, continuous, real-time aggregated stream of semantically enriched news articles from RSS-enabled sites across the world; iDiversiNews (http://aidemo.ijs.si/diversinews/), a system for the processing and visualization of news; EventRegistry (http://eventregistry.org/), a system for identifying world events in news media; Twitter Observatory (http://twitterobservatory.net/), a system for the analysis of selected tweets; Wikifier (http://wikifier.org), a system for annotating documents with links to relevant Wikipedia pages; StreamStory (http://streamstory.ijs.si), an exploratory data-stream analysis tool offering an alternative type of visualization by representing the multivariate data stream using a Markovian model; DataScienceExplorer, a dashboard for the visualizations of data science based on academic papers; Videolectures Explorer (http://explore.videolectures.net/), a tool enabling users to search through the lectures and find similarities between them; EDSA dashboard (http://jobs.videolectures.net/policymakers), a tool aggregating demand data (job postings around Europe) and supply data (training materials) in data science; nextPin (http://traffic.ijs.si/NextPin/?user=demo), a system for the analysis of time-varying data of geographical locations. The laboratory's strategy is to combine scientific excellence with strong industrial collaboration, enabling the transfer of research results into real-world business environments.

Marko Grobelnik was named Digital Champion by Slovenian government

Figure 1: Mobility patterns analytics tool showing user's mobility timeline (on right), selected place statistics (on left) and predicted next location (on map)

In the past 14 years, members of the Artificial Intelligence Laboratory have successfully completed 43 EU projects, of which 3 were concluded in 2016 and 11 were still on going. In 2016, we were also involved in 4 national projects and 1 industrial project. Together with the Department for Communication Systems (E6) in collaboration with Adria Mobil, we have continued and furthered the development of sensor technologies and artificial intelligence methods for the user-friendly and energy efficient functioning of auto-homes, which is being tested in real-world environments.

In 2016, two EU FP7 projects in the area of **statistical data modelling and machine learning** were successfully concluded: Symphony and FI-IMPACT. Our work in Symphony (*Orchestrating Information Technologies and Global Systems Science for Policy Design and Regulation of a Resilient and Sustainable Global Economy*) focused on developing tools and approaches to support economic policy makers through analysis, prediction, and

automated polling based on media monitoring. Our team established a social-media monitoring data infrastructure, connecting social media data with news events from our *EventRegistry* system and gathered market and macro-economic data. We implemented multi-lingual social media sentiment analysis and mainstream media geographical opinion diffusion measurements. Signals extracted from the data are fed into a scalable large-scale system of correlation analysis, together with an intuitive UI, for exposing and exploring connections between the different signals: concepts, companies, people, etc. The correlation analysis system also enables automated feature selection for the nowcasting functionality and is exposed through a friendly UI. Finally, we devised and performed experiments to evaluate our methods and tools. The EU FP7 project FI-IMPACT (*Future Internet Impact Assurance*) focused on measuring and projecting the potential take-up and impact of Phase III Accelerator Projects co-funded under the Future Internet PPP, by collecting and assessing qualitative and quantitative evidence of their potential socio-economic impact to 2020. Together with the Centre for Knowledge Transfer in Information Technologies (CT3), we developed a web-based self-assessment tool to support Accelerator Projects to position their product, verify the market potential and check complementarity with other FI-PPP participants' offerings. A separate set of tools for the benchmarking of accelerator best practices has been developed as a set of "R" statistical tool scripts. Both the reporting environment and best-practices analysis tool have been made available as open-source projects on GitHub. In the H2020 EU project, OPTIMUM (*Multi-source Big Data Fusion Driven Pro-activity for Intelligent Mobility*), our team is building a callable big-data traffic infrastructure p which serves more than 40 traffic-related APIs with the data from Slovenia and EU, both from the project consortium and public at large. Part of this data infrastructure started to be used commercially used, running inside the project partner's premises, serving their data. As part of the project, we also continue to build personal patterns detection and prediction service, which currently (experimentally) has around 3000 units sending GPS locations in real-time. This work represents the continuation of the FP7 project *Mobis*. This service is becoming the main geo-spatial analytics driver inside *OPTIUMUM* as well as other analytics projects. As part of the *OPTIMUM* project and our on-going collaboration with Adria, we are also collaborating on developing custom hardware that will allow the users to control and communicate with the motor-homes, which are eventually becoming smart-connected vehicles. Within the H2020 Marie Skłodowska-Curie ITN project BigDataFinance (*Training for Big Data in Financial Research and Risk Management*) two doctoral students were recruited by our department in order to execute two projects entitled "*Deep Knowledge Extraction from Financial, Business, and Social Text*" and "*Characterising Financial Markets from Event-driven Perspective*". In 2016, *BigDataFinance* implemented two training events. The first, entitled "Data Science in Finance", took place at the Tampere University of Technology in Finland. The second, entitled "High-Frequency Data Econometrics", took place at the Aarhus University in Denmark.

Organizing International conference LREC 2016
- **Introductory messages: Marko Grobelnik - Message of the Chair of the Local Organizing Committee**
- **Invited talk: Simon Krek - Slovene and the South Slavic Language Family - the Obligation of Expressing Duality and Other Stories from the South**

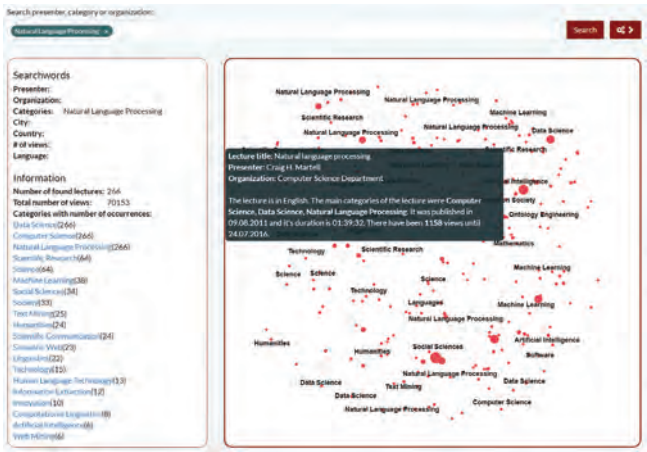


Figure 2: The Videolectures Explorer tool showing the landscape of lectures published on Videolectures.NET and its statistics. On the left side, it shows the keywords used in the query and the basic statistics of the found lectures. On the right side, it shows the lecture landscape with landmarks.

In the areas of **text and network analysis** and **language technologies**, we contributed an invited talk on "Slovene and the South Slavic Language Family - the Obligation of Expressing Duality and Other Stories from the South" at the LREC 2016 conference (Simon Krek). In 2016, together with the Department of Knowledge Technologies (E8), we continued to lead the Slovene research infrastructure CLARIN.SI, which provides easy publication and sustainable access to digital language data for scholars in the humanities and social sciences. In addition to providing support for the CLARIN.SI repository, we contributed Slovene data for the shared task on the automatic identification of verbal Multi-Word Expressions and worked on annotation of Semantic Role Label system for Slovene.

In the area of **semantic technologies**, the team's work has focused on two European projects. The EU FP7 project ProaSense (*The Proactive Sensing Enterprise*) is one of the early adapters of a shift from reactive to proactive computing in the enterprise environment. Within the project, we have developed tools for multivariate data-stream exploration, prediction and anomaly detection. In the past year, we have successfully completed the third and last year of the EU FP7 project xLiMe (*Cross-lingual Cross-media Knowledge Extraction*), in the context of which we have been researching the real-time fusion of information extracted from multiple modalities: text, social media, audio, video and user-behaviour data. We have produced the final prototypes for semantic graph construction, opinion diffusion, behaviour analytics and speech annotation systems, and participated in the integration of our

results into a coherent project pipeline. Within the H2020 Marie Skłodowska-Curie RISE project RENOIR (*Reverse engineering of social information processing*), our work focuses on the discovery and analysis of dynamics of information publication, spreading and consumption. We conducted an extensive analysis of news bias over the global news publisher space and their coverage of millions of events. We have also developed novel methodologies for modelling causal relationships between events reported in the news and the extraction of structured information about events from news media text.

In the area of knowledge management, where the group's main focus includes research and development by using methods and tools from a broader Artificial Intelligence area in real business settings, we have contributed an interview in "Finance" entitled "Vodno kmetovanje: digitalizacija ribogojnic in šoljčišč" given by Dunja Mladenić (http://agrobiznis.finance.si/8843345/Vodno-kmetovanje-digitalizacija-ribogojnic-in-skoljcisc) as well as an interview for RTVSlo entitled "Data modelling in aquaculture" (http://4d.rtvslo.si/arhiv/o-morju-in-pomorscakih/174401690). In collaboration with the Department for Communication Systems (E6), we have continued work on the EU FP7 project SunSeed (*Sustainable and robust networking for smart electricity distribution*). Our main task was the development and deployment of online streaming short-term load forecasting prototype. The prototype consists of two main instances: (1) Data instance and (2) Modelling instance. We have defined data interfaces for integration within the *Sunseed* analytical platform. Several data adapters were developed for connection with internal and external data sources. Streaming data aggregates were developed for each data source for the purpose of data cleaning, pre-processing and data enrichment. In the modelling instance part of the prototype, we have implemented a learning algorithm for online forecasting which is able to forecast in an online fashion. Additionally, the GUI for the prototype was developed for the purpose of testing and investing of the results. Several data visualisation tools were developed and added to the GUI for demonstration purposes. The prototype also includes REST API services for posting and requesting the latest results to the main database. Our current and future work involves scaling the prototype to be able to process and forecast the load for a larger number of nodes. Within the H2020 EU project AquaSmart (*Aquaculture Smart and Open Data Analytics as a Service*), whose aim is to lower production costs and improve the profitability and operational efficiency of fish farms, work has continued on the creation of a central framework, accessible via the web, where our tools implementing several machine-learning methods will be used to evaluate the performance of fish farms' production, identify patterns and trends, optimize feeding and growth models and estimate the fish population. In addition to analytics, we also created a translation service based on the Moses machine translation tool (5 language pairs), which will support the multi-language aspect of the project.

We have successfully concluded three EU FP7 projects: XLime (Cross-Lingual, Cross-Media Knowledge Extraction) (http://xlime.eu/), Symphony (Orchestrating Information Technologies and Global Systems Science for Policy Design and Regulation of a Resilient and Sustainable Global Economy) (http://projectsymphony.eu/), FI-IMPACT (Future Internet Impact Assurance) (http://www.fi-impact.net/)

Promotion of science is continually present in the efforts of the Artificial Intelligence Laboratory. In 2016, Marko Grobelnik was named Digital Champion by the Slovenian government. Digital Champions are ambassadors for the Digital Single Market, appointed by their Members States to help every European citizen become digital. Within this role, Marko has had several interviews promoting digital technologies, one by the Slovenian press agency (http://znanost.sta.si/2312994/novi-glasnik-digitalne-tehnologije-digitalna-tehnologija-prinasa-priloznosti-za-prijetnejse-zivljenje), another by the national RTVSlo (http://www.rtvslo.si/znanost-in-tehnologija/grobelnik-novi-digitalni-glasnik-cez-5-let-se-o-uberju-verjetno-sploh-ne-bomo-vec-sprasevali/405312). He also appeared in the weekly discussion show "Studio-City", for the topic of digitalizing Slovenia (http://4d.rtvslo.si/arhiv/studio-city-prispevki/174440159). The department's success in obtaining funding from the European Commission was also reflected in 2016 in an interview given by Dunja Maldenić for "Manager" regarding how researchers obtain EU funding entitled "Spoznajte raziskovalce, ki pobirajo evropske milijone" (http://manager.finance.si/8843441/Spoznajte-raziskovalce-ki-pobirajo-evropske-milijone?metered=yes&sid=412912399). Within the H2020 EU project EDSA (*European Data Science Academy*), the Artificial Intelligence Laboratory contributed a dashboard aggregating demand and supply data in data science - demand data of data science job postings around Europe and supply data of data science training materials. The department participated in the EDSA curriculum development, collecting and providing materials on the curriculum topic "Statistical/Mathematical Foundations". We have developed training and learning analytics applications based on Videolectures.NET data, such as *Videolectures Explorer* (enabling users to search through the lectures and find similarities between them) and the *Videolectures Learning Analytics Dashboard* (allowing for analysis of viewer behaviour). Together with the Centre for Knowledge Transfer in Information Technologies (CT3), we continued to use the videolectures.NET portal to promote Artificial Intelligence, the Jožef Stefan Institute and Slovenian research in general. Our laboratory is also among the main organizers and supporters of the annual national ACM Computer Science Competition for secondary-school students; in 2016, more than 200 students participated in the competition. We have been organizing a touring exhibition about female PhD

holders from the area of computer science in Slovenia since 2006, thereby promoting the role of women in science (http://ScienceWithArt.ijs.si/).

In 2016 we were very actively involved in submitting new project proposals, particularly within the H2020 Programme. Once again, we were very successful, obtaining funding for four new projects in H2020: *EwShopp*, *euBusinessGraph*, *PrEstoCloud* and *Water4Cities*. We continue with our successful efforts to include Slovenian industry into the European research area, where over the past 11 years we have produced a list of 18 companies participating in EU projects.

Some outstanding publications in the past year

1. Karlovčec, Mario, Lužar, Borut, Mladenić, Dunja. Core-periphery dynamics in collaboration networks: the case study of Slovenia. *Scientometrics*, December 2016, Volume 109, Issue 3, pp 1561–1578
2. Tomašev, Nenad, Buza, Krisztian, Mladenić, Dunja. Correcting the hub occurrence prediction bias in many dimensions. *Computer science and information systems*, 2016, vol. 13, no. 1, pp 1-21
3. Škraba, Primož, Rosen, Paul, Wang, Bei, Chen, Guoning, Bhatia, Harsh, Pascucci, Valerio. Critical point cancellation in 3D vector fields. *IEEE transactions on visualization and computer graphics*, 2016, vol. 22, no. 6, pp 1683-1693
4. Rupnik, Jan, Muhič, Andrej, Leban, Gregor, Škraba, Primož, Fortuna, Blaž, Grobelnik, Marko. News across languages - cross-lingual document similarity and event tracking. *The journal of artificial intelligence research*, 2016, vol. 55, pp 283-316
5. Kudryavtseva, Ganna, Škraba, Primož. The principal bundles over an inverse semigroup. *Semigroup forum*, 2016, 22 pp
6. Fortuna, Carolina, De Poorter, Eli, Škraba, Primož, Moerman, Ingrid. Data driven wireless network design : a multi-level modeling approach. *Wireless personal communications*, [in press] 2016, 15 pp
7. Grobelnik, Marko, Mladenić, Dunja, Witbrock, Michael J. Text Mining For The Semantic Web. V: Sammut, Claude (ur.), WEBB, Geoffrey I. (ur.). Encyclopedia of machine learning and data mining. Heidelberg [etc.]: Springer, 2016, 3 pages
8. Mladenić, Dunja, Brank, Janez, Grobelnik, Marko. Document Classification. In: Sammut, Claude, Webb, Geoffrey I. (eds.). Encyclopedia of machine learning and data mining. Heidelberg [etc.]: Springer, 2016, 5 pages
9. Brank, Janez, Mladenić, Dunja, Grobelnik, Marko. Feature Construction In Text Mining. V: Sammut, Claude (Ur.), Webb, Geoffrey I. (ur.). Encyclopedia of machine learning and data mining. Heidelberg [etc.]: Springer, 2016, 6 pages

Organization of Conferences, Congresses and Meetings

1. FP7 NRG4Cast, Brussels, Belgium, 25 - 26 January 2016
2. H2020 EDSA, Ljubljana, Slovenia, 8 - 10 March 2016
3. FP7 ProaSense, Ljubljana, Slovenia, 24 - 25 February 2016
4. H2020 RENOIR, Ljubljana, Slovenia, 27 - 28 June 2016

INTERNATIONAL PROJECTS

1. ELRC - European Language Resource Coordination
   Dr. Simon Krek
   Dfki Gmbh - Deutsches Forschungszentrum Fuer
2. Services Concerning Ethnical, Communication, Legal, Skills Issues and Methodological Cooperation related to the Use of Big Data in European Statistics
   Marko Grobelnik
   Sogeti Luxembourg S.a.
3. 7FP - ProaSense; The Proactive Sensing Enterprise
   Marko Grobelnik
   European Commission
4. 7FP - SYMPHONY; Orchestrating Information Technologies and Global Systems Science for Policy Design and Regulation of a Resilient and Sustainable Global Economy
   Prof. Dunja Mladenić
   European Commission
5. 7FP - xLiMe; CrossLingual CrossMedia Knowledge Extraction
   Marko Grobelnik
   European Commission
6. 7FP - SUNSEED; Sustainable and Robust Networking for Smart Electricity Distribution
   Prof. Dunja Mladenić
   European Commission
7. 7FP - FI-IMPACT; Future Internet Impact Assurance
   Marko Grobelnik
   European Commission
8. PARSEME: PARSing and Multi-Word Expressions. Towards Linguistic Precision and Computational Efficiency in Natural Language Processing
   Dr. Simon Krek
   Cost Office
9. IS1305, European Network of E-Lexicography (ENeL)
   Dr. Simon Krek
   Cost Office
10. COST CA16105; European Network for Combining Language Learning with Crowdsourcing Techniques
    Dr. Simon Krek
    Cost Office
11. H2020 - EDSA; European Data Science Academy
    Marko Grobelnik
    European Commission
12. H2020 - OPTIMUM; Multi-source Big Data Fusion Driven Proactivity for Intelligent Mobility
    Marko Grobelnik
    European Commission
13. H2020 - BigDataFinance; Training for Big Data in Financial Research and Risk Management
    Marko Grobelnik
    European Commission
14. H2020 - RENOIR; Reverse Engineering of Social Information Processing
    Marko Grobelnik
    European Commission

15. H2020 - MOVING; Training Towards a Society of Data-Savvy Information Professionals to enable Open Leadership Innovation
    Marko Grobelnik
    European Commission
16. H2020 - GlobalDNA; Dynamic Network of Global News Events
    Prof. Dunja Mladenić
    European Commission
17. Representation of Big Data
    Prof. Dunja Mladenić
    Slovenian Research Agency
18. Semantic Role Labeling in Slovene and Croatian
    Dr. Simon Krek
    Slovenian Research Agency

RESEARCH PROGRAM

1. Knowledge Technologies
   Prof. Dunja Mladenić

R&D GRANTS AND CONTRACTS

1. Model for Domain-Specific Trend Prediction based on Semantic Enrichment of Unstructured Patterns
   Prof. Dunja Mladenić
2. Slovene scientific texts: resources and description
   Dr. Simon Krek
3. Learning Topological Representations
   Asst. Prof. Primož Škraba
4. Forbidden Books in the Slovenian Lands in the Early Modern Period
   Dr. Simon Krek

VISITORS FROM ABROAD

1. Chris Creel, Cotiviti , Atlanta, USA, 24 February 2016
2. Janusz Holyst, Politechnika Warszawska, Warsaw, Poland, 1 - 12 March 2016
3. Janek Choloniewski, Politechnika Warszawska, Warsaw, Poland, 1 March - 8 May 2016
4. Janek Choloniewski, Politechnika Warszawska, Warsaw, Poland, 9 May - 8 July 2016
5. Dr. Jasminka Dobša, Fakultet Organizacije i Informatike, Univerza Zagreb, Varaždin, Croatia, 13 - 17 June 2016
6. Dr. Ivan Magdalenić, Fakultet Organizacije i Informatike, Univerza Zagreb, Varaždin, Croatia, 13 - 17 June 2016
7. Dr. Danijel Radošević, Fakultet Organizacije i Informatike, Univerza Zagreb, Varaždin, Croatia, 13 - 17 June 2016
8. Dr. Nicolo Cesa-Bianchi, Università degli Studi di Milano, Milano, Italy, 16 - 17 June 2016
9. Dr. Julian Sienkiewicz, Warsaw University of Technology, Warsaw, Poland, 17 June - 1 July 2016
10. Dr. Jennifer Croft, University of Iowa, Iowa City, ZUSA, 22 - 23 June 2016
11. Krzysztof Suchecki, Warsaw University of Technology, Warsaw, Poland, 22 June - 23 July 2016
12. Anna Grzywacz , Warsaw University of Technology, Warsaw, Poland, 31 August - 14 September 2016
13. Janek Choloniewski, Politechnika Warszawska, Warsaw, Poland, 9 - 10 October 2016
14. Juhan Lepassaar, Evropska Komisija, Bruseels, Belgium, 25 November 2016
15. Darko Dujič, ceneje.si, Ljubljana, Slovenia, 28 November 2016
16. Matija Torlak, Big bang d.o.o., Ljubljana, Slovenia, 28 November 2016
17. Matej Žvan, cde.si, Ljubljana, Slovenia, 28 November 2016

STAFF

Researchers
1. Dr. Damjan Bojadžiev
2. Asst. Prof. Branko Kavšek*
3. Dr. Simon Krek
4. Dr. Gregor Leban
5. **Prof. Dunja Mladenić, Head**
6. John Stewart Shawe-Taylor, B. Sc.
7. Asst. Prof. Primož Škraba

Postdoctoral associates
8. Dr. Janez Brank
9. Dr. Mario Karlovčec
10. Dr. Aljaž Košmerlj
11. Dr. Jurij Leskovec
12. *Dr. Andrej Muhič*, left 01.10.16*
13. Dr. Inna Novalija
14. *Dr. Joao Paulo Pita Da Costa*, left 01.09.16*
15. Dr. Jan Rupnik
16. Dr. Polona Škraba Stanič

Postgraduates
17. Luka Bradeško, B. Sc.
18. Dr. Blaž Fortuna
19. Rayid Ghani, M. Sc.
20. *Dejan Govc*, left 01.10.16*
21. James Alexander Hodson, B. Sc.
22. Mitja Jermol, M. Sc.
23. Blaž Kažič, B. Sc.
24. Klemen Kenda, B. Sc.
25. Blaž Novak, B. Sc.
26. *Janez Starc, B. Sc., left 01.06.16*
27. Luka Stopar, B. Sc.
28. Miha Torkar, B. Sc.

Technical officers
29. Flavio Fuart, B. Sc.
30. *Darja Grošelj, B. Sc., left 23.11.16*
31. Zala Herga, B. Sc.
32. *Dr. Ganna Kudryavtseva*, left 01.10.16*
33. Matjaž Rihtar, B. Sc.
34. Maja Škrjanc*, B. Sc.

Technical and administrative staff
35. Aleš Buh
36. Marko Grobelnik
37. Mojca Kregar Zavrl, B. Sc.
38. Mateja Škraba, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Austin R. Benson, David F. Gleich, Jurij Leskovec, "Higher-order organization of complex networks", *Science (Wash. D.C.)*, vol. 363, no. 6295, pp. 163-166, 2016.
2. Carolina Fortuna, Eli De Poorter, Primož Škraba, Ingrid Moerman, "Data driven wireless network design: a multi-level modeling approach", *Wirel. pers. commun.*, vol. 88, no.1, pp. 63-77, 2016.
3. Polona Gantar, Iztok Kosem, Simon Krek, "Discovering automated lexicography", *International journal of lexicography*, vol. 29, issue 2, pp. 200-225, 2016.
4. Dejan Govc, "On the definition of the homological critical value", *J. homotopy relat. struct.,* vol. 11, iss. 1, pp. 143-151, 2016.
5. Mario Karlovčec, Borut Lužar, Dunja Mladenić, "Core-periphery dynamics in collaboration networks: the case study of Slovenia", *Scientometrics*, vol. 109, iss. 3, pp. 1561-1578, 2016.
6. Mario Karlovčec, Dunja Mladenić, Marko Grobelnik, Mitja Jermol, "Conceptualization of science using collaboration and competences", *Electron. libr.*, vol. 34, no. 1, pp. 2-23, 2016.
7. Ganna Kudryavtseva, Primož Škraba, "The principal bundles over an inverse semigroup", *Semigroup forum*, 22 pp., 2016.
8. João Pita Costa, Karin Cvetko-Vah, "Flat coset decompositions of skew lattices", *Semigroup forum*, vol. 92, no. 2, pp. 361-376, 2016.
9. Georg Rehm *et al.* (44 authors), "The strategic impact of META-NET on the regional, national and international level", *Language resources and evaluation*, vol. 50, no. 2, pp. 351-374, 2016.

10. Jan Rupnik, Andrej Muhič, Gregor Leban, Primož Škraba, Blaž Fortuna, Marko Grobelnik, "News across languages - cross-lingual document similarity and event tracking", *J. artif. intell. res.*, vol. 55, pp. 283-316, 2016.
11. Primož Škraba, Paul Rosen, Bei Wang, Guoning Chen, Harsh Bhatia, Valerio Pascucci, "Critical point cancellation in 3D vector fields", *IEEE trans. vis. comput. graph.*, vol. 22, no. 6, pp. 1683-1693, 2016.
12. Nenad Tomašev, Krisztian Buza, Dunja Mladenić, "Correcting the hub occurrence prediction bias in many dimensions", *Comput. Sci. Inf. Syst.*, vol. 13, no. 1, pp. 1-21, 2016.

Published Conference Contribution

1. Špela Arhar Holdt, Darja Fišer, Tomaž Erjavec, Simon Krek, "Syntactic annotation of Slovene CMC: first steps", In: *Proceedings of the 4th Conference on CMC and Social Media Corpora for the Humanities, 27-28 September 2016, Faculty of Arts, University of Ljubljana, Ljubljana, Slovenia*, pp. 3-6.
2. Katja Berčič, Gabriella Cattaneo, Mario Karlovčec, Flavio Fuart, Gaber Cerle, "Application of advanced analytical techniques in support of socio-economic impact assessment of innovation funding programmes", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 9-12.
3. Jan Chołoniewski, Gregor Leban, Sebastijan Maček, Aljoša Rehar, "Information flow between news articles: Slovene media case study", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 13-16.
4. Ruben Costa, Ricardo Jardim-Gonçalves, Paulo Figueiras, Margherita Forcolin, Mitja Jermol, Richards Stevens, "Smart cargo for multimodal freight transport: when "cloud" becomes "fog"", In: *8th IFAC Conference on Manufacturing Modelling, Management and Control MIM 2016, Troyes, France, 28-30 June 2016*, *IFAC-PapersOnline*, vol. 49, no. 12, pp. 121-126, 2016.
5. Zala Herga, Jan Rupnik, Primož Škraba, Blaž Fortuna, "Modeling probability of default and credit limits: Slovene media case study", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 21-24.
6. Matic Kladnik, Blaž Fortuna, Pat Moore, "Big data analysis combining website visit logs with user segments and website content", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 25-28.
7. Simon Krek, Polona Gantar, Kaja Dobrovoljc, Iza Škrjanec, "Označevanje udeleženskih vlog v učnem korpusu za slovenščino", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 106-110.
8. Simon Krek, Polona Gantar, Iztok Kosem, Vojko Gorjanc, Cyprian Laskowski, "Baza kolokacijskega slovarja slovenskega jezika", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 101-105.
9. Gregor Leban, Blaž Fortuna, Marko Grobelnik, "Using news articles for real-time cross-lingual event detection and filtering", In: *NesIR 2016: proceedings of the First International Workshop on Recent Trends in News Information Retrieval co-located with 38th European Conference on Information Retrieval (ECIR 2016), Padua, Italy, March 20, 2016*, (CEUR workshop proceedings, vol. 1568), 6 pp..
10. Erik Novak, Inna Novalija, "Visual and statistical analysis of VideoLectures.NET", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 29-32.
11. João Pita Costa, Matjaž Rihtar, "Data analytics in aquaculture", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 17-20.
12. Luis Rei, Dunja Mladenić, Simon Krek, "A multilingual social media linguistic corpus", In: *Proceedings of the 4th Conference on CMC and Social Media Corpora for the Humanities, 27-28 September 2016, Faculty of Arts, University of Ljubljana, Ljubljana, Slovenia*, pp. 54-57.
13. Matej Senožetnik, Luka Bradeško, Blaž Kažič, Dunja Mladenić, Tine Šubic, "Spatio-temporal clustering methods: Slovene media case study", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 33-36.
14. Matej Senožetnik, Luka Bradeško, Luka Stopar, Dunja Mladenić, "Ocenjevanje stanja napolnjenosti baterije inteligentnega avtodoma", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. B, pp. 63-66.
15. Jan Štrekelj, Branko Kavšek, "Interactive video management by means of an exercise bike", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 44-47.
16. Jasna Urbančič, Luka Bradeško, Matej Senožetnik, "Near real-time transportation mode detection based on accelerometer readings", In: *Izkopavanje znanja in podatkovna skladišča (SiKDD): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10. oktober 2016, [Ljubljana, Slovenija]: zvezek D*, pp. 5-8.

Independent Component Part or a Chapter in a Monograph

1. Janez Brank, Dunja Mladenić, Marko Grobelnik, "Feature construction in text mining", In: *Encyclopedia of machine learning and data mining*, Claude Sammut, ed., Geoffrey I. Webb, ed., Heidelberg [etc.], Springer, 2016, 6 pp..
2. Marko Grobelnik, Dunja Mladenić, Michael J. Witbrock, "Text mining for the semantic web", In: *Encyclopedia of machine learning and data mining*, Claude Sammut, ed., Geoffrey I. Webb, ed., Heidelberg [etc.], Springer, 2016, 3 pp..
3. Dunja Mladenić, "Text mining", In: *Encyclopedia of machine learning and data mining*, Claude Sammut, ed., Geoffrey I. Webb, ed., Heidelberg [etc.], Springer, 2016, 1 pp..
4. Dunja Mladenić, Janez Brank, Marko Grobelnik, "Document classification", In: *Encyclopedia of machine learning and data mining*, Claude Sammut, ed., Geoffrey I. Webb, ed., Heidelberg [etc.], Springer, 2016, 5 pp..
5. Stefano Pacifico, Janez Starc, Janez Brank, Luka Bradeško, Marko Grobelnik, "Semantic annotation of text using open semantic resources", In: *Encyclopedia of machine learning and data mining*, Claude Sammut, ed., Geoffrey I. Webb, ed., Heidelberg [etc.], Springer, 2016, 6 pp..
6. Mikael Vejdemo-Johansson, Primož Škraba, "Topology, big data and optimization", In: *Big data optimization: recent developments and challenges*, (Studies in big data, vol. 18), Ali Emrouznejad, ed., [S. l.], Springer, 2016, pp. 147-176.

Professional Monograph

1. Sadhana Sihgh, Dunja Mladenić, *Progressing in leadership and success: based on Kundalini yoga as taught by yogi Bhajan*, Waldzell, Wadzel Leadersphip Institute, 2016.

Mentoring

1. Jan Rupnik, *Multi-view canonical correlation analysis:* doctoral dissertation, Ljubljana, 2016 (mentor Dunja Mladenič; co-mentor John Shawe-Taylor).
2. Andreas Thalhammer, *Linked Data Entity Summarization:* doctoral dissertation, Karlsruhe, 2016 (mentor Rudi Studer; co-mentor Dunja Mladenič).
3. Erik Novak, *Nenegativna matrična faktorizacija:* master's thesis, Ljubljana, 2016 (mentor Bor Plestenjak; co-mentor Andrej Muhič).
4. Blaž Sovdat, *Text mining via homology:* master's thesis, Ljubljana, 2016 (mentor Primož Škraba; co-mentor Sergio Cabello).

LABORATORY FOR OPEN SYSTEMS AND NETWORKS E-5

The main activities of the laboratory are the R&D of next-generation networks, telecommunications technologies, components and integrated systems, as well as information-society services and applications, especially those that ensure an efficient and pervasive life-long learning concept.

Head:
Prof. Borka Jerman Blažič

In 2016, the research group implemented the research program "Future Internet Technologies: concepts, architectures, services and socio-economic issues". Research was also carried out in the EU Horizon 2020 project "Flex4Grid", 7FP projects "COURAGE", "EmployID" and "REDIRNET", the "eSENS" project from the CIP (Competitiveness and innovation) programme, the "SENTER" project from the ISFP programme, the EU DG Justice "LIVE_FOR" project, the "GIRDA" project from the Erasmus*plus* programme, and the national basic research project. The main fields of work were technologies and services in advanced next-generation networks, security and privacy in information systems, and technology-enhanced learning. Members of the laboratory are also teaching at the undergraduate and graduate levels at the University of Ljubljana, the Jožef Stefan International Postgraduate School, and the DOBA Faculty. In 2016 they were the mentors of two finished PhD theses, four Master theses, and two diploma theses.

Concepts and architectures of the secure future internet

The first area of R&D was focused on security infrastructures and trusted services. The Laboratory for Open Systems and Networks is involved in the creation of a pan-European infrastructure that is needed for secure cross-border services based on national eID credentials, such as digital identity cards. The work is being performed in collaboration with partners from a large-scale eSENS pilot from the EU Competitiveness and innovation (CIP) programme.

The "Electronic Simple European Networked Services (**eSENS**)" project is consolidating the building blocks of several large-scale pilots, e.g., STORK 2.0, focusing strongly on the core building blocks such as eID, eDocuments, e-Delivery, and e-Signatures. The architecture to be developed will be part of the European Interoperability Architecture (EIA) for the efficient and effective delivery of cross-border and cross-sector electronic public services. Our laboratory is leading the project activities on trust-model implementation in the piloting domains, such as e-procurement, e-health, e-justice, and business lifecycle. The aim is to elaborate (through cooperation with implementation and testing experts) the current trust models in each of the pilots concerned with the project, analyse their completeness with respect to a pre-designed framework, and extract recommendations for further development based on that framework. Furthermore, the laboratory is included in the assessment of the cyber-security principles integrated into the European interoperability reference architecture (EIRA) developed by the project.

We have created building blocks for security infrastructures and trusted services.

In 2016 we have successfully finished with the design and development of interoperability solutions for information exchange among the rescue agencies during accidents and other natural disaster situations. Interoperability solutions address the interoperation of the communication networks of different rescue agencies (e.g., police, traffic and road service, medical aid, fire protection agency, general rescue services, mountain-rescue services, anti-terrorism agencies) used for data exchange and the interoperability of the data. The work has been performed within the frame of the EU FP7 "Emergency Responder Data Interoperability Network (REDIRNET)" project. Our main activities in 2016 included ontology specification and security and a usability evaluation of the developed system. We prepared security recommendations and guidelines for the developers and users of the REDIRNET system. Good practices and modern security challenges faced by the public safety agencies were taken into account. A combination of analytical and empirical evaluation methods (U2XEM) was employed to assess the system's usability and user experience. The final demonstration and practical evaluation of the REDIRNET system with users took place in June 2016 in Bratislava, Slovakia. We presented security aspects of the public safety data interoperability network at an international conference in Sweden, and the specified ontology at a conference in Spain.

In 2016 we continued with the "Prosumer Flexibility Services for Smart Grid management (Flex4Grid)" project from the Horizon 2020 EU programme. The project is part of the call for Competitive low-carbon energy from the Societal Challenges pillar. Based on innovative use of ICT technologies the project aims at improving the smart-grid operation by utilizing the prosumers flexibility. The project has a strong Slovenian contribution with Elektro Celje and Smart Com as partners in the project, besides the Jožef Stefan Institute. Slovenian partners are working together to realize a large-scale pilot in the Celje region. So far, we have developed basic elements and services that enable

prosumers flexibility management, from home gateways to smart mobile applications. The laboratory focus was on cloud storage and processing services, data analytics with forecasting, and security and privacy provisioning. At the end of 2016 a test pilot evaluation of the project system started in Slovenia. Currently, 100 users are involved, while in 2017, a long-term pilot is planned with 2500 users.

The Laboratory for Open Systems and Networks is also involved in a 3-year national project EkoSmart (Ecosystem of a smart city) with the main focus on health, mobility, active lifestyle and well being. The project started in August 2016 and has six research programs to help build an ecosystem for safer and better quality living for individuals and communities alike, based on innovative IKT solutions. The Laboratory for Open Systems and Networks takes part in the Electronic Mobile Health research program, where operative directions include information technologies for whole health care, home support, mobile monitoring of vital and environmental data, method and algorithms development, and the development of corresponding IKT platforms. Our main role within the project is the development of methods and algorithms for personal health data anonymization. Models, such as k-anonymity, l-diversity, and LKC-privacy, will be considered for the protection of personal data privacy. Among other R&D challenges we will also focus on algorithms and mechanisms for the safety of collected data (access and storage), as well as designing machine-learning applications for disease discovery in databases and intelligent support for treatment monitoring.

Under the Infrastructure program in research organizations we again provided support services that enable better communications among members of the various research programs, as well as students and their mentors from geographically distributed institutions.

Security and privacy in information systems

The provision of security and privacy services is crucial for the modern information society. In 2016 our R&D activities in this field were focused on the fight against cybercrime, novel security mechanisms, such as graphical authentication, and trust systems. The results have been published in a scientific book, seven journal papers, and several conference papers at international conferences.

The main goal of the "Cybercrime and cyberterrorism European research agenda (COURAGE)" project was the definition of the R&D agenda in the area of the fight against cybercrime and cyberterrorism (CC/CT). Cybercrime is described as behaviour in which computers or networks are a tool, a target, or a place of criminal activity. The agenda that was finalized in 2016 identifies the major challenges, reveals research gaps, and identifies and recommends detailed practical research approaches to address those gaps through strategies that are aligned to the real-world needs. In total, 12 items that need further research are described by the agenda, for example, definition, characteristics and behaviour of the offenders and victims in cybercrime events, advanced tools for digital investigation in compliance with privacy legislation and regulation, preventing and countering CC/CT activities on the dark web and similar networks, and definition and harmonisation of CC/CT terminology throughout the EU. The agenda recommends short-, mid- and longer-term actions for each of the described research items and the roles of different stakeholders (law-enforcement agencies, solution providers, research and technology organisations, policy makers, legal, ethical and societal stakeholders, accreditation and certification bodies, and educational institutions) in the actions. The main results were also published by Springer in a book with a title "Combatting Cybercrime and Cyberterrorism: Challenges, Trends and Priorities" where we contributed a chapter "Towards the Development of a Research Agenda for Cybercrime and Cyberterrorism - Identifying the Technical Challenges and Missing Solutions", and presented at an international conference.

We co-design the R&D agenda in the area of the fight against cybercrime.

Figure 1: The LIVE_FOR project

The fight against cybercrime is also the main goal of the SENTER (Strengthening European Network Centres of Excellence in Cybercrime) project that started in 2016. SENTER aims at creating a single point of reference for EU national cybercrime centres of excellence (CoE) and developing further the network of national CoE into a well-defined and well-functioning community. The Laboratory for Open Systems and Networks is one of the ten CoEs in cybercrime that are involved in the project. Our main activities in 2016 included preparation of an inventory of best practice material (educational resources, IT tools, expertise) in the area of the fight against cybercrime, as well as preparation of guidelines on the establishment and management of cybercrime centres of excellence. The research activities were also carried out within the two special interest groups formed by the project, i.e., OSINT (Open source intelligence) and Digital forensics.

Laboratory for Open Systems and Networks is coordinating the LIVE_FOR (Criminal Justice Access to Digital Evidences in the Cloud - LIVE_FORensics) project from the EU DG Justice programme. Our partners in this 2-year project that was launched in November 2016 are universities from Belgium (Vrije Universiteit Brussel), Spain (Polytechnic University of Catalonia and Autonomous University of Madrid), Germany (Fachhochschule Albstadt - Sigmaringen), and Czech Republic (Masaryk University). The LIVE_FOR project is one of the vehicles that will bring knowledge and understanding of the new modern technologies being developed for carrying out digital investigation in the cloud-computing environment. In addition, the LIVE-FOR project will investigate the current status of the Directive 2014/41/EU implementation in the EU members' legislation, raise the awareness of the prosecutors and investigators of the new European tool for collecting cross-border evidences in the connected digital world, establish a collection of best practices, and develop standard educational content for training and education in the area of digital forensics. The project will upgrade the competence of judicial authorities in the field of cloud forensics and the use of a European investigation order in criminal matters through several activities that include joint meetings, educational and training workshops, setting up of information centres, and provision of strong awareness and dissemination activities. The project team is also committed to set up cooperation and people networking among all stakeholders in the area of the fight against cybercrime and cyberterrorism, especially prosecutors, judges, law-enforcement agencies, investigators, civil entities working in the prevention of cybercrime and cyberterrorism, business entities, and higher-educational institutions with programs in information security, fight against cybercrime, and digital forensics.

Our R&D results lead to a more secure information society.

Trust management plays an important role in security, dependability, and privacy provision. We have shown trust systems to be lacking some crucial systemic features, which helped define a novel systemic taxonomy of trust. Through an empirical study, the consideration of the human factor was shown to be a major reason for the unpredictable behaviour of trust systems. Recommendations based on Choice architecture were given for an improvement of their design. A formal model for designing trust systems with a limited amount of user bias was also proposed and tested on a static dataset. In the end, a step-by-step design procedure was defined for designing user-centric and context-dependent trust systems. The results were published in a journal "Behaviour & Information Technology" with a high citation impact factor.

Secure authentication is still an issue in the provision of trusted internet services. The problems are connected with safety and security, but at the same time with ease of use and user adoption of the application. Numerous graphical authentication approaches have been proposed on how to address the security and usability, and provide friendlier, but secure authentication. However, the user approach towards graphical password selection and the inherent personal bias in selecting images are still unclear. In 2016 we had a study published in an SCI journal where we investigated user choices in password selection for graphical-based systems for authentication. The study was based on a group of 302 participants that had been using a graphical authentication system during a period of 6 weeks. The results obtained have shown preferences for some image properties like colour, shape, and category. The study provides recommendations for service providers of graphical authentic systems for system design and for the set of graphical choices offered to the users.

In the field of privacy protection in mobile networks and mobile devices we had another study of the data privacy and personal security risks incurred by mobile users published. Our newest results appeared in the "Telematics and informatics" and "Information development" journals.

Figure 2: 25 years since the first internet connection in Slovenia

Technology-enhanced learning

The main focus of the R&D activities in the area of technology-enhanced learning was on serious games and new e-learning services and platforms for public employment services.

The main goal of the "Scalable cost-effective facilitation of professional identity transformation in public employment services (EmployID)" project is to support and facilitate the learning process of PES (Public Employment Services) practitioners in their professional identity development. We envision developing a set of services combining and linking eCoaching, reflection, MOOCs, networking, analytical and learning-support tools, leading to improved individual and organisational performance in the delivery of employment services. Privacy issues are also being tackled in the project through the development of a concept for handling privacy and ethical aspects on all different levels, ranging from organisational policies, via creating awareness, up to technical measures regarding the ownership and stewardship of data. Our activities also ensure that the tools developed are privacy aware, abide privacy principles, and are compliant with the newest EU privacy and data-protection legislation Among other main results of our R&D activities in 2016 we need to mention visualisation of learner's personal development, and the development and

evaluation of a community of practice platform for public employment services. The results have been published in a book with the title "Empowering change in public employment services – The EmployID approach".

The overall goal of the "Gameplay for Inspiring Digital Adoption (GIRDA)" project that started in 2016 is to address the problem of the digital divide, and barriers to learning and adoption faced by older citizens who often have no digital skills. Seven partners from Slovenia, UK, Austria, and Macedonia will investigate the efficacy of an alternative approach to facilitating digital literacy and digital adoption based on digital games designed for adults. Digital learning environments, such as touch-table games, will be used to introduce individuals to digital interaction. The project will develop and deliver new and innovative education materials and methods for learners, as well as best-practice guides for those involved in promoting digital literacy.

Promotion of Science

In October 2016 we celebrated the 25th anniversary of the first international internet connection in Slovenia that was established in 1991 in the Laboratory for Open Systems and Networks. The connection was a result of the EUREKA-8/COSINE (Cooperation of Open Systems Interconnections) project, where the laboratory was involved. The programme of the celebration event was dedicated to young people who presented their view on the meaning of the internet for everyday life, benefits and drawbacks, as well as opinions on the future of the internet. The main invited speaker was European Commissioner Violeta Bulc, while the head of laboratory, prof. dr. Borka Jerman-Blažič, explained what was going on in 1991 when the internet connection was being set up, and gave an overview of the current R&D activities of the EU Horizon 2020 programme and the internet of the future.

Some outstanding publications in the past three years

1. Callanan, Cormac, Jerman-Blažič, Borka, Jerman Blažič, Andrej. User awareness and tolerance of privacy abuse on mobile internet: an exploratory study. Telematics and informatics, ISSN 0736-5853, 2016, vol. 33, iss. 1, pp. 109-128.
2. Pavleska, Tanja, Jerman-Blažič, Borka. User bias in online trust systems: aligning the system designers' intentions with the users' expectations. Behaviour & information technology, ISSN 0144-929X. [Print ed.], [in press] 2016, 15 pages.
3. Mihajlov, Martin, Jerman-Blažič, Borka, Ciunova Shuleska, Anita. Why that picture? Discovering password properties in recognition-based graphical authentication. International journal of human-computer interaction, ISSN 1044-7318, 2016, vol. 12, iss. 12, pp. 975-988.

Organization of conferences, congresses and meetings

1. Organization of the "25th Anniversary of the first Internet connection in Slovenia", Ljubljana, October 10 2016
2. Organisation of the LIVE_FOR project ("Criminal Justice Access to Digital Evidences in the Cloud – LIVE_FORensics") Kick-off meeting, Ljubljana, November 15 2016

Awards and Appointments

1. Primož Cigoj: The Second best Innovation: "MUPOSS" product, 9th International Technology Transfer Conference, Brdo pri Kranju, Slovenia, September 21 2016

INTERNATIONAL PROJECTS

1. 7FP - EmployID; Scalable Cost-effective Facilitation of Professional Identity Transformation in Public Employment Services
   Asst. Prof. Tomaž Klobučar
   European Commission
2. 7FP - REDIRNET; Emergency Responder Data Interoperability Network
   Prof. Borka Džonova Jerman Blažič
   European Commission

7FP - COURAGE; Cybercrime and cyberterrOrism (E)UropeanResearch AGEnda
Prof. Borka Džonova Jerman Blažič
European Commission

3. CIP-e-SENS; Electronic Simple European Networked Services
   Prof. Borka Džonova Jerman Blažič
   European Commission
4. D-FET; Dynamic Forensics Evaluation and Training
   Prof. Borka Džonova Jerman Blažič
   European Commission
5. SENTER - Strengthening European Network Centres of Excellence in Cybercrime
   Prof. Borka Džonova Jerman Blažič
   European Commission
6. ERASMUS+; GIRDA - Gameplay for Inspiring Digital Adoption
   Prof. Borka Džonova Jerman Blažič
   European Commission
7. LIVE_FOR; Criminal Justice Access to Digital Evidences in the Cloud - LIVE_FORensics
   Prof. Borka Džonova Jerman Blažič
   European Commission
8. H2020 - Flex4Grid; Prosumer Flexibility Services for Smart Grid Management
   Dr. Dušan Gabrijelčič
   European Commission

RESEARCH PROGRAM

1. Future Internet Technologies: concepts, architectures, services and socio-economic issues
   Prof. Borka Džonova Jerman Blažič

R&D GRANTS AND CONTRACTS

1. Content and data communication interoperability of first responders networks
   Prof. Borka Džonova Jerman Blažič
2. Smart City Ecosystem – EkoSmart
   Dr. Živa Stepančič

NEW CONTRACTS

1. Guidelines for the integration of service providers with SI-PASS
   Asst. Prof. Tomaž Klobučar
   Ministry of Public Administration of the RS

STAFF

Researchers
1. Asst. Prof. Tanja Arh*
2. Asst. Prof. Rok Bojanc*
3. Prof. Borka Džonova Jerman Blažič, Head
4. Dr. Dušan Gabrijelčič
5. Asst. Prof. Tomaž Klobučar

Postdoctoral associates
6. Dr. Matej Babič
7. Dr. Tanja Pavleska
8. Dr. Živa Stepančič

Postgraduates
9. Primož Cigoj, B. Sc.
10. Blaž Ivanc, B. Sc.
11. Andrej Jerman Blažič, M. Sc.

Technical officers
12. David Djurić, B. Sc.

Technical and administrative staff
13. Tatjana Martun, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Matej Babič, "A new hybrid - system method of Machine Learning using a new method of fractal geometry and a new method of graph theory", *Elektrotehniški vestnik*, vol. 83, no. 1/2, pp. 42-46, 2016.
2. Matej Babič, "New hybrid system using in modelling process of harderning with intelligent system", *Acta Mech. Slovaca (Košice)*, vol. 20, no. 1, pp. 34-40, 2016.
3. Matej Babič, "New method for determination m artensite of microstructure of heat treatment materials", *Journal of production engineering*, vol. 19, no. 1, pp. 91-94, 2016.
4. Matej Babič, "A novel approach of hybrid method of machine learning and statistical properties in pattern recognition", *Journal of production engineering*, vol. 19, no. 2, pp. 84-88, 2016.
5. Cormac Callanan, Borka Jerman-Blažič, Andrej Jerman Blažič, "User awareness and tolerance of privacy abuse on mobile internet: an exploratory study", *Telemat. inform.*, vol. 33, iss. 1, pp. 109-128, 2016.
6. Cormac Callanan, Borka Jerman-Blažič, Andrej Jerman Blažič, "User tolerance of privacy abuse on mobile Internet and the country level of development", *Inf. dev.*, vol. 32, iss. 3, pp. 728-750, Jun. 2016.
7. Primož Cigoj, Borka Jerman-Blažič, "An advanced educational tool for digital forensic engineering", *Int. j.: emerg. technol. learn.*, vol. 11, no. 3, pp. 15-23, 2016.
8. Mateja Gorenc, Borka Jerman-Blažič, Anita Goltnik Urnaut, "Abuse of internet services in the workplace and the emergence of addiction", *Innovative issues and approaches in social sciences*, vol. 9, no. 2, pp. 116-136, 2016.
9. Mateja Gorenc, Borka Jerman-Blažič, Anita Goltnik Urnaut, "Internet addiction - empirical verification for Slovenia", *Innovative issues and approaches in social sciences*, vol. 9, no. 3, pp. 23-42, 2016.
10. Borka Jerman-Blažič, Nikolaos Matskanis, Rok Bojanc, "Semantic ontology design for a multi-cooperative first responder interoperable platform", *Comput. inform.*, vol. 35, no. 6, str. 1249-1276, 2016.
11. Martin Mihajlov, Borka Jerman-Blažič, Anita Ciunova Shuleska, "Why that picture?: discovering password properties in recognition-based graphical authentication", *Int. j. hum.-comput. interact.*, vol. 12, iss. 12, pp. 975-988, 2016.

Published Conference Contribution

1. Matej Babič, "Nov algoritem grafov vidljivosti v 3D prostoru in njegova aplikacije za analizo slik", In: *ROSUS 2016: računalniška obdelava slik in njena uporaba v Sloveniji 2016: zbornik 11. strokovne konference, Maribor, 17. marec 2016*, pp. 39-44.
2. Matej Babič, Borka Jerman-Blažič, "New cybercrime taxonomy of visualization of data mining process", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 367-369.
3. Primož Cigoj, Borka Jerman-Blažič, "Innovative solution for an eID secure management in a multi-platform cloud environment", In: *Proceedings of the Mediterranean Conference on Information & Communication Technologies 2015, MedCT 2015, [May 7 - 9, 2015, Saidia, Morocco], Volume 2*, (Lecture notes in electrical engineering, volume 381), 2016.
4. Blaž Ivanc, Borka Jerman-Blažič, "Development approach to the attack modeling for the needs of cyber security education", In: *Proceedings*, The Third International Conference on Digital Information Processing, Data Mining, and Wireless Communications, DIPDMWC2016, July 06-08 2016, Moscow, Russia, pp. 216-220.
5. Blaž Ivanc, Borka Jerman-Blažič, "Information security aspects of the public safety data interoperability network", In: *EISIC 2016*, 2016 European Intelligence and Security Informatics Conference, 17-19 August 2016, Uppsala, Sweden, pp. 88-91.
6. Andrej Jerman Blažič, Primož Cigoj, Borka Jerman-Blažič, "Serious game design for digital forensics training: incorporating and assessing learnability attributes", In: *Proceedings*, The Third International Conference on Digital Information Processing, Data Mining, and Wireless Communications, DIPDMWC2016, July 06-08 2016, Moscow, Russia, pp. 211-215.
7. Borka Jerman-Blažič, Andrej Jerman Blažič, "Studying the virtual user community in a international innovation project: the attitudes and the cultural background", In: *MCCSIS 2016*, Multi Conference on Computer Science and Information Systems, 1.4 July 2016, Madeira, Portugal, pp. 3-12.
8. Borka Jerman-Blažič, Tomaž Klobučar, "Missing solutions in the fight against cybercrime and cyberterrorism - the new EU research agenda", In: *EISIC 2016*, 2016 European Intelligence and Security Informatics Conference, 17-19 August 2016, Uppsala, Sweden, pp. 128-131.
9. Borka Jerman-Blažič, Nikolaos Matskanis, Rok Bojanc, "Multi-cooperative first responder interoperable platform based on semantic ontology approach", In: *Building bridges between researchers and practitioners*, Book of the proceedings [and] International Joint Conference CIO-ICIEOM-IIE- AIM (IJC 2016), XX. Congreso de Ingeniería de Organización XXII, International Conference on Industrial Engineering and Operations Management, International IISE Conference 2016, International AIM Conference 2016, July 13-15, 2016, San Sebastian, (Spain), pp. 211-218.
10. Živa Stepančič, "Varovanje zdravstvenih podatkov z metodami anonimiziranja", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 81-83.

Independent Component Part or a Chapter in a Monograph

1. Borka Jerman-Blažič, Tomaž Klobučar, "Towards the development of a research agenda for cybercrime and cyberterrorism - identifying the technical challenges and missing solutions", In: *Combatting cybercrime and cyberterrosism: challenges, trends and priorities*, (Advanced sciences and technologies for security applications), Babak Akgbar, ed., Ben Brewster, ed., [S. l.], Springer, 2016, pp. 157-174.

Scientific Monograph

1. Graham Attwell *et al.* (27 authors), *Empowering change in public employment services: the EmployID approach*, [S. l.], European Union's, 2016.

Professional Monograph

1. Borka Jerman-Blažič, Cormac Callanan*, User tolerance for privacy abuse on mobile Internet*, Saarbrücken, LAP Lambert, 2016.

Mentoring

1. Tanja Pavleska, *Alleviating user bias in online trust systems:* doctoral dissertation, Ljubljana, 2016 (mentor Borka Jerman Blažič).
2. Mateja Gorenc, *Abuse of internet services in the workplace and the emergence of addiction:* doctoral dissertation, Celje, 2016 (mentor Borka Jerman Blažič; co-mentor Anita Goltnik Urnaut).
3. Neda Bogdanović Golić, *E-support for the project management:* master's thesis, Ljubljana, 2016 (mentor Borka Jerman Blažič).
4. Matija Jekovec, *Improving the customer service support for on-line users by introducing modern web technologies:* master's thesis, Ljubljana, 2016 (mentor Borka Jerman Blažič).
5. Aleš Leskošek, *Software asset management as a service:* master's thesis, Ljubljana, 2016 (mentor Borka Jerman Blažič; co-mentor Tomaž Turk).
6. Tanja Marolt, *The security of electronic banking: an analysis of the situation in Slovenia:* master's thesis, Ljubljana, 2016 (mentor Borka Jerman Blažič).
7. Dušan Rehberger, *Renewing of the informational infrastructure with the IPV6 technology in the Slovenian environmental agency:* master's thesis, Ljubljana, 2016 (mentor Borka Jerman Blažič).
8. Luka Škof, *An analysis of cyber-crime and its economic damage assessment:* master's thesis, Ljubljana, 2016 (mentor Borka Jerman Blažič).
9. Goran Uršič, *Introducing modern telecommunication tehnologies and services in electro-distribution companies: the case of a transmission system operator:* master's thesis, Ljubljana, 2016 (mentor Borka Jerman Blažič).
10. Matevž Mahorčič, *Introduction of the B2B ICT-service at Vomit d. o. o.:* master's thesis, Maribor, 2016 (mentor Tanja Arh).
11. Franci Rojc, *Feasibility study of the introduction of a document system in SAP at Kolektor Group d. o. o:* master's thesis, Maribor, 2016 (mentor Tanja Arh).

DEPARTMENT OF COMMUNICATION SYSTEMS E-6

The core activities of the Department of Communication Systems comprise the research, development and design of next-generation telecommunication networks, technologies and services; wireless communication, embedded and sensor systems; and new procedures and algorithms for parallel and distributed computing. Within these activities, our research work includes the development of methods and software tools for the modelling, simulation, analysis and synthesis of communication systems, computer simulations supporting biomedical procedures and specialised equipment and procedures for advanced bio-signal processing and interpretation.

Head:
Prof. Mihael Mohorčič

The research and development activities at the department are carried out in three laboratories, the *Communication Technology Laboratory (CTL),* the *Parallel and Distributed Systems Laboratory (PDSL)* and the *Networked Embedded Systems Laboratory (NESL).* The research work of the three laboratories is complementary, which is reflected in the joint applied projects.

In 2016 the research activities within the **Communication Technology Laboratory** were concentrated on different challenges associated with access-segment technologies, enabling end-users to access new multimedia services and applications. As part of the research program on Communication networks and services (P2-0016) the emphasis was on research in the areas of: radio propagation, access architectures for heterogeneous wireless networks, management of radio and network resources and cognitive communications.

The investigation of the radio-signal propagation was focused on two main topics. The first topic concerns the research on radio-signal propagation in special environments, such as caves, long road and railway tunnels. The emphasis was on radio-wave propagation characteristics in curved tunnels for designing reliable communications in subway tunnels. The extensive propagation measurements conducted in subway tunnels provide an insight into the large-scale fading characteristics in real curved subway tunnels at various frequencies (920 MHz, 2400 MHz, in 5705 MHz). The qualitative analysis and corresponding findings are useful for realizing the intelligent transportation system in subway and railway systems as well the provision of wireless communications in caves in the case of emergency.

We applied the concept of rasterization-like discretization to the classic method of images, and thus relaxed the computing requirements with respect to the intensive computational geometry procedures.

The second topic concerns the development, implementation and testing of a software tool for radio-wave propagation modelling in mobile communication systems and the optimization of wireless communication systems. The tool is integrated into an open-source geographical information system (GIS) and incorporates statistical models, channel models based on ray tracing and optimization procedures. We studied computationally efficient radio ray-tracing techniques in the context of physical channel models.

In 2016 we started an applied project in collaboration with Xlab and Alanta on advanced ray-tracing techniques in radio environment characterization and radio localization. The project builds upon our research efforts from the past years on adapting algorithmic concepts known from ray tracing in computer graphics to radio environment modelling, where we have already proposed the efficient use of the massively parallel hardware of graphical processors. Our approach to divergence handling in the single instruction multiple thread (SIMT) architectures is applicable to a wider set of problems that can be solved on graphical processors.

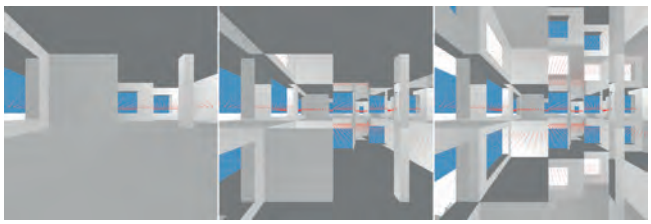


Figure 1: Radio-signal reflections and refractions are recursively traversed using graphic primitives. The illustration shows three snapshots of a framebuffer object at increasing tree depth with black-and-white rendering of the scene objects and visible reception points superimposed as red dots.

We applied the concept of rasterization-like discretization to the classic method of images, which is a well-established method of deterministic radio-propagation modelling. Instead of a computational geometry approach, the spatial coherence of the electromagnetic propagation of surface-reflected or refracted rays is treated simultaneously in rendering-like steps. The proposed rasterization is of a comparable run time to that of the fundamentally parallel shooting and bouncing rays while retaining the superior computational accuracy.

Furthermore, we focused on wireless network optimization using a multi-objective evolutionary algorithm, which determines for a given set of criteria functions the optimal network parameters. The aim of the proposed solution is to maximize the network efficiency, reduce the needed resources and consequently reduce the opera-

tional costs. Based on the terrain profile maps and construction locations, the tool calculates the path loss by applying state-of-the-art statistical models and determines the optimal base-station locations and their parameters by maximizing defined criteria functions. The implemented solution is generic and it could be used for planning any heterogeneous wireless network by appropriately adjusted criteria functions. The optimization algorithms have been included in the GRASS RaPlaT framework and applied for the optimization of frequency channel allocation in the digital wireless system for the Public protection and relief forces of the Republic of Slovenia that is operating in the VHF frequency band.

In collaboration with European partners within the H2020 project eWine "elastic WIreless Networking Experimentation" we started the investigation of the wireless elastic networks that can scale to the needs of users and services through the use of intelligent software and flexible hardware. Within the project, the Communication Technology Laboratory is focused on problems related to retrieving and processing the location of a user as a context of communications applicable for the optimization of wireless communication systems. In an outdoor environment we succeeded to bring the location error close to 1 metre by using radio environment properties and measured received signal level. In the indoor environment we increased the localization precision by using an ultra-wide band (UWB) radio signal by not considering non-line-of-sight connections in triangulation of the user.

In collaboration with the company ComSensus we developed two wide area measurement system (WAMS) devices for the use in smart grids: a synchro-phasor measurement (CP-SPM) device and a power quality measurement and control (PMC) device.

We continued the investigation of advanced concepts and technologies for a capacity increase of wireless mesh networks using network-coding techniques, focusing on the development of advanced adaptive network coding algorithms and their adapted routing procedures. In addition, the design aspects for network-coding-enabled wireless mesh networks and applications were investigated and analysed. We showed that opportunistic network coding can improve the performance of different networks and supported applications in terms of throughput, delay and jitter; however, these benefits are more prominent if the usage of opportunistic network coding is considered upfront in the wireless-network design phase.

In 2016 we successfully concluded the SatProSi-Alpha project, carried out for the European Space Agency (ESA). The purpose of the project was to investigate the atmosphere impacts on radio-wave propagation. Up to now, these effects were rather unexplored, especially at Q-band (39.4 GHz). The experience and measurement results obtained in the project with a newly developed 4-channel Alphasat beacon receiver on the rooftop of JSI will enable engineers to develop an efficient communication technology at high-frequency bands and hence enable high satellite communication throughputs of the order of terabits/s. The measurement results were analysed in collaboration with and contributed to the international European group ASAPE (Group of the AlphaSat Aldo Paraboni propagation Experimenters).

Figure 2: Distribution network state (Kromberk).

In 2016 we started with active participation in the COST Action 15104 IRACON "Inclusive radio communication networks for 5G and beyond", where we are contributing to several disciplinary working groups, manly DWG-1 radio channel, DWG-2 physical layer and DWG-3 network layer, as well in some experimental working groups: EWG-LT localization and tracking and EWG-IoT Internet of things.

In the scope of the FP7 SUNSEED project "Sustainable and robust networking for smart electricity distribution", which aims at the efficient use of the communications infrastructure in smart grids, we applied our research expertise in the field of optimization and management of communication networks also to the field of smart grids. In the last period we were focused on the development of software modules and algorithms for a three-phase estimator in the distribution network. We investigated the optimal placement of synchronized phasor measurement units in the distribution network for the most efficient state estimation and developed software modules for the analysis and visualisation of the state of the distribution network. We also implemented an algorithm for the synchronized phasor measurement unit and optimised it for running in a low-cost device with restricted capabilities.

In the **Parallel and Distributed Systems Laboratory**, we successfully continued interdisciplinary research work in the framework of the research program that also includes the Machine Vision Laboratory from the Faculty of Electrical Engineering and the Laboratory for Algorithms and Data Structures from the Faculty of Computer and Information Science, both from the University of Ljubljana. We also cooperate with researchers from industry and medicine on research projects and with joint papers.

The basic tasks of our laboratory are the investigation of computer algorithms efficiently implementable on parallel and distributed computers and their testing on a 152-core research computer cluster with a flexible interconnection network. The cluster is a part of a cloud established in cooperation with our research and industrial partners. We continued investigations in the field of massive data flows in body sensor networks, flows that exceed the performances of personal computers and require HPC computing and communication resources.

We successfully started to work on a FWO project "Multi-analysis of fretting fatigue using physical and virtual experiments", which resulted in a journal article and several conference articles. In the project consortium we cooperate with researchers from the University of Ghent and the University of Luxembourg. Our task is to design and implement parallel programmes, making possible the accurate simulation of fretting-cracks propagation.

Within an R&D project obtained in a public call from the industrial partner ELES, we together with research partners from the Milan Vidmar Institute and the Slovenian Environment Agency developed and validated a DTRi (Dynamic Thermal Rating - icing) model, on the basis of which we implemented a prototype system for the operative forecasting and prevention of icing on high-voltage power transmission lines. We have validated the prototype system with measurements on an experimental site and through the reconstruction of two real cases from 1.2.2014 and 5.1.2016 on the Beričevo-Divača line. Based on promising results, the contractee decided to put the DTRi system also into the SUMO (System for the Assessment of Operating Limits) operative environment, for which we obtained additional funding from the FP7 TETRACOM project.

Figure 3: The majority of the innovation team at the presentation of the wearable ECG measuring device

We continued the transfer of knowledge related to a wearable ECG measuring device and the associated software for ECG visualisation and analysis. The innovation in the extent of 5 FTE has been bought by an industrial partner, with whom we have also signed contracts for the maintenance and further development of the software and hardware. The ECG measuring device is small and unobtrusive when worn, transmits long-term (weekly, monthly and longer) measurements wirelessly to a smartphone or tablet, and is able to work on battery power for a few days. Devices like this one will represent the base of future tele-health services, which are indispensable for lowering the cost of the general health services. Our ECG wearable device was also certified as a medical device, with which we successfully concluded an FP7 TETRACOM project.

The EkoSmart (Smart City Ecosystem) proposal to the national project call "RRI in chains and value networks" of the Ministry of Education, Science and Sport was accepted. We have already started to work on the project, most notably on implementing the pilot studies about using a wearable ECG measuring device in the medical environment, and on the research of the options for analysing and integrating the measured long-term data into the existing medical records.

A project "Graph optimization and big data" was chosen for financing in the bilateral project call by the Slovenian and Hungarian research agencies. The project addresses the Big Data challenge interpreted in terms of graph models and their processing. Its goals are the proving of theorems about model parameters (chromatic number, independence number, etc.), the design of efficient parallel algorithms for model analysis and the implementation of those algorithms on supercomputers of the next generation (exascale computing). The investigations will contribute results important for graph theory (and discrete mathematics in general) and algorithms, and procedures directly applicable for the more efficient processing of Big Data. The work has already started and the first joint conference article has been published.

With public-private financial investment we have completed the transfer of knowledge about a wearable ECG measuring device to the industry.

In the field of formal methods for discrete event systems, we developed two methods for the synthesis of more efficient conformance tests for final state machines. Besides this we continued our research of the E-LOTOS language for the specification of concurrent real-time reactive systems and proposed operators for the finer specification of reversibility.

In the **Networked Embedded Systems Laboratory** we continued in 2016 the research and development in the fields of the Internet of Things and cognitive communications. The emphasis was placed on the vertical integration of different wireless sensor and communication network technologies in support of the development and introduction of new applications. As the core building block we were using and upgrading the modular platform VESNA, used for the development of wireless sensor networks. We developed a set of new hardware modules and the corresponding software for UWB communication, for the communication with spread spectrum LoRa, for advanced signal processing using onboard DSP chip and for the support of the Linux operating system. A variety of supported features, protocols and technologies, together with an arbitrary combination of developed hardware

and software modules, make the VESNA platform well suited for the implementation of an experimental research sensor networks infrastructure, the deployment of pilot applications, the validation of usage scenarios and the development of end-user solutions.

We continued to upgrade the LOG-a-TEC wireless sensor network testbed at the premises of Jožef Stefan Institute. In the Fed4FIRE (Federation for FIRE) project, the testbed was fully integrated in the Fed4FIRE federation by adopting the federation's interfaces and components and creating the necessary adapters. The testbed thus also became available to the community of external experimenters through a common Fed4FIRE portal. Furthermore, we designed a new architecture of sensor nodes, which will enable easier planning, deployment and debugging of user experiments and the remote collection of experimental data and results.

The LOG-a-TEC testbed was used and validated in the eWINE project for the performance evaluation of localization algorithms and for the investigation of radio spectrum occupancy in various frequency bands. Here, the emphasis was on effective covariance methods and their comparison with other methods of radio signal detection below 1 GHz. To this end we derived a methodology for a quantitative comparison of different spectrum sensing methods. In collaboration with SigFox we started the investigation of ultra-narrowband (UNB) radio signal detection in order to support the performance optimization and the increase of the density of low power wide area (LPWA) devices. We also prepared the first experimental architecture for UNB networks, which allows for the rapid development of experiments based on the data from physical and medium access control (MAC) layers.

As part of the work in eWINE we also developed a UWB radio channel classifier based on a convolutional neuron network approach, which determines (non) line-of-sight link conditions and hence the quality of the link using radio channel impulse response. The classifier was used as a support to increasing the indoor localization algorithm accuracy. The machine-learning approaches were also used in the design of a new link quality predictor for the wireless link quality estimation (LQE) based on measured signal strength (RSSI, received signal strength indicator) and the sequence of received data packets. The predictor can operate on the data obtained from different wireless technologies and enables the development of advanced MAC schemes and routing algorithms with the prioritization of channels. For the use in the LOG-a-TEC testbed the predictor was integrated into the ProtoStack tool used for service and protocol composition and reconfiguration.

In addition to the Fed4FIRE project, in 2016 we successfully concluded also CITI-SENSE project, in which we developed a VESNA-based portable device for air-quality monitoring via a smart user device (a phone or a tablet). The smart device was used for a graphical presentation of the measured data using the custom-developed mobile app and as a relay for sending raw data to a remote data server.

Finally, within the SUNSEED project we developed in collaboration with a company ComSensus two wide area measurement system (WAMS) devices for use in smart grids: one for the measurement of voltage and current phasors in real time (CP-SPM) and the other for the measurement of power quality and for the control of end devices (CP-PMC). We also actively participated in the deployment of these devices in the distribution network pilot of the project partner Elektro Primorska.

Some outstanding publications in the past year

1. Gomez K., Javornik T., et al. Aerial base stations with opportunistic links for next generation emergency communications. *IEEE communications magazine*, [Print ed.], 2016, vol. 54, no. 4, pp. 31-39.
2. Kulin, M.; Fortuna, C.; De Poorter, E.; Deschrijver, D.; Moerman, I. Data-Driven Design of Intelligent Wireless Networks: An Overview and Tutorial. *Sensors* **2016**, *16*, 790.
3. Kourogiorgas C., Kelmendi A, Panagopoulos A. D., and Vilhar A. On rain attenuation time series generation: a new simple Copula-based channel model for satellite slant paths. *IEEE transactions on antennas and propagation*, ISSN 0018-926X. [Print ed.], 2016, vol. 64, no. 7, 3206-3211.
4. Trobec R., Vasiljević R., Tomašević M., Milutinović V., Beivide R., Valero M.. Interconnection networks in petascale computer systems : a survey. *ACM computing surveys*, 49(3), 2016, 44-1-44-24.

Awards and appointments

1. Prof. Aleš Švigelj, dr. Kemal Alič, dr. Radovan Srnec: the Best Paper Award of the IEEE ComSoc Technical Committee on Communications Systems Integration and Modeling, "Network traffic modeling for load prediction: a user-centric approach", IEEE Network, IEEE Globecom 2016, Washington, USA, December 2016.

Organization of Conferences, Congresses and Meetings

1. Nesus ECOST-MEETING-IC1305-070716-076861, Institut "Jožef Stefan", Ljubljana, 7.-8. 7. 2016
2. SUNSEED 7th F2F meeting, Grand hotel Union, Ljubljana, 21.-22. 9. 2016

INTERNATIONAL PROJECTS

1. 7FP - CITI-SENSE; Development of Sensor-based Citizens' Observatory Community for Improving Quality of Life in Cities
   Prof. Mihael Mohorčič
   European Commission
2. 7FP - ProaSense; The Proactive Sensing Enterprise
   Prof. Mihael Mohorčič
   European Commission
3. 7FP - SUNSEED; Sustainable and Robust Networking for Smart Electricity Distribution
   Prof. Mihael Mohorčič
   European Commission
4. 7FP - Fed4FIRE; Federation for FIRE - Federation for Future Internet Research and Experimentation
   Prof. Mihael Mohorčič
   European Commission
5. 7FP - TETRACOM; Technology Transfer in Computing Systems
   Prof. Roman Trobec
   European Commission
6. COST IC1405; Reversible Computation - Extending Horizons of Computing
   Prof. Monika Kapus Kolar
   Cost Office
7. COST IC1305; Network for Sustainable Ultrascale Computing (NESUS)
   Prof. Roman Trobec
   Cost Office
8. COST CA15104; Inclusive Radio Communication Networks for 5G and Beyond (IRACON)
   Asst. Prof. Tomaž Javornik
   Cost Office
9. ESA - SatProSi-Alpha; Ka/Q-band Propagation Measurements and Modelling - Slovenian Contribution to the Alphasat TDP#5 Scientific Mission
   Dr. Andrej Vilhar
   Esa/estec.
10. H2020 - eWINE; Elastic Wireless Networking Experimentation
    Prof. Mihael Mohorčič
    European Commission

RESEARCH PROGRAMS

1. Telecommunication Systems
   Prof. Mihael Mohorčič
2. Parallel and Distributed Systems
   Prof. Roman Trobec

R&D GRANTS AND CONTRACTS

1. Model for Domain-Specific Trend Prediction based on Semantic Enrichment of Unstructured Patterns
   Prof. Roman Trobec
2. Multi-analysis of fretting fatigue using physical and virtual experiments
   Prof. Roman Trobec
3. Graph Optimisation and Big Data
   Dr. Matjaž Depolli
4. Advanced Ray-Tracing Techniques in Radio Environment Characterization and Radio Localization
   Prof. Mihael Mohorčič
5. Smart City Ecosystem – EkoSmart
   Prof. Roman Trobec

NEW CONTRACTS

1. Analysis of operational measures for prevention of ice formation on power lines
   Dr. Gregor Kosec
   Eles, d. o. o.
2. Wearable Multifunctional Body Sensor (MedSens)
   Prof. Roman Trobec
   Simed d. o. o.
3. Dynamic Thermal Rating of overhead power lines in icing conditions
   Dr. Gregor Kosec
   Eles, d. o. o.
4. Advanced Ray-Tracing Techniques in Radio Environment Characterization and Radio Localization
   Prof. Mihael Mohorčič
   Xlab d. o. o.

VISITOR FROM ABROAD

1. Asst. Prof. Vesna Popović-Bugarin, Faculty of Electrical Engineering, University of Montenegro, 2.–7. 4. 2016
2. Prof. Zoran Veljović, Faculty of Electrical Engineering, University of Montenegro, 2.–7. 4. 2016
3. Asst. Prof. Enis Končan, Faculty of Electrical Engineering, University of Montenegro, 17.–31. 5. 2016
4. Prof. Nermin Suljanović, Communications Department Faculty of Electrical Engineering Tuzla, Tuzla, Bosnia and Herzegovina, 30. 9. 2016
5. Ao.Univ.-Prof. Dipl.-Ing. Dr. Erich Leitgeb, Institut für Hochfrequenztechnik / Institute of Microwave and Photonic Engineering Graz University of Technology, Graz, Austria, 30. 11. 2016

STAFF

Researchers

1. Dr. Viktor Avbelj
2. Dr. Carolina Fortuna
3. Dr. Andrej Hrovat
4. Asst. Prof. Tomaž Javornik
5. Prof. Gorazd Kandus
6. Prof. Monika Kapus Kolar
7. Dr. Gregor Kosec
8. Asst. Prof. Andrej Lipej*
9. **Prof. Mihael Mohorčič, Head**
10. Asst. Prof. Roman Novak
11. Dr. Igor Ozimek
12. *Dr. Marjan Šterk, left 01.09.16*
13. Prof. Aleš Švigelj
14. Prof. Roman Trobec
15. Dr. Andrej Vilhar

Postdoctoral associates

16. Dr. Kemal Alič
17. Dr. Matjaž Depolli
18. Dr. Aleksandra Rashkovska Koceva

Postgraduates

19. Klemen Bregar, B. Sc.
20. Gregor Cerar, B. Sc.
21. Urban Kuhar, B. Sc.
22. Tomaž Šolc, B. Sc.
23. Matevž Vučnik, B. Sc.

Technical officers

24. Polona Anžur, B. Sc.
25. Miha Mohorčič, B. Sc.

Technical and administrative staff

26. Tomaž Krištofelc
27. Vanessa Skvarča, B. Sc.
28. Miha Smolnikar, B. Sc.
29. *Polonca Šega, B. Sc., left 05.01.16*

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Matjaž Depolli, Viktor Avbelj, Roman Trobec, Jurij-Matija Kališnik, Tadej Korošec, Tonka Poplas-Susič, Uroš Stanič, Aleš Semeja, "PCARD platform for mHealth monitoring", *Informatica (Ljublj.)*, vol. 40, no. 1, pp. 117-123, 2016.
2. Carolina Fortuna, Eli De Poorter, Primož Škraba, Ingrid Moerman, "Data driven wireless network design: a multi-level modeling approach", *Wirel. pers. commun.*, vol. 88, no.1, pp. 63-77, 2016.
3. Karina Gomez *et al.* (18 authors), "Aerial base stations with opportunistic links for next generation emergency communications", *IEEE commun. mag.*, vol. 54, no. 4, pp. 31-39, 2016.
4. Andrej Hrovat, Gorazd Kandus, Urban Kuhar, Arsim Kelmendi, Andrej Vilhar, "A Ka-band satellite beacon receiver for propagation experiment", *Inf. MIDEM*, vol. 46, no. 1, pp. 13-23, mar. 2016.
5. Monika Kapus-Kolar, "An improved state-counting-based construction of complete test suites for FSM implementations", *Elektrotehniški vestnik*, vol. 83, no. 3, pp. 115-121, 2016.
6. Chariaos Kourogiorgas, Arsim Kelmendi, Athanasios Panagopoulos, Andrej Vilhar, "On rain attenuation time series generation: a new simple Copula-based channel model for satellite slant paths", *IEEE trans. antennas propag.*, vol. 64, no. 7, pp. 3206-3211, 2016.
7. Merima Kulin, Carolina Fortuna, Eli De Poorter, Dirk Deschrijver, Ingrid Moerman, "Data-driven design of intelligent wireless networks: an overview and tutorial", *Sensors*, vol. 16, no. 6, pp. 790-1-790-61, 2016.
8. Andrej Lipej, Duško Mitruševski, "Numerical prediction of inlet recirculation in pumps", *International journal of fluid machinery and systems*, vol. 9, no. 3, pp. 277-286, 2016.
9. Roman Novak, "Discrete method of images for 3D radio propagation modeling", *3D res.*, vol. 7, no. 3, pp. 26-1-26-12, 2016.
10. Kyvia Pereira, Stephane Bordas, Satyendra Tomar, Roman Trobec, Matjaž Depolli, Gregor Kosec, Magd Abdel Wahab, "On the convergence of stresses in fretting fatigue", *Materials (Basel)*, vol. 9, no. 8, pp. 639-1-639-15, 2016.
11. Dana Petcu *et al.* (23 authors), "On processing extreme data", *Scalable Comput., Pract. Exp.*, vol. 16, no. 4, pp. 467-489, 2016.
12. Peter Ruckebusch, Eli De Poorter, Carolina Fortuna, Ingrid Moerman, "GITAR: Generic extension for Internet-of-Things ARchitectures enabling dynamic updates of network and application modules", *Ad hoc networks*, vol. 36, part 1, pp. 127-151, 2016.
13. Biljana Stamatović, Roman Trobec, "Cellular automata labeling of connected components in *n*-dimensional binary lattices", *J. supercomput.*, vol. 72, iss. 11, pp. 4221-4232, 2016.
14. Viktor Švigelj, Matjaž Šinkovec, Viktor Avbelj, Roman Trobec, Ludovit Gaspar, Danijel Petrovič, Peter Kruzliak, "Cardiovagal and adrenergic function tests in unilateral carotid artery stenosis patients - a Valsalva manoeuvre tool to show an autonomic dysfunction?", *Wien. Klin. Wochenschr.*, vol. 128, no. 13/14, pp. 504-512, 2016.
15. Roman Trobec, Radivoje Vasiljević, Milo V. Tomašević, Veljko Milutinović, Ramon Beivide, Mateo Valero, "Interconnection networks in petascale computer systems: a survey", *ACM comput. surv.*, vol. 49, no. 3, pp. 44-1-44-24, 2016.

Published Conference Contribution

1. Klemen Bregar, Andrej Hrovat, Mihael Mohorčič, "NLOS channel detection with multilayer perceptron in low - rate personal area networks for indoor localization accuracy improvement", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 130-139.
2. Matjaž Depolli, Janez Konc, Sándor Szabó, Bogdan Zavalnij, "Usage of hereditary colorings of product graphs in clique search programs", In: *Middle-European Conference on Applied Theoretical Computer Science (MATCOS 2016): zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12.-13. oktober 2016, [Ljubljana, Slovenija]: zvezek H*, pp. 40-43.
3. K. Guan, Bo Ai, Ruisi He, Zhangdui Zhong, Ting Xu, C. Briso-Rodriguez, Andrej Hrovat, "Stochastic modeling for extra propagation loss of tunnel curve", In: *2016 IEEE 83rd Vehicular Technology Conference (VTC Spring), Nanjing, China 15-18 May 2016: proceedings*, 5 pp.
4. Oliver Holland, Tomaž Šolc, Mihael Mohorčič, et al., "Some initial results and observations from a series of trials within the ofcom TV white spaces pilot", In: *2015 IEEE 81st Vehicular Technology Conference (VTC Spring), Glasgow, Scotland, 11-14 May 2015: proceedings*.
5. Andrej Hrovat, Tomaž Javornik, Ke Guan, "Analysis of radio wave propagation at millimeter- wave band in tunnels for 5G communications", In: *Conference proceedings*, ICECom 2016, 22nd International Conference on Applied Electromagnetics and Communications, 19-21 September, 2016, Dubrovnik, Croatia.
6. Arsim Kelmendi, Gorazd Kandus, Aleš Švigelj, Andrej Vilhar, Andrej Hrovat, Erich Leitgeb, "Evaluation of the Gaussian copula prediction method for joint rain attenuation statistics in earth-satellite site diversity systems", In: *Proceedings of the 2016 [1st] International Conference on Broadband Communications for Next Generation Networks and Multimedia Applications, CoBCom 2016, September 14-16, 2016, Graz, Austria*, 6 pp.
7. Arsim Kelmendi, Chariaos Kourogiorgas, Andrej Hrovat, Athanasios Panagopoulos, Gorazd Kandus, Andrej Vilhar, "Modeling of joint rain attenuation in earth-space diversity systems using Gaussian copula", In: *EuCAP 2016*, 5 pp.
8. Maks Kolman, Gregor Kosec, "Correlation between attenuation of 20 GHz satellite communication link and liquid water content in the atmosphere", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 308-313.
9. Gregor Kosec, "Convergence analysis of WLS based solution of Navier Stokes equation", In: *International Conference of Numerical Analysis and Applied Mathematics 2015 (ICNAAM 2015), 22-28 September 2015, Rhodes, Greece*, (AIP conference proceedings, volume 1738), pp. 480101-1- 480101-4, 2016.
10. Janko Kosmač, Gregor Kosec, "De-icing by operational countermeasures", In: *Digests*, First South East European Regional CIGRÉ Conference, Portoroz, Slovenia, 7th-8th June 2016, 9 pp.
11. Ada Krvavica, Špela Likar, Maja Brložnik, Aleksandra Domanjko-Petrič, Viktor Avbelj, "Comparison of wireless electrocardiographic monitoring and standard ECG in dogs", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 416-419.
12. Urban Kuhar, Jurij Jurše, Kemal Alič, Gorazd Kandus, Aleš Švigelj, "A unified three-phase branch model for a distribution-system state estimation", In: *IEEE PES innovative smart grid technologies, Europe, October, 9-12, 2016, Ljubljana: proceedings*, 2016 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe), Ljubljana, Slovenia, 9-12 October, 2016, 6 pp.
13. Primož Lavrič, Matjaž Depolli, "Robust beat detection on noisy differential ECG", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 401-406.
14. Andrej Lipej, Dragan Mitruševski, Boštjan Zafošnik, "Energetic, structural, thermal and fatigue analysis of heavy duty process pumps", In: *IAHR 2016: proceedings*, (IOP conference series. Earth and environmental science, vol. 49), 28th IAHR Symposium on Hydraulic Machinery and Systems, July 4-8th, 2016, Grenoble (France), 10 pp..
15. Miloš Maksić, Gregor Kosec, Vladimir Djurica, Andrej Souvent, Roman Trobec, "Dynamic thermal rating of power lines in raining conditions - model and measurements", In: *Paving the way for grid modernization*, pp. [1-4].
16. Miha Mohorčič, Matjaž Depolli, "Heart rate analysis with NevroEkg", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 487-492.
17. Aleksandra Rashkovska, Viktor Avbelj, Roman Trobec, "Wireless body sensor data analytics: challenges and approaches", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 73-76.
18. Aleksandra Rashkovska, Dragi Kocev, Roman Trobec, "Clustering of heartbeats from ecg recordings obtained with wireless body sensors", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 481-486.
19. Jure Slak, Gregor Kosec, "Detection of heart rate variability from a wearable differential ECG device", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 450-455.
20. Tomaž Šolc, "Low-cost spectrum sensor for ultra-narrowband transmissions", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 193-202.

21. Roman Trobec, "Mechanics of cantilever beam: implementation and comparison of FEM and MLPG approach", In: *International Conference of Numerical Analysis and Applied Mathematics 2015 (ICNAAM 2015), 22-28 September 2015, Rhodes, Greece*, (AIP conference proceedings, volume 1738), pp. 480108-1-480108-4.
22. Andrej Vilhar, Andrej Hrovat, Sebastijan Mrak, Urban Kuhar, Gorazd Kandus, "Štiri-kanalna Alphasat sprejemna postaja za meritve svetilniških signalov v Ka- in Q-pasu", In: *Radijske komunikacije: zbornik: proceedings*, 22. strokovni seminar Radijske komunikacije, Ljubljana, 3.-5. februar 2016 = 22nd Seminar on Radio Communications, Ljubljana, 3-5 February 2016, pp. 69-76.
23. Andrej Vilhar, Arsim Kelmendi, Andrej Hrovat, Gorazd Kandus, "First year analysis of alphasat KA- and Q- band beacon measurements in Ljubljana, Slovenia", In: *Communications satellite systems: a look back at the first 50 years and thoughts on the next 50*, The 22nd Ka and Broadband Communications Conference and the 34th AIAA International Communications Satellite Systems Conference (ICSSC), October 17-20 2016, Cleveland, Ohio, USA, 8 pp..

Independent Component Part or a Chapter in a Monograph

1. A. G. Burr, Laurent Clavier, G. Dimic, Tomaž Javornik, Werner Teich, M. Mostafa, "Evolved physical layer", In: *Cooperative radio communications for green smart environments*, (River publishers series in cmmunications, vol. 47), Narcis Cardona, ed., Gistrup, River Publishers, 2016, pp. 305-339.
2. H. Chamati, Roman Trobec, Janez Ivan Pavlič, "Peculiarities in the study of preformed DSPC lipid vesicles by coarse grain molecular dynamics", In: *Advances in biomembranes and lipid self-assembly. Volume 23*, Aleš Iglič, ed., Chandrashekhar Kulkarni, ed., Michael Rappolt, ed., Amsterdam [etc.], Elsevier, 2016, pp. 169-185.

Mentoring

1. Urban Gregorc, *Implementation of LoRa wireless communication for network of weather stations:* master's thesis, Ljubljana, 2016 (mentor Marko Jankovec; co-mentor Mihael Mohorčič).
2. Sebastijan Mrak, *Q-band (Ka-band) satellite receiver for observing Alphasat beacon:* master's thesis, Ljubljana, 2016 (mentor Matjaž Vidmar; co-mentor Andrej Hrovat).

COMPUTER SYSTEMS DEPARTMENT E-7

The Computer Systems department is concerned primarily with the development of advanced computing structures and efficient algorithms for massive-data processing, and systems for effective human-computer interaction. Within this broad area, we are concentrating on self-reparable and self-adapting systems, modelling and optimizing of complex, dynamic and nondeterministic systems. Our research results are implemented within applications for production, transport, energy, environmental sustainability, bioinformatics, health, and medicine. As an integral part of our research activities, members of the department have close contacts and collaborations with scientists world-wide, through academic links and industrial contacts, thus enabling us to keep at the forefront of rapidly developing fields.

Head:
Asst. Prof. Gregor Papa

Our research work in 2016 in the fields of efficient algorithms for massive-data processing, computing structures for faster and more reliable execution of algorithms, and interactive interfaces for the efficient acquisition and handling of data was enhanced by the design and development of various solutions within 11 European projects in Horizon 2020, ECSEL, ARTEMIS, FP7 and EEA Grants programs. We finished our work in the projects ACCUS, ENJOY IN HEALTH and TRUDEVICE. We continued with projects ISO-FOOD, REFRESH, RICHFIELDS, PD_manager, MANTIS and EU Menu Slovenia. We started to work within three new projects ImAppNIO, SYNERGY and Trans fatty acids.

We were actively involved in the preparation of the JSI's application for strategic research innovative partnership (SRIP) in the field of **Smart Cities and Communities**, as a part of the Slovenian Smart Specialization Strategy. The application was positively evaluated and accepted for execution. The SRIP will allow enhancing the common execution of research and development programs of academic and industrial partners and will merge knowledge and competencies for the development of new products, services and processes.

We developed procedures for the optimal broadcasting of multiple messages in networks.

Computing Structures

In the field of advanced computer structures we continued the development of **self-reparable systems based on FPGA** and developed a platform for quick error penetration into the FPGA with the use of dynamic partial reconfiguration. The SRAM-based field-programmable gate arrays (FPGAs) in mission-critical systems require error mitigation and recovery techniques to protect them from single-event upsets (SEUs) and multiple-event upset (MEU) errors, caused by high-energy radiation. The developed SEU-recovery mechanism has a smaller hardware overhead than the existing solutions. According to the required levels of reliability, different architectures of the self-recoverable mechanism can be employed. The results of our work on an error-recovery mechanism in FPGA using dynamic partial reconfiguration were presented in the scope of our activities in the COST *Action IC1204 TRUDEVICE – Trustworthy Manufacturing and Utilization of Secure Devices* (http://trudevice.com/).

Within the TRUDEVICE project we studied the **security upgrade of the IEEE Std 1149.1 scan design chains** also known as the JTAG standard. The JTAG scan chains are designed to enhance the system's testability and can potentially be used to break in a system and steal intellectual property or perform some other malicious action. The risk of system break-in should be seriously considered and appropriate countermeasures taken. We have analysed currently proposed solutions and pointed out some problems of adding decoding and encoding logic to scan chains as a possible countermeasure. Besides non-negligible logic overhead, this solution requires special software provided by the ASIC vendor for the proper interpretation of the scan test results. The security extension of the JTAG standard aims to prevent unauthorized users from breaking into a system and disturbing its normal operation via IEEE 1149.1 test port. For this solution, a possible attack scenario was described and probabilities that the system gets compromised within a certain time frame were calculated, together with the lower bound values of the Lock register length that ensure the required system security. In the frame of ECSEL JU *MANTIS – Cyber Physical System based Proactive Collaborative Maintenance* (http://www.mantis-project.eu/) we are currently exploring modifications to the locking mechanism, including different PKI architectures, which would allow different authorization levels, and possibly also the change of authorization keys.

In the field of **embedded systems** we developed a new generation of portable BLE kitchen scale with a low power consumption. The scale consists of a communication module built of the BLE113 interface that connects

other parts of the scale, also allowing a power-save mode, and a measurement module that is built around the measurement bridge and an accurate AD converter. For enhancing the battery life, the measurement module turns off when the scale is in standby mode.

We developed a **Bluetooth Low Energy (BLE) sensor network** with a communication mechanism that enables the data acquisition from distant nodes using intermediant BLE sensor nodes as the relays. BLE is a communication technology developed for low-power-consumption and low-cost applications. However, the BLE supports only simple communication schemes and does not support the creation of the communication network. Since the range of the BLE devices is relatively small some sensor nodes can become unavailable from the central acquisition system. To overcome this BLE limitation a new communication mechanism was developed for the BLE sensor node to relay the data from other nodes. This is achieved by switching the role of the intermediant node from a slave to a master, gathering the data from other intermediant and/or leaf nodes, and reporting all the data to its master. A hardware prototype to validate the implemented mechanism was developed.

In the scope of **sensors** research we studied the effect of a temporary presence of liquids that may importantly influence the response of a LTCC-based pressure sensor in s Wheatstone bridge configuration. A specific time response of offsite voltage was observed during the experimentation with droplets of water dispensed on the diaphragm. Such a response may result from the dynamic changes in the temperature distribution due to the local cooling caused by the evaporation of the liquid covering the sensing diaphragm. Based on this assumption an FE model is under development, in which heat transfer resulting from the evaporation of the liquid film was defined as a discrete function of time. An initial FE analysis confirms the trends of experimental measurements.

Algorithms for Data Processing

Our research in the field of efficient algorithms for computer data processing was focused on the development of multi-objective optimization approaches, the study of optimal information transfer in networks and pattern recognition. Some solutions were used on the application level within computer support for diet planning and our Open platform for clinical nutrition (OPEN). Here we can highlight the algorithms for food matching, for the automatic recognition and detection of food and drinks from images by using deep learning, and applications for computer-assisted dietary assessment, weight-loss programmes, and tracking the physical activity of children and teenagers with sport wristbands.

We are developing an algorithm for the automatic detection and recognition of food and drinks from images by using a deep-learning technique.

To improve our excellence and unleash research and innovation potential in the field of **multi-objective optimization, supported by parallelisation and surrogate modelling** we started a Twinning project Horizon 2020 SYNERGY - *Synergy for smart multi-objective optimisation* (http://synergy-twinning.eu/), which we are also coordinating. In the project we are collaborating with the Department of Intelligent Systems at JSI, Cologne University of Applied Sciences (CUAS), and University of Lille (USTL). The goal of the project is to overcome the limitations of the current initial-stage research in multi-objective optimization at the Jožef Stefan Institute, where efficiency measures have only been explored on a very small scale and with no collaboration with other partners. USTL is a leading partner in parallelisation on large-scale heterogeneous architectures, while CUAS provides expertise in surrogate modelling and its deployment in optimisation problems. In 2016 we have carried out several visits to the participating partners, and conducted several joint workshops at renowned international conferences for the needs of education in the framework of the project.

We researched **optimal broadcasting of multiple messages** – in terms of time and the number of messages – in the 1-in port model, where every vertex of a synchronous network can receive at each time unit at most one message. We considered simultaneous broadcasting of multiple messages from the same source in such networks with an additional restriction that every received message can be sent out to neighbours only in the next time unit and never to an already informed vertex. We used a general concept of level-disjoint partitions developed for this scenario. We provided a necessary condition in terms of girth and eccentricity of the root for the existence of k same-rooted level-disjoint partitions of optimal height and provided a structural characterization of graphs that admit simultaneous broadcasting of two messages from a given vertex. We introduced a subgraph extension technique for efficient information spread within the concept of a level-disjoint partition. This approach, with so-called biwheels, leads to the simultaneous broadcasting of the optimal number of messages on a wide class of graphs in an optimal time. In particular, we provided tight results for bipartite tori, meshes, and hypercubes. We successfully presented our results at the COCOA 2016 conference.

We introduced a **new measure for a balanced workload** and we determined its extremal values as well as the graph structures where the extremal values are attained. To measure the extent to which the distribution of the workload in the network can be equalized, a degree-weighted measure for a balanced workload based on betweenness centrality was introduced. The goal was to determine the extremal values of the measure, and the structures where these values are attained.

To work on a **mathematical formalization of artificial genetic representations with neutrality**, a visit to the University of Coimbra was made. The visit was supported by COST Action *ImAppNIO – Improving Applicability of Nature-Inspired Optimisation by Joining Theory and Practice* (http://imappnio.dcs.aber.ac.uk/). The potential that neutral networks have to establish alternative paths for the evolution of the population, and to lead to improved search quality, is the main motivation for the use of redundant representations in evolutionary computation. The role of neutrality in evolutionary search has been widely considered in the literature, but it remains unclear to what extent it may contribute to the search performance. In studies, a promising class of representations based on error-control codes was proposed, leading to families of representations with various degrees of neutrality, synonymity, connectivity, and locality.

Within the European ARTEMIS association we successfully finished our work in the project *ACCUS – Adaptive Cooperative Control in Urban (sub) Systems* (http://www.projectaccus.eu), where we collaborated in the development of the platform for the integration and coordination of urban systems (transportation, outdoor lighting, energy) to build applications across urban systems, to provide adaptive and cooperative control for urban subsystems, and to optimize the combined performance. We upgraded the **traffic-flow simulation framework**, based on the OpenDRIVE logical description of a road network. The framework includes the descriptions of the road network and the traffic lights and allows the simulation of vehicle flows, according to the IDM (Intelligent driver model). It allows simple and intuitive planning of new and/or changed road segments, since their influence can be easily observed. The upgraded simulator also allows the optimization of traffic lights' switch segments, resulting in more fluent traffic flows.

Figure 1: Mobile application for traffic routing and navigation.

In the area of **pattern recognition** we studied electrocardiographic indices as a function of the coupling interval and the site of ventricular premature beats, in an isolated rabbit heart preparation using electrocardiografic multi-lead system. In both ventricles, results have shown significant increases in ventricular depolarization duration. We have also observed that when the ventricular premature beats were applied to the left ventricule, a significant decrease in the total repolarization duration was detected, while the right ventricule premature stimulation has not exhibited significant changes in the total repolarization duration. We compared twenty machine-learning classification techniques to find the optimal electrode placement for the left and the right ventricule stimulation and to interpret the site of the origin of ventricular premature beats.

The Horizon 2020 project *RICHFIELDS – Research Infrastructure on Consumer Health and Food Intake for Escience with Linked Data Sharing* (http://www.richfields.eu/) is focused on food- and nutrition-related data. The main aim of the project is to design the architecture of a platform for collecting, linking and harmonizing big and open data provided by various information systems and mobile apps. In a pilot, which aims to identify gaps and problems in the area of food composition data, we have developed an advanced **algorithm for matching food items** indexed and classified by using different standards, such as LanguaL and FoodEx2. The algorithm is based on POS tagging, also developed at our department. We presented the approach at the Food Forum 2016 in Brussels. The approach was recognized as the most promising among all the approaches presented by European institutions. A similar approach was used in another project *EU Menu – Support to National Dietary Surveys in Complience with the EU Menu methodlogy,* co-financed by the European Food Safety Agency EFSA. This project aims at collecting data on food consumption habits and patterns across Slovenia. Food-consumption data are essential for assessing how exposed people are to potential risks in the food chain. In cooperation with the Slovenian Public Health Institute (NIJZ) we developed a mobile app for 24h recall. The app is based on the food consumption data managed by the OPEN. To enable data transmission to EFSA, the application has been upgraded with web services. Within this project, OPEN has also been extended to support the **statistical analysis of collected data**.

Another Horizon 2020 project *PD_manager – mhealth platform for Parkinson's disease management* (http://www.parkinson-manager.eu/) aims at developing a set of unobtrusive and co-operative mobile devices that will be used by Parkinson's disease patients for symptoms monitoring and the collection of adherence data. As Parkinson's disease patients also have nutritional problems, such as disphagia and constipation, and may experience side-effects of some food on drugs, we have developed a nutrition mobile application for food, drinks and drug tracking. The application is based on the automatic recognition of food and drinks from images taken by a patient or his caregiver with a smartphone. The **recognition algorithm is implemented by deep-learning techniques**. Preliminary results were

Figure 2: User interfaces of mobile apps for people with Parkinson's disease.

presented at the international conference organized by the Slovenian society for dysphagia in Ljubljana in May (http://disfagija.si/sl/home/).

The project *ENJOY IN HEALTH – Celostni inovativni model za zagotavljanje zdravega življenjskega sloga, s poudarkom na prehranjevanju, gibanju, preprečevanju in obravnavi debelosti pri otrocih, mladostnikih ter odraslih in zmanjševanju neenakosti v zdravju* (http://uzivajmovzdravju.si) was financed by the Norway Financial Mechanism. The main objective of the project was to decrease and prevent unhealthy lifestyle-related diseases. The project outcomes included the development and testing of inter-disciplinary prevention teams within the education sector, health/medical sector, social sector and the local communities with the aim to support a healthy lifestyle; and innovative intervention programmes for the non-medicinal treatment of obesity for children, youth and adults. In cooperation with the NIJZ, our department developed a **web-based and a mobile app for assisting a weight-loss programme** performed by the Slovenian health homes. In a pilot, the app was tested in 12 health centres. Another output was a mobile app Fitus aimed at tracking the physical activity of children and teenagers using a wristband. Data about the user's activity and heart rate measured by the wristband are stored in a cloud, which can be accesses by the app via an API. The app tracks the development of the pupil's performances through periods. As the application is also connected by the OPEN, it enables a statistical analysis of collected data as well as a link of data about physical activity and heart rate with data about dietary habits.

Our department is a partner in the consortium of the ARRS applied project *Trans fatty acids*, financed by ARRS. In the first period of the project, groups of pre-packaged foods that are potentially most significant sources of trans fatty acids (TFA) were identified and the content of TFA in vegetable fats was analysed. Our department contributed to the estimation of the intake of TFA in the most risky population group, i.e., students consuming subsidized student food. The estimation was performed by using data on the TFA content in foods collected in database of the **Open platform for clinical nutrition**. The results were published in http://www.delo.si/prosti-cas/zdravje/nutricionisti-bi-vsebnost-trans-mascob-v-zivilih-zakonsko-omejili.html.

In the Horizon 2020 project *REFRESH – Resource Efficient Food and dRink for the Entire Supply cHain* (http://eu-refresh.org/) we will contribute towards the objectives of reducing food waste across Europe by 30 % by 2025, reducing waste-management costs, and maximizing the value from unavoidable food waste and packaging materials. We are developing a database of unavoidable food waste.

In cooperation with the *Milko Kos Historical Institute of ZRC SAZU* we worked on the new portal Slovenian Historical Topography. The long-term goal will be to produce a thorough and reliable **digital interactive version of historical topography of the entire territory of the present-day Republic of Slovenia**. The first step in this objective has already been successfully achieved by the project *Slovenian place-names in time and space*, which covered the territory of the historical province of Carniola. The original printed handbook from 1975 was thus replaced with an up-to-date interactive web application with advanced search possibilities, geolocation, connection of database with online geographical map and a circa 30 % richer – updated and corrected – database (http://topografija.zrc-sazu.si/).

Applying our research results, we developed a **web-based tool for the e-learning of statistics**. This tool is primarily aimed to be used by the ERA Chair ISO-FOOD for distance teaching chemistry and physics students. It leads the student in using different methods for statistical analysis. Currently, we are performing the testing of the tool in collaboration with the *Department of Environmental Sciences* at the JSI.

We have developed an e-learning tool for statistics.

To improve the department's excellence in the field of statistics, we launched a series of **statistical seminars**. The seminars are conducted on a weekly basis and are intended for the staff and associates of the department. The seminars are on two levels. The basic statistical seminar is meant to refresh and deepen the basic knowledge of statistics. It is carried out in the form of the lectures and if follows the curriculum of statistics at Slovenian universities. The advanced group is intended to upgrade their basic knowledge of statistics and study the advanced topics of statistics and machine learning. Our aim is to extend the work of the seminar beyond the boundaries of the department.

In cooperation with the *Department of Intelligent Systems* at the JSI we organized in May the BIOMA 2016 **conference** Bioinspired Optimization Methods and their Applications (http://bioma.ijs.si/conference/2016/). The seventh biennial conference included the presentations and discussions on the newest theoretical and practical results on nature-inspired optimization methods and their applications. The presentations are included in the conference proceedings.

In cooperation with the *Department of Intelligent Systems* at the JSI and the *Faculty of Electrical Engineering and Computer Science, University of Maribor* (Laboratories for Computer Architecture and Languages and Programming Methodologies), we organized, for the thirteen consecutive year, the **workshops on Nature-inspired algorithms** on stochastic optimization techniques.

Human-Computer Interaction

In the area of efficient interaction systems, we focused on a study of **usage scenarios** within human-machine interaction, we developed **serious games** for telerahabilitation, and we continued with development and usage of recognized **procedures and tools for usability testing**.

Our work in the MANTIS project was focused on the **design and development of human-machine interaction**. Following a user-centred design paradigm, our early work comprised gathering the MANTIS system use scenarios from industrial partners, which serve as a cornerstone for the design of intelligent and context-aware user interface for proactive and collaborative maintenance. From the gathered use scenarios, we were deriving requirement specifications for human-machine interaction and developing an interaction model that supports proactive maintenance, collaboration among the users, collaboration between the users and the MANTIS system, and includes context-aware functionalities. In addition, we contributed to the description and representation of different interface types, and the preparation of the guidelines for interface design. We have already started with the implementation of a user-interface prototype.

Within the Horizon 2020 project PD_manager we also developed and implemented the **gamification of physiotherapy for people with Parkinson's disease**. The aim was to show how off-the-shelf equipment could be used to develop serious games for an affordable tele-medicine solution for Parkinson's disease management. Two games have been developed in collaboration with the *Soča rehabilitation institute* aimed at assessing and training a patient's reach of upper limbs (using Kinect v2) and fine motoric skills of fingers (using Leap motion). The games collect player data in terms of the score achieved and the full kinematics of movement during gameplay. The games have been tested with patients within the Soča rehabilitation institute as well as at their homes. We also designed and developed the server side of the system, which consists of a database to store anonymized user data, game scores and kinematic data. It is also used as a service to share data among different client machines and as user interface for clinicians.

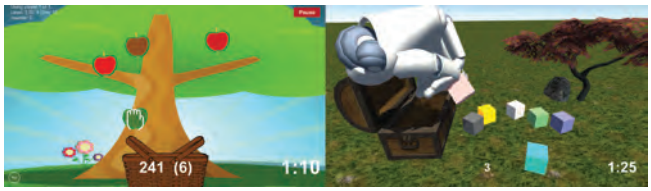


Figure 3: Serious games for the rehabilitation of people with Parkinson's disease.

In cooperation with the informal community *Slovenian human-computer interaction researchers* (http://hci.si/), we organized the 3rd Human-Computer Interaction in Information Society (HCI-IS) conference in October (part of the Information society multiconference). This year's edition saw an increase of attendance from the previous years with contributions from academia and industry. The main purpose of the event is to connect Slovenian researchers interested in HCI in order to exchange ideas, collaborate and accelerate the development of this exciting interdisciplinary field in Slovenia and its surrounding countries. Here, we also reported a usability testing of the graphical user interface of the GUARD simulator developed by Guardiaris d.o.o. This BSc thesis was supervised by a member of our department.

We redesigned the Slovenian avalanche bulletin (http://www.meteo.si/pozor/plaz), of the Slovenian environment agency, with a **usability study of the proposed prototypes**. The study informed the agency about which version is better understood by different user groups and what are their comments. Besides usability, the educational aspect of the bulletin was also taken into consideration. The undertaken testing was a mixture of exploratory and evaluation study aimed at gathering qualitative data. Together with the client, we defined the goals of the study and the questions that the study needs to answer. We then prepared scenarios with tasks that the users performed during testing. After testing and an online survey, the results were analysed and a set of findings and list of possible improvements was given to the client.

Figure 4: Usability study to support the redesign of the Slovenian avalanche bulletin.

Within the TETRACOM *PerNuCAP – Personalized Nutrition Control Aid for Insulin Patch Pump*, we conducted **usability testing of the Insulin Patch Pump** developed by IPDmed company. Following the *Usability Testing of Medical Devices* IEC 62366 standard. We carried out the introductory study of the purpose and intended use of the pump, intended user population and conditions of use. We examined the functionalities of the device and the risk analysis already conducted by IPDmed. From the preceding studies we specified the comprehensive list of the primary operating functions, i.e., frequently used functions and functions, related to the safety of the device. We also identified possible use scenarios and user actions for each function.

The PD_manager platform consists of different modules with different interfaces (web, mobile, natural) and different users. The most sensible ones are the modules that interface with the patients. To ensure accessibility of all the interfaces with the patients, we started a usability study of how patients with Parkinson's interact with the PD_manager platform. In addition, to study **user experience design** we defined the visual language for the project's user interfaces and redesigned the mobile interfaces accordingly. The case study for the new visual language was a mobile app for tracking nutrients and foods consumed by patients with Parkinson's disease. The new interface

allows the patients to recognize objects on the screen, easily perceive their function and interact with them, thus providing an efficient way of entering the dietary intake data.

We conceived UsabEU to provide a **web-based starting point for usability evaluations** with questionnaires in native or mother tongue. We designed a platform that supports the online collaborative translation of usability questionnaires and their validation. It also serves as a repository for all validated questionnaires and a tool to perform usability evaluations. The current proof-of-concept design of the platform supports the translation and validation of the System Usability Scale questionnaire.

Some outstanding publications in the past year

1. A. Kostevšek, J. Klemeš, P. Varbanov, G. Papa, J. Petek, "The concept of an ecosystem model to support the transformation to sustainable energy systems", Applied energy, 184: 1460 – 1469, 2016, doi: 10.1016/j.apenergy.2016.04.010.
2. P. Gregor, R. Škrekovski, V. Vukašinović, "Time-optimal broadcasting of multiple messages in 1-in port model", Combinatorial optimization and applications: 10th International Conference, COCOA 2016, Lecture notes in computer science, 10043: 144-158.
3. J. Klisara, R. Škrekovski, V. Vukašinović, D. Vukičević, "A measure for a balanced workload and its extremal values", Discrete applied mathematics, 200: 59-66, 2016. doi: 10.1016/j.dam.2015.07.006.
4. P. Virtič, M. Vražić, G. Papa "Design of an axial flux permanent magnet synchronous machine using analytical method and evolutionary optimization", IEEE transactions on energy conversion, 31: 150-158, 2016, doi: 10.1109/TEC.2015.2477319.
5. A. Biasizzo, F. Novak, "Security problems of scan design and accompanying measures", Journal of electrical engineering, 67: 192-198, 2016.

Organization of conferences, congresses and meetings

1. AVN, The 28th Workshop Nature-Inspired Algorithms, Bled, Slovenia, 18. 5. 2016
2. SYNERGY project-meeting, Bled, Slovenia 18.–19. 5. 2016
3. MANTIS, full consortium project-meeting, Ljubljana, Slovenia 17.–20. 5. 2016
4. BIOMA 2018, The 7th International Conference on Bioinspired Optimization Methods and their Applications, Bled, Slovenia, 18.–20. 5. 2016
5. HCI-IS 2016, Conference Human-Computer Interaction in Information Society, Ljubljana, Slovenia 9. 10. 2016
6. AVN, The 29th Workshop Nature-Inspired Algorithms, Maribor, Slovenia, 2. 12. 2016

Patent granted

1. Gregor Papa, Barbara Koroušić-Seljak, Marko Pavlin, Device and method for acquisition and transfer of signals, SI24792 (A), Slovenian Intellectual Property Office , 29. 02. 2016.

INTERNATIONAL PROJECTS

1. 7FP - TETRACOM; Technology Transfer in Computing Systems
   Prof. Franc Novak
   European Commission
2. Adaptive Cooperative Control in Urban (sub) Systems
   Asst. Prof. Gregor Papa
   Ministrstvo za Gospodarstvo
3. 7 FP; ERA CHAIR ISO-FOOD - Era Chairs for Isotope Techniques in Food Quality, Safety and Traceability
   Asst. Prof. Barbara Koroušić Seljak
   European Commission
4. EU MENU Slovenija; LOT 1; Support to National Dietary Survey in Compliance with the EU MENU Methodology - Fourth Support
   Asst. Prof. Barbara Koroušić Seljak
   European Food Safety Authority - Efsa
5. EU MENU Slovenija; LOT 2; Support to National Dietary Survey in Compliance with the EU MENU Methodology - Fourth Support
   Asst. Prof. Barbara Koroušić Seljak
   European Food Safety Authority - Efsa
6. COST IC1204; Trustworthy Manufacturing and Utilization of Secure Devices
   Prof. Franc Novak
   Cost Office
7. COST CA15140 - ImAppNIO; Improving Applicability of Nature-Inspired Optimisation by Joing Theory and Practise
   Dr. Vida Vukašinović
   Cost Office
8. H2020 - MANTIS; Cyber Physical System based Proactive Collaborative Maintenance
   Asst. Prof. Gregor Papa
   European Commission
9. H2020 - REFRESH; Resource Efficient Food and Drink for the Entire Supply Chain
   Asst. Prof. Barbara Koroušić Seljak
   European Commission
10. H2020 - RICHFIELDS; Research Infrastructure on Consumer Health and Food Intake using E-science with Linked Dara Sharing
    Asst. Prof. Barbara Koroušić Seljak
    European Commission
11. H2020 - PD_manager; Mhealth Platform for Parkinson's Disease Management
    Asst. Prof. Barbara Koroušić Seljak
    European Commission
12. H2020 - SYNERGY; Synergy for Smart Multi-Objective Optimisation
    Prof. Peter Korošec
    European Commission

RESEARCH PROGRAM

1. Computer Structures and Systems
   Asst. Prof. Gregor Papa

R & D GRANTS AND CONTRACTS

1. Advanced electrocaloric energy Conversion
   Asst. Prof. Barbara Koroušić Seljak

2. Norway Grants „Enjoy in Health"; An Integrated Innovative Model for the Provision of a Healthy Lifestyle, with a Focus on Nutrition, Physical Activity, Obesity Prevention and Treatment in Children, Adolescents and Adults and
   Asst. Prof. Barbara Koroušić Seljak
   Republic of Slovenia, Government Office for Development and European Cohesion Policy
3. Adaptive Cooperative Control in Urban (sub) Systems
   Asst. Prof. Gregor Papa
   Republic of Slovenia, Ministry of Economic Development and Technology
4. Upgrade of the Open Platform for Clinical Nutrition to suit the needs of the Federation of EU member National Associations of Dietitians EFAD
   Asst. Prof. Barbara Koroušić Seljak
   Eurofir Aisbl
5. Conference BIOMA 2016; The 7th International Conference on Bioinspired Methods and their Applications, Bled, Slovenia, 18.-20.05.2016
   Asst. Prof. Gregor Papa
6. Electronic Questionaire; Data Collection and Monitoring about Gastrointestinal Simptoms
   Asst. Prof. Barbara Koroušić Seljak
   Espghan Office

NEW CONTRACTS

1. Personalized Nutrition Control Aid for Insulin Patch Pump – PerNuCAP
   Prof. Franc Novak
   Ipd Med d. o. o.

VISITORS FROM ABROAD

1. Thomas Bartz Beielstein, Boris Naujoks, Jörg Stork, Technische Hochschule Köln, Germany, 10.–11. 2. 2016
2. Nouredine Melab, El-Ghazali Talbi, Universite des Sciences et Technologies de Lille I, Lille, France, 10.–11. 2. 2016
3. Thomas Bartz Beielstein, Boris Naujoks, Technische Hochschule Köln, Germany, 17.–20. 5. 2016
4. Nouredine Melab, El-Ghazali Talbi, Universite des Sciences et Technologies de Lille I, Lille, France, 17.–20. 5. 2016
5. Goran Martinović, Fakultet elektrotehnike, računarstva i informacijskih tehnologija Osjek (FERIT) Osijek, Croatia, 17.–20. 5. 2016
6. Roberto Uribeetxeberria, Urko Zurutuza, Mondragon Unibertsitatea, Faculty of Engineering, Arrasate-Mondragon, Spain, 23.–25. 5. 2016
7. Roberto Gonzalez, Fundacion Tekniker, Eibar, Spain, 23.–25. 5. 2016
8. Salvatore Esposito, Mario Riccardi, Ansaldo STS, Genova, Italy, 23.–25. 5. 2016
9. Stanislava Velkova, 3E, Brussels, Belgium, 23.–25. 5. 2016
10. Erkki Jantunen, Teknologian tutkimuskeskus VTT, Espoo, Finland, 23.–25. 5. 2016
11. Antti Niemela, Lapin Ammattikorkeakoulu, Kemi, Finland, 23.–25. 5. 2016
12. Bas Tijsma, Philips Consumer Lifestyle, Drachten, Netherlands, 23.–25. 5. 2016
13. Jerker Delsing, Luleå University of Technology, Department of Computer Science, Electrical and Space Engineering, Lule , Sweden, 23.–25. 5. 2016
14. Marjan Šterk, XLAB, Ljubljana, Slovenia, 23.–25. 5. 2016
15. Boris Naujoks, Technische Hochschule Köln, Germany, 10.–11. 11. 2016

STAFF

Researchers
1. Asst. Prof. Anton Biasizzo
2. Prof. Peter Korošec
3. Asst. Prof. Barbara Koroušić Seljak
4. Prof. Stanislav Kovačič*
5. Prof. Franc Novak
6. **Asst. Prof. Gregor Papa, Head**
7. Asst. Prof. Jurij Šilc

Postdoctoral associates
8. Dr. Bojan Blažica
9. Dr. Marko Pavlin*
10. Dr. Drago Torkar
11. Dr. Vida Vukašinović

Postgraduates
12. Rok Hribar, B. Sc.
13. Martin Pečar, B. Sc.

Technical officers
14. Špela Poklukar, B. Sc.

Technical and administrative staff
15. Jolanda Jakofčič

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Anton Biasizzo, Franc Novak, "Security problems of scan design and accompanying measures", *J. Elektr. Eng.*, vol. 67, no. 3, pp. 192-198, 2016.
2. Jelena Klisara, Riste Škrekovski, Vida Vukašinović, Damir Vukičević, "A measure for a balanced workload and its extremal values", *Discrete appl. math.*, vol. 200, pp. 59-66, 2016.
3. Anja Kostevšek, Jiri Klemeš, Petar Varbanov, Gregor Papa, Janez Petek, "The concept of an ecosystem model to support the transformation to sustainable energy systems", *Appl. energy*, vol. 184, pp. 1460-1469, 2016.
4. Matej Kristan, Vildana Sulić Kenk, Stanislav Kovačič, Janez Perš, "Fast image-based obstacle detection from unmanned surface vehicles", *IEEE trans. cybern.*, vol. 46, no. 3, pp. 641-654, Mar. 2016.
5. Peter Virtič, Mario Vražić, Gregor Papa, "Design of an axial flux permanent magnet synchronous machine using analytical method and evolutionary optimization", *IEEE trans. energy convers.*, issue 1, vol. 31, pp. 150-158, mar. 2016.

Published Conference Contribution (invited lecture)

1. Gregor Papa, Urko Zurutuza, Roberto Uribeetxeberria, "Cyber physical system based proactive collaborative maintenance", In: *Proceedings of 2016 International Conference on Smart Systems and Technologies, (SST), Osijek, Croatia, October 12-14, 2016*, pp. 173-178.

Published Conference Contribution

1. Simon Beltram, Gregor Papa, "Optimizacija geometrije profila letalskega krila", In: *Zbornik petindvajsete mednarodne Elektrotehniške in računalniške konference ERK 2016, 19. - 21. september 2016, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ..., 25), zv. B, pp. 75-78.
2. Bojan Blažica, Franc Novak, Anton Biasizzo, Ciril Bohak, "3D serious games for Parkinson's disease management", In: *Interakcija človek-računalnik v informacijski družbi: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11. oktober 2016, [Ljubljana, Slovenija]: zvezek E*, pp. 9-12.

3. Tome Eftimov, Peter Korošec, Barbara Koroušić-Seljak, "Disadvantages of statistical comparison of stochastic optimization algorithms", In: *Bioinspired optimization methods and their applications: proceedings of the Seventh International Conference on Bioinspired Optimization Methods and their Applications - BIOMA 2016, 18-20 May 2016, Bled, Slovenia*, pp. 105-118.
4. Tome Eftimov, Peter Korošec, Barbara Koroušić-Seljak, "Knowledge extraction of evidence - based dietary recommendations", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 149-153.
5. Dimitros Gatsios, George Rigas, Dragana Miljković, Barbara Koroušić-Seljak, Marko Bohanec, María Soledad Arredondo, Angelo Antonini, Spyros Konitsiotis, Dimitrios I. Fotiadis, "Mhealth platform for Parkinson's disease management", In: *Final program*, CBHI 2016, 18th International Conference on Biomedicine and Health Informatics, Februar 25-26, Dubai, UAE, 5 pp..
6. Petr Gregor, Riste Škrekovski, Vida Vukašinović, "Time-optimal broadcasting of multiple messages in 1-in port model", In: *Combinatorial optimization and applications: 10th International Conference, COCOA 2016, Hong Kong, China, December 16-18, 2016: proceedings*, (Lecture notes in computer science, vol. 10043), pp. 144-158.
7. Žiga Kopušar, Franc Novak, "Towards the improvement of GUARD graphical user interface", In: *Interakcija človek-računalnik v informacijski družbi: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11. oktober 2016, [Ljubljana, Slovenija]: zvezek E*, pp. 33-36.
8. Peter Novak, Barbara Koroušić-Seljak, Franc Novak, "Designing visual interface for nutrition tracking of patients with Parkinson's disease", In: *Interakcija človek-računalnik v informacijski družbi: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11. oktober 2016, [Ljubljana, Slovenija]: zvezek E*, pp. 13-16.
9. Gal Pavlin, Marko Pavlin, "Towards affordable mobile crowd sensing device", In: *Interakcija človek-računalnik v informacijski družbi: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11. oktober 2016, [Ljubljana, Slovenija]: zvezek E*, pp. 37-39.
10. Drago Torkar, Pedro David Arini, "Analysis of an electrocardiographic multilead system by means of artificial neural networks, Study of repolarization during premature ventricular stimula tion", In: *BIOSTEC 2016: proceedings*, (Biosignals, volume 4), 9th International Joint Conference on Biomedical Engineering Systems and Technologies, February 21 - 23, 2016, Rome, Italy, pp. 34-41.

Independent Component Part or a Chapter in a Monograph

1. Barbara Koroušić-Seljak, E. Vasco, Paula Alvito, "OPEN platform for clinical nutrition - an online dietary assessment: an online dietary assessment", In: *Food contaminants and human health: challenges in chemical mixtures*, pp. 63-66.

Scientific Monograph

1. Miha Kosi, Matjaž Bizjak, Miha Seručnik, Jurij Šilc, *Historična topografija Kranjske (do leta 1500)*, (Slovenska historična topografija, 1), 1. e- izd., Ljubljana, Založba ZRC, 2016.

Patent

1. Gregor Papa, Barbara Koroušić-Seljak, Marko Pavlin, *Device and method for acquisition and transfer of signals,* SI24792 (A), Urad RS za intelektualno lastnino, 29. 02. 2016.

Mentoring

1. Anja Gaber, *Design and evaluation of the nutritional profile of gluten-free foods:* master's thesis, Ljubljana, 2016 (mentor Marjan Simčič; co-mentor Barbara Koroušić Seljak).
2. Andraž Škoda, *Detection of surface defects on highly glossy objects:* master's thesis, Ljubljana, 2016 (mentor Stanislav Kovačič).

DEPARTMENT OF KNOWLEDGE TECHNOLOGIES E-8

Department of Knowledge Technologies performs research in advanced information technologies aimed at acquiring, storing and managing knowledge to be used in the development of an information- and knowledge-based society. Established areas of our work include intelligent data analysis (machine learning, data mining, and knowledge discovery in databases), language technologies and computational linguistics, computational creativity, decision support and knowledge management. In addition to research in knowledge technologies, we are also developing applications in environmental sciences and management, agronomy, medicine, biomedicine and bioinformatics, economics, finance and marketing. The department is also a recognised centre for linguistic research and digital humanities.

Head:
Prof. Nada Lavrač

In 2016 we were involved in twelve national projects, eight EU FP7 and four Horizon 2020 projects, one COST action, two bilateral projects, one infrastructure project and four industry projects. The department hosted nine junior researchers working towards their PhDs.

In the area of **intelligent data analysis and data mining** we have developed several new methods and used them in a number of application domains. In the area of semantic data mining we have developed a method for explaining mixture models through semantic pattern mining and banded matrix visualization, published in the respected Machine Learning journal and a method for network-ranking-assisted semantic data mining. In the area of heterogeneous network analysis we developed new search-heuristics-based text mining. We continued work in the area of multi-view clustering using multi-target predictive clustering trees, with a similar method applied to clustering of Alzheimer's disease patients. A new web platform for text mining and natural language processing TextFlows was developed, together with complex language processing workflows, and presented in the Science of Computer Programming journal. In text mining we continued research in bisociative cross-domain link discovery. Within the PD_manager project, which we coordinate at JSI, we developed a multi-view methodology for determining groups of patients with similar symptoms and detecting patterns of medication changes that lead to the improvement or decline of patients' quality of life.

Our team won the ESA's Mars Express Power Challenge, designing the most accurate solution for predicting a space probe's power consumption.

We have developed new methods for the automated modelling of dynamic systems, using both data and domain knowledge, and have applied them to problems in the areas of environmental and life sciences. These include methods for learning ensembles of deterministic process-based models and methods for learning stochastic process-based models. We have adapted the methods for learning process-based models for the task of designing dynamic biological systems and demonstrated their utility on several problems from synthetic biology.

We are coordinating the FP7 FET project MAESTRA (Learning from Massive, Incompletely Annotated, and Structured Data), which focuses on analysing data that may be complex in several ways. Within MAESTRA we have developed many new methods for structured output prediction in a batch or streaming setting. These include methods for multi-target regression, such as learning option trees in batch setting, as well as learning trees and tree ensembles in streaming setting. The latter have been used to perform multi-label classification on data streams. We have also developed methods for feature ranking for different types of structured outputs. Finally, we have proposed a method to organize the labels in multi-label classification into a hierarchy, which improves the predictive performance.

We have used methods of predictive clustering for the analysis of various aspects of the biology of extremophilic fungi, which can act as opportunistic human pathogens. We have also used these methods for the identification of multi-output dynamic systems in batch and streaming settings. Finally, we used methods for multi-target regression in the ESA Mars Express Power Challenge, where the task was to predict the power consumption of 33 different lines of the thermal subsystem for the Mars Express orbiter.

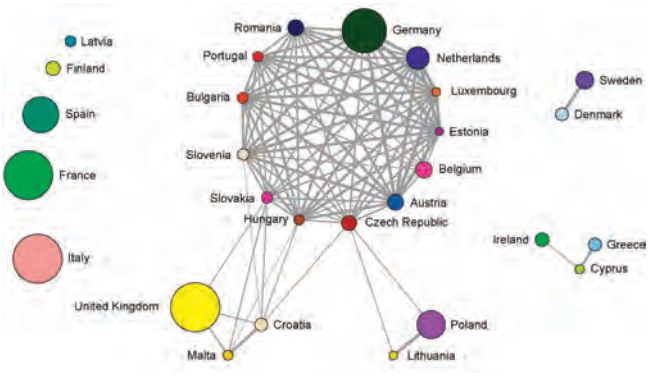


Figure 1: A network of the EU countries, linked by tweet sharing. The size of a node is proportional to the number of EP members from that country. The network contains one large connected component consisting of 18 countries, with a core of 13 countries around Germany that are densely connected.

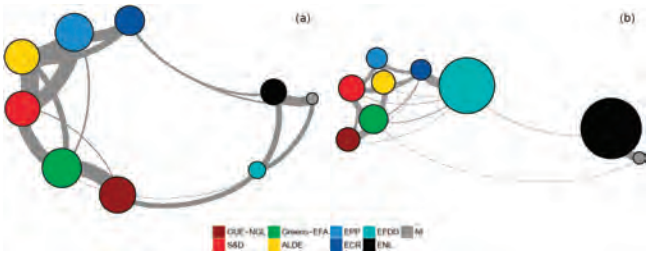


Figure 2: Networks of roll-call votes and retweets. (A) Co-voting agreement within and between political groups in the EP. (B) Average retweets within and between political groups.

In the context of the FET Flagship HBP (Human Brain Project) project, we are developing new data-mining methods and applying them to discover biological signatures of neurodegenerative diseases, such as Alzheimer's and Parkinson's. A new multi-view clustering method was developed and used for the identification of gender-specific biomarkers for Alzheimer's disease. Several methods for redescription mining, based on predictive clustering, were developed and applied to data on Alzheimer's disease. Finally, we have applied predictive clustering trees to relate biomarkers and clinical scores for Parkinson's disease.

In collaboration with the French Institute ARVALIS (Institut du végétal), we launched the project BIODIV (Understanding and managing biodiversity in agricultural ecosystems by data mining and decision support). We organized a workshop where we explored the current state of data collection and the modelling of habitats and population dynamics for auxiliary species that perform biological control of pests (such as aphids) in cereal crops. We performed extensive and complex data pre-processing, grouping organisms into functional categories and linking sampling sites to their environmental characteristics, thus getting ready to apply data mining and decision modelling.

In the area of **text and web mining, and heterogeneous information network analysis**, we successfully completed (with an excellent evaluation) the MULTIPLEX project (Foundational Research on MULTIlevel comPLEX networks and systems). We continued work on an existing FP7 project SIMPOL (Financial Systems Simulation and Policy Modelling) and a H2020 FET project DOLFINS (Distributed Global Financial Systems for Society). We also started a new national project FORMICA (Influence of formal and informal corporate communications on capital markets).

The NAO robot talking through the WHIMBOT interface, developed within the WHIM project, attracted a lot of attention at this year's International fair of crafts and entrepreneurship in Celje.

The main emphasis of the research in this area is combining text mining, network analysis and sentiment analysis to reveal and highlight underlying properties in different domains. The main sources of data that we analyse are social media (Twitter, Facebook), online news, and other relevant data (e.g., voting in the European Parliament, stock prices, results of elections and referendums).

We collected tweets from the members of the European Parliament (EP), constructed retweet networks, and identified political and national communities. We also analysed the voting of the current, eighth EP, and compared the relation between the co-voting and retweeting. The results show that retweeting is very similar to co-voting, but also that the right-wing political groups are much more active and coherent in social media.

Figure 3: Winning team of the ESA's Mars Express Power Challenge visiting ESA Mission Control Centre (ESOC) in Darmstadt.

We developed methodology and tools to analyse Twitter sentiment (or stance) in different languages and for different topics. Our approach relies on a large set of manually annotated tweets by domain experts, and results in high-quality domain- and language-specific classification models. We showed how to estimate an upper bound of performance for a classification model and how to monitor the annotation process.

Finally, we applied the above-developed methodology to a highly relevant European use-case: the UK referendum on Brexit. We developed a Brexit-specific Twitter stance classification model and used it to monitor the public mood before and during the referendum. We also identified the most influential Twitter users and noted that the proponents of Brexit were considerably more active than the remain camp.

In the area of **decision support** our long-term goal is to develop methods and techniques of decision modelling, support them with software and integrate them with data-mining systems. In 2016 we published the results of applying these methods in two areas: assessment of long-term sustainability of electric energy production in Slovenia and assessment of potential presence of genetically modified crops in food and feed based on traceability data (Project DECATHLON). In each of these areas we developed a corresponding decision-support system. We also successfully used our qualitative multi-criteria modelling method DEX for the assessment of anthropogenic activities on the ecology of the Fifth Triglav Lake in the Julian Alps and for the evaluation of business process simulation software. We investigated and compared three methods for approximating incompletely defined utility functions with the DEX method. In the framework of the European project HeartMan we were developing decision models and systems for supporting patients having Congestive Heart Failure. For the European project PD_manager we have developed several decision-support models based on the expert knowledge of the clinical project partners, which reflect current knowledge in the Parkinson's disease domain regarding the medication changes, but had not been previously formalized. Regarding software

tools, in addition to updating the existing DEXi model-development program and JDEXi library, we developed the DEXi HTML Evaluator, a new software for the evaluation of decision alternatives using DEX models, which runs on web pages that require almost no programming to set up.

In the area of **language technologies and digital humanities** we work on producing language resources and methods to annotate text with linguistic information, with a focus on the Slovene language. In 2016 we helped to produce the digital text-critical edition of the 18th century Kapla passion play and worked on methods to modernise historical Slovene language, as well as standardising Slovene as found on the web. We have converted the ssj500k treebank into the Universal Dependencies framework and made the resulting treebank available in the scope of the UD project.

Vid Podpečan received the Prometheus of Science award for excellence in communication for the year 2016 from the Slovenian Science Foundation.

We continued work on the national research project JANES "Resources, Tools and Methods for Research of Non-standard Internet Slovene", where we compiled the penultimate version of the JANES corpus of user-generated internet Slovene, which contains over 160 million words of tweets, news comments, forums, blogs and Wikipedia talk pages and researched ways in which to make such corpora openly available. We developed a method for restoring diacritics which are often missing in internet texts, developed a new part-of-speech tagger and lemmatiser, made our tools available as web applications, performed and analysed automatic sentiment labelling on internet texts, developed a method to detect semantic shifts in Slovene tweets, to distinguish private from corporate users, and performed analytics over them. We also studied the global use of emojis in tweets as well as sociolinguistic aspects, regarding the relation between the topic and gender of the user as well as the gender-representation on the web. We worked on the manual annotation of user-generated internet texts, concentrating on normalisation, part-of-speech tagging, lemmatisation and syntactic annotation with the motivation to produce training sets for machine-learning annotation tools for (non-standard) Slovene. We started work on a dictionary of Twitter-specific lexis and undertook several linguistic analyses on various aspects of user-generated internet texts, such as the use of the comma.

Figure 4: Our NAO WHIMBOT attracted a lot of attention at the International fair of crafts and entrepreneurship in Celje.

We started work on our new national research project KAS "Slovene scientific texts: resources and description", where we produced the prototype version of the KAS corpus, which contains almost one billion words of scientific texts gathered from the digital libraries of Slovene universities and, on the basis of this corpus, performed an analysis on the use of the passive in Slovene scientific writing. As preparation on terminology extraction, we constructed a term grammar for the Sketch Engine corpus analysis platform.

In the scope of the industrial project TermIolar with the Slovene translation company Iolar, we developed a system for terminology management, integrating automatic terminology extraction from translation memories and existing terminological databases.

We lead the Slovene research infrastructure CLARIN.SI, which provides easy publication and sustainable access to digital language data for scholars in the humanities and social sciences. In 2016 the CLARIN.SI repository for language resources and tools was recognised as a CLARIN Center B, certifying it as a stable and trusted repository that conforms to the CLARIN technical and organisational standards. In this year the number of deposited resources in the repository more than doubled, reaching 47 at the end of the year, with the most interesting additions being a transcribed speech corpus of Slovene public lectures and a corpus of parliamentary debates from the years 1990–1992. In 2016 CLARIN.SI has also organised the international workshop "Multilingual corpus annotation tools: development and integration" and supported several conferences and summer schools.

We collaborated in the work of the Slovene Institute for Standardization as the Slovene representatives in ISO/TC37/SC4 (Terminology and Other Language and Content Resources / Language Resources Management) by reviewing, translating and approving Slovene standards from this field. We also continue to serve as technical editors for the on-line Slovene Biographic Lexicon.

In 2016 we organised the 10th biennial conference on Language Technologies, which was this year extended with the theme of Digital Humanities. The conference, which took place at the Arts Faculty of the University of Ljubljana, lasted three days with parallel sessions, and comprised five invited lectures, a round table on terminology, a student session, and 47 regular contributions.

In the field of **computational creativity** we continued to develop new prototype solutions using our tool ConCreTeFlows, which is based on our platform ClowdFlows. Within the FP7 project CONCRETE (Concept Creation Technologies) we prepared a workflow for the multimodal mixing of concepts, which also served for the demonstra-

tion of ConCreTeFlows and its ability to support teamwork and the use of a variety of program elements in a single workflow. Presentation of the system with this demonstration at the International Conference on Computational Creativity ICCC 2016 was met with a positive response from the research community. We analysed the role of optimality principles in different conceptual blending systems and proposed the conceptualization of computational creativity. Within FP7 project WHIM (The What-If Machine) we conducted the final experiments of human appreciation modelling of computer generated what-if ideas and presented the system for scientific question generation. This year, the project WHIM achieved a remarkable achievement for the computational creativity research community: on the basis of computer-generated ideas from the WHIM system and other computational creativity approaches, a musical was made and presented on stage in London. In relation to that, a documentary was filmed about this venture and the technologies that were used to achieve it. In 2016, the projects of FP7: Prosecco, WHIM (The What-If Machine) and ConCreTe (Concept Creation Technologies) were finished and the results of the projects, as well as the wider area of computational creativity, were presented at invited talk of the TTT conference TTT 2016.

Sašo Džeroski was elected to the European Academy of Sciences (Academia Europaea).

Some outstanding publications in the last year

1. Adhikari, P. R., Vavpetič, A., Kralj, J., Lavrač, N., Hollmén, J. Explaining mixture models through semantic pattern mining and banded matrix visualization. *Machine learning*, ISSN 0885-6125. 2016, 37 pp., doi: 10.1007/s10994-016-5550-3.
2. Bohanec, M., Mileva-Boshkoska, B., Prins, T. W., Kok, E. SIGMO: a decision support System for Identification of genetically modified food or feed products. Food control, ISSN 0956-7135. 2016, vol. 71, pp. 168-177, doi: 10.1016/j.foodcont.2016.06.032.
3. Bohanec, M., Trdin, N., Kontić, B. A qualitative multi-criteria modelling approach to the assessment of electric energy production technologies in Slovenia. Central European Journal of Operations Research, ISSN 1435-246X, 2016, 15 pp., doi: 10.1007/s10100-016-0457-4.
4. Cherepnalkoski, D., Karpf, A., Mozetič, I., Grčar, M. Cohesion and coalition formation in the European Parliament: Roll-call votes and Twitter activities, PLoS ONE 11(11): e0166586, doi: 10.1371/journal.pone.0166586, 2016.
5. Mozetič, M. Grčar, J. Smailović. Multilingual Twitter sentiment classification: The role of human annotators, PLoS ONE 11(5): e0155036, doi: 10.1371/journal.pone.0155036, 2016.
6. Osojnik, A., Panov, P., Džeroski, S. Multi-label classification via multi-target regression on data streams. *Machine learning*, ISSN 0885-6125. In press, 2016, 26 pp., doi: 10.1007/s10994-016-5613-5.
7. Perovšek, M., Kranjc, J., Erjavec, T., Cestnik, B., Lavrač, N. TextFlows : a visual programming platform for text mining and natural language processing. *Science of computer programming*, ISSN 0167-6423, 2016, vol. 121, str. 128-152, doi: 10.1016/j.scico.2016.01.001.
8. Scherrer, Y., Erjavec, T. Modernising historical Slovene words. *Natural language engineering*, ISSN 1351-3249, 2016, vol. 22, no. 6, pp. 881-905, doi: 10.1017/S1351324915000236.
9. Tanevski, J., Todorovski, L., Džeroski, S. Process-based design of dynamical biological systems. Scientific reports, ISSN 2045-2322, 2016, vol. 6, pp. 34107-1-34107-13, doi: 10.1038/srep34107.
10. Tanevski, J., Todorovski, L., Džeroski, S. Learning stochastic process-based models of dynamical systems from knowledge and data. *BMC systems biology*, ISSN 1752-0509, 2016, vol. 10, pp. 30-1-30-17, doi: 10.1186/s12918-016-0273-4.

Awards and appointments

1. Matej Petković was awarded the Prešeren Prize of the Faculty of Mathematics and Physics of the University of Ljubljana for his master's thesis titled "Evaluation of the importance of continuous features with the ReliefF method", written under the supervision of Sašo Džeroski.
2. Sašo Džeroski, corresponding member of the Macedonian Academy of Arts and Sciences, was elected for a full member of the European Academy of Sciences (Academia Europaea).
3. Vid Podpečan received the Prometheus of Science award for excellence in communication for the year 2016 from the Slovenian Science Foundation for the all-round promotion of robotics, especially humanoid robot use among young people.
4. Special recognition for successful cooperation with the Committee on Science and Technology of the Chamber of craft and small business of Slovenia and for an interesting presentation of the Department of Knowledge Technologies of the Jožef Stefan Institute at the International fair of crafts and entrepreneurship in Celje.

5. Martin Breskvar, Dragi Kocev, Jurica Levatić, Aljaž Osojnik, Matej Petković, Nikola Simidjievski and Bernard Ženko won the ESA's Mars Express Power Challenge, designing the most accurate solution for predicting the space probe's power consumption.

Organization of conferences, congresses and meetings

1. Workshop CLARIN "Multilingual corpus annotation tools: development and integration", Ljubljana, 10.–11. 11. 2016
2. "Summer school on mining big and complex data", Ohrid, Macedonia, 4.–8. 9. 2016
3. Final meeting of EU project "Concept Creation Technology" - ConCreTe, Bled, 14.–16. 9. 2016.

INTERNATIONAL PROJECTS

1. BIODIV - Understanding and Managing Biodiversity in Agricultural Ecosystems by Data Mining and Decision Support
   Prof. Sašo Džeroski
   Arvalis - Institut Du Végétal
2. 7FP - PROSECCO; Promoting the Scientific Exploration of Computational Creativity
   Prof. Nada Lavrač
   European Commission
3. 7FP - ConCreTe; Concept Creation Technology
   Prof. Nada Lavrač
   European Commission
4. 7FP - WHIM; The What-If Machine
   Prof. Nada Lavrač
   European Commission
5. 7FP - DECATHLON; Development of Cost efficient Advanced DNA-based methods for specific Traceability issues and High Level On-site applicatioNs
   Prof. Marko Bohanec
   European Commission
6. 7FP - SIMPOL; Financial Systems Simulation and Policy Modelling
   Prof. Igor Mozetič
   European Commission
7. 7FP - MULTIPLEX; Foundational Research on Multilevel Complex Networks and Systems
   Prof. Igor Mozetič
   European Commission
8. 7FP - HBP; The Human Brain Project
   Prof. Sašo Džeroski
   European Commission
9. 7FP - MAESTRA; Learning from Massive, Incompletely Annotated, and Structured Data
   Prof. Sašo Džeroski
   European Commission
10. PARSEME: PARSing and Multi-Word Expressions. Towards Linguistic Precision and Computational Efficiency in Natural Language Processing
    Prof. Tomaž Erjavec
    Cost Office
11. H2020 - DOLFINS; Distributed Global FInancial Systems for Society
    Prof. Igor Mozetič
    European Commission
12. H2020 - HBP SGA1; Human Brain Project Specific Grant Agreement 1
    Prof. Sašo Džeroski
    European Commission
13. H2020 - PD_manager; Mhealth Platform for Parkinson's Disease Management
    Dr. Dragana Miljković
    European Commission
14. H2020 - HeartMan; Personal Decison Support System for Heart Failure Management
    Prof. Marko Bohanec
    European Commission
15. Mining Complex Data in Environmental and Life Sciences
    Prof. Sašo Džeroski
    Slovenian Research Agency
16. Mining Heterogeneous Linked Biomedical Data
    Prof. Nada Lavrač
    Slovenian Research Agency
17. Semantic Role Labeling in Slovene and Croatian
    Prof. Tomaž Erjavec
    Slovenian Research Agency

RESEARCH PROGRAM

1. Knowledge Technologies
   Prof. Nada Lavrač

R & D GRANTS AND CONTRACTS

1. Slovenian Literature in Unknown Early Modern Manuscripts: Information-Technology Aided Analyses and Scholarly Editions
   Prof. Tomaž Erjavec
2. Integrative research of sexual dimorphism evolution
   Prof. Sašo Džeroski
3. Resources, Tools and Methods for the Research of Nonstandard Internet Slovene
   Prof. Tomaž Erjavec
4. Slovene scientific texts: resources and description
   Prof. Tomaž Erjavec
5. Analysis of heterogeneous information networks for knowledge discovery in life-sciences
   Prof. Nada Lavrač
6. Molecular bases of interactions among the grapevine and phytoplasmal causing agents of the grapevine yellows diseases
   Prof. Nada Lavrač
7. Development of a multimethod approach to study wildlife behavior: investigating humanbear conflicts in contrasting landscapes of Europe
   Prof. Sašo Džeroski
8. Influence of formal and informal corporate communications on capital markets
   Dr. Senja Pollak
9. Development and applications of new semantic data mining methods in life sciences
   Prof. Nada Lavrač
10. Machine Learning for Systems Sciences
    Prof. Sašo Džeroski
11. Forbidden Books in the Slovenian Lands in the Early Modern Period
    Prof. Tomaž Erjavec
12. Structured output prediction with applications in sustainable agricultural production
    Prof. Sašo Džeroski
13. ReLDI - Regional Linguistic Data Initiative
    Dr. Nikola Ljubešić
    University Of Zurich, Urpp Language And Space
14. CLARIN Workshop: „Multilingual Corpus Annotation Development and Integration", IJS, Ljubljana, Slovenia; 10.11.-11.11.2016
    Prof. Tomaž Erjavec
    Clarin Eric
15. Methods of digital ethnography and monitoring of experiences and the development of global competencies of Erasmus students
    Dr. Martin Žnidaršič
    CMEPIUS

NEW CONTRACTS

1. Development of a Prototype program solution for support of semi-automatic extraction and management of monolingual and multilingual corpora
   Dr. Senja Pollak
   Iolar d. o. o.

VISITORS FROM ABROAD

1. Dario Stojanovski, Ss. Cyrill and Methodius, Faculty of Computer Science and Engineering, Skopje, Macedonia, 18.1.-7.2. 2016
2. Dr. Gjorgi Strezoski, Ss. Cyrill and Methodius, Faculty of Computer Science and Engineering, Skopje, Macedonia, 18.1.-7.2. 2016
3. Dr. Gjorgi Madjarov, Ss. Cyrill and Methodius, Faculty of Computer Science and Engineering, Skopje, Macedonia, 31.1.-7.2.2016
4. Dr. Ivica Dimitrovski, Ss. Cyrill and Methodius, Faculty of Computer Science and Engineering, Skopje, Macedonia, 31.1.-7.2.2016

5. Andreas Karpf, UPIP - Centre d'Economie de la Sorbonne, Université Paris, Paris, France, 20.2.-31.3.2016
6. Matej Mihelčić, Institut Ruđer Bošković, Zagreb, Croatia, 3.3.2016
7. Matija Piškorec, Institut Ruđer Bošković, Zagreb, Croatia, 3.3.2016
8. dr. Larisa Soldatova, Brunel University, London, Great Britain, 21. 3. 2016
9. prof. dr. Ross King, University of Manchester, Manchester, Great Britain, 21.3.2016
10. Fabiana Zollo, IMT, School for Advanced studies Lucca, Lucca, Italy, 9.4.–1.7.2016.
11. Amilcar Cardoso, Coimbra University, Coimbra, Portugal, 13.–15. 4. 2016
12. Ana Oliveira Alves, Coimbra University, Coimbra, Portugal, 13.–15. 4. 2016
13. João Carlos Gonçalves, Coimbra University, Coimbra, Portugal, 13.–15. 4. 2016
14. dr. Tomislav Šmuc, Institut Ruđer Bošković, Zagreb, Croatia, 3.3.2016 and 9.–13. 5. 2016
15. prof. dr. Filip Železny, Department of Computer Science, Faculty of Electrical Engineering, Czech Technical University in Prague, Prague, Czech Republic, 8.–10. 5. 2016
16. Jožef Mišutka, Karlova univerza v Pragi, Prague, Czech Republic, 11.–16. 4. 2016
17. dr. Barry Hardy, Douglas Connect, Basel, Switzerland , 3.–6. 5. 2016
18. prof. dr. Ljupčo Kocarev, Macedonian Academy of Sciences and Arts, Skopje, Macedonia, 22.–24. 5. 2016
19. Ivan Stojković, Temple University, Philadelphia, USA, 20.–22.7.2016
20. Dr. Daniel Zeman, Karlova Univerza, Prague, Czech Republic, 28.9.–1. 10. 2016
21. dr. Petru Juelu Henrichsenu, Copenhagen Business School, Copenhagen, Denmark, 29. 9.– 1. 10. 2016
22. Filip Petkovski, Zagreb, Croatia, 26.–28.9.2016
23. Vera Veleva, BILSP, Bulgaria, 25. 10. 2016
24. Yordan Dimitrov, BILSP, Bulgaria, 25. 10. 2016
25. Ben Verhoeven, University of Antwerp, Antwerp, Belgium, 31. 10.-26. 11. 2016
26. prof. dr. Bogdan Draganski Centre hospitalier universitaire vaudois, Luzana, Switzerland, 13.–15. 11. 2016
27. dr. Florence Leprince, ARVALIS-Institut du végétal, Pau, France, 24.–25. 11. 2016
28. dr. Markus Schedl, Department of Computational Perception, Johannes Kepler University (JKU) Linz, Austria, 15. 12. 2016

STAFF

Researchers
1. Prof. Marko Bohanec
2. Prof. Bojan Cestnik*
3. Prof. Marko Debeljak
4. Prof. Sašo Džeroski
5. Prof. Tomaž Erjavec
6. Dr. Darja Fišer*
7. Dr. Dragi Kocev
8. **Prof. Nada Lavrač, Head**
9. Prof. Zoran Levnajić*
10. Prof. Igor Mozetič
11. Prof. Ljupčo Todorovski*
12. Prof. Tanja Urbančič*
13. Asst. Prof. Martin Žnidaršič

Postdoctoral associates
14. Dr. Darko Aleksovski
15. *Dr. Darko Cherepnalkoski, left 01.11.16*
16. Dr. Miha Grčar
17. Dr. Petra Kralj Novak
18. Dr. Nikola Ljubešić
19. Asst. Prof. Biljana Mileva Boshkoska
20. Dr. Dragana Miljković
21. Asst. Prof. Panče Panov
22. Dr. Vid Podpečan
23. Dr. Senja Pollak
24. Dr. Nikola Simidjievski
25. *Dr. Borut Sluban, left 01.10.16*
26. Dr. Jasmina Smailović
27. Dr. Jovan Tanevski
28. Dr. Aneta Trajanov
29. Dr. Anže Vavpetič
30. Dr. Vedrana Vidulin
31. Asst. Prof. Bernard Ženko

Postgraduates
32. Martin Breskvar, B. Sc.
33. Jan Kralj, B. Sc.
34. Janez Kranjc, B. Sc.
35. Jurica Levatić
36. Aljaž Osojnik
37. *Dr. Matic Perovšek, left 01.07.16*
38. Matej Petković, B. Sc.
39. Tomaž Stepišnik Perdih, B. Sc.
40. Anita Valmarska, B. Sc.
41. Katja Zupan, B. Sc.

Technical officers
42. Tina Anžič, B. Sc.
43. Milica Bauer, B. Sc.

Technical and administrative staff
44. *Teja Đukić, 01.10.16, transferred to Department K7*

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Prem Raj Adhikari, Anže Vavpetič, Jan Kralj, Nada Lavrač, Jaakko Hollmén, "Explaining mixture models through semantic pattern mining and banded matrix visualization", *Mach. learn.*, vol. 105, iss. 1, pp. 3-39, 2016.
2. Darko Aleksovski, Juš Kocijan, Sašo Džeroski, "Ensembles of fuzzy linear model trees for the identification of multi-output systems", *IEEE trans. fuzzy syst.*, vol. 24, no. 4, pp. 916-929, 2016.
3. Marko Bohanec, Biljana Mileva-Boshkoska, Theo W. Prins, Esther Kok, "SIGMO: a decision support System for Identification of genetically modified food or feed products", *Food control*, vol. 71, pp. 168-177, 2016.
4. Marija Brbić, Matija Piškorec, Vedrana Vidulin, Anita Kriško, Tomislav Šmuc, Fran Supek, "The landscape of microbial phenotypic traits and associated genes", *Nucleic acids res.*, vol. 44, no. 21, pp. 10074-10090, 2106.
5. Darko Čerepnalkoski, Andreas Karpf, Igor Mozetič, Miha Grčar, "Cohesion and coalition formation in the European parliament: roll-call votes and twitter activities", *PloS one*, vol. 11, no. 11, pp. 0166586-1-0166586-27, 2016.
6. Darko Čerepnalkoski, Igor Mozetič, "Retweet networks of the European Parliament: evaluation of the community structure", *Appl. netw. sci.*, vol. 1, no. 1, pp. 2-1-2-20, 2016.
7. Nadja Damij, Pavle Boškoski, Marko Bohanec, Biljana Mileva-Boshkoska, "Ranking of business process simulation software tools with DEX/QQ hierarchical decision model", *PloS one*, vol. 11, no. 2, pp. 0148391-1-0148391-16, 2016.
8. Ivica Dimitrovski, Dragi Kocev, Suzana Loskovska, Sašo Džeroski, "Improving bag-of-visual-words image retrieval with predictive clustering trees", *Inf. sci.*, vol. 329, pp. 851-865, 2016.
9. Tomaž Erjavec, Jaka Čibej, Darja Fišer, "Omogočanje dostopa do korpusov slovenskih spletnih besedil v luči pravnih omejitev", In: *Računalniško posredovana komunikacija*, (Slovenščina 2.0, Tematska številka, vol. 4 (2016), no. 2), Darja Fišer, ed., Ljubljana, Trojina, zavod za uporabno slovenistiko, 2016, vol. 4, no. 2, pp. 189-219, 2016.
10. Darja Fišer, Tomaž Erjavec, Nikola Ljubešić, "JANES v0.4: korpus slovenskih spletnih uporabniških vsebin", In: *Računalniško posredovana komunikacija*, (Slovenščina 2.0, Tematska številka, vol. 4 (2016), no. 2), Darja Fišer, ed., Ljubljana, Trojina, zavod za uporabno slovenistiko, 2016, vol. 4, no. 2, pp. 67-99, 2016.
11. Dragan Gamberger, Bernard Ženko, Alexis Mitelpunkt, Netta Shachar, Nada Lavrač, "Clusters of male and female Alzheimer's disease patients in the Alzheimer's Disease Neuroimaging Initiative (ADNI) database", *Brain inform.*, vol. 3, iss. 3, pp. 169-179, 2016.
12. Sašo Jančič, Jens C. Frisvald, Dragi Kocev, Cene Gostinčar, Sašo Džeroski, Nina Gunde-Cimerman, "Production of secondary metabolites in extreme environments: food- and airborne Wallemia spp. produce toxic

metabolites at hypersaline conditions", *PloS one*, vol. 11, no. 12, pp. e0169116-1-e0169116-20, 2016.
13. Sašo Jančič, Polona Zalar, Dragi Kocev, Hans-Josef Schroers, Sašo Džeroski, Nina Gunde-Cimerman, "Halophily reloaded: new insights into the extremophilic life-style of Wallemia with the description of Wallemia hederae sp. nov", *Fungal divers.*, vol. 76, issue 1, pp. 97-118, 2016.
14. Branko Kontić, Marko Bohanec, Davor Kontić, Nejc Trdin, Maruša Matko, "Improving appraisal of sustainability of energy options - a view from Slovenia", *Energy policy*, vol. 90, pp. 154-171, 2016.
15. Zoran Krstanoski, Nadja Kokalj-Vokač, Andreja Zagorac, Boris Pospihalj, Miha Munda, Sašo Džeroski, Rastko Golouh, "TMPRSS2:ERG gene aberrations may provide insight into pT stage in prostate cancer", *BMC Urol*, vol. 16, pp. 1-6, 2016.
16. Marta Macedoni-Lukšič, Tanja Urbančič, Ingrid Petrič, Bojan Cestnik, "Autism research dynamic through ontology-based text mining", *Advances in autism*, vol. 2, no. 3, pp. 131-139, 2016.
17. Gjorgji Madjarov, Dejan Gjorgjevikj, Ivica Dimitrovski, Sašo Džeroski, "The use of data-derived label hierarchies in multi-label classification", *Journal of intelligent information systems*, vol. 47, iss. 1, pp. 57-90, 2016.
18. Maja Miličević, Nikola Ljubešić, "Tviterasi, tviteraši or twitteraši?: producing and analysing a normalised dataset of Croatian and Serbian tweets", In: *Računalniško posredovana komunikacija*, (Slovenščina 2.0, Tematska številka, vol. 4 (2016), no. 2), Darja Fišer, ed., Ljubljana, Trojina, zavod za uporabno slovenistiko, 2016, vol. 4, no. 2, pp. 156-188, 2016.
19. Igor Mozetič, Miha Grčar, Jasmina Smailović, "Multilingual twitter sentiment classification: the role of human annotators", *PloS one*, vol. 11, no. 5, pp. e0155036-1-e0155036-26, 2016.
20. Monika Novak, Polona Zalar, Bernard Ženko, Sašo Džeroski, Nina Gunde-Cimerman, "Yeasts and yeast-like fungi in tap water and groundwater, and their transmission to household appliances", *Fungal ecology*, vol. 20, pp. 30-39, 2016.
21. Aljaž Osojnik, Panče Panov, Sašo Džeroski, "Modeling dynamical systems with data stream mining", *Comput. Sci. Inf. Syst.*, vol. 13, no. 2, pp. 453-473, 2016.
22. Panče Panov, Larisa N. Soldatova, Sašo Džeroski, "Generic ontology of datatypes", *Inf. sci.*, vol. 329, pp. 900-920, 2016.
23. Matic Perovšek, Janez Kranjc, Tomaž Erjavec, Bojan Cestnik, Nada Lavrač, "TextFlows: a visual programming platform for text mining and natural language processing", *Sci. comput. program.*, vol. 121, pp. 128-152, 2016.
24. Tina Ravnikar, Marko Bohanec, Gregor Muri, "Monitoring and assessment of anthropogenic activities in mountain lakes: a case of the Fifth Triglav Lake in the Julian Alps", *Environ. monit. assess.*, vol. 188, pp. 253-1-253-17, mar. 2016.
25. Yves Scherrer, Tomaž Erjavec, "Modernising historical Slovene words", *Nat. lang. eng.*, vol. 22, no. 6, pp. 881-905, 2016.
26. Nikola Simidjievski, Ljupčo Todorovski, Sašo Džeroski, "Modeling dynamic systems with efficient ensembles of process-based models", *PloS one*, vol. 11, no. 4, pp. 0153507-1-0153507-27, 2016.
27. Ana Marija Sobočan, Senja Pollak, "Manifestacije moralne panike v medijskih podobah novele družinske zakonodaje", *Čas. krit. znan.*, vol. 44, no. 266, pp. 163-187, 2016.
28. Darja Šemrov, Rok Marsetič, Marijan Žura, Ljupčo Todorovski, Aleksander Srdič, "Reinforcement learning approach for train rescheduling on a single-track railway", *Transp. res., Part B: methodol.*, vol. 86, no. apr., pp. 250-267, 2016.
29. Bosiljka Tadić, Miroslav Andjelković, Biljana Mileva-Boshkoska, Zoran Levnajić, "Algebraic topology of multi-brain connectivity networks reveals dissimilarity in functional patterns during spoken communications", *PloS one*, vol. 11, no. 11, pp. e0166787-1-e0166787-25, 2016.
30. Jovan Tanevski, Ljupčo Todorovski, Sašo Džeroski, "Learning stochastic process-based models of dynamical systems from knowledge and data", *BMC systems biology*, vol. 10, pp. 30-1-30-17, 2016.
31. Jovan Tanevski, Ljupčo Todorovski, Sašo Džeroski, "Process-based design of dynamical biological systems", *Scientific reports*, vol. 6, pp. 34107-1-34107-13, 2016.
32. Vedrana Vidulin, Tomislav Šmuc, Fran Supek, "Extensive complementarity between gene function prediction methods", *Bioinformatics (Oxf.)*, vol. 32, no. 23, pp. 3645-3653, 2016.

Published Conference Contribution

1. Darko Aleksovski, Dejan Dovžan, Sašo Džeroski, Juš Kocijan, "A comparison of fuzzy identification methods on benchmark datasets", In: *Proceedings of the 4th IFAC Conference on Intelligent Control and Automation, ICONS 2016, 1-3 June 2016, Reims, France*, (IFAC papersOnline, Vol. 49, no. 5, 2016), pp. 31-36.
2. Špela Arhar Holdt, Darja Fišer, Tomaž Erjavec, Simon Krek, "Syntactic annotation of Slovene CMC: first steps", In: *Proceedings of the 4th Conference on CMC and Social Media Corpora for the Humanities, 27-28 September 2016, Faculty of Arts, University of Ljubljana, Ljubljana, Slovenia*, pp. 3-6.
3. Renato Barišić, Biljana Mileva-Boshkoska, "MIMOSA OSA-EAI: an information exchange standard: standard razmjene informacija", In: *Kvaliteta čini razliku: zbornik radova: proceedings*, pp. 45-57.
4. Michael Beißwenger *et al.* (12 authors), "Integrating corpora of computer-mediated communication into the language resources landscape: initiatives and best practices from French, German, Italian and Slovenian projects", In: *Proceedings*, pp. 1-5.
5. Jože Bučar, Janez Povh, Martin Žnidaršič, "Sentiment classification of the Slovenian news texts", In: *Proceedings of the 9th International Conference on Computer Recognition Systems CORES 2015*, (Advances in intelligent systems and computing, Vol. 403, 2016), pp. 777-787.
6. Bojan Cestnik, Elsa Fabbretti, Donatella Gubiani, Nada Lavrač, Tanja Urbančič, "Exploring outlier documents to investigate potential links between gut microbiota and Alzheimer's disease", In: *Proceedings, extended abstracs*, IWBBIO 2016, International Work-Conference on Bioinformatics and Biomedical Engineering, April 20-22, 2016, Granada, Spain, pp. 475-486.
7. Bojan Cestnik, Natalia Manakova, Aram Karalič, Tanja Urbančič, "Engaging the net generation students in enhanced teaching and leaning with QTvity: the next steps", In: *Proceedings: European thematic network, future education and training in computing: how to support learning at anytime anywhere*, International Conference on e-Learning, 8-9 September, Bratislava, Slovakia, pp. 86-93.
8. Jaka Čibej, Špela Arhar Holdt, Tomaž Erjavec, Darja Fišer, "Razvoj učne množice za izboljšano označevanje spletnih besedil", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 40-46.
9. Jaka Čibej, Darja Fišer, Tomaž Erjavec, "Normalisation, tokenisation and sentence segmentation of Slovene tweets", In: *Normalisation and analysis of social media texts (NormSoMe): [workshop proceedings]*, pp. 5-10.
10. Marko Debeljak, Andrej Ficko, Robert Brus, "Ocena ogroženosti avtohtonih drevesnih vrst pred invazivnimi tujerodnimi vrstami na primeru črnega topola (Populus nigra L.): the case of Black poplar (Populus nigra L.)", In: *Invazivne tujerodne vrste v gozdovih ter njihov vpliv na trajnostno rabo gozdnih virov: zbornik prispevkov posvetovanja z mednarodno udeležbo: lectures presented at the conference with international participation*, 2016, pp. 119-124.
11. Tomaž Erjavec, Špela Arhar Holdt, Jaka Čibej, Kaja Dobrovoljc, Darja Fišer, Cyprian Laskowski, Katja Zupan, "Annotating CLARIN.SI TEI corpora with WebAnno", In: *Proceedings*, 2016, pp. 1-5.
12. Tomaž Erjavec, Jaka Čibej, Špela Arhar Holdt, Nikola Ljubešić, Darja Fišer, "Gold-standard datasets for annotation of Slovene computer-mediated communication", In: *RASLAN 2016: Recent Advances in Slavonic Natural Language Processing: proceedings*, pp. 29-40.
13. Tomaž Erjavec, Darja Fišer, Nikola Ljubešić, Nataša Logar, Milan Ojsteršek, "Slovenska znanstvena besedila: prototipni korpus in načrt analiz", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 58-64.
14. Darja Fišer, Tomaž Erjavec, "Analysis of sentiment labeling of Slovene user-generated content", In: *Proceedings of the 4th Conference on CMC and Social Media Corpora for the Humanities, 27-28 September 2016, Faculty of Arts, University of Ljubljana, Ljubljana, Slovenia*, pp. 22-25.
15. Darja Fišer, Nikola Ljubešić, "Detecting semantic shifts in Slovene twitterese", In: *RASLAN 2016: Recent Advances in Slavonic Natural Language Processing: proceedings*, pp. 43-50.
16. Darja Fišer, Jasmina Smailović, Tomaž Erjavec, Igor Mozetič, Miha Grčar, "Sentiment annotation of Slovene user-generated content", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 65-70.
17. Darja Fišer, Vit Suchomel, Miloš Jakubiček, "Terminology extraction for academic Slovene using sketch engine", In: *RASLAN 2016: Recent Advances in Slavonic Natural Language Processing: proceedings*, pp. 135-141.
18. Dragan Gamberger, Bernard Ženko, Alexis Mitelpunkt, Nada Lavrač, "Homogeneous clusters of Alzheimer's disease patient population", In: *Selected articles of the 3rd International Work-Conference on*

Bioinformatics and Biomedical Engineering (IWBBIO 2015), 15-17 April 2015, Grenada, Spain, (BioMedical engineering online, Vol. 15, suppl. 1, 2016), pp. 578-1-578-34.
19. Polona Gantar, Iza Škrjanec, Darja Fišer, Tomaž Erjavec, "Slovar tviterščine", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 71-76.
20. Dimitros Gatsios, George Rigas, Dragana Miljković, Barbara Koroušić-Seljak, Marko Bohanec, María Soledad Arredondo, Angelo Antonini, Spyros Konitsiotis, Dimitrios I. Fotiadis, "Mhealth platform for Parkinson's disease management", In: *Final program*, CBHI 2016, 18th International Conference on Biomedicine and Health Informatics, Februar 25-26, Dubai, UAE, 5 pp..
21. Teja Goli, Eneja Osrajnik, Darja Fišer, "Analiza krajšanja slovenskih sporočil na družbenem omrežju Twitter", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 77-82.
22. Jan Kralj, Marko Robnik Šikonja, Nada Lavrač, "Heterogeneous network decomposition and weighting with text mining heuristics", In: *New frontiers in mining complex patterns: 4th International Workshop, NFMCP 2015 held in conjunction with ECML-PKDD 2015 Porto, Portugal, September 7, 2015: revised selected papers*, (Lecture notes in computer science, Lecture notes in artificial intelligence, 9607), pp. 194-208.
23. Jan Kralj, Anže Vavpetič, Michel Dumontier, Nada Lavrač, "Network ranking assisted semantic data mining", In: *Bioinformatics and Biomedical Engineering, IWBBIO 2016*, (Lecture notes in computer science, 9656), pp. 752-764.
24. Vladimir Kuzmanovski, Aneta Trajanov, Sašo Džeroski, Marko Debeljak, "Integrating predictive and decision modelling in decision support system for water protection from phytochemicals", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp.165-174.
25. Agnieszka Lawrynowicz, Diego Esteves, Panče Panov, Tommaso Soru, Sašo Džeroski, Joaquin Vanschoren, "An algorithm, implementation and execution ontology design pattern", In: *WOP 2016: Worskop on Ontology and Semantic Web Patterns (7th edition) 2016, 18th October 2016, Kobe, Japan*, 12 pp..
26. Nikola Ljubešić, Tomaž Erjavec, "Corpus vs. lexicon supervision in morphosyntactic tagging: the case of Slovene", In: *LREC 2016: [proceedings]*, Tenth International Conference on Language Resources and Evaluation, Portorož, Slovenia 23-28 May, 2016, pp. 1527-1531.
27. Nikola Ljubešić, Tomaž Erjavec, Darja Fišer, "Corpus-based diacritic restoration for South Slavic languages", In: *LREC 2016: [proceedings]*, Tenth International Conference on Language Resources and Evaluation, Portorož, Slovenia 23-28 May, 2016, pp. 3612-3616.
28. Nikola Ljubešić, Tomaž Erjavec, Darja Fišer, Tanja Samardžić, Maja Miličević, Filip Klubička, Filip Petkovski, "Easily accessible language technologies for Slovene, Croatian and Serbian", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 120-124.
29. Nikola Ljubešić, Darja Fišer, "A global analysis of emoji usage", In: *Proceedings of the 10th Web as Corpus Workshop (WAC-X) and The EmpiriST Shared Task: ACL 2016*, The 10th Web as Corpus Workshop (WAC-X) and The EmpiriST Shared Task, August 12, Berlin, Germany, pp. 82-89.
30. Nikola Ljubešić, Darja Fišer, "Private or Corporate? Predicting user types on Twitter", In: *WNUT 2016: proceedings of the Workshop*, 2016, pp. 4-12.
31. Nikola Ljubešić, Darja Fišer, "Slovene Twitter analytics", In: *Proceedings of the 4th Conference on CMC and Social Media Corpora for the Humanities, 27-28 September 2016, Faculty of Arts, University of Ljubljana, Ljubljana, Slovenia*, pp. 39-43.
32. Nikola Ljubešić, Tanja Samardžić, Curdin Derungs, "TweetGeo - a tool for collecting, processing and analysing geo-encoded linguistic data", V: *Proceedings of COLING 2016: technical papers*, The 26th International Conference on Computational Linguistics, December 11-16, 2016, Osaka, Japan, str. 3412-3421, 2016.
33. Nikola Ljubešić, Katja Zupan, Darja Fišer, Tomaž Erjavec, "Normalising Slovene data: historical texts vs. user-generated content", In: *Proceedings of the 13th Conference on Natural Language Processing (KONVENS), September 19-21, 2016, Bochum, Germany*, (Bochumer linguistische Arbeitsberichte, 16), pp. 146-155.
34. Mitja Luštrek, Erik Dovgan, Aljoša Vodopija, Marko Bohanec, Anneleen Baert, Sofie Pardaens, Els Clays, "Aplikacija za pomoč pri telesni vadbi bolnikov s srčnim popuščanjem", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]*, pp. 61-62.
35. Pedro Martins, Senja Pollak, Tanja Urbančič, Amilcar Cardoso, "Optimality principles in computational approaches to conceptual blending: do we need them (at) all?", In: *Proceedings of the 7th International Conference on Computational Creativity, ICCC 2016, 27 June - 1 July*, pp. 346-353.
36. Matej Mihelčić, Sašo Džeroski, Nada Lavrač, Tomislav Šmuc, "Redescription mining with multi-target predictive clustering trees", In: *New frontiers in mining complex patterns: 4th International Workshop, NFMCP 2015 held in conjunction with ECML-PKDD 2015 Porto, Portugal, September 7, 2015: revised selected papers*, (Lecture notes in computer science, Lecture notes in artificial intelligene, 9607), pp. 125-143, 2016.
37. Vanja Mileski, Dragi Kocev, Bogdan Draganski, Sašo Džeroski, "Multi-dimensional analysis of PPMI data", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp. 175-179.
38. Biljana Mileva-Boshkoska, Marko Bohanec, Theo W. Prins, Esther Kok, "Usage of SIGMO, a decision support system for the assessment of genetically modified organisms in food and feed", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 5-8.
39. Dragana Miljković, Nada Lavrač, Marko Bohanec, Biljana Mileva-Boshkoska, "Detection of dependencies between literature domains through relation extraction and copulas", In: *International Conference on Control, Decision and Information Technologies, CoDIt 2016, April 6-8, 2016, St. Paul's Bay, Malta*, pp. 302-307.
40. Aljaž Osojnik, Sašo Džeroski, Dragi Kocev, "Option predictive clustering trees for multi-target regression", In: *Discovery science: 19th International Conference, DS 2016 Bari, Italy, October 19-21, 2016: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, LNCS 9956), pp. 118-133, 2016.
41. Aljaž Osojnik, Panče Panov, Sašo Džeroski, "Comparison of tree-based methods for multi-target regression on data streams", In: *New frontiers in mining complex patterns: 4th International Workshop, NFMCP 2015 held in conjunction with ECML-PKDD 2015 Porto, Portugal, September 7, 2015: revised selected papers*, (Lecture notes in computer science, Lecture notes in artificial intelligene, 9607), pp. 17-31, 2016.
42. Matej Petković, Panče Panov, Sašo Džeroski, "A comparison of different data transformation approaches in the feature ranking context", In: *Discovery science: 19th International Conference, DS 2016 Bari, Italy, October 19-21, 2016: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, LNCS 9956), pp. 310-324, 2016.
43. Senja Pollak, Biljana Mileva-Boshkoska, Dragana Miljković, Geraint Wiggins, Nada Lavrač, "Computational creativity conceptualisation grounded on ICCC papers", In: *Proceedings of the 7th International Conference on Computational Creativity, ICCC 2016, 27 June - 1 July*, pp. 123-130.
44. Damjan Popič, Darja Fišer, Katja Zupan, Polona Logar, "Raba vejice v uporabniških spletnih vsebinah", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 106-110.
45. Aleksandra Rashkovska, Dragi Kocev, Roman Trobec, "Clustering of heartbeats from ecg recordings obtained with wireless body sensors", In: *Mipro proceedings*, (MIPRO ... (Tisak)), MIPRO 2016, 39th International Convention, May 30-June 3, 2016, Opatija, Croatia, pp. 481-486.
46. Nikola Simidjievski, Ljupčo Todorovski, Sašo Džeroski, "Learning ensembles of process-based models by bagging of random library samples", In: *Discovery science: 19th International Conference, DS 2016 Bari, Italy, October 19-21, 2016: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, LNCS 9956), pp. 245-260, 2016.
47. Borut Sluban, Miha Grčar, Igor Mozetič, "Temporal multi-layer network construction from major news events", In: *Complex networks VII: proceedings of the 7th Workshop on Complex Networks, CompleNet 2016, March 23 to 25, 2016, Bourgogne, Dijon, France*, (Studies in computational intelligence, volume 644), pp. 29-41.
48. Borut Sluban, Jasmina Smailović, Igor Mozetič, "Understanding financial news with multi-layer network analysis", In: *Proceedings of ECCS 2014: European Conference on Complex Systems, 22 to 26 September 2014, Lucca, Italy*, 2016, pp. 193-207.
49. Jasmina Smailović, Miha Grčar, Nada Lavrač, Martin Žnidaršič, "Dynamic parameter adaptation of SVM based active learning methodology", In: *AL@iKNOW 2016: proceedings of the Workshop on Active Learning: Applications, Foundations and Emerging Trends co-*

located with International Conference on Knowledge Technologies and Data-driven Business (i-KNOW 2016), Graz Austria, October 18, 2016, (CEUR workshop proceedings, vol. 1707).

50. Jasmina Smailović, Martin Žnidaršič, Nada Lavrač, Senja Pollak, Janez Kranjc, "Modelling human appreciation of machine generated What-if ideas", In: *Constructive machine learning: NIPS 2016, Neural Information Processing Systems, December 10, 2016, Barcelona, Spain*, 5 pp.
51. Larisa N. Soldatova, Panče Panov, Sašo Džeroski, "Ontology engineering: from an art to a craft", In: *Ontology engineering: 12th International Experiences and Directions Workshop on OW, OWLED, 2015, Co-located with ISWC 2015, Bethlehem, Pa, USA, October 9-10, 2015: revised selected papers*, (Lecture notes in computer science, vol. 9557), pp. 174-181, 2016.
52. Tomaž Stepišnik Perdih, Panče Panov, Andrej Bauer, Sašo Džeroski, "Primerjava razdalj pri klasifikaciji in regresiji", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 68-71.
53. Iza Škrjanec, Senja Pollak, "Topic ontologies of the Slovene blogosphere: a gender perspective", In: *Proceedings of the 4th Conference on CMC and Social Media Corpora for the Humanities, 27-28 September 2016, Faculty of Arts, University of Ljubljana, Ljubljana, Slovenia*, pp. 62-65.
54. Tadej Škvorc, Nada Lavrač, Marko Robnik Šikonja, "Co-bidding graphs for constrained paper clustering", In: *5th Symposium on Languages, Applications and Technologies: SLATE'16, June 20-21, 2016, Maribor, Slovenia*, (Open access series in informatics, vol. 51), pp. 1-13.
55. Alan Tapscott, Javier Gomez, Pablo Gervas, Jasmina Smailović, Martin Žnidaršič, "Empirical evidence of the limits of automatic assessment of fictional ideation", In: *Proceedings of the Workshop on Computational Creativity, Concept Invention, and General Intelligence (C3GI 2016) co-located with the 28th European Summer School in Logic, Language and Information (ESSLLI 2016), Bozen-Bolzano, Italy, August 20-22, 2016*, 14 pp..
56. Anita Valmarska, Dragana Miljković, Nada Lavrač, Marko Robnik Šikonja, "Towards multi-view approach to Parkinson's disease quality of life data analysis", In: *ECML-PKDD 2016, The European Conference on Machine Learning and Principles and Practice of Databases: 5th International Workshop on New Frontiers in Mining Complex Patterns, 19-23 September 2016, 2016, Riva de Garda, Italy*, 12 pp.
57. Vedrana Vidulin, Marija Brbić, Fran Supek, Tomislav Šmuc, "Evaluation of fusion approaches in large-scale bio-annotation setting", In: *4th Workshop on Machine Learning in Life Science, 23 September 2016, Riva del Garda, Italy*, pp. 37-51.
58. Darko Zelenika, Janez Povh, Bernard Ženko, "Text detection in document images by machine learning algorithms", In: *Proceedings of the 9th International Conference on Computer Recognition Systems CORES 2015*, (Advances in intelligent systems and computing, Vol. 403), pp. 169-179.
59. Katja Zupan, Tomaž Erjavec, "Generiranje kritičnih prepisov s strojnim prevajanjem na ravni znakov", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 175-179.
60. Ana Zwitter Vitez, Darja Fišer, "Linguistic analysis of emotions in online news comments: an example of the Eurovision song contest", In: *Proceedings of the 4th Conference on CMC and Social Media Corpora for the Humanities, 27-28 September 2016, Faculty of Arts, University of Ljubljana, Ljubljana, Slovenia*, pp. 74-76.
61. Martin Žnidaršič, Janez Kranjc, Nada Lavrač, "Computational creativity infrastructure for online software composition: a conceptual blending use case", In: *Proceedings of the 7th International Conference on Computational Creativity, ICCC 2016, 27 June - 1 July*, pp. 371-378.

Independent Component Part or a Chapter in a Monograph

1. Tina Jukić, Ljupčo Todorovski, András Nemeslaki, "Iskanje identitete raziskovalnega področja e-uprave", In: *Slovenska javna uprava na razpotju strateških sprememb*, (Upravna misel), Aleksander Aristovnik, ed., et al, 1. natis, Ljubljana, Fakulteta za upravo, 2016, pp. 111-136.
2. Petra Kralj Novak, Nada Lavrač, Geoffrey I. Webb, "Supervised descriptive rule induction", In: *Encyclopedia of machine learning and data mining*, Claude Sammut, ed., Geoffrey I. Webb, ed., Heidelberg [etc.], Springer, 2016, 4 pp..
3. Jan Kralj, Anita Valmarska, Miha Grčar, Marko Robnik Šikonja, Nada Lavrač, "Analysis of text-enriched heterogeneous information networks", In: *Big data analysis: new algorithms for a new society*, (Studies in big data, volume 16), Nathalie Japkowicz, ed., Jerzy Stefanowski, ed., Cham, Springer, 2016, pp. 115-139.
4. Nataša Logar, Špela Arhar Holdt, Tomaž Erjavec, "Slovenski strokovni jezik: korpusni opis trpnika", In: *Toporišičeva obdobja*, (Obdobja, Simpozij, = Symposium, 35), Erika Kržišnik, ed., Miran Hladnik, ed., 1. natis, Ljubljana, Znanstvena založba Filozofske fakultete, 2016, pp. 237-245.
5. Dragana Miljković, Darko Aleksovski, Vid Podpečan, Nada Lavrač, Bernd Malle, Andreas Holzinger, "Machine learning and data mining methods for managing Parkinson's disease", In: *Machine learning for health informatics: state-of-the-art and future challenges*, (Lecture notes in computer science, Lecture notes in artificial intelligence, LNAI 9605), Andreas Holzinger, ed., Cham [etc.], Springer, 2016, lNAI 9605, pp. 209-220, 2016.
6. Matic Perovšek, Matjaž Juršič, Bojan Cestnik, Nada Lavrač, "Empowering bridging term discovery for cross-domain literature mining in the textflows platform", In: *Machine learning for health informatics: state-of-the-art and future challenges*, (Lecture notes in computer science, Lecture notes in artificial intelligence, LNAI 9605), Andreas Holzinger, ed., Cham [etc.], Springer, 2016, lNAI 9605, pp. 59-98, 2016.
7. Erich Prunč, Matija Ogrin, Tomaž Erjavec, "Kapelski pasijon v elektronski znanstvenokritični izdaji. "Nov" rokopis, nove raziskovalne poti", In: *Toporišičeva obdobja*, (Obdobja, Simpozij, = Symposium, 35), Erika Kržišnik, ed., Miran Hladnik, ed., 1. natis, Ljubljana, Znanstvena založba Filozofske fakultete, 2016, pp. 395-402.
8. Tanja Urbančič, Davor Orlič, "Opening up education: towards affordable and sustainable solutions", In: *Developing successful strategies for global policies and cyber transparency in E-learning*, Gulsun Eby, ed., T. Volkan Yuzer, ed., Simber Atay, ed., Hershey, Information Science Reference, 2016, pp. 133-144.
9. Špela Vintar, Darja Fišer, "Using WordNet-based word sense disambiguation to improve MT performance", In: *Hybrid approaches to machine translation*, (Theory and applications of natural language processing), Marta Ruiz, ed., Berlin, Springer, 2016, pp. 191-205.

Encyclopaedia, Lexicon, Dictionary Entry

1. Kristina Hmeljak Sangawa, Tomaž Erjavec, Irena Srdanović, *Japanese-Slovene learner's dictionary jaSlo 3.1: Slovenian language resource repository CLARIN.SI*, Ljubljana, Department of Asian Studies, [Faculty of Arts], University of Ljubljana, 2016.
2. Tomaž Erjavec, *Lexicon of historical Slovene imp25k 1.1*, Ljubljana, Slovenian Language Resource Repository CLARIN.SI, 2014.
3. Tomaž Erjavec *et al.* (14 authors), *MULTEXT-East non-commercial lexicons 4.0*, Ljubljana, Slovenian Language Resource Repository CLARIN.SI, 2010.
4. Tomaž Erjavec *et al.* (19 authors), *MULTEXT-East free lexicons 4.0*, Ljubljana, Slovenian Language Resource Repository CLARIN.SI, 2010.

Mentoring

1. Vladimir Kuzmanovski, *Integrating decision support and data mining for risk evaluation and management: a methodological framework and a case study in agriculture:* doctoral dissertation, Ljubljana, 2016 (mentor Marko Debeljak; co-mentor Sašo Džeroski).
2. Matic Perovšek, *Advanced text processing workflows in a web-based text mining platform:* doctoral dissertation, Ljubljana, 2016 (mentor Bojan Cestnik; co-mentor Nada Lavrač).
3. Nikola Simidjievski, *Ensembles of process-based models of dynamic systems:* doctoral dissertation, Ljubljana, 2016 (mentor Sašo Džeroski; co-mentor Ljupčo Todorovski).
4. Jovan Tanevski, *Deterministic and stochastic process-based modeling and design of dynamic systems in biology:* doctoral dissertation, Ljubljana, 2016 (mentor Sašo Džeroski; co-mentor Ljupčo Todorovski).
5. Anže Vavpetič, *Semantic subgroup discovery:* doctoral dissertation, Ljubljana, 2016 (mentor Nada Lavrač).
6. Darja Šemrov, *Railway traffic scheduling with use of reinforcement learning:* doctoral dissertation, Ljubljana, 2016 (mentor Marijan Žura; co-mentor Ljupčo Todorovski).
7. Katarina Klanšek, *Analiza vpliva zunanjega izvajanja IKT storitev na konkurenčnost slovenskih podjetij:* master's thesis, Ljubljana, 2016 (mentor Bojan Cestnik).
8. Anamarija Leben, *Life-event modelling for development of active e-government portals:* master's thesis, Ljubljana, 2016 (mentor Ljupčo Todorovski).

9. Primož Njegač, *Implementacija sistema za upravljanje odnosov s strankami (CRM) v podjetje trgovina Njegač, d.o.o.:* master's thesis, Ljubljana, 2016 (mentor Bojan Cestnik).
10. Janez Pagon, *Floodplain forests of Soča river between Kobarid and confluence with river Tolminka: current situation and development:* master's thesis, Nova Gorica, 2016 (mentor Marko Debeljak).
11. Anja Šostar, *Increasing customer loyalty with data mining methods:* master's thesis, Ljubljana, 2016 (mentor Irena Ograjenšek; co-mentor Nada Lavrač).
12. Jože Železnikar, *Analysis of digital signing in the cloud:* master's thesis, Ljubljana, 2016 (mentor Ljupčo Todorovski).
13. Jerneja Boslič, *Analysis of the user satisfaction with the government information system for European Union affairs:* master's thesis, Ljubljana, 2016 (mentor Ljupčo Todorovski).
14. Blaž Bunc, *Analysis of the dynamic of copyright infringement around the world:* master's thesis, Ljubljana, 2016 (mentor Ljupčo Todorovski).
15. Gašper Cesar, *Comparative analysis of internet neutrality in chosen countries:* master's thesis, Ljubljana, 2016 (mentor Ljupčo Todorovski).
16. Danjel Cotič, *Improving the system of monitoring employees competences in Mahle Letrika company:* master's thesis, Nova Gorica, 2016 (mentor Tanja Urbančič).
17. Klaudija Habjan, *The analysis of students' characteristics related to the achievement in the introduction course to programming:* master's thesis, Ljubljana, 2016 (mentor Irena Nančovska Šerbec; co-mentor Ljupčo Todorovski).
18. Dušan Likar, *Študija vključitve zunanjih dobaviteljev v enotni poslovni informacijski sistem podjetja Pipistrel:* master's thesis, Nova Gorica, 2016 (mentor Bojan Cestnik).
19. Senada Medara, *Comparing the development of information society in Slovenia with selected EU countries:* master's thesis, Ljubljana, 2016 (mentor Ljupčo Todorovski).
20. Primož Pahor, *Assessment and selection of technical solutions for stator production:* master's thesis, Nova Gorica, 2016 (mentor Marko Bohanec).
21. David Rejc, *Selecting soldering technology: A comparison of multi-attribute decision-making methods:* master's thesis, Nova Gorica, 2016 (mentor Marko Bohanec).
22. Tomaž Stepišnik Perdih, *Razdalje na strukturiranih podatkih:* master's thesis, Ljubljana, 2016 (mentor Sašo Džeroski; co-mentor Andrej Bauer).
23. Jernej Ušaj, *Selecting a hydraulic wood splitter using multi-criteria assessment and financial analysis:* master's thesis, Nova Gorica, 2016 (mentor Marko Bohanec).
24. Johannes Vuga Gregorič, *A decision support system for selecting forms of online advertising messages to inform selected categories of users:* master's thesis, Nova Gorica, 2016 (mentor Marko Bohanec).

DEPARTMENT OF INTELLIGENT SYSTEMS E-9

The Department of Intelligent Systems develops new methods and techniques for intelligent computer systems, with applications in the areas of the information society, computer science and informatics, and network communication systems. The main research areas are ambient intelligence, computational intelligence, agent and multi-agent systems, language and speech technologies, and smart cities together with electronic and mobile health. The department collaborates closely with the Faculty of Computer and Information Science of the University of Ljubljana on the joint research program "Artificial Intelligence and Intelligent Systems", led by Prof. Dr. Ivan Bratko. The department also closely collaborates with industry and significantly contributes the introduction of intelligent systems into products and services.

Head:
Prof. Matjaž Gams

Intelligent systems simulate intelligence so that a typical user perceives them as truly intelligent. In reality, these systems use complex mechanisms and implement them on digital computers to imitate human behavior, while they also exploit raw, exponentially growing computer power. This field is somewhat broader than only artificial intelligence, both are rapidly improving worldwide and enabling the development of information society.

Ambient intelligence is a research area aiming to introduce technology into our everyday environment in a friendly way undemanding for the user. The main topic of ambient intelligence tackled by the department in 2016 was e-health. We started the H2020 project **HeartMan**, which we also coordinate. The project is developing an application that will help congestive-heart-failure patients manage their condition: it will monitor them with a sensing wristband, and provide advice on exercise, nutrition etc. So far we have developed decision models based on medical guidelines and user requirements, which will serve as the foundation for the application. Related to this project is the development of methods for the prediction of hospitalizations of heart-failure patients, and for the evaluation of their health based on stethoscope sound recordings. In the H2020 project **IN LIFE**, we are attempting to translate some solutions intended to prolong the independence of the elderly into real life. We prepared a smart-watch application that detects falls and similar events. This application is connected to a web application through which the carers can monitor their charges, send them messages and organize home visits. By the end of the year this solution was sufficiently mature to be used in pilots with 150 users, to be organized in cooperation with the Slovenian company Doktor 24 in early 2017. The AAL project **Fit4Work** is aiming to help older workers do their job more easily by providing advice on relaxation, exercise and work environment (temperature, CO_2 in the air etc.). To this end, we developed a method that recognizes mental stress using a wristband with physiological sensors. The method takes into account the context of a potentially stressful event, which makes it highly accurate. We also developed a method that can analyze physical activity with the sensors in the wristband and smartphone regardless of which device is worn and where. Finally, we use an ontology to select reasonable actions to improve the work environment, after which we simulate the outcome of each and recommend the best one. All our ambient-intelligence projects use wearable sensing devices, whose use is limited by their typically small batteries. As **doctoral research**, we are therefore developing a general method that can intelligently turn sensors on and off in such a way that the energy consumption is as small as possibly without sacrificing a lot of quality of the results obtained with these sensors.

Computational intelligence is a study of stochastic search, optimization and learning methods, inspired by biological and physical systems. Research in this area at the Department of Intelligent Systems focuses on

In the IN LIFE project we developed a smart watch for the elderly and we are running pilot tests on 150 users.

Figure 1: Within the framework of the H2020 IN LIFE project we developed a smart watch for the elderly and prepared 150 pieces for a 6-month-long pilot testing. The watch allows around 10 functions, including calls to the carer, automatic fall detection, location identification and call for help, notifications, monitoring of physical activity, etc. The system is a personal assistant and carer for the elderly. Our vision is to introduce it to the care of the elderly Europe-wide, thus increasing the quality of life.

In the AAL project Fit4Work we developed a method for stress detection using a wristband with physiological sensors. The method takes into account the context of a potentially stressful event, which makes it highly accurate.

The embedded computer system for manufacturing quality control developed by the Jožef Stefan Institute and Kolektor Group company is a key achievement of the COPCAMS project.

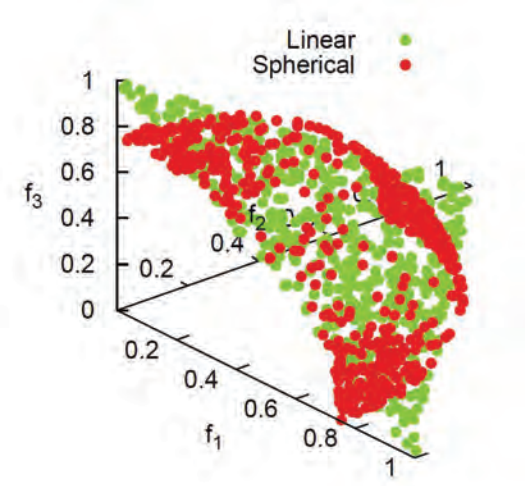


Figure 2: We design visualization methods for multiobjective optimization that assist decision-makers in selecting among trade-off solutions. A series of publications in the previous years was complemented with a tutorial given at the Genetic and Evolutionary Computation Conference (GECCO) 2016.

The ACCUS project developed a coordination platform for smart cities that enables the control of various city subsystems and provides several services for citizens.

Figure 3: A manufacturing quality control system resulting from the COPCAMS project is based on machine vision, machine learning and optimization.

In the Smart Specialisation programs we are developing several solutions for smart cities and communities, smart building and homes, and sustainable food.

the evolutionary computation methods. We study evolutionary algorithms for multiobjective optimization, their acceleration through parallel computing and surrogate models, visualization of their results, and applications in engineering design and optimization problems. These methods are being transferred to practice, especially in the area of production process optimization. In 2016, we finished the **COPCAMS** project approved for funding under the Artemis call. Together with the Slovene industrial partner Kolektor Group and international partners, we developed a procedure for product quality control that is based on machine vision, machine learning and optimization, and operates on an embedded computer architecture. The procedure is now used in manufacturing of graphite commutators for automotive industry in Kolektor. It supports dimensional measurements, assessment of the cooper-graphite joints and non-contact measurements of commutator roughness. According to project reviewers, this was the most successful project achievement. We also started an H2020 Twinning project **SYNERGY** whose objective is to strengthen our research and innovation potential in parallelization and surrogate modelling and to explore the potential of combining the two techniques in multi-objective optimization. Three partners with complementary expertise cooperate in this endeavor: the Jožef Stefan Institute, the University of Lille, and Cologne University of Applied Sciences. The expertise and solutions gained through this cooperation will be disseminated to both academic and industrial organizations, particularly those participating in the Slovene Smart Specialisation Stategy. In addition, a **bilateral Slovenian-Japanese research project** was approved for funding and initiated. It is aimed at advancing the methodology of evolutionary multiobjective optimization for real-world applications. We cooperate with Shinshu University, Nagano, on developing optimization algorithms for space exploration and transportation network design.

In the field of **agent and multi-agent systems** the key research areas are focused on the development of smart autonomous systems for the control of smart cities, smart homes and the preservation of cultural heritage. In this year we have successfully concluded the European project **ACCUS** that aimed at developing an integration and coordination platform for urban systems to build applications across various domains, providing adaptive and cooperative control for urban subsystems, and optimizing the combined performance of the city. In the final presentation we presented a system for balancing the overall electricity consumption in the city by curbing the electricity spikes that occur during the day. In addition, the system optimizes the electricity consumption in smart houses and the production in thermal power plants, and manages the traffic flow and thus affects the external parameters, such as air quality. We continue the research in this area in the Smart Specialisation program **EkoSMART** in the field of smart cities and communities. The purpose of the program is to develop a smart city ecosystem with all the support mechanisms that are necessary for efficient, optimized and gradual integration of different smart city areas into a unified and well connected system. Within the program we are involved in activities linked to the research and development projects *"Zasnova ekosistema pametnega mesta"* and *"Elektronsko in mobilno zdravstvo"* (**EMZ**), where we are the lead partner. We are also involved in the Smart Specialisation program **IQDOM** in the field of smart buildings and homes, coordinated by Gorenje. Our focus will be on the development of smart home automation services. The aim is to apply advanced machine learning and optimization methods in order to generate real-time control strategies that increase the users' comfort and, at the same time, decrease operational costs of the smart home. We will apply similar learning algorithms also to heat pumps. The controller learns the user's behaviour and formulates a strategy for water heating during periods of cheaper electricity and, at the same time, lowers the temperature of the stored water during days of lower consumption. In the Interreg **AS-IT-IC** project we will develop an integrated touristic platform for cross-border tourist exchange, tour planning and effective communication between tourists and tourist offices. In the

Horizon 2020 Twinning project **eHeritage** we continue to provide support to increase the capacity and quality of the research and innovation excellence of the Romanian partner in the area of cultural heritage preservation using intelligent methods and 3D modelling, and employing augmented and virtual reality. To this end, we organized the eHeritage workshop within the Information Society 2016 multiconference. During the same event the project partners presented products and applications based on the virtual reality technology (Heritage awareness day).

In the field of **speech and language technologies** we work on speech synthesis, semantic analysis of text and question answering. Together with companies Alpineon and Amebis we developed a new, high-quality speech synthesizer eBralec (http://ebralec.si/). The synthesizer is improved on both understandability and natural perception of the speech. The software package already has more than a thousand subscribers and is an indispensable tool of blind and visually-impaired users (it is the »official« speech synthesizer for the Society of visually impaired of Slovenia) and people with reading impairments (society Bravo). For these users, eBralec is free of charge and can be ordered in the Library for the blind and visually impaired (http://www.kss-ess.si/ebralec-sintetizator-govora-slovenskega-jezika/). Since 2016, the application DarsTraffic+, which provides users traffic information, also uses the eBralec software. This application was 1st on the App Store and 3rd in Google Play. According to the media, its key functionality and advantage are the audio settings. We have also developed the free service of speech synthesis for mobile devices (http://dis.ijs.si/dyslex/).

Figure 4: Fit4Work application, which helps older workers relax, be physically fit and have a good work environment (left). Measurements of human energy expenditure needed to develop the application (right).

Together with companies Amebis and Alpineon, we developed a high-quality speech synthesizer eBralec (http://ebralec.si/).

In collaboration with the Computer Systems Department, we organized the **7th International Conference on Bioinspired Optimization Methods and their Applications – BIOMA 2016** that took place from 18 to 20 May 2016 in Bled, Slovenia. The conference was devoted to theoretical and practical aspects of computer optimization methods inspired by natural phenomena. Its program consisted of 19 presentations by 45 coauthors from 11 countries. The invited lecturers were Prof. Thomas Bartz-Beielstein from the Cologne University of Applied Sciences and Prof. El-Ghazali Talbi from the University of Lille. Selected papers from the conference will be published in the extended form in the Applied Soft Computing journal. Collocated events were the 28th Slovene Workshop on Nature-Inspired Algorithms and the H2020 SYNERGY project meeting and training.

From 10 to 14 October 2015, the **19th International Multiconference Information Society – IS 2015** (is.ijs.si) took place at Jožef Stefan Institute. It consisted of 13 independent conferences with 200 presented papers. Four conference awards were presented: for lifetime achievements ("Donald Michie and Alan Turing" award) to Prof. Tomaž Pisanski, for current achievements in the field of information society to Prof. Blaž Zupan, and the information strawberry and lemon for the best and worst public information-society services.

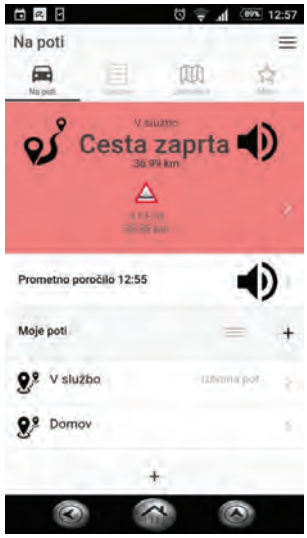


Figure 6: The application DarsTraffic+, which safely provides users traffic information, uses the eBralec software.

Some outstanding publications in the past year

1. Cvetković, B., Janko, V., Romero, A. E., Kafali, Ö., Stathis, K., Luštrek, M. Activity recognition for diabetic patients using a smartphone. J. med. syst., 40 (2016) 256-1-256-8
2. Gjoreski, M., Gjoreski, H., Luštrek, M., Gams, M. How accurately can your wrist device recognize daily activities and detect falls?. Sensors, 16 (2016) 800-1-800-21
3. Tavčar, A., Kužnar, D., Gams, M. Hybrid multi-agent strategy discovering algorithm for human behavior. Expert systems with applications, 71 (2017) 370-382
4. Veček, N., Mernik, M., Filipič, B., Črepinšek, M. Parameter tuning with Chess Rating System (CRS-Tuning) for meta-heuristic algorithms. Information Sciences, 372 (2016), 446-469

Organization of conferences, congresses and meetings

1. 28th Slovene Workshop on Nature-Inspired Algorithms, AVN, Bled, 18. 5. 2016
2. 7th International Conference on Bioinspired Optimization Methods and their Applications, BIOMA 2016, Bled, 18.–20. 5. 2016
3. Conference Genetic and Evolutionary Computation Conference, GECCO 2016, Denver, USA, 20.–24. 7. 2016

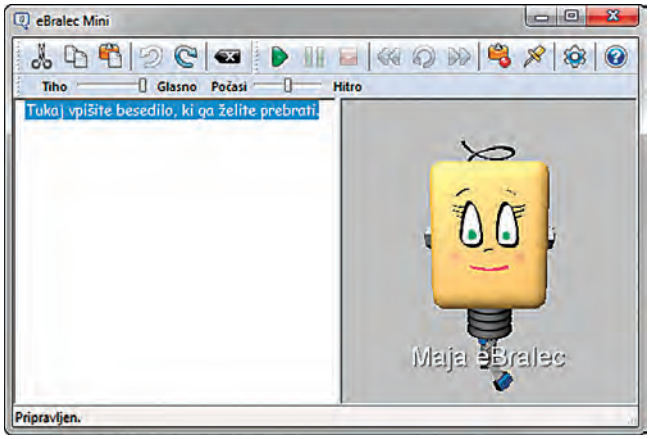


Figure 5: A new, high-quality speech synthesizer eBralec (http://ebralec.si/).

4. Workshop BBOB (Bi-Objective Blackbox Optimization Benchmarking) at Genetic and Evolutionary Computation Conference, GECCO 2016, Denver, USA, 20. 7. 2016
5. Workshop Women@GECCO at conference Genetic and Evolutionary Computation Conference, GECCO 2016, Denver, USA, 21. 7. 2016
6. Special Section Multiobjective Optimization with Surrogate Models, IEEE World Congress on Computational Intelligence, IEEE WCCI 2016, Vancouver, Canada, 24.–29. 7. 2016
7. Workshop Austrian-Slovenian Intelligent Tourist Information Center (AS–IT–IC), Ljubljana, Slovenia, 26. 9. 2016.
8. 19th International Multiconference Information Society, IS 2016, Ljubljana, Slovenia, 10.–14. 10. 2016; independent conferences:
   - Slovenian conference on artificial intelligence
   - Facing demographic challenges
   - Cognitive science
   - Collaboration, software and services in information society
   - Data mining and data warehouses
   - Human-computer interaction in information society (HCI-IS)
   - Workshop E-Heritage
   - Computer science and informatics: yesterday for tomorrow
   - 25th anniversary of internet in Slovenia
   - 3rd student computer science research conference
   - Ekosmart in EMZ
   - Education in information society (VIVID)
   - Middle-European conference on applied theoretical computer science (Matcos 2016)
9. eHeritage awareness day: presentation of virtual reality applications, Ljubljana, 13. 10. 2016
10. NATO Lecture series SET-235, Ljubljana, 27.–28. 10. 2016

Patent granted

1. Matjaž Gams, Hristijan Gjoreski, Mitja Luštrek, Method and system for detecting a person driving a vehicle while using a mobile computing device, SI24796 (A), Slovenian Intellectual Property Office , 29. 02. 2016.

INTERNATIONAL PROJECTS

1. Adaptive Cooperative Control in Urban (sub) Systems
   Prof. Matjaž Gams
   Ministrstvo za Gospodarstvo
2. COgnitive & Perceptive CAMeraS: COPCAMS
   Prof. Bogdan Filipič
   Ministrstvo za Gospodarstvo
3. Austrian-Slovenian Intelligent Tourist Information Center (AS-IT-IC)
   Prof. Matjaž Gams
   Služba Vlade Republike Slovenije za Razvoj
4. COST TD1405; ENJECT, European Network for the Joint Evaluation of Connected Health Technologies
   Božidara Cvetković, B. Sc.
   Cost Office
5. H2020 - IN LIFE; INdependent Living support Functions for the Elderly
   Prof. Matjaž Gams
   European Commission
6. H2020 - eHERITAGE; Expanding the Research and Innovation Capacity in Cultural Heritage Virtual Reality Applications
   Prof. Matjaž Gams
   European Commission
7. H2020 - HeartMan; Personal Decison Support System for Heart Failure Management
   Dr. Mitja Luštrek
   European Commission
8. H2020 - SYNERGY; Synergy for Smart Multi-Objective Optimisation
   Prof. Bogdan Filipič
   European Commission
9. Advanced Methodology of Evolutionary Multi- and Many-Objective Optimization for Real-World Applications
   Prof. Bogdan Filipič
   Slovenian Research Agency

RESEARCH PROGRAM

1. Artificial Intelligence and Intelligent Systems
   Prof. Matjaž Gams

R & D GRANTS AND CONTRACTS

1. Adaptive Cooperative Control in Urban (sub) Systems
   Prof. Matjaž Gams
   COgnitive & Perceptive CAMeraS: COPCAMS
   Prof. Bogdan Filipič
   Ministry of Economic of the Republic of Slovenia

Self-management of physical and mental fitness of older workers
   Dr. Mitja Luštrek
   Ministry of Education, Science and Sport of the Republic of Slovenia
2. Conference BIOMA 2016; The 7th International Conference on Bioinspired Methods and their Applications, Bled, Slovenia, 18.-20.05.2016
   Prof. Bogdan Filipič
3. The 19th International Multiconference Information Society 2016 (IS2016), JSI, Ljubljana, Slovenia, 10 October - 14 October 2016
   Prof. Matjaž Gams
4. Intelligent home of the new generation designed on smart appliances and wood
   Prof. Matjaž Gams
   Ministry of Education, Science and Sport of the Republic of Slovenia
5. Smart City Ecosystem – EkoSmart
   Prof. Matjaž Gams
   Ministry of Education, Science and Sport of the Republic of Slovenia

NEW CONTRACT

1. The inclusion of off-line speech synthesizer into the eBralec Mobile app for the Android operating system
   Dr. Tomaž Šef
   Amebis, d. o. o., Kamnik

VISITORS FROM ABROAD

1. Boris Naujoks, Jörg Stork, Cologne University of Applied Sciences (TH Köln), Gummersbach, Germany, 10.–11. 2. 2016
2. El–Ghazali Talbi, prof. dr. Nouredine Melab, University Lille 1, Lille, France, 10.–11. 2. 2016
3. dr. Christian Fabre, dr. Alexandre Guerre, Julie Foucault, Commissariat à l'énergie atomique et aux énergies alternatives (CEA), Grenoble, France, 18. 4. 2016
4. Kenzi Djouhri, IUT de Cachan IUT de Cachan Génie Electrique, Paris, France, 25. 4.–15. 7. 2016
5. Thomas Justice, IUT de Cachan IUT de Cachan Génie Electrique, Paris, France, 25. 4.– 15. 7. 2016
6. Hakim Kebli, IUT de Cachan IUT de Cachan Génie Electrique, Paris, France, 3. 5.–15. 7. 2016
7. Thomas Bartz–Beielstein, Jörg Stork, Martin Zaefferer, Cologne University of Applied Sciences (TH Köln), Gummersbach, Germany, 17. 5. 2016
8. Adam Benjelloun, IUT de Cachan, IUT de Cachan Génie Electrique, Paris, France, 20. 5.–12. 8. 2016
9. Timothée Foullon, IUT de Cachan, IUT de Cachan Génie Electrique, Paris, France, 20. 5.–12. 8. 2016
10. Florian Lemaître, IUT de Cachan IUT de Cachan Génie Electrique, Paris, France, 20. 5.– 12. 8. 2016
11. prof. dr. Kiyoshi Tanaka, prof. dr. Hernán Aguirre, Shinshu University, Nagano, Japan, 23.–24. 5. 2016
12. Marzhan Kulbulatova, Kazakh-British Technical University, Almaty, Kazakhstan, 6. 6.– 12. 8. 2016
13. Martin Bonchanoski, Faculty of Computer Science and Engineering, Ss Cyril and Methodius University, Skopje, Republic of Macedonia, 10. 9.–14. 10. 2016
14. prof. Csaba Antonya, Faculty of Mechanical Engineering, Transylvania University of Brasov, Brasov, Romania, 25. 9.–16. 10. 2016
15. dr. Eng. Eugen Valentin Butilă, Faculty of Technological Engineering, Transylvania University of Brasov, Brasov, Romania, 25. 9.–16. 10. 2016
16. Monika Simjanoska, Faculty of Computer Science and Engineering, Ss Cyril and Methodius University, Skopje, Republic of Macedonia, 24. 10.–30. 12. 2016
17. Boris Naujoks, Cologne University of Applied Sciences (TH Köln), Gummersbach, Germany, 10.–11. 11. 2016

STAFF

Researchers
1. Prof. Ivan Bratko*
2. Asst. Prof. Aleš Dobnikar*
3. Prof. Bogdan Filipič
4. **Prof. Matjaž Gams, Head**
5. Dr. Anton Gradišek
6. Dr. Mitja Luštrek
7. Dr. Tomaž Šef

Postdoctoral associates
8. Dr. Erik Dovgan*
9. *Dr. Hristijan Gjoreski, on leave 01.12.16*
10. Dr. Matej Guid
11. Dr. Boštjan Kaluža
12. Dr. Miha Mlakar
13. Dr. Aleksander Pivk*
14. Dr. Tea Tušar
15. *Dr. Vedrana Vidulin, 11.11.16, transferred to Department E8*

Postgraduates
16. Jani Bizjak, B. Sc.
17. Robert Blatnik, M. Sc.
18. Božidara Cvetković, B. Sc.
19. Martin Gjoreski, B. Sc.
20. Vito Janko, B. Sc.
21. Tomaž Kompara*, B. Sc.
22. Dr. Jana Krivec*
23. Damjan Kužnar, B. Sc.
24. *Martin Pečar, B. Sc., 01.12.16, transferred to Department E7*
25. Dr. Rok Piltaver*
26. Aleš Tavčar, B. Sc.
27. Jernej Zupančič, B. Sc.

Technical officers
28. *Martin Frešer, B. Sc., left 01.10.16*
29. Gregor Grasselli, B. Sc.
30. *Matej Krebelj, B. Sc., left 13.02.16*
31. Jure Šorn, B. Sc.
32. Aljoša Vodopija, B. Sc.

Technical and administrative staff
33. Grigory Evseev, B. Sc.
34. Vesna Koricki, B. Sc.
35. Mitja Lasič
36. Liljana Lasič
37. Blaž Mahnič, B. Sc.
38. Pavel Maslov, B. Sc.
39. Lana Zemljak

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Franci Bajd, Anton Gradišek, Tomaž Apih, Igor Serša, "Dry-cured ham tissue characterization by fast field cycling NMR relaxometry and quantitative magnetization transfer", *Magn. reson. chem.*, vol. 54, no. 10, pp. 827-834, 2016.
2. Božidara Cvetković, Hristijan Gjoreski, Vito Janko, Boštjan Kaluža, Anton Gradišek, Mitja Luštrek, Igor Jurinčič, Anton Gosar, Simon Kerma, Gregor Balažič, "E-turist: an intelligent personalised trip guide", *Informatica (Ljubl.)*, vol. 40, no. 4, pp. 447-455, 2016.
3. Božidara Cvetković, Vito Janko, Alfonso E. Romero, Özgür Kafali, Kostas Stathis, Mitja Luštrek, "Activity recognition for diabetic patients using a smartphone", *J. med. syst.*, vol. 40, no. 12, pp. 256-1-256-8, 2016.
4. Božidara Cvetković, Radoje Milić, Mitja Luštrek, "Estimating energy expenditure with multiple models using different wearable sensors", *IEEE j. biomed. health inform.*, vol. 20, no. 4, pp. 1081-1087, 2016.
5. Valentina Domenici, Anton Gradišek, Tomaž Apih, Věra Hamplová, Vladimíra Novotná, Pedro José Sebastião, "^{1}H NMR relaxometry in the TGBA* and TGBC* phases", *Ferroelectrics*, vol. 495, iss. 1, pp. 17-27, 2016.
6. Matjaž Gams, Eva Černčič, Angelo Montanari, "A temporal perspective on the paradox of pinocchio's nose", *Informatica (Ljubl.)*, vol. 40, no. 3, pp. 365-368, 2016.
7. Martin Gjoreski, Hristijan Gjoreski, Mitja Luštrek, Matjaž Gams, "How accurately can your wrist device recognize daily activities and detect falls?", *Sensors*, vol. 16, no. 6, pp. 800-1-800-21, 2016.
8. Anton Gradišek, Valentina Domenici, Tomaž Apih, Vladimíra Novotná, Pedro José Sebastião, "^{1}H NMR relaxometric study of molecular dynamics in a "de vries" liquid crystal", *J. phys. chem., B Condens. mater. surf. interfaces biophys.*, vol. 120, iss. 20, pp. 4706-4714, 2016.
9. Anton Gradišek, Lars Haahr Jepsen, Torben R. Jensen, Mark S. Conradi, "Nuclear magnetic resonance study of molecular dynamics in ammine metal borohydride $Sr(BH_4)_2(NH_3)_2$", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 120, no. 43, pp. 24646-24654, 2016.
10. Vito Janko, Matej Guid, "A program for Progressive chess", *Theor. comp. sci.*, vol. 644, pp. 76-91, Sep. 2016.
11. Aljaž Kramberger, Rok Piltaver, Bojan Nemec, Matjaž Gams, Aleš Ude, "Learning of assembly constraints by demonstration and active exploration", *Ind. rob.*, vol. 43, no. 5, pp. 524-534, 2016.
12. Jana Krivec, "How to approach a migrant: a psychosocial view", *Research in social change*, no. 8, iss. 1, pp. 79-102, Jan. 2016.
13. Damjan Kužnar, Aleš Tavčar, Jernej Zupančič, Mihai Duguleana, "Virtual assistant platform", *Informatica (Ljubl.)*, vol. 40, no. 3, pp. 285-289, 2016.
14. Rob Patro *et al.* (14 authors), "A computational method for designing diverse linear epitopes including citrullinated peptides with desired binding affinities to intravenous immunoglobulin", *BMC bioinformatics*, vol. 17, pp. 155-13-155-13, 2016.
15. Rok Piltaver, Mitja Luštrek, Matjaž Gams, Sanda Martinčić-Ipšić, "What makes classification trees comprehensible?", *Expert syst. appl.*, vol. 62, pp. 333-346, 2016.

16. Aleš Tavčar, Csaba Antonya, Valentin Butila, "Recommender system for virtual assistant supported museum tours", *Informatica (Ljubl.)*, vol. 40, no. 3, pp. 279-284, 2016.
17. Niki Veček, Marjan Mernik, Bogdan Filipič, Matej Črepinšek, "Parameter tuning with Chess Rating System (CRS-Tuning) for meta-heuristic algorithms", *Inf. sci.*, vol. 372, pp. 446-469, Dec. 2016.
18. Jure Žabkar, Ivan Bratko, Janez Demšar, "Extracting qualitative relations from categorical data", *Artif. intell.*, vol. 239, pp. 54-69, Oct. 2016.

Published Conference Contribution

1. Csaba Antonya, Silviu Butnariu, Matjaž Gams, "Haptic interface design for experiencing ancient works", In: *Delavnica e-Heritage: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11.-12. oktober 2016, [Ljubljana, Slovenija]: zvezek F*, pp. 16-19.
2. Anne Auger, Dimo Brockhoff, Nikolaus Hansen, Dejan Tušar, Tea Tušar, Tobias Wagner, "Benchmarking MATLAB's gamultiobj (NSGA-II) on the bi-objective BBOB-2016 test suite", In: *GECCO comp'16: proceeding of the 2016 on Genetic and Evolutionary Computation Conference Companion, July 20-24, 2016, Denver, Colorado, USA*, pp. 1233-1239.
3. Anne Auger, Dimo Brockhoff, Nikolaus Hansen, Dejan Tušar, Tea Tušar, Tobias Wagner, "Benchmarking RM-MEDA on the bi-objective BBOB-2016 test suite", In: *GECCO comp'16: proceeding of the 2016 on Genetic and Evolutionary Computation Conference Companion, July 20-24, 2016, Denver, Colorado, USA*, pp. 1241-1247.
4. Anne Auger, Dimo Brockhoff, Nikolaus Hansen, Dejan Tušar, Tea Tušar, Tobias Wagner, "Benchmarking the pure random search on the bi-objective BBOB-2016 testbed", In: *GECCO comp'16: proceeding of the 2016 on Genetic and Evolutionary Computation Conference Companion, July 20-24, 2016, Denver, Colorado, USA*, pp. 1217-1223.
5. Anne Auger, Dimo Brockhoff, Nikolaus Hansen, Dejan Tušar, Tea Tušar, Tobias Wagner, "The impact of search volume on the performance of RANDOMSEARCH on the bi-objective BBOB-2016 test suite", In: *GECCO comp'16: proceeding of the 2016 on Genetic and Evolutionary Computation Conference Companion, July 20-24, 2016, Denver, Colorado, USA*, pp. 1257-1264.
6. Anne Auger, Dimo Brockhoff, Nikolaus Hansen, Dejan Tušar, Tea Tušar, Tobias Wagner, "The impact of variation operators on the performance of SMS-EMOA on the bi-objective BBOB-2016 test suite", In: *GECCO comp'16: proceeding of the 2016 on Genetic and Evolutionary Computation Conference Companion, July 20-24, 2016, Denver, Colorado, USA*, pp. 1225-1232.
7. Jan Bizjak, Hristijan Gjoreski, Matjaž Gams, "Deep learning for diagnosing heart problems from ECG signals", In: *BOOM 2016*, 1st International Workshop on Biomedical Informatics with Optimization and Machine Learning in conjunction, BOOM 2016, with 25th International joint Conference on Artificial Intelligence (IJCAI), July 9, 2016, New York, USA, 1 pp.
8. Jani Bizjak, Hristijan Gjoreski, Matjaž Gams, "Pametna ura za starejše", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 10-13.
9. Jani Bizjak, Hristijan Gjoreski, Matjaž Gams, "Projekt IN LIFE v Sloveniji", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 7-9.
10. Martin Bonchanoski, Hristijan Gjoreski, Jani Bizjak, Matjaž Gams, "Smartwatch fall detection", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 17-20.
11. Božidara Cvetković, Martin Gjoreski, Martin Frešer, Michał Kosiedowski, Mitja Luštrek, "Monitoring and management of physical, mental and environmental stress at work", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 13-16.
12. Božidara Cvetković, Vito Janko, Anton Gradišek, Mitja Luštrek, Tanja Kajtna, Boro Štrumbelj, "Mobile application to stimulate physical activity in schoolchildren", In: *IE 2016*, The 12th International Conference on Intelligent Environments, 14-16 September 2016, London, United Kingdom, pp. 206-209.
13. Božidara Cvetković, Urška Pangerc, Anton Gradišek, Mitja Luštrek, "Monitoring patients with diabetes using wearable sensors: predicting glycaemias using ECG and respiration rate", In: *Proceedings*, 1st ECAI Workshop on Artificial Intelligence for Diabetes, AID, at the 22nd European Conference on Artificial Intelligence (ECAI 2016), 30 August 2016, The Hague, Holland, pp. 18-21.
14. Božidara Cvetković, Aljoša Vodopija, Drago Rudel, Zdravko Balorda, Mitja Luštrek, "Hospitalisation prediction from telemonitoring data in congestive heart failure patients", In: *Workshop on Knowledge Discovery in Healthcare Data [in conjunction with] 25th International joint Conference on Artificial Intelligence (IJCAI), July 9, 2016, New York, USA*, 1st International Workshop on Biomedical Informatics with Optimization and Machine Learning in conjunction, BOOM 2016, with 25th International joint Conference on Artificial Intelligence (IJCAI), July 9, 2016, New York, USA, 7 pp..
15. Erik Dovgan, "Multiobjective discovery of driving strategies using the SCANeR Studio", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 21-24.
16. Martin Frešer, Božidara Cvetković, Anton Gradišek, Mitja Luštrek, "Anticipatory system for T-H-C dynamics in room with real and virtual sensors", In: *UbiComp 2016: The 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, September 12-16, 2016, Heildeberg, Germany*, pp. 1267-1274.
17. Martin Frešer, Božidara Cvetković, Anton Gradišek, Mitja Luštrek, "An intelligent system to improve T-H-C parameters at the workplace", In: *UbiComp 2016: The 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, September 12-16, 2016, Heildeberg, Germany*, pp. 61-64.
18. Matjaž Gams, "Man vs. computer", In: *Kognitivna znanost: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 13. oktober 2016, [Ljubljana, Slovenija]: zvezek B*, pp. 12-15.
19. Matjaž Gams, Hristijan Gjoreski, "Elektronsko in mobilno zdravje: opis in struktura projekta", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 39-42.
20. Hristijan Gjoreski, Jani Bizjak, Matjaž Gams, "Using smartwatch as telecare and fall detection device", In: *IE 2016*, The 12th International Conference on Intelligent Environments, 14-16 September 2016, London, United Kingdom, pp. 242-245.
21. Hristijan Gjoreski, Jani Bizjak, Martin Gjoreski, Matjaž Gams, "Comparing deep and classical machine learning methods for human activiy recognition using wrist accelerometer", In: *Proceedings of the Twenty-Fifth International Joint Conference on Artificial Intelligence, ICJAI 2016, 9-15 July 2016, New York, USA*, 7 pp..
22. Martin Gjoreski, Hristijan Gjoreski, Mitja Luštrek, Matjaž Gams, "Continuous live stress monitoring with a wristband", In: *ECAI 2016: 22nd European Conference on Artificial Intelligence, including Prestigious Applications of Artificial Intelligence (PAIS 2016), 29 August-2 September 2016, The Hague, The Netherlands,* (Frontiers in artificial intelligence and applications, volume 285), pp. 1803-1804.
23. Martin Gjoreski, Hristijan Gjoreski, Mitja Luštrek, Matjaž Gams, "Continuous stress detection using a wrist device: in laboratory and real life", In: *UbiComp 2016: The 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing, September 12-16, 2016, Heildeberg, Gemany*, pp. 1185-1193.
24. Martin Gjoreski, Vito Janko, Hristijan Gjoreski, Božidara Cvetković, Mitja Luštrek, Matjaž Gams, "Activity and stress monitoring using smartphone and wrist device", In: *Zbornik*, 8. študentska konferenca Mednarodne podiplomske šole Jožefa Stefana, 31. maj in 1. junij 2016, Ljubljana, Slovenija, pp.154-164.
25. Martin Gjoreski, Mitja Luštrek, Matjaž Gams, "Machine learning method for stress detection with an EEG device", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 56-59.
26. Janez Grad, Anton Gradišek, Matjaž Gams, "Čmrlji: pašna dejavnost in zvok brenčanja: daily foraging behavior and buzzing sounds", In: *Zbornik referatov*, 2. znanstveno posvetovanje o čebelah in čebelarstvu [tudi] Poklukarjevi dnevi, Ljubljana, 25. oktober 2016, str 18-23.
27. Anton Gradišek, Jani Bizjak, Matjaž Gams, "Platforma za prepoznavanje in klasifikacijo različnih tipov zvokov", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 46-48.
28. Anton Gradišek, Andraž Kocjan, Miha Mlakar, "Ali nam metode strojnega učenja lahko pomagajo pri načrtovanju novih visokoentropijskih zlitin?", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 25-27.

29. Borut Grošičar, Tomaž Kompara, Vladimir Cindro, Jose Bernabeu Verdu, "Integracija elementov na osnovi poliamida in alu substrata CCL v bivanjsko okolje", In: *Zbornik recenziranih znanstvenih prispevkov*, (Ventil, Posebna številka, 2016, okt.), pp. 123-128.
30. Vito Janko, Mitja Luštrek, "Markov chain model for energy-efficient context recognition", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 28-31.
31. Cristina Knapic, A. Zanichelli, Erik Dovgan, M. Nanni, M. Stagni, S. Righini, Nada Sponza Mimica, F. Bedosti, A. Orlati, Riccardo Smareglia, "Radio data archiving system", In: *Software and Cyberinfrastructure for Astronomy IV: 26-30 June 2016, Edinburgh*, (Proceedings of SPIE, vol. 9913), pp. 99132D-1-99132D-15.
32. Tanja Knific, Tadej Malovrh, Marko Potočnik, Matija Pretnar, Milica Krković, Aljoša Vodopija, Jasna Prezelj-Perman, "Modeliranje širjenja kužnih bolezni: primer bolezni modrikastega jezika v Sloveniji", In: *6. Slovenski veterinarski kongres 2016: Portorož, 2. -3. December 2016*, (Slovenian veterinary research, Vol. 53, suppl. 17, 2016), pp. 73-77.
33. Toni Lunka, Hristijan Gjoreski, Mihai Duguleana, "Inteligentni upravljavski in nadzorni sistem za bivanjske rešitve v objektih", In: *Zbornik recenziranih znanstvenih prispevkov*, (Ventil, Posebna številka, 2016, okt.), pp. 113-116.
34. Mitja Luštrek, Erik Dovgan, Aljoša Vodopija, Marko Bohanec, Anneleen Baert, Sofie Pardaens, Els Clays, "Aplikacija za pomoč pri telesni vadbi bolnikov s srčnim popuščanjem", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 61-62.
35. Tadej Magajna, Jani Bizjak, Hristijan Gjoreski, Matjaž Gams, "IN LIFE web portal for care-giver support", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 63-64.
36. Gabriel Boboc Răzvan, Florin Grbacia, Aleš Tavčar, Eugen Butilă, "Reviving the memory of demolished buildings using Augmented Reality", In: *Delavnica e-Heritage: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11.-12. oktober 2016, [Ljubljana, Slovenija]: zvezek F*, pp. 5-8.
37. Tomaž Šef, "Sinteza slovenskega govora na mobilni platformi Android", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 48-51.
38. Domen Šoberl, Ivan Bratko, "Unified approach to qualitative motion planning in dynamic environments", In: *Qualitative reasoning*, 2016, pp. 117-124.
39. Vesna Švab, Jana Krivec, Kristina Voda, "How to reduce stigma and discrimination of people with mental health problems within educational process", In: *Izboljševanje procesov učenja in poučevanja v visokošolskem izobraževanju: zbornik konference: conference proceedings*, 2016, pp. 74-80.
40. Aleš Tavčar, Csaba Antonya, Eugen Butilă, Matjaž Gams, "Providing recommedations for virtual museum tours using intelligent assistants", In: *Delavnica e-Heritage: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11.-12. oktober 2016, [Ljubljana, Slovenija]: zvezek F*, pp. 24-26.
41. Aleš Tavčar, Csaba Antonya, Gabriel Boboc Răzvan, Leon Noe Jovan, Matjaž Gams, "Computer-generated knowledge base for virtual assistants", In: *Delavnica e-Heritage: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11.-12. oktober 2016, [Ljubljana, Slovenija]: zvezek F*, pp. 31-32.
42. Aleš Tavčar, Damjan Kužnar, Csaba Antonya, Matjaž Gams, "A web framework for the creation of virtual assistants for municipalities", In: *Delavnica e-Heritage: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 11.-12. oktober 2016, [Ljubljana, Slovenija]: zvezek F*, pp. 37-39.
43. Aleš Tavčar, Jure Šorn, Matjaž Gams, "Platforma za pametna mesta", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 84-86.
44. Tea Tušar, Bogdan Filipič, "Performance of the DEMO algorithm on the bi-objective BBOB test suite", In: *GECCO comp'16: proceeding of the 2016 on Genetic and Evolutionary Computation Conference Companion, July 20-24, 2016, Denver, Colorado, USA*, pp. 1249-1256.
45. Tea Tušar, Bogdan Filipič, "Showing the knee of a 4-D Pareto front approximation via different visualization methods", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 52-55.
46. Tea Tušar, Klemen Gantar, Bogdan Filipič, "The pitfalls of overfitting in optimization of a manufacturing quality control procedure", In: *Bioinspired optimization methods and their applications: proceedings of the Seventh International Conference on Bioinspired Optimization Methods and their Applications - BIOMA 2016, 18-20 May 2016, Bled, Slovenia*, pp. 241-253.
47. Aljoša Vodopija, Božidara Cvetković, Mitja Luštrek, Drago Rudel, Zdravko Balorda, "Napovedovanje hospitalizaciji pri bolnikih s srčnim popuščanjem iz podatkov telespremljanja", In: *Delavnica Elektronsko in mobilno zdravje: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 10.-11. oktober 2016, [Ljubljana, Slovenija]: zvezek G*, pp. 89-92.
48. Jernej Zupančič, Damjan Kužnar, Matjaž Gams, "Model selection on the JSI grid: Metis use-case", In: *Slovenska konferenca o umetni inteligenci: zbornik 19. mednarodne multikonference Informacijska družba - IS 2016, 12. oktober 2016, [Ljubljana, Slovenija]: zvezek A*, pp. 44-47.
49. Jerneja Žganec Gros, Boštjan Vesnicer, Simon Rozman, Peter Holozan, Tomaž Šef, "Sintetizator govora za slovenščino eBralec", In: *Zbornik konference Jezikovne tehnologije in digitalna humanistika, 29. september - 1. oktober 2016, Filozofska fakulteta, Univerza v Ljubljani, Ljubljana, Slovenija*, pp. 180-185.

Independent Component Part or a Chapter in a Monograph

1. Ivan Bratko, Dayana Hristova, Matej Guid, "Search versus knowledge in human problem solving: a case study in chess", In: *Model-based reasoning in science and technology: logical, epistemological, and cognitive issues*, (Studies in applied philosophy, epistemology and rational ethics, vol. 27), Lorenzo Magnani, ed., Claudia Casadio, ed., [S. l.], Springer, cop. 2016, pp. 569-583.

Scientific Monograph

1. Azlan Iqbal, Matej Guid, Simon Colton, Jana Krivec, Shazril Azman, Boshra Haghighi, *The digital synaptic neural substrate: a new approach to computational creativity*, (Springer briefs in cognitive computation), [S. l.], Springer, cop. 2016.
2. Boštjan Kaluža, *Machine learning in Java: design, build, and deploy your own machine learning applications*, Birmingham, Packt Publishing, 2016.

Patent Application

1. Matjaž Gams, Hristijan Gjoreski, Mitja Luštrek, *Method and system for detecting a person driving a vehicle while using a mobile computing device,* GB2528877 (A), Intellecual Property Office, 02. 10. 2016.

Patent

2. Matjaž Gams, Hristijan Gjoreski, Mitja Luštrek, *Method and system for detecting a person driving a vehicle while using a mobile computing device,* SI24796 (A), Urad RS za intelektualno lastnino, 29. 02. 2016.

Mentoring

1. Rok Piltaver, *Constructing comprehensible and accurate classifiers using data mining algorithms:* doctoral dissertation, Ljubljana, 2016 (mentor Matjaž Gams; co-mentor Mitja Luštrek).
2. Martin Gjoreski, *Continuous stress monitoring using a wrist device and a smartphone:* master's thesis, Ljubljana, 2016 (mentor Matjaž Gams; co-mentor Mitja Luštrek).
3. Martin Frešer, *Analysis and prediction of ambiental data with machine-learning and recommender system for better air-quality in work-places:* master's thesis, Ljubljana, 2016 (mentor Dejan Lavbič; co-mentor Mitja Luštrek).
4. Leon Noe Jovan, *Data preparation for municipal virtual assistant using machine learning:* master's thesis, Ljubljana, 2016 (mentor Matjaž Kukar; co-mentor Matjaž Gams).

DEPARTMENT OF REACTOR ENGINEERING

R-4

The Department of Reactor Engineering is involved in basic and applied research in the fields of nuclear engineering and safety. Topics include the modelling of basic thermal-hydrodynamic phenomena, thermal-hydraulic safety analyses of design-basis and severe accidents, structural safety analyses and probabilistic safety assessments. Most research activities are part of international cooperation programs. The research results are incorporated into projects for industry and for the regulatory authorities, as well as in undergraduate and doctoral studies programmes.

Head:
Prof. Leon Cizelj

An experiment on hydrogen combustion, proposed by JSI and NRG, was performed in the HYMIT facility at Shanghai Jiao Tong University (China).

Modelling of basic thermal-hydrodynamic phenomena

Turbulent heat transfer was investigated by performing Direct Numerical Simulations, using the spectral element method and the computer code nek5000, within the European Commission (EC) project SESAME, dedicated to the thermal hydraulics of liquid metals. Simulations are being performed in the geometry of a backward-facing step, which will be implemented in one of the SESAME experiments. Inlet boundary conditions are obtained with prescribed mean mass flow rate and a "recycling method", while outlet boundary conditions are implemented with a method that prevents backflow into the domain.

Investigations of jet impingement cooling phenomenology were continued. Based on an analysis of an extensive Large Eddy Simulation (LES) database of a selected experimental case with multiple turbulent impinging jets, the instantaneous heat-transfer phenomenology was comprehensively interpreted and explained.

Conjugate heat-transfer simulations were started with the development of a wall-resolved LES model, using the open-source code Code_Saturne and in collaboration with Electricité de France (EDF). The final goal is the development and qualification of LES models for detailed simulations of turbulent heat transfer in geometries where the penetration of turbulent fluctuations into solid walls must be predicted.

The flow in a fuel bundle with a grid spacer was simulated using the URANS (Unsteady Reynolds Averaged Navier-Stokes) turbulence model. The simulations have shown a clear decoupling of large vortices induced by the flow separation, which were explicitly simulated, and small scale turbulent vortices, which were modelled with a RANS turbulence model. The results were validated with the MATiS-H experiment (Measurement and analysis of turbulent mixing in sub-channels – horizontal) performed at the Korea Atomic Energy Research Institute.

Separated upward air-water flow in a vertical pipe, which is related to the flooding phenomenon during nuclear reactor accidents, was simulated using interface-capturing methods. The influence of the liquid inlet on the flooding wave frequency was investigated and a strong correlation between the two was demonstrated.

The basic phenomena of vapour explosion and debris bed coolability, which might occur during a hypothetical severe accident in a nuclear power plant if the hot reactor-core melt comes into contact with the coolant, were also investigated. Analyses of the material influence of the oxide and metallic corium on the ex-vessel vapour explosion in the cavity of a pressurized water reactor have shown that with metallic corium, stronger explosions may occur. We also continued with studies of vapour explosions in stratified melt-coolant configurations. The recently performed experiments in the PULiMS/SES facility (Royal Institute of Technology, Sweden) have revealed that strong stratified explosions may develop spontaneously. In order to investigate the premixed layer formation mechanisms in stratified conditions, a SES test with an underwater melt delivery has been proposed within the EC FP7 SAFEST project by an international user group led by JSI and EDF. The test resulted in a strong spontaneous explosion right after the initiation of the melt spreading. Analyses of X-ray images of the OECD SERENA KROTOS experiments (Commissariat à l'Energie Atomique - CEA, France), in parallel with supporting MC3D code (Institut de Radioprotection et de Sûreté Nucléaire - IRSN, France) calculations, provided additional insights into the complex premixing processes. Apart from that, the potential of vapour explosions during melt-sodium interactions was also investigated.

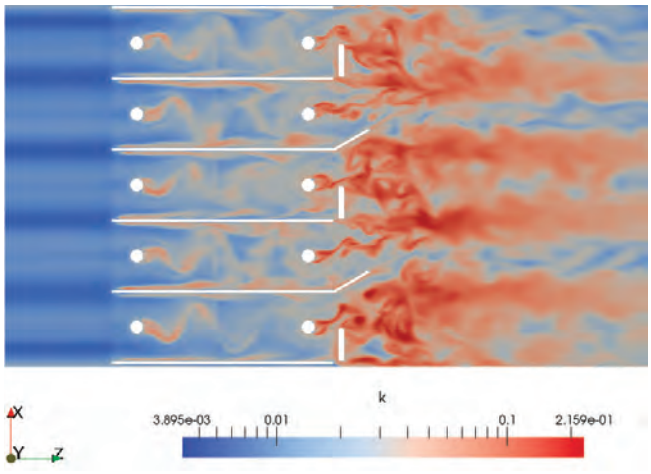


Figure 1: Enhancement of instantaneous turbulent kinetic energy for a mixing grid in the plane cut through a 5×5 rod bundle.

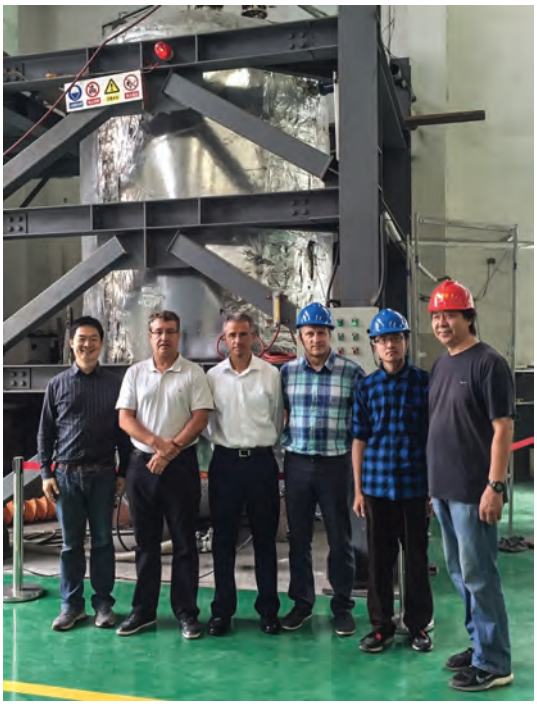


Figure 2: Execution of a hydrogen combustion experiment in the HYMIT experimental facility at Shanghai Jiao Tong University (China).

The analysis of experiments, dedicated to the film boiling regime, led to the proposal of an improved approach to model this boiling regime. The MC3D code was also used to perform simulations of recently performed PEARL experiments (IRSN), which are dedicated to debris bed coolability issues.

In the field of research on hydrogen combustion in NPP containment, an experiment on hydrogen deflagration was performed within the Chinese-EU project ALISA at Shanghai Jiao Tong University (China) in the HYMIT facility. The experiment specification was proposed by JSI and Nuclear Research and Consultancy Group (NRG, Netherlands). The results of the experiment are now being used for our further research on the theoretical modelling of hydrogen combustion. Apart from that, simulations of a similar experiment that we performed in 2012 at the Karlsruhe Institute of Technology (KIT, Germany) were continued with a modified combustion modelling, again in cooperation with NRG.

With regard to the new experimental laboratory for fluid mechanics and heat-transfer research under construction, there were important advances performed in an attempt to close the primary fluid loop. An important part of the test facility's instruments was installed and wired. However, most of the focus in the past year was dedicated to the design and construction of a unique test section that will allow for local heat-transfer coefficient measurements on a heated rod in an annulus during single-phase flow, flow boiling, convective condensation and critical heat flux, while allowing a visual inspection of the studied phenomenon at desired locations. The one-of-a-kind measuring device will allow for diabatic fluid flow measurements at controlled wall temperatures.

Within our current experimental activities, coolant temperature distributions in the cooling channels of the TRIGA research reactor were measured and compared with computational fluid dynamics (CFD) simulations. A simplified CFD model is being used for coupled neutronic and thermal hydraulic simulations of the experimental reactor.

Thermal-hydraulic safety analyses

The accident at the Fukushima Daichi nuclear power plant in 2011 demonstrated that external events may cause the loss of all active safety systems. Therefore, safety upgrade programs (SUP) for existing nuclear power plants were initiated. We demonstrated that a developed input model of a two-loop pressurized water reactor (PWR) for the TRACE thermal-hydraulic systems code can be used for an independent assessment of the RELAP5 computer code calculations, which were used in the frame of the Krško NPP SUP. As a demonstration, the response of a PWR to loss-of-coolant accident (LOCA) break spectrum of 12", 8", 6", 5" and 4" equivalent diameter cold leg breaks was simulated. Only passive components, i.e., accumulators, were assumed available, and the time available before significant core heatup was estimated.

The development of the thermal shielding concept for the demonstration fusion reactor DEMO was carried out within the frame of the EUROfusion project. A preliminary calculation of heat conduction loads from the thermal shield supports and from the magnet support was performed. The total power of the DEMO cryo-coolant system was predicted, taking into account thermal radiation and heat-conduction heat losses. The overall efficiency of the cryo-cooling was optimised in terms of different cooling temperatures of the vacuum vessel and thermal shields.

We simulated loss-of-coolant and loss-of-cooling accidents in the spent-fuel pool of the Fukushima (Japan) nuclear power plant.

In the frame of the NUGENIA+ Air SFP project, we participated in a benchmark simulation of loss-of-coolant and loss-of-cooling accidents in the spent fuel pool of the Fukushima NPP. We developed a suitable model for the ASTEC system code, specifically for the ICARE module, which is used to simulate heat up and degradation of the reactor core.

Within the European CESAM project, we simulated five experiments of hydrogen combustion in a non-homogeneous atmosphere (both in terms of atmosphere composition as well as temperature) with upward and downward flame propagation, performed in the THAI experimental facility (Becker Technologies, Germany), with the ASTEC code. Although system codes use a volume-averaged description of the containment, they are suitable for the safety analyses of real plants.

Structural safety analyses

In cooperation with CEA, the recently developed micro-mechanical crystal plasticity model for neutron-irradiated stainless steel was re-calibrated by using a representative finite-element model of a realistic tensile specimen. The finite-element model was identified by extrapolating the results of tensile simulations on various finite aggregate models to a continuum limit. Using a representative model and a novel fitting approach, the adjustment of the model parameters was performed with respect to tensile measurements on 304L stainless steel up to the necking point.

Within the EC project SOTERIA and in collaboration with CEA, the normal stresses and cumulative plastic strains were calculated at grain boundaries in neutron-irradiated stainless steel for uniaxial tensile loading conditions. Polycrystalline simulations were performed on Voronoi and realistic steel-wire aggregates. Once rescaled by the macroscopic stress, the obtained intergranular stress distributions were found to be well approximated by a bi-modal master curve.

The uncertainties in the prediction of thermal fatigue lives of pipes subjected to turbulent fluid mixing were estimated using total-life and damage-tolerant approaches with an improved spectral loading method, developed at the JSI, for the generation of fluid-temperature histories. The influence of various fluid-flow parameters and heat-transfer coefficients on the predicted fatigue lives and crack growth were analysed.

Uncertainties in the prediction of the thermal fatigue lives of pipes, subjected to turbulent fluid mixing, were estimated using an improved spectral loading method developed at the JSI.

We participated in two EC projects in the field of nuclear fusion. Within the WPDC project (diagnostic and control), the initial feasibility assessment was carried out on the divertor thermo-current measurement diagnostics for the DEMO fusion reactor. Maximum voltage differences were calculated along the divertor cassette for a given current power and various couplings of the divertor with vacuum vessel and divertor cooling pipes. A split-cassette design was shown to provide reasonably high voltage drops for plasma detachment control.

Within the PMI-PPPT-FU project (plant level system engineering), the initial concept design for the expansion joints between the vacuum vessel port and the cryostat in the DEMO reactor, referred as port duct bellows, was studied. The initial geometry of the bellows was defined and the first results on the mechanical stresses, due to gravity loading and relative movements of the connecting parts, were reported.

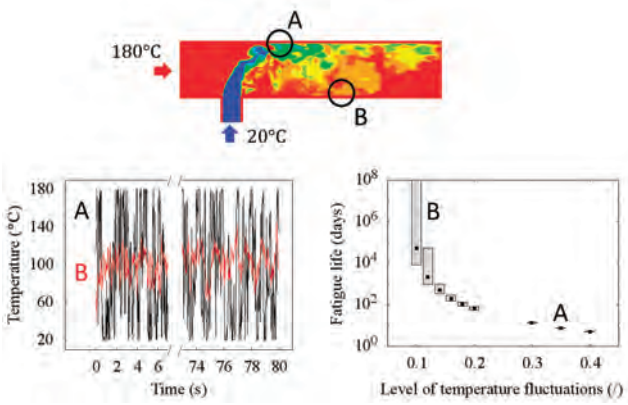


Figure 3: In a T-junction (top), synthetic fluid temperature signals (bottom left), generated with an improved spectral loading method developed at JSI, are used to predict fatigue lives as well as associated uncertainties (bottom right).

Probabilistic safety assessment

Within the EC ASAMPSA_E project, which aims at promoting good practices for the identification of a combination of two correlated extreme external events having significant influences on nuclear safety with the help of probabilistic safety assessment (PSA), we studied how "extended PSA" can be developed efficiently, as well as specific problems, related to Level 2 PSA (expected frequency, quantity, composition, location, etc. of radioactive releases into the environment because of barrier failure and failure of containment systems). We also participated in the organisation of the ASAMPSA_E end-user workshop. The purpose of the workshop was to review, together with end-users, comments and improvements provided during the review process of the preliminary ASAMPSA_E reports. Regulatory bodies, nuclear power plant operators, technical organisations and research organisations, which work or are related to PSA, were involved in the review process.

Technical cooperation, consulting services and education

In 2016, the Department of Reactor Engineering cooperated in projects for industry as well. As an authorized institution for radiation and nuclear safety, we prepared a report with proposals for safety improvements to the Krško NPP, based on inspection activities on safety structures, systems and components during the plant 2016 outage. In addition, an independent evaluation of the modified Krško fuel design was performed. Mechanical changes to the fuel resulted in a change of critical heat flux and consequently influenced the results of the large-break loss-of-coolant-accident event analysis within the Updated Safety Analysis Report.

Members of the department are also actively involved in nuclear engineering undergraduate, master and doctoral studies at the Faculty of Mathematics and Physics at the University of Ljubljana. The programmes are associated with the European Nuclear Education Network (ENEN).

Some outstanding publications in the past three years

1. B.Mikuž, I.Tiselj, Wall-resolved Large Eddy Simulation in grid-free 5 x 5 rod bundle of MATiS-H experiment, Nuclear Engineering and Design, 298 (2016), 64-77.
2. M.Tekavčič, B.Končar, I.Kljenak, Simulation of flooding waves in vertical churn flow, Nuclear Engineering and Design, 299 (2016), 214-224.
3. M.Leskovar, V.Centrih, M.Uršič, Simulation of steam explosion in stratified melt-coolant configuration, Nuclear Engineering and Design, 296 (2016), 19-29.

4. O.Costa Garrido, S.El Shawish, L.Cizelj, Uncertainties in the thermal fatigue assessment of pipes under turbulent fluid mixing using an improved spectral loading approach, International Journal of Fatigue, 82 (2016), 550-560.
5. M.Leskovar, M.Uršič, Analysis of PWR ex-vessel steam explosion for axial and side melt release, Nuclear Engineering and Design, 283 (2015), 40-50.
6. R.Henry, I.Tiselj, L.Snoj, Analysis of JSI TRIGA MARK II reactor physical parameters calculated with TRIPOLI and MCNP, Applied Radiation and Isotopes, 97 (2015), 140-148.
7. O.Costa Garrido, S.El Shawish, L.Cizelj, Stress assessment in piping under synthetic thermal loads emulating turbulent fluid mixing, Nuclear Engineering and Design, 283 (2015), 114-130.
8. A.Prošek, A.Volkanovski, Extended blackout mitigation strategy for PWR, Nuclear Engineering and Design, 295 (2015), 360-373.

Awards and appointments

1. Oriol Costa Garrido: Winner prize for the best presentation of relevant research in nuclear fields (ENC 2016 conference, Warsaw, Poland), European Nuclear Education Network, Life-time predictions accuracy of the thermally fatigued pipes under turbulently mixing fluids
2. Oriol Costa Garrido: Best poster award (ICONE 24 conference, Charlotte, North Carolina, USA), American Society of Mechanical Engineers, Probabilistic prediction of fatigue life of pipes under turbulent fluid mixing
3. Tadej Holler: Best paper award (ICONE 24 conference, Charlotte, North Carolina, USA), American Society of Mechanical Engineers, Large-scale homogeneous hydrogen-air-steam deflagration experiment simulated using two turbulent flame speed closure models
4. Janez Kokalj, Matjaž Leskovar, Mitja Uršič: Best poster award (NENE 2016 conference, Portorož, Slovenia), Nuclear Society of Slovenia, Modelling of Debris Bed Coollability in Bottom Reflooding Conditions with MC3D
5. Matic Kunšek: Certificate; European master of nuclear engineering (IAEA General conference, Vienna, Austria), European Nuclear Education Network

Organization of conferences, congresses and meetings

1. SOTERIA Project General Assembly, Jožef Stefan Institute Reactor Center, Ljubljana (29.-30.09.2016)

INTERNATIONAL PROJECTS

1. Research of Conjugate Heat Transfer in Turbulent Pipe Flow
   Prof. Iztok Tiselj
   Electricite De France S.a.
2. Overheating of Containers for Dry Storage of Spent Fuel after Full Blockage of Ventilation Channels
   Dr. Matjaž Leskovar
   Areva Gmbh
3. 7FP - CESAM; Code for European Severe Accident Management
   Asst. Prof. Ivo Kljenak
   European Commission
4. 7FP - ASAMPSA_E; Advanced Safety Assesment: Extended PSA
   Dr. Andrej Prošek
   European Commission
5. 7FP - ARCADIA; Assessment of Regional Capabilities for New Reactors Development through an Integrated Approach
   Prof. Leon Cizelj
   European Commission
6. 7 FP - NUGENIAS-PLUS (AIR-SFP); Spent Fuel Pool Behaviour in Loss of Cooling of Loss of Coolant Accidents
   Asst. Prof. Marko Matkovič
   European Commission
7. Better understanding and recognition of nuclear skills and qualifications
   Prof. Leon Cizelj
   University Politehnica of Bucharest
8. Training and Tutoring for Experts of the National Regulatory Authorities and their Technical Support Organisations for Developing or Strengthening their Regulatory and Technical Capabilities - MC3.01/13
   Prof. Leon Cizelj
   Iter-consult Srl - Independent
9. H2020 - SESAME; thermal hydraulics Simulations and Experiments for the Safety Assessment of MEtal cooled reactors
   Prof. Iztok Tiselj
   European Commission
10. H2020 - SOTERIA; Safe Long Term Operation of Light Water Reactors based on Improved Understanding of Radiation Effects in Nuclear Structural Materials
    Prof. Leon Cizelj
    European Commission
11. H2020 - ANNETTE; Advanced Networking for Nuclear Education and Training and Transfer of Expertise
    Prof. Leon Cizelj
    European Commission
12. RU-FU, EUROFUSION; Research Unit - Administration and Services
    Dr. Boštjan Končar
    European Commission
13. Education-ED-FU, EUROFUSION
    Dr. Boštjan Končar
    European Commission
14. Diagnostic and Control-WPDC-PPPT-FU, EUROFUSION
    Dr. Samir El Shawish
    European Commission
15. Plant Level System Engineering-PMI-PPPT-FU
    Dr. Boštjan Končar
    European Commission
16. Investigation of Coolant Flow and Heat Transfer Characteristics in a High Temperature Gas-cooled Reactor
    Prof. Leon Cizelj
    Slovenian Research Agency
17. MS-MZDR/16-1-B2-125; SNETP - Sustainable Nuclear Energy Technology Platform; SNETP General Assembly, Meeting of the Governing Board; Brussels, Belgium, 21.-23.3.2016, 19.-20.10.2016
    Prof. Leon Cizelj
    Slovenian Research Agency
18. MS-MZDR/16-1-B2-053; General Assembly of the ENEN Association, President of the Governing Board; Paris, France, 13.-14.10.2016, 15.-16.12.2016
    Prof. Leon Cizelj
    Slovenian Research Agency
19. MS-MZDR/16-1-B2-112; General Assembly of the ETSON Association, Member of the Governing Board; Paris, France, 13.-14.7.2016; Munchen, Germany, 7.-9.11.2016
    Prof. Leon Cizelj
    Slovenian Research Agency
20. Investigation of stratified steam explosions
    Dr. Matjaž Leskovar
    Slovenian Research Agency

21. Towards quantitative prediction of stress corrosion cracking initiation stress threshold for PWR's internals
    Dr. Samir El Shawish
    Slovenian Research Agency

RESEARCH PROGRAM

1. Reactor engineering
   Prof. Leon Cizelj

R&D GRANTS AND CONTRACTS

1. Feasibility of the Modelling of Interaction between Molten Corium and Sodium in the MC3D Software for SFR Applications
   Dr. Mitja Uršič
   Institut De Radioprotection Et De
2. JOPRAD; Joint Programming on Radioactive Waste
   Prof. Leon Cizelj
   ANDRA - The French National Radioactive Waste

NEW CONTRACTS

1. Cooperation in an international CAMP program
   Dr. Andrej Prošek
   Nuklearna Elektrarna Krško
2. Independent Evaluation of Modified Krško 16x16 VANTAGE+Fuel design fully in accordance with NEK Technical Specification SP-ES1250 Rev.0
   Dr. Matjaž Leskovar
   Nuklearna Elektrarna Krško d. o. o.
3. Understanding and managing the processes related to SFP under loss of cooling and loss of coolant accident scenario
   Assist. Prof. Marko Matkovič
   Nuklearna Elektrarna Krško
4. Joint Expert Assessment of the Outage Activities, Interventions and Tests during a shutdown and refueling outage 2016
   Dr. Mitja Uršič
   Elektroinštitut Milan Vidmar

VISITORS FROM ABROAD

1. Ms. Zoya Trafimchik, Ms. Ylyana Kruk, Dr. Natallia Lukashenka: Department of Nuclear Radiation Safety of the Ministry of Emergency Situations of the Republic of Belarus (Minsk, Belarus), 09.09.2016
2. Mr. Virgil Aurelian Iliescu: National Commission for Nuclear Activities Control - CNCAN (Bucharest, Romania), 09.09.2016
3. Dr. Asif Arastu, Mr. Clayton Smith, Mr. Robert Stakenborghs: The American Society of Mechanical Engineers - ASME (USA), 09.09.2016
4. Dr. Sofiane Benhamadouche, Dr. Martin Ferrand: Electricité de France (EDF) Research and Development (Chatou, France), 24.-26.10.2016
5. Mr. Stefan Reisinger, Mr. Matjaž Kavčič: Embassy of the United States of America in Slovenia (Ljubljana, Slovenia), 15.12.2016

STAFF

Researchers
1. **Prof. Leon Cizelj, Head**
2. Dr. Samir El Shawish
3. *Ljubo Fabjan, M. Sc., retired 01.09.16*
4. Asst. Prof. Ivo Kljenak
5. Dr. Boštjan Končar
6. Dr. Matjaž Leskovar
7. Asst. Prof. Marko Matkovič
8. Dr. Andrej Prošek
9. Prof. Iztok Tiselj
10. Dr. Mitja Uršič
11. *Dr. Andrija Volkanovski, on leave 16.05.15*

Postdoctoral associates
12. Dr. Oriol Costa Garrido
13. Dr. Martin Draksler
14. Dr. Cedric Cyril Henri Flageul
15. Dr. Blaž Mikuž

Postgraduates
16. *Ovidiu-Adrian Berar, B. Sc., left 01.05.16*
17. Romain Claude Francis Henry, B. Sc.
18. Tadej Holler, B. Sc.
19. Janez Kokalj, B. Sc.
20. Rok Krpan, B. Sc.
21. Matic Kunšek, B. Sc.
22. Jure Oder, B. Sc.
23. Matej Tekavčič, B. Sc.

Technical officers
24. Sandi Cimerman, B. Sc.
25. Andrej Sušnik, B. Sc.

Technical and administrative staff
26. Tanja Klopčič
27. *Urška Knific Terze, B. Sc., left 01.04.16*
28. Zoran Petrič, B. Sc.
29. Nina Rehar, B. Sc.

BIBLIOGRAPHY

Original Article

1. Samir El Shawish, Leon Cizelj, "Numerical investigation of grain misorientations at and close to the free surface of FCC polycrystalline metals", *Comput. mater. sci.*, vol. 113, pp. 133-142, feb. 2016.
2. Oriol Costa Garrido, Samir El Shawish, Leon Cizelj, "Uncertainties in the thermal fatigue assessment of pipes under turbulent fluid mixing using an improved spectral loading approach", *Int. j. fatigue*, vol. 82, part 3, pp. 550-560, 2016.
3. Romain Henry, Iztok Tiselj, Marko Matkovič, "Natural and mixed convection in the cylindrical pool of TRIGA reactor", *Heat mass transf.*, 15 pp..
4. Jeremy Hure, Samir El Shawish, Leon Cizelj, Benoit Tanguy, "Intergranular stress distributions in polycrystalline aggregates of irradiated stainless steel", *J. nucl. mater.*, vol. 476, pp. 231-242, avg. 2016.
5. Duško Kančev, Blaže Gjorgiev, Andrija Volkanovski, Marko Čepin, "Time-dependent unavailability of equipment in an ageing NPP: sensitivity study of a developed model", *Reliab. eng. syst. saf.*, vol. 148, pp. 11-20, 2016.
6. Matjaž Leskovar, Vasilij Centrih, Mitja Uršič, "Analysis of oxidation influence on steam explosion energetics", *Ann. nucl. energy*, vol. 90, pp. 441-449, 2016.
7. Matjaž Leskovar, Vasilij Centrih, Mitja Uršič, "Simulation of steam explosion in stratified melt-coolant configuration", *Nucl. Eng. Des.*, vol. 296, pp. 19-29, 2016.
8. Matjaž Leskovar, Mitja Uršič, "Ex-vessel steam explosion analysis for pressurized water reactor and boiling water reactor", *Nucl. Eng. and Technol.*, vol. 48, no. 1, pp. 72-86, 2016.
9. Blaž Mikuž, Iztok Tiselj, "Wall-resolved Large Eddy Simulation in grid-free 5 x 5 rod bundle of MATiS-H experiment", *Nucl. Eng. Des.*, vol. 298, pp. 64-77, 2016.
10. Pratap Sathiah, Tadej Holler, Ivo Kljenak, Ed. M. J. Komen, "The role of CFD combustion modeling in hydrogen safety management. V., Validation for slow deflagrations in homogeneous hydrogen-air experiments", *Nucl. Eng. Des.*, vol. 310, pp. 520-531, 2016.

11. Matej Tekavčič, Boštjan Končar, Ivo Kljenak, "Simulation of flooding waves in vertical churn flow", *Nucl. Eng. Des.*, vol. 299, pp. 214-224, 2016.
12. Andrija Volkanovski, Antonio Ballesteros Avila, Miguel Peinador Veira, "Statistical analysis of loss of offsite power events", *Sci. Technol. Nucl. Install.*, vol. 2016, pp. 7692659-1-7692659-9, 2016.
13. Andrija Volkanovski, Antonio Ballesteros Avila, Miguel Peinador Veira, Duško Kančev, Michael Maqua, Jean-Luc Stephan, "Analysis of loss of offsite power events reported in nuclear power plants", *Nucl. Eng. Des.*, vol. 307, pp. 234-248, 2016.

Published Conference Contribution

1. Vasilij Centrih, Matjaž Leskovar, "Analysis of x-ray images in SERENA KROTOS experiments with premixing simulations", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 811-1-811-9.
2. Vasilij Centrih, Matjaž Leskovar, "Influence of melt pouring on stratified steam explosion", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 806-1-806-10.
3. Leon Cizelj, P. Porras Dieguez, W. Ambrosini, P. Anzieu, Michèle Coeck, J. Dies, M. Eaton, R. Geisser, M. Kropík, F. Tuomisto, "The european nuclear education network and its actions in favour of education, training, information and transfer of expertise", In: *Nuclear education training, NESTet 2016: conference proceedings: 22-26 May 2016, Berlin*, 95-401-101-401.
4. Leon Cizelj, Iztok Tiselj, Ivo Kljenak, "Research based education as a necessary infrastructure for sustainable development of nuclear energy", In: *Nuclear education training, NESTet 2016: conference proceedings: 22-26 May 2016, Berlin*, 88-401-94-401.
5. Martin Draksler, Leon Cizelj, Boštjan Končar, "Impinging jets: a potential cooling method for plasma- facing components in demo fusion reactor", In: *Extended abstracts: European Nuclear Conference, ENC 2016, 9-13 October 2016, Warsaw, Poland*, pp. 188-196.
6. Samir El Shawish, Leon Cizelj, Benoit Tanguy, Jeremy Hure, "Macroscopic validation of the micromechanical model for neutron-irradiated stainless steel", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 603-1-603-10.
7. Cedric Flageul, Benhamadouche Sofiane, Lamballais Éric, Laurence Dominique, Iztok Tiselj, "On the discontinuity of $\eta\theta$–the dissipation rate associated with the temperature variance–at the fluid-solid interface for cases with conjugate heat transfer", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 507-1-507-8.
8. Oriol Costa Garrido, Leon Cizelj, "Life-time predictions accuracy of thermally fatigued pipes under turbulently mixing fluids", In: *Extended abstracts: European Nuclear Conference, ENC 2016, 9-13 October 2016, Warsaw, Poland*, pp. 167-176.
9. Oriol Costa Garrido, Leon Cizelj, "Probabilistic prediction of fatigue life of pipes under turbulent fluid mixing", In: *ICONE24*, The 24th International Conference on Nuclear Engineering, June 26-30, 2016, Charlotte, NC, USA, 9 pp.
10. Oriol Costa Garrido, Samir El Shawish, Leon Cizelj, "Crack growth assessment in pipes under turbulent fluid mixing using an improved spectral loading approach and linear elastic fracture mechanics", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 504-1-504-12.
11. Romain Henry, Marko Matkovič, "Coolant temperature measurements in the core of TRIGA research reactor", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 205-1-205-8.
12. Romain Henry, Iztok Tiselj, Marko Matkovič, "Coolant temperature measurements in TRIGA research reactor", In: *11th International Meeting on Nuclear Reactor Thermal-Hydraulics, Operation and Safety, NUTHOS-11: October 9-13. 2016, Gyeongju, Korea*, pp. 1-12.
13. Romain Henry, Iztok Tiselj, Luka Snoj, "Multi-physics simulation of the Triga reactor", In: *Annual Meeting of the American Nuclear Society, June 12-16, 2016, New Orleans, USA*, (Transactions of the American Nuclear Society, Vol. 114, 2016), pp. 678-681.
14. Tadej Holler, Varun Jain, Ed. M. J. Komen, Ivo Kljenak, "Large-scale homogeneous hydrogen-air-steam deflagration experiment simulated using two turbulent flame speed clore models", In: *ICONE24*, The 24th International Conference on Nuclear Engineering, June 26-30, 2016, Charlotte, NC, USA, 6 pp.
15. Tadej Holler, Ed. M. J. Komen, Ivo Kljenak, "Comparison of CFD and LP codes for the simulation of hydrogen combustion experiments", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 809-1-809-12.
16. Tadej Holler, Ed. M. J. Komen, Ivo Kljenak, "Flame propagation dependency analysis on confinement geometry shape in hydrogen-air-steam combustion simulations", In: *World Congress on Momentum, Heat and Mass Transfer, MHMT 2016, April 4-5, 2016, Prague, Czech Republic*, pp. 113-1-113-7.
17. Luka Klobučar, Boštjan Končar, "Thermal Loading of DEMO divertor cassette during maintenance conditions", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 909-1-909-10.
18. Janez Kokalj, Mitja Uršič, Matjaž Leskovar, "Analysis of debris bed coolability in bottom reflooding conditions", In: *Conference proceedings and book of abstracts: former "Nuclear Option in Countries with Small and Medium Electricity Grids"*, 11th International Conference of the Croatian Nuclear Society, June 05-08, 2016, Zadar, Croatia, pp. 040-1-040-10.
19. Janez Kokalj, Mitja Uršič, Matjaž Leskovar, "Modelling of debris bed collability in bottom reflooding conditions with MC3D code", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 808-1-808-11.
20. Rok Krpan, Boštjan Končar, "Development of turbulent mixing layer in horizontal confined two-component flow", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 512-1-512-10.
21. Matic Kunšek, Yasushi Saito, Daisuke Ito, "Experiments on bubbly to slug flow transition in a vertical cylindrical tube", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 513-1-513-9.
22. Giovanni Manzini, Ivo Kljenak, Mantas Povilaitis, "Vented explosion phenomena - hydrogen combustion benchmark on confined vessel experiments", In: *ICONE24*, The 24th International Conference on Nuclear Engineering, June 26-30, 2016, Charlotte, NC, USA, 6 pp.
23. Marko Matkovič, Leon Cizelj, Ivo Kljenak, Boštjan Končar, Matjaž Leskovar, Andrej Prošek, Iztok Tiselj, "Designing an advanced experimental test apparatus for conjugate heat transfer studies", In: *SWINTH-16*, Specialists Workshop on Advanced Instrumentation an d Measurement Techniques for Nuclear Reactor Thermal Hydraulics, June 15-17, 2016, Livorno, Italy, 9 pp.
24. Blaž Mikuž, Iztok Tiselj, "Modelling of turbulent flow in a fuel assembly of pressurized water reactor", In: *Extended abstracts: European Nuclear Conference, ENC 2016, 9-13 October 2016, Warsaw, Poland*, pp. 197-207.
25. Blaž Mikuž, Iztok Tiselj, "Wall-resolved large eddy simulation of secondary flow in grid-free fuel assembly", In: *CFD for Nuclear Reactor Safety Applications CFD4NRS-6 Workshop September 13-15, 2016, Cambridge Massachusetts, USA*, 13 pp.
26. Stéphane Mimouni, Dirk Lucas, Iztok Tiselj, "CFD calculations of multiphase flows with a multifield approach", In: *CFD for Nuclear Reactor Safety Applications CFD4NRS-6 Workshop September 13-15, 2016, Cambridge Massachusetts, USA*, 14 pp.
27. Jure Oder, Jernej Urankar, Iztok Tiselj, "Spectral element direct numerical simulation of sodium flow over a backward facing step", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 511-1-511-9.
28. Andrej Prošek, "Comparison between TRACE and RELAP5 calculation of SB LOCA in PWR", In: *Spring 2016 CAMP Meeting: April 26-29, 2018, Abu Dhabi, Združeni arabski emirati*, 20 pp.
29. Andrej Prošek, "LOCA spectrum calculations for PWR by RELAP5 and TRACE", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 082-1-082-10.
30. Andrej Prošek, "RELAP5/MOD3.3 analyses of core heatup prevention strategy during extended station blackout in PWR", In: *Conference proceedings and book of abstracts: former "Nuclear Option in Countries with Small and Medium Electricity Grids"*, 11th International Conference of the Croatian Nuclear Society, June 05-08, 2016, Zadar, Croatia, pp. 007-1-007-15.
31. Tomaž Skobe, Matjaž Leskovar, "Material influence on ex-vessel steam explosion", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 813-1-813-10.
32. Matej Tekavčič, Boštjan Končar, Ivo Kljenak, "Impact of gas velocity profile on simulated wave frequencies in vertical air-water churn flow",

In: *ICME 2016 proceedings*, 9th International Conference on Multiphase Flow, ICMF 2016, May 22-27, 2016, Firenze, Italy, 6 pp.
33. Matej Tekavčič, Boštjan Končar, Ivo Kljenak, "The influence of imposed gas velocity profile on wave dynamics in the simulation of vertical air-water churn flow", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 509-1-509-12.
34. Mitja Uršič, Matjaž Leskovar, Renaud Meignen, Stéphane Picchi, Julie-Anne Zambaux, "Fuel coolant interaction modelling in sodium cooled fast reactors", In: *Eurosafe forum: 7 & 8 November 2016, Munich, Germany*, 14 pp.
35. Ingrid Vavtar, Martin Draksler, Boštjan Končar, Oriol Costa Garrido, "The effect of multilayer insulation on thermal loading in DEMO systems", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 905-1-905-10.
36. Andrija Volkanovski, Antonio Ballesteros Avila, Miguel Peinador Veira, "Results of the loss of offsite power events analysis", In: *ICONE24*, The 24th International Conference on Nuclear Engineering, June 26-30, 2016, Charlotte, NC, USA, 7 pp.
37. Andrija Volkanovski, Antonio Ballesteros Avila, Miguel Peinador Veira, "Trend analysis of loss of offsite power events", In: *ICONE24*, The 24th International Conference on Nuclear Engineering, June 26-30, 2016, Charlotte, NC, USA, 6 pp.
38. Andrija Volkanovski, V. Matuzas, "A new method for evaluation of the qualitative importance measures", In: *Risk, reliability and safety: innovating theory and practice: 26th European Safety and Reliability Conference, ESREL 2016, September 25th-29th 2016, Glasgow, UK*, pp. 2650-2655.
39. Boštjan Zajec, Ivo Kljenak, "Simulation of natural circulation experiment in MISTRA experimental containment with OpenFOAM CFD code", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 807-1-807-10.

Scientific Monograph

1. Andrija Volkanovski, Antonio Ballesteros Avila, Miguel Peinador, *European clearinghouse on operating experience feedback for nuclear power plants: summary report on events related to loss of offsite power and station blackout at NPPs*, (JRC tehnical reports, 100227), Brussels, EU Commission, 2016.

Professional Monograph

1. Andrej Prošek, Andrija Volkanovski, *RELAP5 analysis of mitigation strategy for extended blackout power condition in PWR RELAP5 analysis of mitigation strategy for extended blackout power condition in PWR: prepared as part of The Agreement on Research Participation and Technical Exchange Under the Thermal -Hydraulic Code Applications and Maintenance Program (CAMP)*, (International agreement report, NUREG/IA-0467), Washington, U.S. Nuclear Regulatory Commission, 2016.

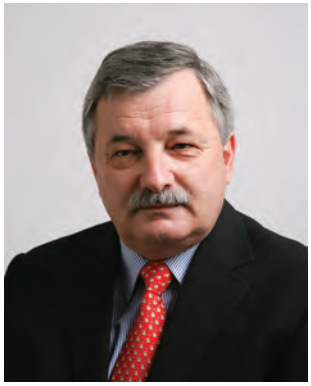
Mentoring

1. Oriol Costa *Garrido, Random thermal loads in the thermal fatigue assessment of nuclear piping:* doctoral dissertation, Ljubljana, 2016 (mentor Leon Cizelj; co-mentor Iztok Tiselj).
2. Blaž Mikuž, *Modelling of turbulent flow in a fuel assembly of pressurized water reactor:* doctoral dissertation, Ljubljana, 2016 (mentor Iztok Tiselj).
3. Tomaž Skobe, *Analysis of steam explosion in flooded reactor cavity:* master's thesis, Ljubljana, 2016 (mentor Matjaž Leskovar).
4. Luka Klobučar, *Simulation of thermal loading on divertor cassette in fusion reactor:* master's thesis, Ljubljana, 2016 (mentor Iztok Tiselj; co-mentor Boštjan Končar).
5. Janez Kokalj, *Modelling of debris bed reflooding in PEARL experimental facility:* master's thesis, Ljubljana, 2016 (mentor Iztok Tiselj; co-mentor Mitja Uršič).
6. Rok Krpan, *Simulation of a low-momentum steam jet interaction with a light gas layer in a containment facility:* master's thesis, Ljubljana, 2016 (mentor Ivo Kljenak).

REACTOR INFRASTRUCTURE CENTRE RIC

The Reactor Infrastructure Centre (RIC) incorporates a TRIGA Mark II research reactor and a Hot Cells Facility. The reactor, operating since 1966, is used for neutron research, training and for radioactive isotope production. A detailed technical description of the reactor is available at http://www.rcp.ijs.si/~ric/. The Hot Cells Facility is used for the treatment and handling of radioactive materials and radioactive waste within research and applicative projects. In addition, it is used for performing regular radiological measurements of radioactive waste and irradiated samples.

Besides operating and maintaining the reactor, the members of the reactor staff participate in other activities requiring specialists skilled in work with sources of radiation and in reactor technology, such as the servicing of industrial radioactive sources and surveillance of the fuel management in NPP Krško.



Head:
Prof. Borut Smodiš

The reactor operated in accordance with a programme approved by the Heads of the RIC and the Radiation Protection Unit – RPU (SVPIS in Slovene) for each week. In 2016 the reactor operated 134 days and produced 104.8 MWh of heat. Altogether, six pulses were carried out. A total of 758 samples were irradiated in the rotary specimen rack and 35 in the pneumatic transfer system.

The reactor operators supported researchers by performing the operations and services for which the researchers are not qualified and authorized, such as operating the reactor, performing irradiations and manipulating radioactive samples.

In 2016 the reactor was mainly used as a neutron source for neutron-activation analysis, irradiation of electronic components and education. For educational purposes, it was mostly used for the needs of the J. Stefan Institute's Nuclear Training Centre. For the irradiation of samples, it was mostly used by the Department of Environmental Sciences – O2 and Department of Experimental Particle Physics – F9. The Reactor Physics Department – F8 used the reactor for experiments in reactor physics, and Reactor Engineering Department – R4 used the reactor for thermal-hydraulic experiments.

The shutdown reactor, being a powerful source of gamma radiation, was repeatedly used for testing the resistance of electronic components to radiation.

In the Hot Cells Facility the activities were mostly performed by the Department of Environmental Sciences – O2, the Radiation Protection Unit and the Slovenian Agency for Radioactive waste Management (ARAO) – processing and preparation of radioactive waste for storage needs.

The reactor was used for the following research activities:

- Reactor physics and neutronics;
- Activation analysis;
- Research on the radiation damage of semiconductors;
- Neutron dosimetry and spectrometry;
- Activation of materials, nuclear waste and decommissioning;
- Radiation hardness studies;
- Irradiation of materials for fusion reactors;
- Irradiation of electronic and medical components;
- Development and testing of new detectors;
- Development of new methods for measuring power profiles, neutron spectra, etc.;
- Verification and validation of methods for calculating the transport of neutrons, photons and electrons;
- Development of educational tools in reactor physics.

A series of experiments involving the irradiation of various detectors were conducted in the framework of a collaboration between F8 and the French Alternative Energies and Atomic Energy Commission (CEA), Cadarache.

In the scope of the NATO SPS project E-SiCure (http://e-sicure.web.ua.pt/) aimed at engineering silicon carbide material for detectors of special nuclear material for border and port security, in which F8 is involved, the reactor was used to perform test irradiations of silicon carbide samples to study the neutron-induced defects in the material.

Within the F4E project "Gas Production Experiment and TBM Nuclear Instrumentation" the reactor was used to perform irradiations of TLDs and Al-Mn activation foils to determine the possibility of tritium production monitoring using the $^{55}Mn(n,\gamma)$ nuclear reaction.

In collaboration with R4 temperature measurements in the cooling channels of the reactor core were carried out.

In collaboration with F8 and F9, the reactor channel no. 6 was rearranged so as to allow for irradiating larger samples with neutrons.

Preparations for the Krško Nuclear Power Plant (NPP) reactor pre start-up tests were also conducted at the TRIGA reactor.

Since 2011, The TRIGA reactor participates in the FP7 AIDA (Advanced Infrastructures for Detectors and Accelerators) project that brings together advanced European infrastructures for future particle-physics experiments. In the framework of the international project *"Horizon 2020 - the AIDA-2020 GA No. 654168, Task 15.5 - Irradiation Facilities"* a contract was signed, together with F8, for the period from 1 May 2015 until 31 October 2016.

In the field of training, different lectures and practical exercises were conducted at the reactor. The participants were students from the following Slovenian universities: Faculty of Mathematics and Physics, Faculty of Electrical Engineering (University of Ljubljana) and Faculty of Energy Technology (University of Maribor). To carry out the exercises, the reactor was used for about three months, the average number of participants per experiment was 10. All the exercises were performed by our personnel in collaboration with F8.

The reactor will also be used for practical exercises within the training program of the NPP Krško reactor operators (practical training in the area of secure and efficient operation of nuclear reactors), lasting from 14 November 2016 to 11 April 2017, and attended by four participants.

In December, a course on the "Requirements and Safety Evaluation of Research Reactors" within the project Instrument for Nuclear Safety Cooperation (INSC) was organized together with the Nuclear Training Centre. The course was held from 5 to 9 December; it was attended by 12 trainees.

In 2016 the reactor celebrated the 50th anniversary of its safe operation. A ceremony was held on 31 May 2016, attended by about 120 invitees from various fields related to the nuclear field.

In the last week in May the reactor staff hosted a TV crew from the *Radio-Television Slovenia* that was following up on the reactor-related activities by filming a documentary about the reactor. The film was broadcasted on the Slovenian national television in November.

In 2016, there were more than 40 group visits to the reactor. The visitors were mainly foreign scientists, students and 33 groups of schoolchildren. Their total number was more than 1600. In March the *Jožef Stefan Institute´s Open Days* were organized, during which the reactor was visited by around 200 people.

Organization of conferences, congresses and meetings

1. Research reactor operating group meeting, 26th Annual Meeting, Ljubljana, 18–21 May 2016.

A ceremony for the 50th anniversary of the safe operation of the TRIGA Mark II research reactor

INTERNATIONAL PROJECTS

1. H2020 - AIDA-2020; Advanced European Infrastructures for Detectors at Accelerators
   Prof. Borut Smodiš
   European Commission
   Anže Jazbec, B. Sc.
   National Nuclear Research Center

R & D GRANTS AND CONTRACTS

1. Irradiation for FT-TIMS Method at the JSI TRIGA Mark II Reactor
   Asst. Prof. Luka Snoj
2. Irradiation and Analysis of Nano SiC Samples

NEW CONTRACT

3. Processing and preparation of radioactive waste for the purpose of storage
   Prof. Borut Smodiš
   ARAO

VISITORS FROM ABROAD

1. Ms. Zoya Trafimchik, Ms. Ylyana Kruk and Dr Natalia Lukashenka, Department of Nuclear Radiation Safety of the Ministry of Emergency Situations of the Republic of Belarus – Gosatomnadzor, Minsk, Republic of Belarus; and Mr. Virgil Aurelian Iliescu, National Commission for Nuclear Activities Control – CNCAN, Bucharest, Romania, 9 September 2016 (Belarus Scientific visit at Jožef Stefan Institute under IAEA technical cooperation programme).

STAFF

Researcher
1. **Prof. Borut Smodiš, Head**

Postgraduates
2. Anže Jazbec, B. Sc.

Technical officers
3. Dr. Tinkara Bučar

Technical and administrative staff
4. Andrej Gyergyek, B. Sc.
5. Darko Kavšek, B. Sc.
6. Marko Rosman
7. Sebastjan Rupnik, B. Sc.
8. Nina Udir, B. Sc.

BIBLIOGRAPHY

Original Article

1. Ilona Matveyeva, Radojko Jaćimović, Petra Planinšek, Borut Smodiš, Mukhambetkali Burkitbayev, "Uptake of uranium, thorium and radium isotopes by plants growing in dam impoundment Tasotkel and the Lower Shu region (Kazakhstan)", *Radiochim. Acta*, vol. 104, iss. 1, pp. 51-57, 2016.
2. Petra Planinšek, Borut Smodiš, Ljudmila Benedik, "Simultaneous determination and uptake assessment of selected radionuclides in plants grown in substrate contaminated with U-mill tailings", *J. radioanal. nucl. chem.*, vol. 309, no. 1, pp. 351-365, 2016.
3. Sebastjan Rupnik, Borut Smodiš, "Automation of a TRIGA-type pneumatic transfer system", *J. radioanal. nucl. chem.*, vol. 309, iss. 1, pp. 107-113, 2016.

Published Conference Contribution

1. Sebastjan Rupnik, "Posodobitev standardne pnevmatske pošte na reaktorju TRIGA", In: *Zbornik 3. konference mladih z Odseka za reaktorsko fiziko (F8) Instituta Jožef Stefan: povzetki prispevkov, predstavljenih na konferenci v Reaktorskem centru Podgorica, 29. februarja 2016*, pp. 23-25.
2. Luka Snoj, Igor Lengar, Anže Jazbec, Vladimir Radulović, Gašper Žerovnik, Aljaž Kolšek, Patrick Sauvan, Francisco Ogando, Javier Sanz, Andrej Trkov, "Feasibility study of installing a thermal to 14 MeV neutron converter into a reseach nuclear reactor", In: *Conference proceedings*, Berlin, 2016, 12 pp.
3. Marko Štrok, Borut Smodiš, Darja Mazej, "^{210}Bi - from interference to advantage in ^{210}Pb determination with liquid scintillation counter", In: *Proceedings of the 20th International Conference on Radionuclide Metrology and its Applications, 8-11 June 2015, Vienna, Austria*, (Applied radiation and isotopes, vol. 109, 2016), pp. 296-300.

Independent Component Part or a Chapter in a Monograph

1. Jernej Jerman, Andrej Lešnjak, Luka Snoj, Borut Smodiš, "Inspection of the TRIGA reactor tank", In: *History, development and future of TRIGA research reactors*, (Technical report series, no. 482), Vienna, IAEA = International Atomic Energy Agency, 2016, 10 pp.
2. Borut Smodiš, Luka Snoj, "The JSI TRIGA Mark II reactor, Slovenia", In: *History, development and future of TRIGA research reactors*, (Technical report series, no. 482), Vienna, IAEA = International Atomic Energy Agency, 2016, pp. 76-89.

Mentoring

1. Petra Planinšek, *Plant uptake of selected natural radionuclides from contaminated environment:* doctoral dissertation, Ljubljana, 2016 (mentor Borut Smodiš; co-mentor Ljudmila Benedik)..

NETWORKING INFRASTRUCTURE CENTRE NIC

The Networking Infrastructure Centre (NIC) is responsible for the administration, development, management and expansion of the core network, ICT services and infrastructure for the Jožef Stefan Institute. It also supports the development of the computational, communication, data and security infrastructure for our research departments, centres and services.

Head:
Vladimir Alkalaj, M. Sc.*

The NIC's main mission is to maintain the computing networks, services and hardware necessary to support the operation of research departments, programmes, groups and projects at the Jožef Stefan Institute. We provide a high level of connectivity to and integration with local and international communication networks and infrastructures, but we also deliver ICT support for research activities at the Jožef Stefan Institute, including the development, management and administration of the ICT infrastructure, computing facilities and services at the institute. We work in four main domains: networking infrastructure, network security, network services and distributed network computing.

Networking Infrastructure. The Networking Infrastructure Centre is responsible for the development, management, administration and support of the physical networking infrastructure for the Institute. It delivers support for local networks so as to ensure local and internet connectivity for users and services at the Institute. This task includes the management of wireless networks at the Institute locations and also a number of dedicated networks for specific services, projects and activities (i.e., dedicated links to other institutions, secure links to the Reactor Infrastructure Centre Podgorica, etc.).

A modern up-to-date 10 Gbit/s network backbone, the IPv6 protocol and dedicated external links are the basis of a flexible modern network at the Jožef Stefan Institute that has to support high availability and advanced services with many fixed and wireless clients.

Physical Network: In 2016 we continued our on-going extension and optimisation of the physical network, cabling installations, active equipment and wireless access points installations and equipment upgrades (specifically core backbone network routers). We expanded the network and its support for virtual network links used for a number of internal networks, (super) computing clusters and virtual machine farms. We continued our work on expanded IPv6 protocol stack feature support and optimizations to the Institute backbone network.

The load on our additional 10 Gbit/s connection to the dedicated LHCONE network (LHC Open Network Environment) used for high network throughput for the ATLAS project inside the WLCG (Worldwide Large Hadron Collider Computing Grid) has steadily increased, prompting us to upgrade the capacity of the connection to 2 × 10 Gbit/s between the Institute and ARNES, and 3 × 10 Gbit/s between ARNES and LHCONE over the GÉANT network.

In the scope of the IR Optika at Arnes, we have been able to provide optical connectivity to the Hard Coatings Center in Domžale and to completely integrate their network with the Institute's network.

Monitoring: New components and services have been continuously integrated with existing traffic, event and status-monitoring infrastructure, implemented on the basis of software packages Nagios, Ganglia, Cacati, Observium and a customised dynamic analytical visualisation package built with Kibana and ElasticSearch as a backend. In combination with internally developed solutions and our internally developed system for environmental monitoring the monitoring system enables us to react to usage fluctuations and unexpected events in the domain of web services, security policies, firewalls, authentication and authorization, network time systems e-mail delivery, analysis, processing and security systems, physical machine sensory status, environmental data, power line data, etc.

Figure 1: Gradually increasing network traffic over the LHCONE link during 2016 (from Observium monitoring).

Wireless network: We strive to improve the coverage and density of our wireless networks by adding a number of smaller wireless access points. This allows us to alleviate the effect of increasing numbers of users and devices and their more frequent and more critical usage patterns.

IPv6 support: Support for the IPv6 protocol stack across all the network segments is crucial in our long-term strategy for alleviating the load on the already mostly spent IPv4 address pool. Continuous upgrading and improvements in the network router protocol stack provides flexible support for new protocols, where IPv6 support and expanded use is our core strategy.

**Photo by Sašo Radelj*

Network Security. The NIC is responsible for implementing security measures and policies in three domains: external network connectivity security, security of the network itself and security of the services and software deployments. External network security is implemented with dynamic management and configuration of active deep packet inspection firewall systems and routing configurations, with the exception of dedicated links where passive measures (configuration, filtering and supervision) are used. Constant dynamic supervision, traffic monitoring and event analysis is needed to ensure suitable security in the complex constraints and requirements of an open academic network that collide with current security considerations due to the increased detection of threats from the outside network. Therefore, ensuring the secure and open environment requires disproportionate increases in equipment capabilities and efforts in the dynamic security policy configuration, event monitoring and analytics.

Internal development of e-mail security and dynamic network firewalling, virtual networks, and advanced analysis and monitoring ensure the security of an open academic network in the age of a hostile Internet.

Since the NIC is responsible for the security of the ICT infrastructure of the institute, we are active members of relevant institutions and groups, notably the national security response centre SICERT, FIRST (Forum of Incident Response and Security Teams) and EGI CSIRT (European Grid Initiative distributed computing security incident response team). We also take part in the response team of the national distributed computing network SLING (Slovenian Initiative for National grid). The national science certificate agency SiGNET CA (Slovenian Grid Network Certification Authority), managed by the NIC, is a full member of the EU Grid PMA (EU Grid Policy Management Authority) and IGTF (Interoperable Global Trust Federation). We participate in the work of Slovenian network technology and security association SINOG (Slovenian Network Operators Group) and supported the organization by hosting two of the technical workshops at the Institute this year.

E-Mail: In the area of e-mail security and protection against undesired or malignant messages we have continued with our in-house software development, notably of the SpamAssassin package, and with continuous improvements in the support for international character sets in domain-name handling and e-mail message protocol stacks.

Cryptography and certification: We have continued with the gradual integration of DNSSEC-signed internet domain names using automated mechanisms for the verification of the signatures and with gradual introduction of the DANE system (integration of TLS certificates with the DNS system) in e-mail transfers and publishing SSHFP records via DNS servers. The number of issued digital certificates based on the SiGNET CA scientific certificate PKI system has increased, but also many free DigiCert server certificates, courtesy of Arnes support, have been issued for services that are offered to the general public, since DigiCert certificates are recognised by the major operating systems and browsers. The number or users of our VPN infrastructure has been steadily increasing, in particular also for connections to the user network at the Reactor Infrastructure Centre Podgorica. The system is not used only by researches at foreign conferences and exchanges who have to deal with foreign networks that block certain types of connections, but is also more frequently used by users who are working from their homes and users that need it for access to on-line resources, such as scientific publication repositories. To alleviate the need of VPN for this common use case, we have worked with the Science Information Centre in an on-going effort to ensure accessibility of scientific publications using the eduGAIN single-sign-on federation credentials.

Figure 2: New server racks in the Jožef Stefan Institute Computing Centre at Teslova

ICT services. The NIC provisions, develops and maintains a number of core and some secondary ICT services. The most important among these are e-mail (e-mail routing and delivery, in-box management, directory management, webmail services, etc.) and world wide web support (main Institute web server, web hosting for users, departments and projects, a web directory). Secondary ICT services are provided for the support of certain core or specific activities at the Institute, such as web presentations, a conference system, supervision and monitoring, etc. In some of these services the NIC is directly invested in the software or infrastructure development, such as the network time services and e-mail filtering and security, while others are simply administered and maintained. The third NIC service category is comprised of services supporting our users (calendaring, event management, directories) and software/system developers (code repositories, integration and verification, licence management, mobile platform software development, integration and shipping for Apple Appstore, Google Play and Microsoft Store). The software development repository has stood out by attracting a large number or new users in the last year. In addition, we provide physical server hosting and management, aimed primarily at larger projects and systems, the administration of directories for personal computing and user

management (such as departmental single sign-on or directory services) and the administration of mission-critical workstations and components.

In 2015 we have established a new dedicated computing centre in the Technology Park building at Teslova. We have moved the majority of computationally-intensive infrastructure from our data centre at NIC during 2015 and 2016 this new data centre along with the installation of the new common supercomputing cluster, to better use the modern cooling, electrical and security systems and ample room for future growth. The NIC computing centre, on the other hand, has since been able to provide cooling, network facilities and high-performance uninterrupted power supply not only for critical services, but also for less computationally-intensive servers from several departments. We have also expanded our web-hosting activity (over 75 distinct virtual servers) and started deploying a test bed for virtualised hosting. The increased load on our personnel due to demands for hosting and services is forcing us to continue our automated provisioning efforts, which are planned to culminate in fully automated virtual and physical services on demand.

We have continued the updating of our user-facing documentation and our user interfaces. A Single-Sign-On (SSO) service, integrated with the national AAI federation at Arnes and European eduGAIN federation is gaining popularity since it gives our users easier access to numerous national and international services using their institute credentials. At the same time, the new feature is meant to simplify user and authentication management to software developers who work on internal projects and services.

The constant growth of network services and network computing provides better support for collaboration and teamwork, software development, data protection and access to large computing and data resources for scientific research. A new common facility is an important step further for collaboration in the field of high-performance and network computing at JSI fostering interdepartmental collaboration.

Network computing. In the field of network computing technology and infrastructure, including high-throughput computing, high-performance computing, network supercomputing, grids and HPC clouds (ICT as a service), the NIC is collaborating with individual computing clusters at the institute and contributing directly to the Slovenian National Grid Initiative SLING as a founding member and core partner. The NIC maintains the Slovenian certification agency SLING CA for science, research and grid computing, takes part in the maintenance and support of the core national supercomputing grid network services and coordinates work with international infrastructure projects and collaborations.

In 2016, New System Cluster (NSC), the common computing cluster in the new facilities of the Jožef Stefan Institute's Computing Centre Teslova, has seen a very noticeable increase in usage and the number of users. The new cluster with 1984 64-bit computing cores, 16 GPGPU accelerators (NVidia Kepler 40), almost 9 TB RAM and 90 TB disk storage is far from the biggest cluster at the Institute, but it is an important step in the evolving traditions of supercomputing at the Jožef Stefan Institute, since it is available to all the researchers at the Institute and is thus providing and important modern computing platform to all of our departments. As a common infrastructure, it is instrumental in forwarding collaboration among departments with their own computing facilities and among researchers and groups with similar software requirements or computational problems that can be solved in an environment that can support supercomputing and high-throughput computing. In the context of this work, we have continued with support for users of JSI clusters and with work on the integration of the clusters with the national network SLING using the NorduGrid ARC Grid Middleware to enable users to use all the resources in the network with the same interfaces and in the same way.

Figure 3: Water-temperature gauges on the cooling-system pipes in the Jožef Stefan Institute Computing Centre at Teslova

In the domain of network computing we have been most involved with Slovenian National Grid Initiative (SLING), but we also worked with in the European Grid Initiative EGI (with development of the EGI Federated Cloud pilot – federated infrastructure as a service), the NorduGrid ARC collaboration and a number of international projects (ATLAS – dedicated link, Belle2 – computing grid network support planning, CLARIN – support for different services of Slovenian national node, ELIXIR – collaboration with the national node and the European collaboration). SLING has supported a number or research projects and applications in 2016, among others in high-energy physics, medical sensor and image analysis, theoretical physics, astrophysics, biochemistry, protein folding simulations, crystal analysis, knowledge technologies, statistical analysis and fluid dynamics, computational linguistics etc. In a number of cases we have been involved as part of the SLING support group in the parallelization and preparation of computing tasks and administration of required run-time environments.

STAFF

Technical officers
1. **Vladimir Alkalaj, M. Sc., Head**
2. Dr. Jan Jona Javoršek
3. Barbara Krašovec, M. Sc.
4. Mark Martinec, B. Sc.

Technical and administrative staff
5. Ivan Ivanjko
6. Janez Jezeršek
7. Matjaž Levstek
8. Janez Srakar
9. Matej Wedam

BIBLIOGRAPHY

PROFESSIONAL MONOGRAPH

1. Borut Bohanec, Mišo Alkalaj, *Kaj je res o GSO*, 2. dopolnjena izd., Ljubljana, Orbis, 2016.
2. Borut Bohanec, Mišo Alkalaj, *Yes to GMOs!: for us and the environment*, Ljubljana, Geanetic, 2016.

SCIENCE INFORMATION CENTRE SIC

The Jožef Stefan Institute Science Information Centre is the central Slovenian physics research library and the largest research library in Slovenia. Our main tasks are the acquisition, archiving, and loan of books and periodicals, and the input, update and control of bibliographic data of the Institute's staff, as requested by the funding ministry.

Head:
Dr. Luka Šušteršič

Our collection of over 100,000 publications covers the fields of physics, chemistry, biochemistry, electronics, information science, artificial intelligence, nuclear technology, energy management and environmental science. We provide access to over 4000 electronic journals. We are a founding member of the ScienceDirect, SpringerLink, Wiley online library, IEEExplore and ACS consortia. We subscribe to the SCOPUS, INSPEC and Web of Science databases, and to the SciVal research evaluation and management tool.

We manage bibliographic data for approximately 700 researchers. Our bibliographic database, which is a part of the COBISS system, contains about 80,000 records, going back to the Institute's inception in 1949. Last year's data is included as part of this report.

STAFF

Technical officers
1. **Dr. Luka Šušteršič, Head**
2. Marjan Verč, M. Sc.

Technical and administrative staff
3. Suzi Korošec, B. Sc.
4. Jasna Malalan
5. Katarina Modic, B. Sc.
6. Alenka Ana Stante, B. Sc.
7. Jože Škulj
8. Branka Štrancar
9. Ana Tratnik
10. Nada Tratnik
11. Saša Žnidar, B. Sc.

ENERGY EFFICIENCY CENTRE

EEC

The basic activities of the Energy Efficiency Centre are in efficient energy use, long-term planning in energy and the reduction of greenhouse-gases emissions. The centre is a focal point for the collection and transfer of energy-efficiency technologies to energy users, the state, energy service and equipment providers, and other interested agencies. At the same time, it covers the environmental effects of energy use and conversion. The most significant part of the EEC's activities is thus cooperation with state institutions in the preparation of strategic documents and legislation in the field of efficient energy use, energy planning, distributed electricity production, and emissions trading. Nevertheless, it still remains strongly connected, by its consulting and training role in energy, with industrial companies and other institutions as well as also being more and more involved in European research projects.

Head:
Stane Merše, M. Sc.

Energy and the environment

In 2016 the Energy Efficiency Centre with its professional work ensured high-quality support to ministries in the preparation of the strategic development documents and transfer of EU legislation in the field of energy planning, energy efficiency, use of renewables and greenhouse-gases emissions and the reduction of other pollutants.

Research and development work of the Energy Efficiency Centre is an important contribution to the preparation of key documents in Slovenia in the field of energy development, energy efficiency, renewables exploitation and the transition of Slovenia to a low-carbon society. With training activities and support to industry it significantly contributes to an increase in competitiveness and development restructuring.

Slovenia has ambitious goals in the framework of climate energy policy regarding an increase of energy efficiency, the exploitation of renewable energy sources (RES) and a reduction of greenhouse-gases emissions. Energy efficiency is a priority field to achieve these goals, in accordance with the demands of the European Commission and the directive on energy efficiency (2012/27/EU). In accordance with this directive a report on carrying out the Action plan for energy efficiency for the period 2014–2020 was elaborated. The EEC also cooperated in the updating of the Action plan for renewable sources for the period 2010–2020 and inclusion in the procedure for the integrated assessment of impacts on the environment. The EEC was also included in the updating of the national long-term strategy for the promotion of investments in the energy renovation of buildings.

The EEC cooperates with the Statistical Office of the Republic of Slovenia, where it prepares a model calculation for fuels and energy use in households for the national energy statistics.

Also in 2016, the centre continued with activities of the state referential centre for energy with the preparation of an expanded set of indicators for energy and the environment.

In the field of greenhouse-gases emissions reduction, the activities of the Centre for the Ministry of Environment and Space focused on the preparation of the Second annual report on carrying out the Operative programme of measures for the reduction of GHG emissions for the period 2013–2020, updating of GHG emissions projections by 2035 and the preparation of analytical bases for international reporting in the framework of the MMR mechanism. A professional support for the design of goals and national policy concerning pollutants from the NEC directive up to 2030 continued and a detailed study of transit road and impacts on motor fuel sales in Slovenia was elaborated (Figure 1).

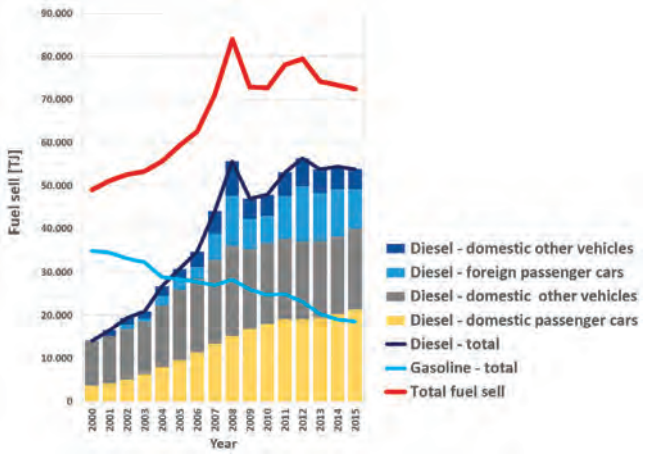


Figure 1: Trends of fuel sales in road transport in Slovenia – increase of diesel fuel use for personal vehicles and transit transport.

Promotion of efficient energy use and energy consulting

The Energy Efficiency Centre in 2016 continued with its training activities where the ninth cycle of energy managers training was successfully concluded within the European programme EUREM. Due to a very positive reaction of participants and their interest (in Slovenia there is already more than 190 energy managers with the

Figure 2: Four European award EUREM winners in 2016: Goran Matešić (Luka Koper), Drago Zupanc (Maksim), Kristjan Plesnik (Metal Ravne) and Jani Uranič (Xella porobeton) and their mentors at the Annual conference of European energy managers in Berlin

EUREM licence), it is clear that there is a great need for such training. High-quality knowledge in this field is of key importance for the execution of efficient solutions in practice.

This year an intensive development of the GIS tool for the spacial analysis of heat consumption in buildings ("heatmap") has been going on. With the elaboration of spacial analysis of heat use and production concept for the preparation of the local energy concept it has been tested as a pilot project in the Municipality of Maribor (Figure 3).

In 2016 the Energy Efficiency Centre carried out several consulting tasks in industry and the public sector, where with the study of optimization of energy system started the cooperation with the company KOTO. The professional cooperation with Luka Koper, Energetika Ljubljana, BTC, etc. continued. For the company Petrol Energetika Ravne an elaboration of a study for the introduction of advanced energy services for industry and the local community, which are based on smart energy networks, started.

The centre continued professional cooperation with the company Petrol d.d. in carrying out the largest programme of large consumers to ensure energy savings for end users. The centre prepared the programme for the eighteenth conference "Energy Managers Days", the annual meeting of energy managers with more than 200 participants confirms the quality and public profile of the EEC professional work.

International cooperation

In 2016 the EEC carried out as many as 7 international projects, financed from the European Union resources in the framework of HORIZON 2020 and programme Intelligent Energy for Europe.

Projects cover activities in the fields of:

- compiling and elaboration of current data on renewable energy sources use (EurObserv` ER Barometer),
- carrying out the EU directive on energy efficiency (CA – EED),
- carrying out the EU directive on renewable energy sources (CA – RES),
- monitoring of indicators for energy use and energy efficiency in the EU (ODYSSEE MURE 2012).
- Energy contracting Plus (EPC Plus)
- Promotion of the introduction of energy contracting in the public and private sectors in the EU (guarantEE),
- Tool for the evaluation of the suitability of integrated energy retrofit (ENERFUND).

Projects include cooperations with research and development organisations from Europe with a strong emphasis on concrete applications and the promotion of energy efficiency. In the framework of each project the EEC staff took part in numerous foreign professional meetings and visits.

Some outstanding achievements in the past year

1. Preparation of several key support documents for the government of the Republic of Slovenia in the field of energy policy (Green paper and strategic studies for the National Energy Programme), energy efficiency (First and Second National Action Plan for Energy Efficiency), renewable energy sources (Action Plan for Renewable energy sources for the period 2010–2020) and climate policy (Operative programme of GHG emissions reduction up to 2020).
2. Establishment of energy managers training in the framework of the European project EUREM and professional support to industry and other institutions by carrying out energy audits, feasibility studies and other consulting (Goodyear, TE-TOL, Luka Koper, Salonit Anhovo, Telekom Slovenije, Letrika–Mahle, BTC, KOTO, etc.).
3. In the framework of the European project Transparense the EEC led, very successfully, the preparation of the European code of Conduct for energy contracting. The Code identifies the basic values and principles, which are of key importance for the successful preparation and carrying out of projects with third-party financing. The Code was very successfully accepted at the European level and currently already has 171 signatories, among them also the European association of companies for energy services (eu.ESCO) and the European federation for intelligent services of energy efficiency (EFIEES), supported also by the European Commission. In Slovenia the code was already tested in practice in a project of integrated energy renovation of the municipal building of the municipality Brda.

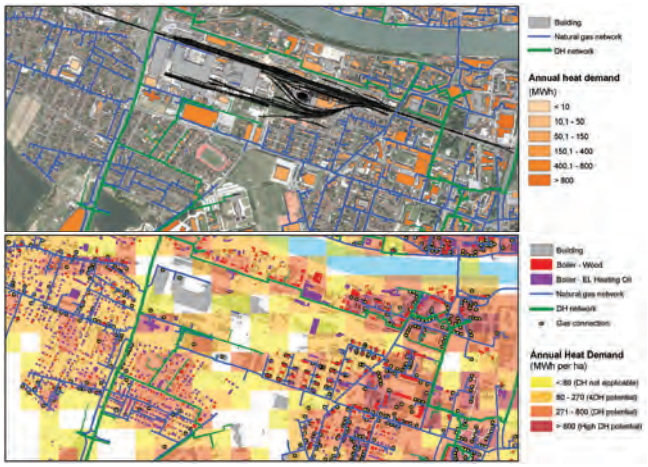


Figure 3: Spacial analysis of heat use in the area of Maribor: annual heat use in buildings, space density of heat use, types of heating appliances and energy infrastructure (distribution network of district heating and natural gas).

Awards and appointments

1. Award TARAS – for successfully carrying out the project for the useful exploitation of waste heat in the steel industry in a district heat system in Ravne na Koroškem, which is a recognition for the most successful cooperation of economic and scientific research work

Organization of conferences, congresses and meetings

1. Energy Managers Days 2016 – 18th meeting of Slovenian energy managers, Portorož, 19. – 20. 4. 2016
2. Partnerships of small and medium enterprises (SMEs) for standardized energy contracting, Ljubljana, 14.10.2016
3. European energy managers, Ljubljana, 13.-15.1.16, 2.-4.3.16, 16.-18.3.16, 12.-15.4.16

Figure 4: EEC and companies Petrol Energetika and Metal Ravne were awarded a prize TARAS for successfully carrying out a project for the useful exploitation of waste heat from the steel industry in the system of district heating in Ravne na Koroškem, which is a recognition for the most successful cooperation of economy and scientific research work in the field of innovations, development and technologies.

INTERNATIONAL PROJECTS

1. IEE; EurObservER, The EurObserv'ER Barometer (2013-2016)
   Matjaž Česen, B. Sc.
   European Commission
2. H2020 - EPC_PLUS; Energy Performance Contracting Plus
   Damir Staničić, M. Sc.
   European Commission
3. H2020 - ENERFUND; An ENErgy Retroit FUNding rating tool
   Peter Bevk, B. Sc.
   European Commission
4. H2020 - ODYSSEE-MURE; ODYSSEE-MURE, A Decision Support Tool for Energy Efficiency Policy Evaluation
   Dr. Fouad Al-Mansour
   European Commission
5. H2020 - guarantEE; Energy Efficiency with Performance Guarantees in Private and Public Sector
   Damir Staničić, M. Sc.
   European Commission

RESEARCH PROGRAM

1. Modelling and environmental impact assessment of processes and energy technologies
   Dr. Fouad Al-Mansour

NEW CONTRACTS

1. A supermonitoring of the guarantee measurements of the Flue Gas Desulphurization Plant of unit 6 of the Šoštanj Thermal Power Plant
   Boris Sučić, M. Sc.
   Teš d. o. o.
2. Elaboration of a study of energy system optimization
   Stane Merše, M. Sc.
   Koto d. o. o.
3. Concerted action in the field of the Directive on end energy efficiency (CA ESD II)
   Damir Staničić, M. Sc.
   Ministry for Infrastructure and Spatial Planning
4. Allocation of financial means and cooperation in the European project Concerted action in the field of the RES II directive
   Damir Staničić, M. Sc.
   Ministry for Infrastructure and Spatial Planning
5. Action plan for energy efficiency and reporting on its carrying out
   Damir Staničić, M. Sc.
   Ministry for Infrastructure and Spatial Planning
6. Framework agreement on the professional advising in the field of cogeneration
   Stane Merše, M. Sc.
   Energetika Ljubljana, d. o. o.
7. Updating, Upgrading and Publishing on the Web of Energy and Environment Indicators 2015 and preparation of a framework proposal for the publication Environment and energy in Slovenia
   Matjaž Česen, B. Sc.
   Ministry for Environment and Spatial Planning
8. Strategic Studies for the Revision of the NEC Directive, Questionnaires CLRTAP and Improvement of Emission Inventory
   Matjaž Česen, B. Sc.
   Ministry for Environment and Spatial Planning
9. Inclusion in the procedure of integrated assessment of impacts on the environment for an updated Action plan for RES for the period 2010 – 2020
   Andreja Urbančič, M. Sc.
   Ministry for Infrastructure
10. Preparation of the second two-year report of developped countries for carrying out of the Kyoto Protocol in accordance with relevant conclusions of the Conference of the Parties of the UN Framework Convention on Climate Change
    Andreja Urbančič, M. Sc.
    Ministry for Environment and Spatial Planning
11. Preparation of the tender ELENA for acquiring grants for carrying out Preparation and financing of investments in sustainable energy in littoral municipalities
    Damir Staničić, M. Sc.
    Golea, Nova Gorica
12. Strategic studies for elaboration of a report on measures for the reduction of greenhouse gases emissions and projections of GHG emissions, Second annual report on carrying out of the Operative programme of emissions reduction measures
    Andreja Urbančič, M. Sc.
    Ministry for Environment and Spatial Planning
13. European energy manager IX
    Stane Merše, M. Sc.
14. Energy managers days
    Časnik Finance
    Stane Merše, M. Sc.
15. Refreshment, Upgrading and Publishing on the Web of Energy and Environment Indicators 2015
    ARSO
    Matjaž Česen
16. Energy Consumption of Slovenian Households Based on Model Calculation for 2015
    SURS
    Matjaž Česen
17. Improvement of model data on energy use in transport and impact of transit transport
    MOP
    Matjaž Česen
18. Preparation of strategic studies for elaboration of strategic documents, action plans and measures from the field of energy
    MzI
    Stane Merše, M. Sc.
19. Elaboration of the concept of space analysis of heat consumption and production for carrying out of the local energy concept of the Municipality of Maribor
    JP Energetika Maribor d.o.o.
    Damir Staničić
20. Study of the natural gas consumption in the Coastal-Karst region
    Plinovodi d.o.o.
    Stane Merše, M. Sc.
21. Elaboration of a concept of introduction of advanced energy services and solutions for industry and local communities based on smart energy grids
    Petrol Energetika Ravne
    Aleš Podgornik, M. Sc.
22. Refreshment, of indicators from the field of Environment and Energy for the needs of the report on Environment for 2017
    MOP
    Matjaž Česen

STAFF

Researchers
1. Dr. Fouad Al-Mansour
2. **Stane Merše, M. Sc., Head**
3. Damir Staničić, M. Sc.
4. Andreja Urbančič, M. Sc.

Technical officers
5. Matjaž Česen, B. Sc.
6. Jure Čižman, M. Sc.
7. Polona Lah, B. Sc.
8. Marko Pečkaj, B. Sc.
9. Barbara Petelin Visočnik, M. Sc.
10. Aleš Podgornik, M. Sc.
11. Dr. Matevž Pušnik
12. Boris Sučić, M. Sc.

Technical and administrative staff
13. Peter Bevk, B. Sc.
14. Marko Đorić, B. Sc.
15. Roza Pergarec, B. Sc.
16. Igor Ribič

BIBLIOGRAPHY

Original Article

1. Matevž Pušnik, Fouad Al-Mansour, Boris Sučić, Andrej Gubina, "Gap analysis of industrial energy management systems in Slovenia", *Energy (Oxford)*, vol. 108, pp. 41-49, 2016.
2. Boris Sučić, Fouad Al-Mansour, Matevž Pušnik, Tomaž Vuk, "Context sensitive production planning and energy management approach in energy intensive industries", *Energy (Oxford)*, vol. 108, pp. 63-73, 2016.

Published Conference Contribution

1. Viktor Jejčič, Fouad Al-Mansour, Tomaž Poje, "Ogljični odtis sadjarske pridelave", In: *Actual tasks on agricultural engineering: Proceedings of the 44th International symposium on agricultural engineering, Opatija, Croatia, 23rd-26th february 2016*, pp. 447-457.
2. Aleš Podgornik, Boris Sučić, Boštjan Blažič, "Effects of customized consumption feedback on energy efficient behaviour in low-income households", In: *SDEWES 2014*, 9th Conference on Sustainable Development of Energy, Water and Environment Systems, Istambul-Venice, September 20-27, 2014, *J. Clean. Prod.*, vol. 130, pp. 25-34, 2016.

Mentoring

1. Matevž Pušnik, *Contextual model of energy use in industry:* doctoral dissertation, Ljubljana, 2016 (mentor Andrej Gubina).
2. Kristijan Lesan, *Recommissioning for more efficient use of energy in non-residential buildings:* master's thesis, Krško, 2016 (mentor Zdravko Praunseis; co-mentor Boris Sučić).

CENTRE FOR ELECTRON MICROSCOPY AND MICROANALYSIS CEMM

Head:
Prof. Miran Čeh

The Centre for Electron Microscopy and Microanalysis (CEMM) is an instrumental centre at the JSI that combines analytical equipment in the field of electron microscopy and microanalysis. Access to the research equipment of the CEMM is provided to other JSI departments as well as other research institutions, universities and industrial partners. The equipment at the CEMM is used by researchers interested in the morphology and the structural and chemical characterization of materials between the micrometre and atomic levels. At the CEMM there are three scanning electron microscopes (JSM-5800, JXA-840A, JSM-7600F), two transmission electron microscopes (JEM-2100 (CO NIN), JEM-2010F) and the equipment for sample preparation. CO NAMASTE contributed to the equipment for electron microscopy with a CCD camera and an ADF detector for the JEM-2010F microscope and an EBSD system for the JSM-7600F. In 2015, the JSI also contributed a GIF spectrometer for the transmission electron microscopy ARM 200CF installed at the KI, and thus became a 20% owner of the entire microscope.

Research, involving staff and equipment at CEMM, is diverse regarding the investigated materials and also the used methods. Scanning electron microscopy (SEM) is used to observe the morphology and structure of surfaces and for a microstructural investigation and determination of the chemical composition of polycrystalline oxide and non-oxide ceramic materials, nanostructures, metallic magnetic materials, metals, alloys, glass, etc. All of the scanning electron microscopes in the CEMM are equipped with an energy-dispersion (EDXS) and/or the wavelength dispersion (WDXS) spectrometers of X-rays, allowing a non-destructive determination of the chemical composition of the investigated materials. The scanning electron microscope JSM-7600F is additionally equipped with an electron back-scattered diffraction (EBSD) detector and an electron lithography system.

Transmission electron microscopy (TEM) provides an insight into the structure of the material on the nano-scale. Transmission electron microscopy enables structural and chemical analyses of the grain boundaries, planar defects, dislocations and precipitates. The transmission electron microscope JEM-2100 is equipped with an EDXS spectrometer and a CCD camera, and the JEM-2010F is additionally equipped with a STEM unit, EDXS and EELS spectrometers, and a CCD camera. The CEMM also manages the necessary equipment for the SEM and TEM sample preparation.

The operation of the centre is managed by properly trained employees. Besides maintenance of the equipment, among other CEMM activities are the training of new operators, the organization of workshops and conferences on the topic of electron microscopy, providing services for industrial partners and the introduction of new analytical techniques. CEMM personnel are also responsible for the demonstration of electron microscopy to the general public in the scope of organized visits to the IJS, as well through publications in traditional and digital media. In cooperation with the project "Science on the Street" we successfully completed a "best idea in electron microscopy competition" for the general public. For users of microscopes the CEMM organized the 3rd and 4th workshops (SEM graphical user interface on a JSM-7600F and Microanalysis-EDS). The aim of the workshops was to present the operation of the equipment and microanalysis techniques, especially EDS.

In 2016 the CEMM collaborated with institutions and researchers from the following countries: Croatia, Serbia, Austria, Greece, Portugal, Finland and Iran.

Some outstanding publications in the past year

1. Journal of materials chemistry. C (Montazer, Amir Hassan, Ramazani, Abdolali, Almasi Kashi, Mohammad, Zavašnik, Janez. Angular-dependent magnetism in Co(001) single-crystal nanowires : capturing the vortex nucleation fields)
2. Sensors and actuators. B, Chemical, (Stanković, Dalibor M., Mehmeti, Eda, Zavašnik, Janez, Kalcher, Kurt. Determination of nitrite in tap water : a comparative study between cerium, titanium and selenium dioxide doped reduced graphene oxide modified glassy carbon electrodes)
3. Journal of physics (Montazer, Amir Hassan, Ramazani, Abdolali, Almasi Kashi, Mohammad, Zavašnik, Janez. Developing high coercivity in large diameter cobalt nanowire arrays.)

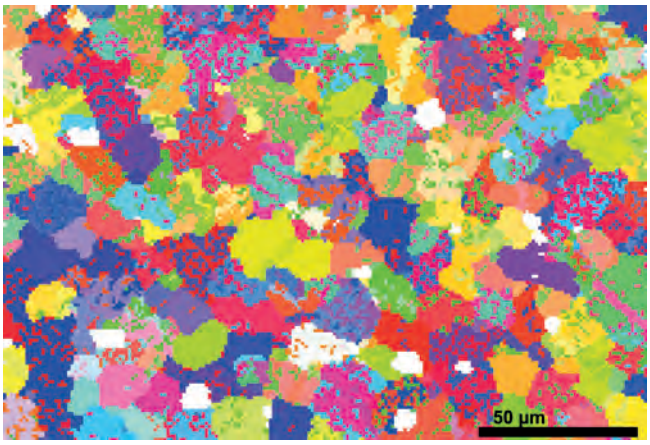


Figure 1: EBSD image of grains in a $BiFeO_3$ thick film (published in: ACS Appl. Mater. Interfaces 2016, 8, 19626–19634, "Self-Poling of $BiFeO_3$ Thick Films", DOI: 10.1021/acsami.6b05885) (Evgeniya Khomyakova, K5, Jeol JSM-7600F)

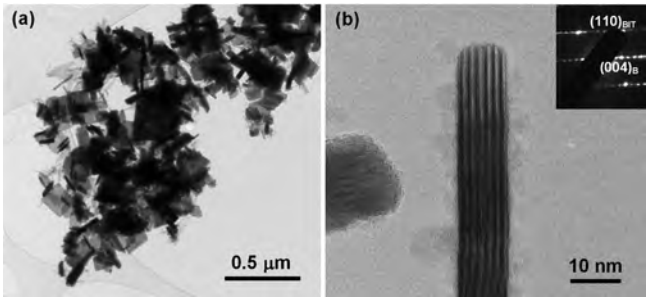


Figure 2: Transmission electron microscopy (TEM) image (a) shows ferroelectric bismuth titanate (BIT) platelets. A high-resolution image with the corresponding electron-diffraction pattern (b) shows a coating of amorphous iron-oxihydroxide nanoparticles deposited at the BIT platelet (author: Blaž Belec).

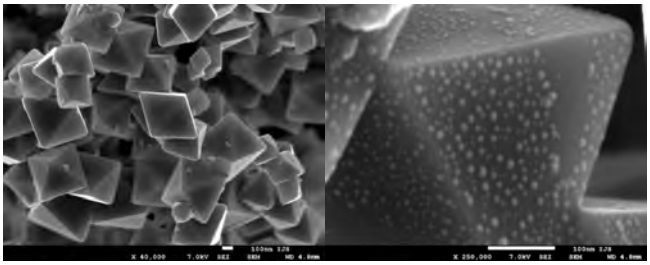


Figure 3: FESEM images of In_2O_3 octahedrons decorated with Pt nanoparticles; at lower (left) and higher (right) magnification. Material was synthesized by the AACVD (ang. aerosol assisted chemical vapour deposition) technique. Results were published in S. Roso, C. Bittencourt, P. Umek, O. González, Frank Güell, A. Urakawa and E. Llobet, Journal of Materials Chemistry C (2016), 4, 9418–9425.

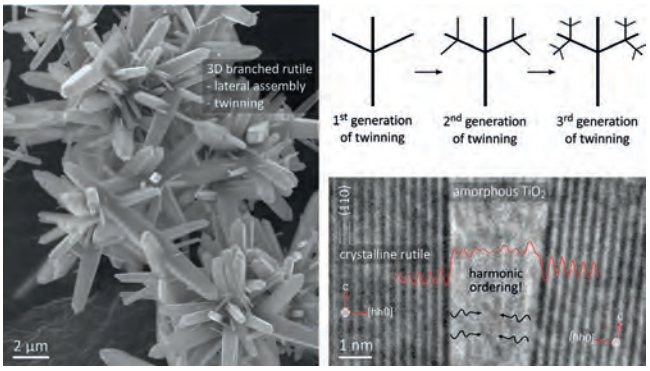


Figure 4: Multilevel branched TiO_2 structures were shown to be a result of mesocrystal assembly of precipitated rutile fibers that are attached exclusively by low-energy {110} and {101} planes. Harmonic ordering of amorphous material encaptured in intercrystal pores indicates the presence of force-fields that are responsible for oriented attachment of crystals. Scientific Reports, DOI: 10.1038/srep24216 (Vanja Jordan, K7, Jeol JSM-7600F & JSM-2100).

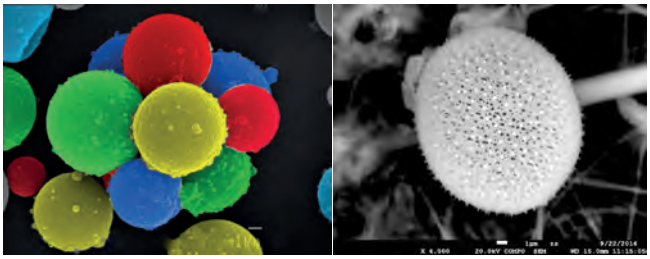


Figure 5: Microcapsule (left) and spherical microporous silicate structure from the river Pesnica suspended matter (right). Published in Kanduč, Tjaša, Samardžija, Zoran, Mori, Nataša, Jerebic, Andreja, Levačič, Ines, Kračun, Miha, Robinson, Johanna A., Žigon, Stojan, Blažeka, Željko, Kocman, David. Hydrogeochemical and isotopic characterization of Pesnica River, Slovenia = Hidrogeokemične in izotopske značilnosti reke Pesnice. Geologija, ISSN 0016-7789. 2016, vol. 59, št. 2, str. 179-192. (Dr. Zoran Samardžija, K7, Jeol JXA-840 & JSM-7600F).

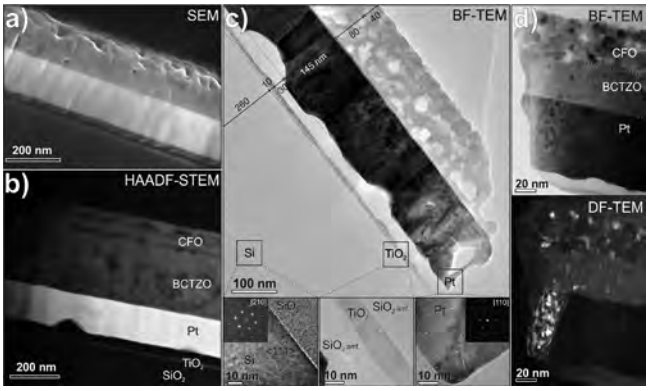


Figure 6: CFO-BCTZO thin-film characterization. J. Appl. Phys. doi: 10.1063/1.4961394; CEMM, Jeol S/TEM JEM-2010F

INTERNATIONAL PROJECT

1. Education-ED-FU, EUROFUSION
   Andreja Šestan, B. Sc.

NEW CONTRACT

1. Compatibility assessment between chosen primary wrapper and biological drug
   Prof. Miran Čeh

STAFF

Researcher
1. Prof. Miran Čeh, Head

Postdoctoral associates
2. Dr. Jitka Hreščak
3. Dr. Janez Zavašnik

Postgraduates
4. Andreja Šestan, B. Sc.

Technical officers
5. Maja Koblar, B. Sc.

BIBLIOGRAPHY

Original Article

1. Nevena Ćelić, Egon Pavlica, Miloš Borovšak, Jure Strle, Jože Buh, Janez Zavašnik, Gvido Bratina, Patrick Denk, Markus Scharber, Niyazi Serdar Sariciftcic, Dragan Mihailović, "Factors determining large observed increases in power conversion efficiency of P3HT:PCBM solar cells embedded with $Mo_6S_{9-x}I_x$ nanowire", *Synth. met.*, vol. 212, pp. 105-112, 2016.
2. Marja Jerič, Johannes de Boor, Janez Zavašnik, Miran Čeh, "Lowering the thermal conductivity of $Sr(Ti_{0.8}Nb_{0.2})O_3$ by SrO and CaO doping emicrostructure and thermoelectric properties: microstructure and thermoelectric properties", *J. Mater. Sci.*, vol. 51, no. 16, pp. 7660-7668, 2016.
3. Luka Kelhar, Janez Zavašnik, Paul J. McGuiness, Spomenka Kobe, "The impact of processing parameters on the properties of Zn-bonded Nd-Fe-B magnet", *J. magn. magn. mater.*, vol. 419, pp. 171-175, 2016.
4. Amir Hassan Montazer, Abdolali Ramazani, Mohammad Almasi Kashi, Janez Zavašnik, "Angular-dependent magnetism in Co(001) single-crystal nanowires: capturing the vortex nucleation fields", *J. mater. chem. C*, vol. 4, no. 45, pp. 10664-10674, 2016.
5. Amir Hassan Montazer, Abdolali Ramazani, Mohammad Almasi Kashi, Janez Zavašnik, "Developing high coercivity in large diameter cobalt nanowire arrays", *J. phys., D, Appl. phys.*, vol. 49, no. 44, pp. 445001-1-445001-14, 2016.
6. Branko Pivac, Pavo Dubček, Jasminka Popović, Jasna Dasović, Sigrid Bernstorff, Nikola Radić, Janez Zavašnik, "Influence of stress on the properties of Ge nanocrystals in an SiO_2 matrix", *J. Appl. Crystallogr.*, vol. 49, part 6, pp. 1957-1966, 2016.
7. Aleksander Rečnik, Janez Zavašnik, Lei Jin, Andrea Čobić, Nina Daneu, "On the origin of "iron-cross" twins of pyrite from Mt. Katarina, Slovenia", *Mineralogical Magazine*, vol. 80, no. 6, pp. 937-948, 2016.
8. Dalibor M. Stanković, Eda Mehmeti, Janez Zavašnik, Kurt Kalcher, "Determination of nitrite in tap water: a comparative study between cerium, titanium and selenium dioxide doped reduced graphene oxide modified glassy carbon electrodes", *Sens. actuators, B, Chem.*, vol. 236, pp. 311-317, 2016.
9. E. Venkata Ramana, Janez Zavašnik, M. P. F. Graça, M. A. Valente, "Magnetoelectric studies on $CoFe_2O_4/0.5(BaTi_{0.8}Zr_{0.2}O_3) - 0.5(Ba_{0.7}Ca_{0.3}TiO_3)$ lead-free bilayer thin films derived by the chemical solution deposition", *J. appl. phys.*, vol. 120, no. 7, pp. 074108-1-074108-10, 2016.

Published Conference Contribution

1. Janez Zavašnik, "Pyrite - pyrrhotite intergrowths in calcite marble from Bistriški Vintgar, Slovenia", In: *Proceedings of the 14th European Workshop on Modern Developments and Applications in Microbeam Analysis (EMAS 2015), Portorož*, (IOP conference series, Materials science and engineering, Vol. 109), pp. 012020-1-012020-7, 2016.

Ph. D. Thesis

1. Jitka Hreščak, *Synthesis and characterization of undoped and strontium-doped potassium sodium niobate ceramics:* doctoral dissertation, Ljubljana, 2016 (mentor Andreja Benčan Golob; co-mentor Barbara Malič).

CENTRE FOR KNOWLEDGE TRANSFER IN INFORMATION TECHNOLOGIES CT-3

The Centre for Knowledge Transfer in Information Technologies performs educational, promotional and infrastructural activities and provides for the direct exchange of information and experience between researchers and the users of their research results.

Head:
Mitja Jermol, M. Sc.

By partnering and active engagement in different European research projects the centre successfully extends its activities to research and development. Most of the research is performed in the area of knowledge management for traditional and emerging forms of organizations, like networked and virtual organizations. In 2016 the centre was active in several European projects from FP7: NRG4CAST (Energy Forecasting), SYMPHONY (Orchestrating Information Technologies and Global Systems Science for Policy Design and Regulation of a Resilient and Sustainable Global Economy), X-LIME (crossLingual crossMedia knowledge extraction), PROASENSE (The Proactive Sensing Enterprise), SUNSEED (Sustainable and Robust Networking), FI-IMPACT (Future Internet Impact), and some projects from H2020 program: EDSA (European Data Science Academ), AQUASMART (Aquaculture Smart and Open Data Analytics as a Service), OPTIMUM (Multi-source Big Data Fusion Driven Proactivity for Intelligent Mobility) and MOVING (TrainInG towards a society of data-saVvy inforMation prOfessionals to enable open leadership Innovation)

In 2016 the centre was active in 10 European projects. The centre prepares and organizes educational events, such as: conferences, seminars, workshops, and summer schools. They are targeted at experts who would like to apply the latest knowledge and achievements from intelligent data analysis, knowledge technologies, data mining, text mining and decision support to the areas of network organizations, business decisions, finance, marketing, automatization and process control. A special consideration is put on the managers and decision makers who are aware of the strengths and benefits to the success of their business. All educational events are designed to transfer basic, additional and the latest expert knowledge to the companies, research and educational organizations.

In 2016 the Centre for Knowledge Transfer in IT was actively involved in 10 European projects.

In order to make the knowledge transfer efficient we are combining traditional and ICT-supported training methods. For this purpose we are operating a number of training web portals. The most popular one is http://videolectures.net/. It now offers 22,561 recorded tutorials from different scientific events and it was visited by 744,027 different visitors from around the world. The main purpose of the portal is to provide free and open access to high-quality video lectures presented by distinguished scholars and scientists at the most important and prominent events. In today's world VideoLectures.NET represents a free knowledge hub, it is a way of opening up education to everyone for everyone as there is a great need to share educational content on all levels in order to benefit society and foster economy. It also gives a learning opportunity to audiences of all social levels.

CT3 operates the web portal http://videolectures.net/, which is now the biggest world reference portal presenting high-quality scientific lectures.

VideoLectures.Net has strong connections to the Open Cast Foundation, Open Course Ware Consortium and Knowledge 4 All Foundation Ltd.

In 2016 we organized the 11th Student Competition in Computer Science, attended by 202 students from Slovenian secondary schools. We have also organized project meetings for different EU projects (Xlime, EDSA), coorganized LREC - 10th edition of the Language Resources and Evaluation Conference attended by more than 1000 experts from linguistic field and ESWC "Extended Semantic Web Conference" Summer School, held in Dubrovnik in Croatia.

Within the UNESCO Chair (http://unesco.ijs.si/), we attended several international meetings of experts on open education and free educational resources. In March 2016 we represented our achievements at the annual informal meeting of the European Network of National Commissions for UNESCO, held in Krakow at Poland.

In 2016 we finished the second cycle of the My Machine project where 10 prototypes of child dream machines were presented.

The UNESCO chair also participated in the publication of the "Making Sense of MOOCs: A Guide to Policy Makers and Developing Countries". Most of the work based on the preparations for the the 2nd World Open Educational Resources (OER) Congress and participation in the Advisory Group for the preparation of "Slovenian package promotion" in the field of OER, which will be presented at the Congress. The Congress will be held in September 2017 in Ljubljana. The Chair is also included in the advisory committee for the regional consultations conducted by the Commonwealth of Learning, which will be held in six regions of the world. The results will be presented at the 2nd World Congress in Ljubljana.

In June 2016 we completed the second cycle of the My Machine project. The final exhibition was organized in "Ramp Lab" in Ljubljana. There were 10 prototypes of child dream machines that we have achieved together with teachers, pupils, students, and professors from 27 different educational institutions. Our activities in the past year included the preparation of the interim exhibition in January 2016, where the students and pupils – creators of the dream machine – met to exchange ideas, proposals and plans for the implementation of prototypes. In October 2016, we launched the third cycle of the project. This time we collaborate with 12 educational institutions from Ljubljana, Škofja Loka and Velenje. The cycle will be completed in June 2017. More information about that project is available on http://www.mymachineglobal.org/tag/slovenia/.

Within the UNESCO Chair (http://unesco.ijs.si/), we attended several international meetings of experts on open education and free educational resources.

Organization of conferences, congresses and meetings

1. 11th Student competition in computer science, Ljubljana, 19. 3. 2016
2. Project meeting of the EU project Xlime, Dubrovnik, Croatia, 16.-18.5. 2016
3. Coorganization of the LREC conference, Portorož, Slovenia, 23.-28. 5. 2016
4. Final My Machine Exhibition, Ljubljana, 16. 6. 2016
5. Project meeting of the EU project EDSA, Dubrovnik, Croatia, 23.-24. 6. 2016
6. Coorganization of the ESWC "Extended Sematic Web Conference" Summer School, Dubrovnik, Croatia, 5.-10. 9. 2016

INTERNATIONAL PROJECTS

1. European Language Resource Coordination (ELRC) 2015, 08.12.2015, JSI, Ljubljana
   Mitja Jermol, M. Sc.
   Dfki Gmbh - Deutsches Forschungszentrum Fuer
2. 7FP - ProaSense; The Proactive Sensing Enterprise
   Mitja Jermol, M. Sc.
   European Commission
3. 7FP - SYMPHONY; Orchestrating Information Technologies and Global Systems Science for Policy Design and Regulation of a Resilient and Sustainable Global Economy
   Mitja Jermol, M. Sc.
   European Commission
4. 7FP - xLiMe; CrossLingual CrossMedia Knowledge Extraction
   Mitja Jermol, M. Sc.
   European Commission
5. 7FP - SUNSEED; Sustainable and Robust Networking for Smart Electricity Distribution
   Mitja Jermol, M. Sc.
   European Commission
6. 7FP - FI-IMPACT; Future Internet Impact Assurance
   Mitja Jermol, M. Sc.
   European Commission
7. H2020 - EDSA; European Data Science Academy
   Mitja Jermol, M. Sc.
   European Commission
8. H2020 - OPTIMUM; Multi-source Big Data Fusion Driven Proactivity for Intelligent Mobility
   Dr. Matej Kovačič
   European Commission
9. H2020 - MOVING; Training Towards a Society of Data-Savvy Information Professionals to enable Open Leadership Innovation
   Gaber Cerle
   European Commission

R&D GRANTS AND CONTRACTS

1. Videorecording and Post-Processing
   Mitja Jermol, M. Sc.
2. My Machine Slovenia
   Mitja Jermol, M. Sc.

STAFF

Postgraduates
1. *Dr. Katja Berčič, left 01.07.16*
2. Anja Polajnar, B. Sc.

Technical officers
3. **Mitja Jermol, M. Sc., Head**
4. Dr. Matej Kovačič
5. *Marjana Plukavec*, B. Sc., left 01.04.16*
6. Špela Sitar, B. Sc.

Technical and administrative staff
7. Aleš Buh
8. Gaber Cerle, B. Sc.
9. Mihajela Črnko
10. Ana Fabjan, B. Sc.
11. Adis Krečo, B. Sc.
12. Monika Kropej, B. Sc.
13. Davor Orlić, B. Sc.
14. Tanja Zdolšek Draksler, B. Sc.

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Article

1. Mario Karlovčec, Dunja Mladenić, Marko Grobelnik, Mitja Jermol, "Conceptualization of science using collaboration and competences", *Electron. libr.*, vol. 34, no. 1, pp. 2-23, 2016.

Published Conference Contribution

1. Ruben Costa, Ricardo Jardim-Gonçalves, Paulo Figueiras, Margherita Forcolin, Mitja Jermol, Richards Stevens, "Smart cargo for multimodal freight transport: when "cloud" becomes "fog"", In: *8th IFAC Conference on Manufacturing Modelling, Management and Control MIM 2016, Troyes, France, 28-30 June 2016*, *IFAC-PapersOnline*, vol. 49, no. 12, pp. 121-126, 2016.

MILAN ČOPIČ NUCLEAR TRAINING CENTRE ICJT

The mission of the training centre ICJT is training in the field of nuclear technologies and radiation protection. In addition, ICJT is actively informing the public about those technologies.

Head:
Dr. Igor Jenčič

Training in the area of nuclear technologies is our primary mission. In the autumn of 2016, the 37th course *Basics of Nuclear Technology* was conducted. The participants were mainly from the Slovenian Nuclear Safety Administration (SNSA) and there were also two participants from Krško NPP and two participants from technical support organizations. In parallel, the 16th edition of course *Nuclear Technology* started. This course is the initial theoretical training of future nuclear-power-plant control-room operators and is normally organized every second year.

There were 29 **radiological protection training** courses for medical, industrial and research use of radioactive sources.

In collaboration with the reactor physics division, we organized an **international course** in the area of regulatory control of research reactors.

Public information remains an important part of our activities. Groups of visitors (mainly schoolchildren, students and various societies) were regularly attending the lectures and visiting the permanent exhibition on nuclear energy, smaller groups the TRIGA reactor and/or the accelerator. In addition to traditional lectures on electricity from nuclear energy, radioactive waste or fusion, we have prepared two new lectures for general public, an energy workshop and a lecture on isotopes. Altogether, there were 161 groups or 6825 visitors this year. Since 1993, a total of 168,644 pupils, teachers and others, visited our information centre. We have continued monitoring and analysing media reports on nuclear energy.

In 2016 we prepared two new lectures for general public: an energy workshop, suitable for junior elementary school pupils, and a lecture on isotopes that is focused on the uses of analysing stable isotopes.

Figure 1: IJS Open day at the Nuclear Training Centre

Figure 2: Energy Workshop at the Elementary School Hotič

Figure 3: Basics of Nuclear Power Plant Technology Course (radioactivity workshop)

Figure 4: Training Course on Requirements and safety evaluation of Research Reactors (EC INSC Project MC3.01/13), December 2016

Table of training activities at the Nuclear Training Centre in 2016

Date	Title of the course	Partici-pants	Lecturers	Weeks	Participants × weeks
25. - 29.1.	Radiation protection for RP department staff - Refresher course	13	6	1	13
10.2.	Radiation protection for industrial and other practices	11	2	0.2	2.2
17.2.	Radiation protection for industrial and other practices	10	2	0.2	2
25. - 26.2.	Radiation protection for Dental Radiography	4	3	0.2	0.8
7. - 10.3.	Radiation protection for Dental Radiography	1	5	0.4	0.4
7. - 9.3.	Radiation protection for industrial and other practices (unsealed sources)	3	4	0.6	1.8
7. - 9.3.	Radiation protection for industrial and other practices (sealed sources)	9	4	0.6	5.4
7. - 9.3.	Radiation protection for workers exposed to radon and thoron	1	5	0.6	0.6
15.3.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	27	4	0.2	5.4
15.3.	Radiation protection for industrial and other practices (measurement of road-way density and humidity) - Refresher Course	3	4	0.2	0.6
15.3.	Radiation protection for industrial and other practices (radiography) - Refresher Course	6	4	0.2	1.2
17.3.	Training Extension for RP Officers	1	2	0.2	0.2
17.3.	Training Extension for RP Officers	15	2	0.2	3
18.3.	Radiation protection for Dental Radiography - Refresher Course	11	4	0.2	2.2
18.3.	Radiation protection for exposed workers in medicine and veterinary - Refresher Course	1	4	0.2	0.2
21. - 23.3.	Radiation protection for medical and veterinary workers - radiological diagnostic	1	4	0.6	0.6
21. - 23.3.	Radiation protection for medical and veterinary workers	2	4	0.6	1.2
5.4.	Radiation protection for industrial and other practices (min. exposed workers)	17	3	0.2	3.4
6. - 10.6.	Radiation protection for exposed workers in Krško Nuclear Power Plant	11	7	1	11
10. - 14.10.	Radiation protection for medical and veterinary workers - Nuclear medicine workers	2	9	1	2
10. - 12.10.	Radiation protection for industrial and other practices (sealed sources)	9	4	0.6	5.4
10. - 13.10.	Radiation protection for Dental Radiography	2	5	0.4	0.8
18.10.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	19	4	0.2	3.8
18.10.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	2	5	0.2	0.4
18.10.	Radiation protection for industrial and other practices (measurement of road-way density and humidity) - Refresher Course	1	4	0.2	0.2
20.10.	Training Extension for RP Officers	7	2	0.2	1.4
20.10.	Training Extension for RP Officers	1	0	0.2	0.2
21.10.	Radiation protection for Dental Radiography - Refresher Course	9	3	0.2	1.8
2. - 30.11.	Basics of nuclear technology, theory	11	13	4.2	46.2
14.11 - (14.4.2017)	Nuclear Technology, Theory	5	23	21.6	108

Table of training activities at the Nuclear Training Centre in 2016

Date	Title of the course	Partici-pants	Lecturers	Weeks	Participants × weeks
1. - 23.12.	Basics of nuclear technology, systems	10	10	3.4	34
5. - 9.12.	EU Dedicated Training Course on "Requirements and safety evaluation of Research Reactors"	11	9	1	11
19.12.	Radiation protection for exposed workers in medicine and veterinary - Refresher Course	1	2	0.2	0.2
TOTAL		237	166	41.2	270.6

INTERNATIONAL PROJECTS

1. 7FP - EAGLE; Enhancing Education, Training and Communication Processes for Informed Behaviors and Decision-making related to Ionizing Radiation Risks
   Rado Istenič, B. Sc.
   European Commission
2. Training and Tutoring for Experts of the National Regulatory Authorities and their Technical Support Organisations for Developing or Strengthening their Regulatory and Technical Capabilities - MC3.01/13
   Saša Bobič
   Iter-consult Srl - Independent

R & D GRANTS AND CONTRACTS

1. Trainings of the RP for Foreign Market
   Matejka Južnik, M. Sc.
2. Trainings of the Radiation protection
   Matejka Južnik, M. Sc.

NEW CONTRACTS

1. Public information and monitoring of media regarding nuclear energy and activities of GEN-energija
   Dr. Igor Jenčič
   Gen Energija, d. o. o.
2. ICJT Training Programme implementation in the year 2016 and 2017
   Dr. Igor Jenčič
   Nuklearna Elektrarna Krško
3. Basic Training Course on Nuclear Technology and Nuclear Power Plants
   Dr. Igor Jenčič
   Ministrstvo za okolje in prostor

STAFF

Researcher

1. **Dr. Igor Jenčič, Head**

Technical officers

2. Jure Hribar, B. Sc.
3. *Rado Istenič, B. Sc., retired 01.08.16*
4. Matjaž Koželj, M. Sc.
5. Tomaž Skobe, M. Sc.
6. Vesna Slapar Borišek, B. Sc.
7. Luka Tavčar, B. Sc.
8. *Nina Udir, B. Sc., 01.06.16, transferred to Department SVPIS*

Technical and administrative staff

9. Saša Bobič
10. Matejka Južnik, M. Sc.
11. Borut Mavec, B. Sc.

BIBLIOGRAPHY

Original Article

1. Matjaž Koželj, Bruno Cvikl, "The negative mobility: An outcome of the electric field at the hole-injecting metal/organic semiconductor interface that varies as a linear function of the applied bias", *Thin solid films*, vol. 616, str. 786-792, 2016.

Published Conference Contribution

1. Radko Istenič, Igor Jenčič, "Public Opinion about Nuclear Energy - Year 2016 Poll", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 8 pp.
2. Igor Jenčič, "The use of Ljubljana TRIGA reactor in training of NPP operators and public information", In: *2016 ANS Winter Meeting and Nuclear Technology Expo*, November 6-10, 2016, Las Vegas, *Transactions of ANS*, vol. 115, p. 92, 2016.
3. Igor Jenčič, Luka Snoj, "The use of Ljubljana TRIGA reactor for training and public information", In: *Role of research reactors in providing support to nuclear power programmes*, Report of the IAEA Technical Meeting on "Role of Research Reactors in providing support to Nuclear Power Programmes", 21-24 June 2016, Vienna, p. 44.
4. Tomaž Skobe, Matjaž Leskovar, "Material influence on ex-vessel steam explosion", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, pp. 813-1-813-10.
5. Vesna Slapar Borišek, " Energy for children", In: *Proceedings*, 25th International Conference Nuclear Energy for New Europe - NENE 2016, Portorož, Slovenia, September 5-8, 2016, 6 pp.

Master's thesis

1. Tomaž Skobe, *Analysis of steam explosion in flooded reactor cavity:* master's thesis, Ljubljana, 2016 (mentor Matjaž Leskovar).

RADIATION PROTECTION UNIT SVPIS

SVPIS has been involved in ionizing-radiation measurements and radiation protection since the commissioning of the TRIGA MARK II Research reactor in 1966. The responsibility of SVPIS is the radiation control of all the activities at the Institute dealing with ionizing radiation. Our main task is the supervision of the reactor and the 17 laboratories that use sources of ionising radiation in their research work. More than one hundred different sources are used, such as sealed sources, open sources, X-ray units and the accelerator TANDETRON, which need regulatory control.

SVPIS is authorized by the Slovenian radiation-protection administration to perform control in industrial and research institutions dealing with open or sealed radioactive sources and X-ray units. Furthermore, we are involved in radioactive waste management.

The measurements of dose rate, contamination and gamma spectrometry are performed using an accredited method (EN ISO/IEC 17025).

Head:
Matjaž Stepišnik, M. Sc.

Personal dosimetry

The personal doses of 126 workers that regularly or occasionally deal with ionizing radiation were monitored with Thermo Luminescent Dosimeters. The maximum individual yearly dose was 0.21 mSv. This is only 1 % of the regulatory limit for occupational exposure (20 mSv per year) and 21 % of the limit for the general public (1 mSv per year). The collective dose at the JSI in 2016 was 1.5 man-mSv.

Supervision of research reactor and laboratories

The controlled area of the Research Reactor, the Hot Cell Facility and the Department of Environmental Sciences was monitored on a weekly basis. During some activities the constant presence of a radiation-protection worker was needed (i.e., for the opening of activated samples or radioactive-waste management). Measurements of dose rate, surface contamination, contamination of different objects and personal contamination were performed routinely. In most cases, no or very low contamination levels could be measured in the controlled areas.

In 2016 19 inspections in other JSI laboratories were performed. An independent inspection by an external authorized institution was performed in the SVPIS laboratory and two additional laboratories at the JSI. There were no deficiencies recognized that could be important for radiation protection.

At present, 112 sources of radiation are used, which require regulatory control. Additionally, 4443 low-activity sources are also used in different laboratories.

Environmental monitoring

The environmental monitoring of the Reactor Center was performed according to the existing program. The monitoring program consists of effluent measurements and measurements of samples in the environment. Activity concentrations of gamma emitters in water samples, filters, noble gases, soil samples and sediment samples were measured periodically. About 350 different samples have been measured with gamma spectrometry. Environmental passive dosimeters have been used to monitor radiation levels in the surroundings of the reactor. Based on the effluent measurements and a conservative environmental transfer model, the effective dose to the reference group of the public was estimated to be less than 1 μSv/year. **The public exposure in 2016 due to activities at the Reactor Center was insignificant.**

Expert assessments and measurements for outside customers

The Radiation Protection Unit is authorized to supervise measurements and conduct expert assessments in the field of radiation protection. In the past year several radiological control investigations were carried out in industrial and research institutions. Our group has participated in an evaluation of the radiological monitoring of Krško NPP, research reactor TRIGA and storage for low- and intermediate-level waste in Brinje.

STAFF

Technical officer
1. Dr. Tinkara Bučar
2. Matjaž Stepišnik, M. Sc., Head

Technical and administrative staff
3. Emira Bašić, B. Sc.
4. Thomas Breznik, B. Sc.
5. Nina Udir, B. Sc.

BIBLIOGRAPHY

Published Conference Contribution

1. Michel Cindro, Matjaž Stepišnik, Damir Pinezić, Davor Sinka, Dejan Skanata, "Physical and radiological characterisation of measuring sites within the Croatian gamma dose rate early warning network", In: *Conference proceedings and book of abstracts: former "Nuclear Option in Countries with Small and Medium Electricity Grids"*, 11th International Conference of the Croatian Nuclear Society, June 05-08, 2016, Zadar, Croatia, pp. 113-1-113-15.

Independent Component Part or a Chapter in a Monograph

1. Matjaž Stepišnik, "Reka Sava", In: *Ovrednotenje izpustov iz NEK in primerjava z meritvami v okolju*, Matjaž Stepišnik, et al, 1. izd., Ljubljana, Institut Jožef Stefan, 2016, pp. 1-20.

CENTER FOR TECHNOLOGY TRANSFER AND INNOVATION CTT

In 1996 the Office of Technology Transfer was established and – based on its work – since January 2011 an independent Center for Technology Transfer and Innovation (CTT) continues its mission at the Jožef Stefan Institute. We assist in the process of technology and knowledge transfer from the JSI to the economy, which includes licensing, spin-out creation, associated procedures for the protection of intellectual property and assisting companies with finding suitable local and international research partners for contract and collaborative research. We also transfer knowledge from science to the school system and promote the recognisability of the JSI and science in general among young people and the wider population.

Head:
Dr. Špela Stres, MBA, LLM

The center's success is based on the work of 9 professionals, 5 of which are educated in natural sciences and engineering, 4 in economics, 2 in law and 2 in social sciences, while one of the experts is also qualified as a patent attorney. We are members of the ASTP (Association of Science and Technology Professionals), the LES (Licensing Executives Professionals) and we hold the U. S. certificate "Certified Licensing Professional".

An important tool in our work is the networks of contacts successfully created with enterprises and other organisations in Slovenia and abroad. Our services, fine-tuned towards individual needs, are offered to JSI researchers and external organisations and include first meeting, needs analysis, registration and protection of intellectual property, marketing of intellectual property (including secret know-how), negotiations and the preparation of suitable agreements. The part of financial means is contributed by researchers of the JSI through their commission, while our direct clients in 2016 were represented by numerous companies and other research organisations.

Marketing of 15 JSI technologies, procedures for the creation of spin-out companies, 40 identified RR topics.

In 2016 the CTT was partly funded through five larger and numerous smaller EU and national projects. These projects belonged to various funding programmes and schemes: Openismes (CIP scheme), Enterprise Europe Network Slovenia (CIP scheme), We4SMESLO (Horizon 2020) and two projects connected to science in school system: SciChallenge (Horizon 2020) and STEM4YOUTH (Horizon 2020). Project activities were connecting and completing our core TT activities.

Internally, CTT is divided into four groups, whose activities mutually interact and complement each other.

Group for protection and marketing of intellectual property deals with cases that were applied through the single entry point (36 cases), gives first advice to researchers (27), prepares assessments of patentability – reviews state of the art (12). The number of these activities has risen considerably in comparison with previous years. The group also evaluates market potential, helps prepare the invention for disclosure within the research organisation, helps draft the patent applications, prepares agreements on the ownership of intellectual property, advises on the choice of patent attorney, prepares and files the patent application and gives advice about the strategy of the international (3) and national expansion of patent protection. The group also takes care of the active marketing of technologies IJS (7 technologies promoted to 250 enterprises and other organisations, 12 technologies promoted on global base Enterprise Europe Network). It manages received interests and starts the negotiations (16). Moreover, group members arrange for the signing of non-disclosure agreements (19), manage affairs with partners in different consortia (5), take part in negotiations (16), prepare license agreements (3) and arrange their signature. Experts that belong to this group provide individual consulting regarding all the phases of spin-out company formation, help with the preparation of business plans, manage discussions on the arrangement of the relationship between JSI and the researcher and prepare license agreements for the use of technology within the spin-out company. To encourage the researches in their entrepreneurial aspirations, this group's experts organize a contest for the selection of innovations with the highest commercial potential and various workshops for young researches. In 2016 one spin-out company was created, two cases were in the final stages.

Organisation of two visiting groups BioChem-Tech and Materials, composed of experts in the field of technology transfer.

Organisation of 9th International Technology Transfer Conference – more than 125 visitors, competition for best innovation idea, international visit from Slovenia, EU countries and China, 68 B2R meetings.

The above-mentioned group closely cooperates with the **Group for contractual collaboration with economy,** which visits both large (45 since 2012) and small companies (18 in 2016), organises their return visits to the JSI, organises sector and regional visits of companies to the JSI and collaborates with other support environment entities. This group's members are trying to find new topics for cooperation within the development projects amongst companies and researches (40), prepare technology offers, arrange for the signing of non-disclosure agreements and acquire written consent for further cooperation (14). The group also takes part in various events; in the course of the 9th International Technology Transfer Conference it organised individual meetings between companies and researchers (63).

4000 visitors during the Open Day at JSI, 83 school visits.

In 2016 we hosted two sector groups, which function within the Enterprise Europe Network, namely sector group Materials and sector group BioChemTech (altogether 39 foreign visitors). In the course of the visit the members of sector groups met 11 Slovenian companies and visited 7 JSI departments. CTT has actively promoted some spin-out companies of JSI (4), for which 5 different potential partners are currently interested.

Group for promotion, education and project management has prepared and disseminated lists of Slovenian and EU tenders (12) and foreign partner searchers, helped prepare project applications, especially in the Exploitation and Dissemination parts, weekly disseminated other information to TT coordinators, which has efficiently contributed to the application of new projects with foreign partners (13). The group has successfully spread various information through the CTT e-newsletter and CTT's Facebook profile, organised Open Day at the JSI (4000 visitors, which is almost 3 times more than the previous year), organised 83 school visits at the JSI (with an additional 3160 visitors), provided entrepreneurial education to young researchers in compliance with Slovenian Research Agency's requirements (25 participants), and organised the 9th International Technology Transfer Conference (125 participants, one-third of them from abroad).

Group for research in the field of technology transfer and innovation has participated in two studies of the Europe Commission Advisory Group for Future and Emerging technologies; it has participated in the realization of the first boot camp in the field of technology transfer at EU level, which was supported by our own lecturers. We have given lectures on our experience with cohesion funds in Brussels, Prague etc. As members of Europe Commission Advisory group for Science with and for Society we helped designing criteria for the evaluation of respective science for further calls. In the frame of the EU support system for progressive technology transfer offices called Progress-TT we develop additional services; we work as evaluators and external experts in the frame of European Commission for different international institutions (Academy of Science Finland; Federal Ministry of Science, Research and Economics, Austria; Investment Fund South East Europe). We have participated in the working group DG Grow, Enterprise Europe Network, which has made recommendations to the European Commission and members of the Enterprise Europe Network about how to implement specialized support services to help companies that are undergoing rapid growth or are entering this phase. As one of the best-rated commercialization external experts in the EU we work for the European Commission and advise different consortia within H2020, with the emphasis on program Industrial Leadership (FoF, NMP, ICT).

2 studies for European Commission. Progress-TT program for progressive technology transfer offices in EU. Some of best-rated commercialization experts of European Commission.

Organization of Conferences, Congresses and Meetings

1. 9th International Technology Transfer Conference, Brdo pri Kranju, 21. September 2016
2. Mladi upi 2016, Education for young researchers, NLB, Ljubljana, 30. May 2016
3. The open-house day, JSI, Ljubljana, 19. March 2016

INTERNATIONAL PROJECTS

1. STPII - Second Science and Technology Project - Preparation of Feasibility Studies with Cost Benefit Analysis for Three RDI Instrastructure Projects
   Dr. Špela Stres
   Wyg Savjetovanje d. o. o.
2. OPENiSME; Open Platform for Innovative SMEs; EACI, CIP Programme
   Dr. Špela Stres
   European Commission
3. COSME - EEN Slovenia; EEN Slovenia Services in Support of Business and Innovation in Slovenia
   Dr. Špela Stres
   European Commission
4. H2020 - SCICHALLENGE; Next Generation Science Challenges using Participatory Techniques and Digital Media
   Dr. Špela Stres
   European Commission
5. H2020 - STEM4youth; Promotion of STEM Education by Key Scientific Challenges and their Impact on Our Life and Career Perspectives
   Dr. Špela Stres
   European Commission
6. H2020 - INPRO; Improving IPR Management Service to SMEs Engaging in Peer Learning Activities
   Dr. Špela Stres
   European Commission
7. H2020 - We4SMESLO; Enhancing the Innovation Management Capacity fo SMEs (by EEN), Slovenia
   Dr. Špela Stres
   European Commission

8. H2020 - ReconCell; A Reconfigurable Robot Workcell for Fast Set-up of Automated Assembly Processes in SME-s
   Dr. Špela Stres
   European Commission
9. Promotion of Research Achievements in Applied Projects of the Jožef Stefan Institute on the Autumn Conference ASTP PROTON „Making a Difference trough Knowledge Transfer“
   Dr. Špela Stres
   Slovenian Research Agency

VISITORS FROM ABROAD

1. Tony Raven, Chief Executive, Cambridge Enterprise Limited, University of Cambridge, Cambridge, United Kingdom, 21. September 2016
2. Henric Rhedin, School of Business, Economics and Law, University of Gothenburg, Gothenburg, Sweden, 21. September 2016
3. Jean-Pierre Nozieres, eVaderis, Grenoble, France
4. Silvi Serreqi, EASME, Bruselj, Belgium, 21. September 2016
5. Sergej Paveliev, Zenit Zentrum Fur Innovation Und Technik In Nordrhein-Westfalen Gmbh, Mulheim An der ruhr, Germany, 20.–21. September 2016
6. Wojciech Szmit, Podlaska Fundacja Rozwoju Regionalnego, Lomza, Poland, 20.–21. September 2016
7. Can Kartoglu, Sabanci Universitesi, Istanbul, Turkey, 20.–21. September 2016
8. Tomasz Charkot, Dolnoslaska Agencja Rozwoju Regionalnego Sa, Szczawno-Zdroj, Poland 20.–21. September 2016
9. Ondrej Petrasek, Jic, Zajmove Sdruzeni Pravnickch Osob, Brno –Medlanky, Czech Republic, 20.–21. September 2016
10. Aleksandar Sedmak, Inovacioni Centar Masinskog Fakulteta Doo, Beograd, Serbia, 20.–21. September 2016
11. Sara Maiez-Tribut, Agence Regionale Du Developpement De L'innovation Ardi Rhone-Alpes, Lyon, France, 20.–21. September 2016
12. Jedrzej Danilewicz, Uniwersytet Zielonogorski, Zielona Gora, Poland, 20.–21. September 2016
13. Dries Stoel, Kamer Van Koophandel, Amsterdam, Netherlands, 20.–21. September 2016
14. Tomasz Lyzwinski, Zachodniopomorski Uniwersytet Technologiczny W Szczecinie, Szczecin, Poland, 20.–21. September 2016
15. Aneta Aleksander, Gornoslaska Agencja Przedsiebiorczosci I Rozwoju Sp Zoo, Gliwice, Poland, 20.–21. September 2016
16. Nicole Okoye, Gottfried Wilhelm Leibniz Universitaet Hannover, Hannover, Germany, 20.–21. September 2016
17. Pero von Strasser, Stiftung Fachhochschule Osnabrueck, Osnabrück, Germany, 20.–21. September 2016
18. Elena Cortés Ventura, Red De Institutos Tecnologicos De La Comunidad Valenciana Redit Asociacion, Valencia, Spain, 20.–21. September 2016
19. Emilie MARCELET, Chambre De Commerce Et D'industrie De Region Picardie, Amiens Cedex 1, France, 20.–21. September 2016
20. Olaf Jüptner, Hessen Trade & Invest GmbH, Wiesbaden, Germany, 20.–21. September 2016
21. Elsa Luciani, Agencia Per A La Competitivitat De La Empresa, Barcelona, Spain, 20.–21. September 2016
22. Antonio Cusma, Consiglio Nazionale Delle Ricerche, Rim, Italy, 20.–21. September 2016
23. Andrew Hebb, University Of Greenwich, Chatham, Kent, United Kingdom, 20.–21. September 2016
24. Silvi Serreqi, Executive Agency for Small and Medium Enterprises, Brussels, Belgium, 20.–21. September 2016
25. Magali Parent, Agentschap Voor Innovatie Door Wetenschap En Technologie, Brussels, Belgium, 20.–21. September 2016
26. Stan Francke, Ministerie Van Economische Zaken, Utrecht, Netherlands, 20.–21. September 2016
27. Tim Benzie, University Of Greenwich, Greenwich, United Kingdom, 4.–5.October.2016
28. Sara Di Falco, Regione Piemonte, Piemonte, Italy, 4.–5.October.2016
29. Nunzia Ciliberti, Aster - Societa Consortile Per Azioni, Bologna, Italy, 4.–5.October.2016
30. Claire Melville, Scottish Enterprise, Glasgow, United Kingdom, 4.–5.October.2016
31. Georges De Lacoste, Centre D'accompagnement De Projets Innovants Asbl, Nivelles, Belgium 4.–5.October.2016
32. Isabelle Pottier, Chambre De Commerce Et D'industrie De Region Paris Ile-De-, Paris, France, 4.–5.October.2016
33. Astrid Pauli, Zenit Zentrum Fur Innovation Und Technik In Nordrhein-Westfalen GMBH, Mulheim An der ruhr, Germany, 4.–5.October.2016
34. Bénédicte Ganivet, Chambre De Commerce Et D Industrie De Region Languedoc Roussillon, Perols, France, 4.–5.October.2016
35. Melanie Albrecht, Investitions-Und Forderbank Niedersachsen (NBANK), Hanover, Germany, 4.–5.October.2016
36. Cemile Koseler Usta, Istanbul Sanayi Odasi, Istanbul, Turkey, 4.–5.October.2016
37. Katerina Papadouli, Foundation For Research And Technology Hellas, Athens, Greece, 4.–5.October.2016
38. Frédéric Suche, Agence Bruxelloise Pour L'entreprise, Brussels, Belgium, 4.–5. October.2016
39. Snezana Kirin, Inovacioni Centar Masinskog Fakulteta Doo, Beograd, Serbia, 4.–5. October.2016
40. Leo Donato, Rtc North Limited, Leeds, United Kingdom, 4.–5.October.2016
41. Aleksandar Sedmak, Inovacioni Centar Masinskog Fakulteta Doo, Beograd, Serbia, 4.–5. October.2016
42. dr. Andrea Basso, Progress TT, MITO Technology, Milano, Italy, 5.–6.December. 2016

STAFF

Researcher
1. **Dr. Špela Stres, MBA, LLM, Head**

Postdoctoral associates
2. *Dr. Asja Grafy, left 05.09.16*
3. *Dr. Duško Odić, left 01.05.16*
4. Dr. Levin Pal

Postgraduates
5. Robert Blatnik, M. Sc.

Technical officers
6. Lea Aissatou Levpušček, B. Sc.
7. Tomaž Lutman, B. Sc.
8. France Podobnik, B. Sc.
9. Marjeta Trobec, B. Sc.

Technical and administrative staff
10. Barbara Bercko, B. Sc.
11. Špelca Kompara, B. Sc.
12. Tamara Matevc, B. Sc.
13. Luka Virag, B. Sc.

BIBLIOGRAPHY

Original Article

1. Tomas Ekeberg *et al.* (60 authors), "Single-shot diffraction data from the Mimivirus particle using an X-ray free-electron laser", *Scientific data*, vol. 3, pp. 160060-1-160060-7, 2016.
2. Gijs van der Schot *et al.* (44 authors), "Open data set of live cyanobacterial cells imaged using an X-ray laser", *Scientific data*, vol. 3, pp. 160058-1-160058-7, 2016.