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Jožef Stefan Institute, Ljubljana, Slovenia

1949-2009

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INTRODUCTION

When preparing the Annual Report of the Jožef Stefan Institute, writing the introduction is always the most difficult part. As the Institute operates in such a wide area, it is not possible to mention all the achievements for a particular year. After selecting some of them, I soon realise that there are several other, equally excellent and important, achievements. Each year I am pleased to read the annual report, but this time I have also read it with a view to the approaching 60th anniversary of the Institute's establishment, which we will celebrate on Jožef Stefan's birthday, 24 March 2009. The extent and the quality of our research results have had an international impact, so it is not surprising that the funds that the Institute obtained with projects included in the EU 6FP and EU 7FP are increasing at an annual rate of 50%, currently amounting to 15% of the Institute's total income. Additionally, the efforts of our researchers aimed at contributing their knowledge and innovations for the common good are not in vain, as the Institute annually carries out more than two hundred projects for industry and other direct users. Unfortunately, I have also discovered that Slovenian science still gets very little attention from the state, and that the best scientific and technological achievements are more often the result of the efforts of individuals and small groups than of a national programme or an effective system.

In its development resolutions Slovenia set itself some ambitious objectives; however, these objectives are not being achieved, the conditions for research activities and technological development are not being improved, and our investments lag behind the investments in other developed countries. Consequently, Slovenian researchers do not focus enough on achievements at the highest level, cooperation and exchange with the colleagues around the world, and the transfer of knowledge to industry. Instead, we spend a lot of time solving everyday difficulties. Sometimes we hear that the reason for this situation is the fact that not enough research results are transferred to industry. In reply to such claims, we should point out that the funds for cooperation between science and industry in Slovenia are almost non-existent, while more successful countries make most of their investments in this area. Where can our researchers and those researchers active in industry find the means to work on joint projects? We also have to understand that creativity in science, as well as creativity in other areas, cannot be assessed only in terms of an immediate profit. Creativity is a long-term and sensitive process, fostering the development of both the individual and society; however, in order to succeed, scientists sometimes have to take actions that do not have an immediate practical value. Science has to develop on the basis of both creative freedom and the developmental needs of society. Without this freedom and without the responsibility to society, no progress is possible in science or in other areas. I am worried when I see that in Slovenia people wish to have better results, but they are not prepared to change the old ways of doing things. However, it seems that this is not only a Slovenian disease, as it is also to be found in many other parts of Europe.

In 2008 we celebrated the hundredth anniversary of the birth of the academician Anton Peterlin, the founder and first director of the Institute. The celebration took place on 25 September, and on the same day the book Anton Peterlin 1908-1993,



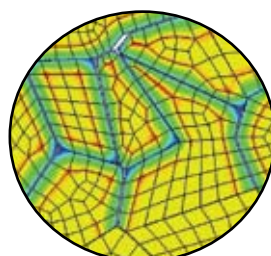
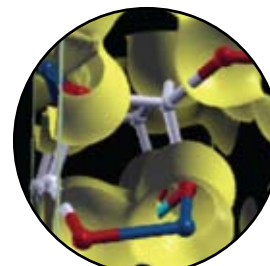
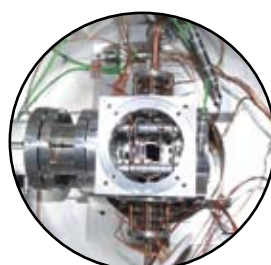
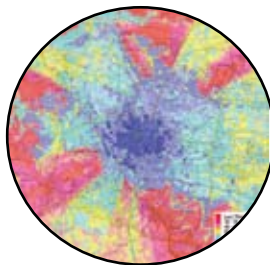
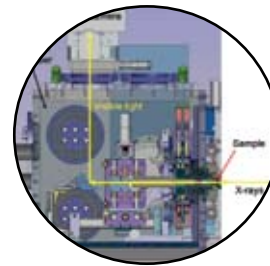
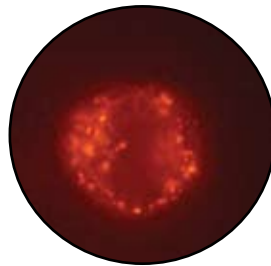
Director of the Jožef Stefan Institute
Prof. Jadran Lenarčič

his life and work was published jointly by the Slovenian Academy of Sciences and Arts and our Institute. The book brings together facts about Anton Peterlin, physics and other sciences in Slovenia, the political events of the period concerned, and the setting up of the Jožef Stefan Institute. It is an important document that deserves our attention.

Following the vision of Anton Peterlin, I wish to point out that the Jožef Stefan Institute is not only a scientific establishment; it is also an important cultural centre that extends beyond the Slovenian ethnic borders. In particular, I would like to remind you that in the past year we presented Boris Pahor, when visiting the Institute, with the Institute's award, celebrating his 95th birthday. Together with Drago Jančar and Boštjan Žekš, Boris Pahor took part in the Discussion about Creativity, which we organised at the end of September. Let me, for this reason, conclude with the words of this great humanist, esteemed writer, a man to whom the most influential authorities pay their respect: "May freedom finally come, the freedom that I have never experienced in my life. A freedom that is not mine, and so a feeling I do not know."



*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

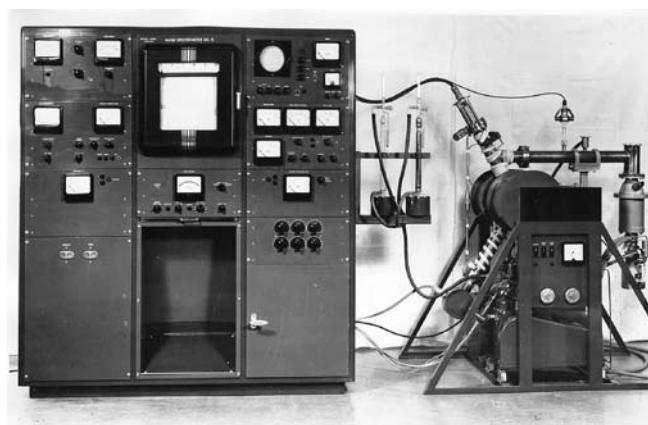
~ Van de Graaff accelerator, constructed at the institute, started operation

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 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

1987

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



Nuclear magnetic resonance spectrometer

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



The beginnings of robotics at the JSI, in 1985

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

Lucijan Šinkovec, B. Sc., 1959–1963

Prof. Milan Osredkar, 1963–1975

Prof. Boris Frlec, 1975–1984

Prof. Tomaž Kalin, 1984–1992

Prof. Danilo Zavrtnik, 1992–1996

Prof. Vito Turk, 1996–2005

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Complex Matter (F-7)

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Reactor Engineering (R-4)

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Energy Efficiency Centre (EEC)
Stane Meršič, M. Sc.

Centre for Knowledge Transfer in Information Technologies (CT-3)
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Milan Čopič Nuclear Training Centre (ICJT)
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Prof. Marija Kosec

Centre for Electron Microscopy (CEM)
Ass. Prof. Miran Čeh

Microanalytical Instrumental Centre (MIC)
Dr. Primož Pelicon

National High Resolution NMR Spectroscopy
Prof. Janez Dolinšek

Centre for Protein Structure
Prof. Dušan Turk

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Jože Kašman, B. Sc.

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Regina Gruden, B. Econ.

Public Relations
Polona Strnad, B. Sc.

Technical Services (TS)
Slavko Zalar, B. Sc.

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Technology Transfer Office (U-9)
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Radiation Protection Unit (SVPIS)
Matjaž Stepišnik, M. Sc.

Quality Assurance (QA)
Ljubo Fabjan, M. Sc.

Centre for Business Applications (CPO)
Mato Nowak, B. Sc.

Workshops
Bogdan Veber, B. Sc.

PARTICIPATION IN REGIONAL DEVELOPMENT OF RESEARCH

Ljubljana Technology Park Ltd.

Founders:
Jožef Stefan Institute
National Institute of Biology
National Institute of Chemistry
Lek
City of Ljubljana
Iskra Sistemi
IskraTel

University of Nova Gorica

Founders:
Jožef Stefan Institute
Nova Gorica Municipality
Ajdovščina Municipality
Scientific Research Centre of the Slovenian
Academy of Sciences and Arts, Ljubljana

Jožef Stefan International Postgraduate School

Founders:
Jožef Stefan Institute
Gorenje, Velenje
Kolektor Group, Idrija
Salonit, Anhovo
Slovenian Insurance Association, Ljubljana

Technology Centres

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

**Security Technology
Competence Centre (SETCCE)**

**Technology Centre for Circuits,
Components, Materials,
Technologies and Equipment for
Electrotechnic (TC SEMTO)**

Nanotesla Institute Ljubljana

**Development Centre for Hydrogen
Technologies**

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Dr. Boris Pukl

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Advisers

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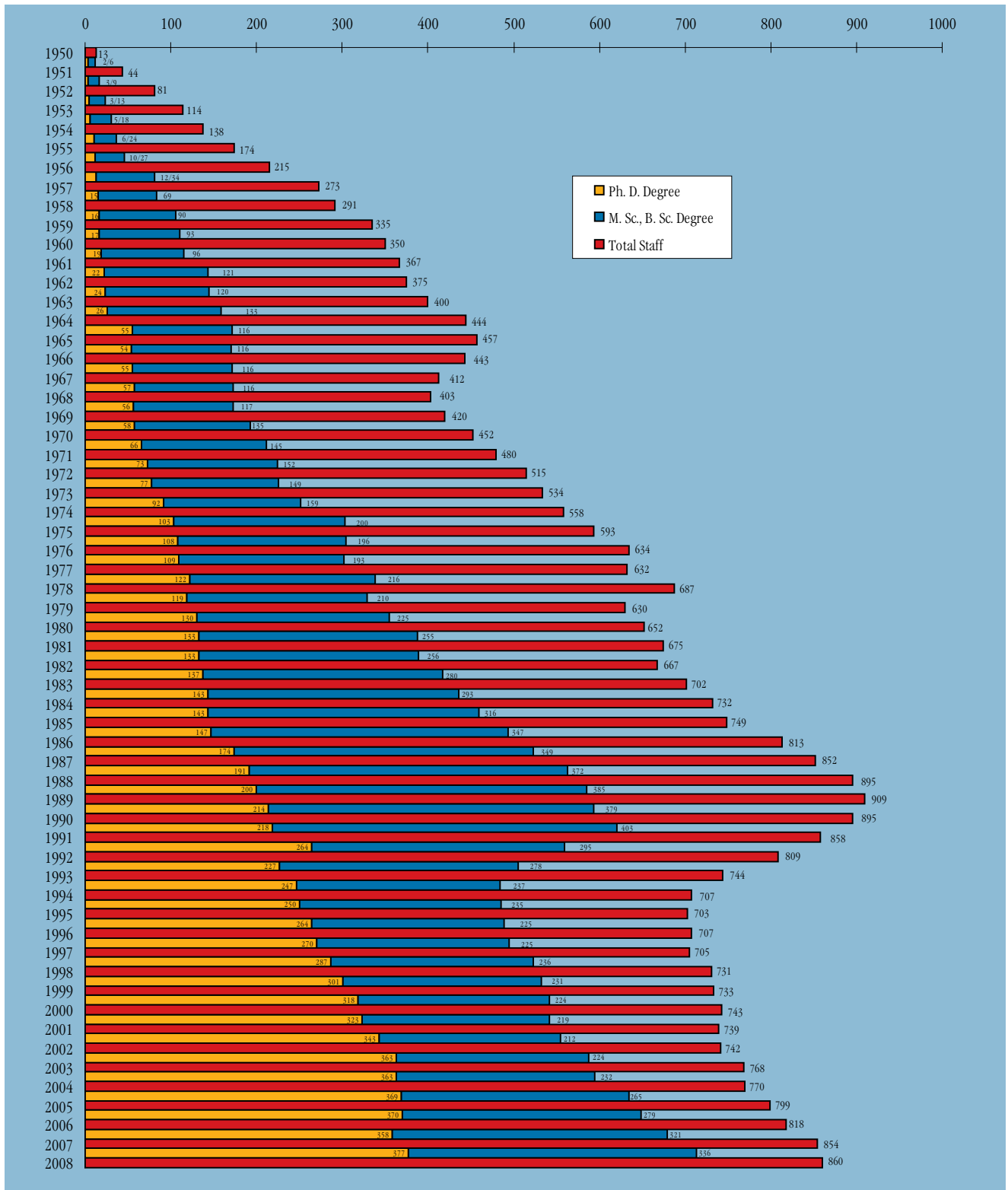
Prof. Stanislav Strmčnik

Prof. Danilo Suvorov

Prof. Vito Turk

STAFF QUALIFICATIONS

1949-2008



RECIPIENTS OF THE JSI AWARDS AND TITLES

HONORARY MEMBERS

- Prof. Robert Blinc, President of the Scientific Council from 1992 to 2007
Prof. Boris Frlec, Director of the Jožef Stefan Institute from 1975 to 1984
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)

ASSOCIATE MEMBERS

- Prof. David C. Ailion, University of Utah, Salt Lake City, Utah, USA
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Prof. Rudolf Hoppe, Universität Giessen, Giessen, Germany
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Prof. Vlado Valković, Zagreb, Croatia
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Prof. Gabrijel Kernel
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 Prof. Günther Petzow, Max-Planck-Institut für Metallforschung, Stuttgart, Germany
 Prof. Bernard Roth, Stanford University, Stanford, California, USA
 Prof. John Ryan, University of Oxford, Oxford, United Kingdom
 Prof. Volker Sörgel, Ruprecht-Karis-Universität, Heidelberg, Germany
 Prof. H. Eugene Stanley, Boston University, Boston, Massachusetts, USA
 Prof. Thomas Walcher, Universität Mainz, Mainz, Germany

INTERNATIONAL COOPERATION AGREEMENTS

In 2008, cooperation agreements were signed between the Jožef Stefan Institute and:

1. European Food Safety Authority (EFSA), Parma, Italy
2. Institute of Mathematics, Physics and Mechanics (IMPM), Ljubljana, Slovenia
3. Forschungszentrum Jülich GmbH, Jülich, Germany
4. The European Organization for Nuclear Research (CERN), Geneva, Switzerland
5. Argonne National Laboratory, Argonne, Illinois, USA
6. Korea Institute of Material Science (KIMS), Changwon, Korea
7. The Walter and Eliza Hall Institute of Medical Research, Parkville, Victoria, Australia
8. University Health Network, The Microarray Centre, Toronto, Ontario, Canada
9. University of Wollongong, Thermal Physiology Laboratory, Wollongong, Australia
10. Université Louis Pasteur, Laboratoire d'Imagerie et de Neurosciences Cognitives, Strasbourg, France
11. Kobe University, Faculty of Human Development, Laboratory for Applied Human Physiology, Kobe, Japan
12. University of Portsmouth, Human and Applied Physiology Laboratory, Portsmouth, Hampshire, Great Britain
13. National and Kapodistrian University of Athens, Faculty of Physical Education and Sport Science, Department of Sport Medicine and Biology of Exercise, Athens, Greece
14. Japan Advanced Institute of Science and Technology, Ishikawa, Japan
15. Cycorp, Inc., Austin, Texas, USA
16. The Korea Atomic Energy Research Institute (KAERI), Yuseong, Daejeon, Korea
17. Veneto Innovazione Spa, Venezia Marghera, Italy; Veneto Nanotech Scpa, Padova, Italy

INTERNATIONAL COOPERATION

Multilateral international cooperation	No. of projects
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)	31
7. FP - EURATOM	20
6. FP (LIFESCIHEALTH, IST, NMP, AERO, TREN, SPACE, FOOD, ENERGY, TRANSPORT, GLOBAL, CITIZENS, SSP, NEST, SME, INCO, ERA-NET, MOBILITY, INFRASTRUCTURES, SCIENCE AND SOCIETY, RESEARCH/INNOVATION POLICIES)	68
6. FP - EURATOM	1
IEE	6
CENTRAL EUROPE	1
LEONARDO DA VINCI	3
ECONTENTPLUS (PHEA)	3
SOCRATES / MINERVA, ERASMUS	1
EUREKA	4
COST	11
NATO (SfP, CLG, RIG)	4
IAEA	15
ESF (EMAR)	1
UNESCO-ROSTE	1
INTERREG	1
INTAS	1
ERA-NET (MATERA, MNT, SEE)	7
HFSP0	2
OTHERS (DELPHI, HERA-B, ATLAS, CERN RD-39, CERN RD-42, CERN RD-50, BELLE, CIMA, ARM, FEBS, UNEP, EATEL, OECD/NEA, CAMP, TRIGA...)	17
TOTAL	198

Bilateral cooperation	No. of projects
Albania	2
Argentina	2
Austria	10
Belgium	4
Bulgaria	1
Bosnia and Herzegovina	5
Cyprus	1
Czech Republic	3
Montenegro	1
Denmark	1
Finland	1
France (PROTEUS - 11)	15
Croatia	5
Italy	12
Japan	10
China	9
Hungary	3

Bilateral cooperation	No. of projects
Macedonia	4
Germany	3
The Netherlands	3
Norway	1
Poland	3
Portugal	8
Romania	3
Russia	1
Slovakia	2
Serbia	12
Switzerland	1
Turkey	3
Ukraine	6
Great Britain (PSP - 1)	3
USA	19
TOTAL	157

DELEGATIONS AND VISITORS

H. E. dr. Villur Sundararajan Seshadri, Ambassador of the Republic of India in Slovenia,
28 January 2008

Prof. Rado Bohinc, Rector University of Primorska, February 1 2008

Prof. Stane Pejovnik, Dean, Faculty of Chemistry and Chemical Technology
12 February 2008

Dr. Franc Gider, Director, Public Agency for Technology of the Republic of Slovenia,
26 February 2008

Dr. Andrej Stritar, Director, The Slovenian Nuclear Safety Administration,
7 March 2008

Delegation of the European Commission, 10 March 2008:

Dr. Janez Potočnik, Commissioner for Science & Research

Dr. Zoran Stancič, Deputy Director General of Research Directorate

Dr. Lino Barañao, Argentinean Minister for Science, 21 April 2008

Delegation of the Embassy of the United States of America, 8 May 2008:

H. E. Ms. Maryruth Coleman, Chargé d' Affaires a.i.

Ms. Susan M. Shultz

Prof. Bai He with delegation, Liaoning Cancer hospital, Shenyang, China,
12 May 2008

Ms. Katarina Kresal, president of Liberal democracy of Slovenia, 16 May 2008

Dr. Franci Demšar, Director Slovenian Research Agency, 19 May 2008

Korean delegation, 3 June 2008:

Dr. Lee, G. Brian Kim

Visit of participants of ministerial conference EUREKA, 5 June 2008

Delegation of Government Office for Growth and Elaphe firm, d. o. o., 15 July 2008:

Dr. Žiga Turk, minister and representatives of Elaphe, d. o. o.

Dr. Chris Hull, 20 August 2008

Discussion about Creativity, 30 September 2008:

Mr. Boris Pahor

Prof. Boštjan Žekš

Mr. Drago Jančar

H. E. Ms. Ivana Hlavsova, Ambassador of the Czech Republic ,
7 October 2008

Delegation of NATO, Research and Technology Agency, IST Panel,
16 October 2008

Visit of Executive board of the Association of Europe's specialised research and technology organisations (EARTO), 23 October 2008:

Prof. Erkki KM Leppävuori, president VTT, Finland, president of EARTO

G. Dirk-Meints Polter, vice-president, Fraunhofer, Germany, vice-president EARTO and others

Korean delegation, 30 October 2008:

Sang Sup Han, Korea Institute of Energy Research, Daejeon

Seong Hyeon Hong, Korea Institute of Materials Science, Daejeon

Hae Jin Kim, Korea Basic Science Institute, Daejeon

Delegation ETA Cerklno, d. d., 6 November 2008:

Mr. Zorko Golob, chairman of executive board with co-workers

Delegation of Korea Institute of Materials Science (KIMS), 20 November 2008:

Dr. Kim Byoung-Kee, president, Dr. Jeon Jae-Ho

Mr. Gregor Golobič, Minister for Higher Education, Science and Technology,
27 November 2008

ART EXHIBITIONS AT THE JSI

Martin Avsenik, 21 January–13 February 2008

13. Artists' Colony, Vienna, 18 February–20 March 2008

Štefan Planinc, 25 March–17 April 2008

Stojan Kerbler, 21 April–12 May 2008

Rajko Čuber, 26 May–16 June 2008

Arjan Pregl, 16 June–14 July 2008

Beti Bricelj, 14 July–4 August 2008

Mateja Sever, 4 August–11 September 2008

Katjuša Rojac, 15 September–9 October 2008

Lado Jakša, 13 October–6 November 2008

Silvester Plotajs-Sicoe, 10 November–4 December 2008

Štefan Marflak, 8 December–8 January 2009



Štefan Planinc at the opening of the exhibition of his work

COOPERATION WITH UNIVERSITIES

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35. **Dr. Andrej Zorko**, University of Ljubljana, Faculty of Natural Sciences and Technology and Faculty of Chemistry and Chemical Technology
36. **Anže Zupanc, B. Sc.**, University of Ljubljana, Faculty of Mathematics and Physics
37. **Dr. Dušan Žigon**, Jožef Stefan International Postgraduate School, Ljubljana

INSTITUTE COLLOQUIA

4 January 2008: **Prof. Bruno Siciliano**

PRISMA Lab, Università degli Studi di Napoli Federico II, Napoli, Italy

Force and Visual Control for Physical Human-Robot Interaction

9 January 2008: **Dr. Alexei Y. Smirnov**

Abdus Salam ICTP, Trieste, Italy

Neutrinos: Discovering a New Physics World

30 January 2008: **Dr. Bojan O. Bosković**

University of Cambridge, Cambridge in Meggitt Aircraft Braking Systems, Coventry, Great Britain

Carbon Nanotubes: Synthesis and Applications

13 February 2008: **Prof. Philippe Mendels**

University Paris-Sud 11 Orsay, France

Novel States in Frustrated Antiferromagnets

12 March 2008: **Dr. Mark Pleško**

Cosylab d. o. o., Ljubljana, Slovenia

Cosylab: IJS spin-off that transformed into an international high-tech company

25 March 2008: **Prof. Ivan Bratko**

University of Ljubljana, Faculty of Computer and Information Science and Jožef Stefan Institute, Ljubljana, Slovenia

Computer analysis of chess champions

26 March 2008: **Prof. Igor Gregorič**

Texas Heart Institute at St. Luke's Episcopal Hospital, Huston, USA

Left ventricular assist devices in treatment of heart failure

27 March 2008: **Prof. Svjetlana Fajfer**

University of Ljubljana, Faculty of Mathematics and Physics and Jožef Stefan Institute, Ljubljana, Slovenia

Success and limitations of quantum chromodynamics

28 March 2008: **Dr. Joao da Silva**

Directorate Converged Networks and Services, DG-INFOS European Commission, Belgium

The Future of the Internet, Perspectives emerging from R&D in Europe

9 April 2008: **Miha Pavšek**

Anton Melik Geographical institute, Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Ljubljana, Slovenia

Snow avalanches in Slovenia

7 May 2008: **Dr. Viktor Kabanov**

Jožef Stefan Institute, Ljubljana, Slovenia

Magnetic quantum oscillations in 2D metals and metallic nanowires

14 May 2008: **Dr. Bojan Cestnik**

Temida d. o. o., Ljubljana, Slovenia and Jožef Stefan Institute, Ljubljana, Slovenia

Bridge between science and practical applications: examples of modern technologies in computer applications

11 June 2008: **Dr. Alexandre Gloter**

CNRS - University of Orsay, France

Transmission electron microscopy for nanomaterial characterization, how far can we go?

18 June 2008: **Prof. Martin Frenz**

Institute of Applied Physics, University of Bern, Switzerland

Optoacoustic imaging, a promising technique for non-invasive diagnosis of cancer

22 August 2008: **Prof. Susan Trolier-McKinstry**

Pennsylvania State University, USA

Piezoelectric Thin Films for Sensors, Actuators, and Energy Harvesting

3 September 2008: **Prof. S. Fred Singe**

Science & Environmental Policy Project, USA

Nature, not human activity, rules the climate

1 October 2008: **Prof. Jean-Marie DUBOIS**

Institut Jean Lamour, Ecole des Mines, Nancy, France

Complex Metallic Alloys: Concept, Properties, and Perspective

22 October 2008: **Prof. Gregor Cevc**

Idea AG., München, Germany

The first approved nanotechnological therapeutic product: Diractin(R)

12 November 2008: **Andrej Detela**

Jožef Stefan Institute, Ljubljana, Slovenia

About the creativity on the way to innovation

19 November 2008: **Prof. Florentin Wörgöter**

Bernstein Center for Computational Neuroscience, Göttingen, Germany

Robots under Adaptive Neural Control

11 December 2008: **Asst. Prof. Primož Zihnerl**

University of Ljubljana, Faculty of Mathematics and Physics and Jožef Stefan Institute, Ljubljana, Slovenia

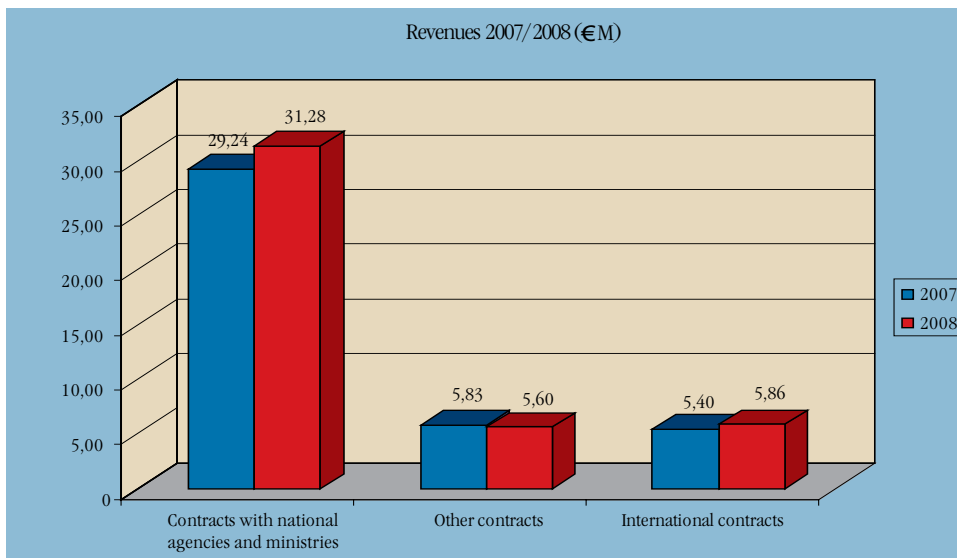
A simple insight into the structure of cellular clusters

FINANCING

REVENUES JSI* (€) AND NUMBER OF PROJECTS

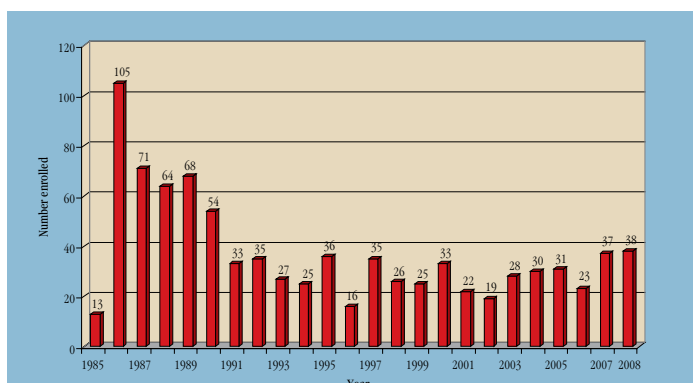
	2007	2008	2008/2007	Contribution 2008	No. of projects in 2008
Contracts with national agencies and ministries	29,243,094	31,284,128	106,98 %	73,18 %	236
Other contracts	5,831,586	5,602,719	96,08 %	13,11 %	73
International contracts	5,396,049	5,860,905	108,61 %	13,71 %	354
TOTAL	40,470,729	42,747,752	105,63 %	100,00 %	663

* Without financial revenues



POSTGRADUATES FINANCED BY ARRS**

1985-2008



** ARRS - Slovenian Research Agency

JSI UNDERGRADUATE SCHOLARSHIPS

1977-2008

Year	FMF		FKKT UNI LJ	FKKT UNI MB	FFA	FDV	BF	FE and FRI	FS	EF	FG and FERI	MF	UNG	Total
	Physics	Mathematics												
... 1982	115	38	100					50	9	3				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	1	1				71
1989	26	6	10		2		1	19	1		1			66
1990	26	5	11				2	25			1			70
1991	23	2	9		2		2	24			1			63
1992	22	3	16		1		3	17						62
1993	21	1	15		1		3	13						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			2	1	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
TOTAL	375	88	370	3	6	4	48	419	15	4	17	2	7	1358

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
FFA Faculty of Pharmacy, University of Ljubljana
FDV Faculty of Social Sciences, 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
FS Faculty of Mechanical Engineering, University of Ljubljana
EF Faculty of Economics, University of Ljubljana
MF Faculty of Medicine, 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

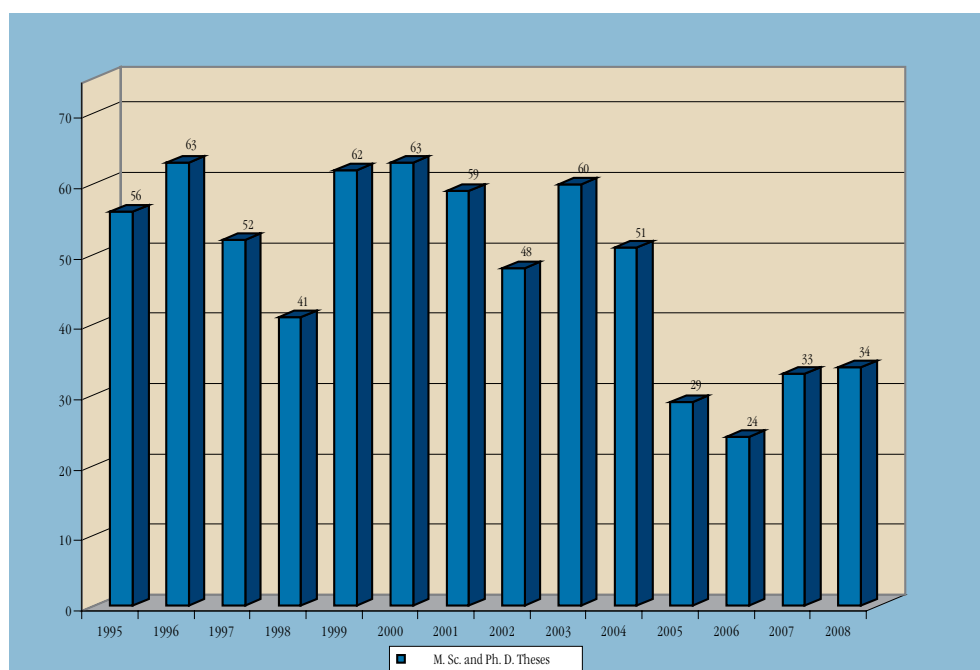
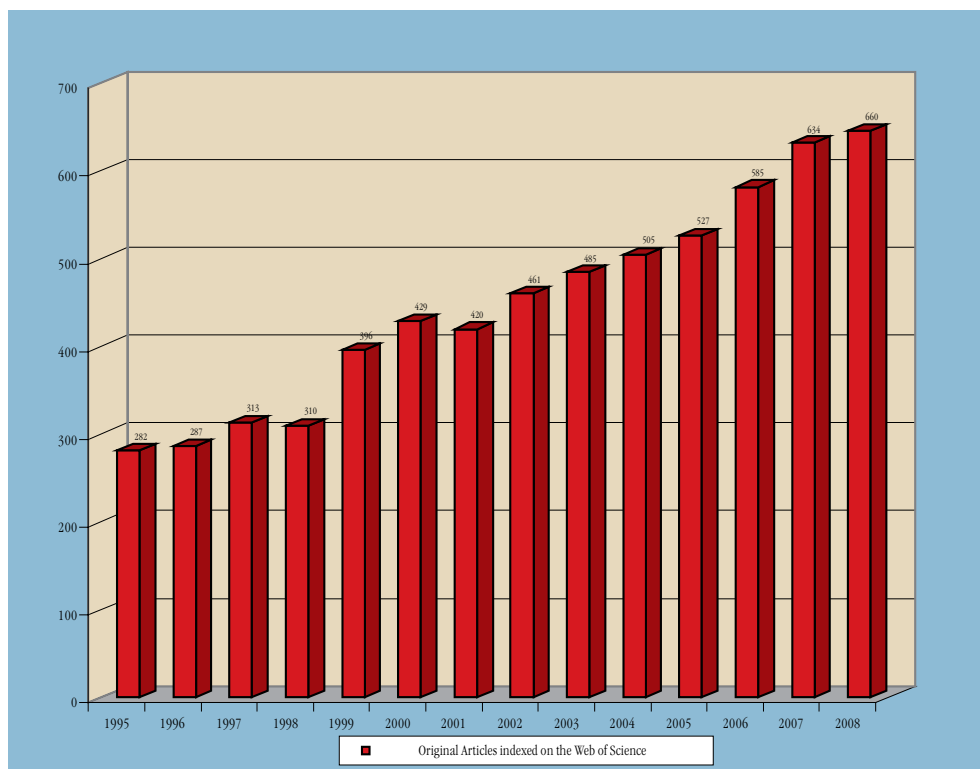
COMPLETED THESES

UNTIL 2008

Year	Ph. D. Theses	M. Sc. Theses	Total	Year	Ph. D. Theses	M. Sc. Theses	Total
...1962	15	6	21	1986	8	15	23
1963	7		7	1987	18	21	39
1964	7	2	9	1988	12	26	38
1965	16		16	1989	15	33	48
1966	2		2	1990	16	41	57
1967		8	8	1991	22	47	69
1968	4	8	12	1992	19	42	61
1969	3	6	9	1993	28	36	64
1970	2	12	14	1994	27	37	64
1971	7	6	13	1995	34	22	56
1972	11	24	35	1996	38	25	63
1973	8	14	22	1997	29	23	52
1974	21	10	31	1998	21	20	41
1975	10	20	30	1999	33	29	62
1976	6	31	37	2000	36	27	63
1977	5	16	21	2001	31	28	59
1978	10	20	30	2002	29	19	48
1979	7	11	18	2003	41	19	60
1980	13	10	23	2004	31	20	51
1981	12	15	27	2005	22	7	29
1982	13	18	31	2006	22	2	24
1983	5	10	15	2007	26	7	33
1984	14	17	31	2008	29	5	34
1985	6	14	20	TOTAL	791	829	1620

PUBLICATIONS

1995-2008



AWARDS AND APPOINTMENTS

AWARDS MADE TO JSI RESEARCHERS BY THE REPUBLIC OF SLOVENIA

Zois Recognitions and Award of the Republic of Slovenia

Prof. Robert Blinc

Presented with the Zois Award for his lifetime achievements

Prof. Peter Križan

Presented with the Zois Award for his outstanding achievements in experimental particle physics

Asst. Prof. Denis Arčon

Presented with the Zois Recognition for his achievements the field of solid-state physics

Dr. Gregor Dolanc

Presented with the Puh Recognition for automatic control of a steel-strip slitting line



The recipients of Zois awards and recognitions

JSI AWARDS AND APPOINTMENTS

The Jožef Stefan Golden Emblem Prize

presented to the following for doctoral theses with high impact :

Dr. Urh Černigoj, University of Nova Gorica,

Photodegradation of organic pollutants in aqueous solutions catalyzed by immobilized titanium dioxide: Novel routes towards higher efficiency

Asst. Prof. Peter Korošec, Jožef Stefan International Postgraduate School and Jožef Stefan Institute

Stigmergy as an Approach to Metaheuristic Optimization

Dr. Rok Žitko, Faculty of Mathematics and Physics University of Ljubljana and Jožef Stefan Institute

Many-particle effects in resonant tunneling of electrons through nanostructures

INTERNATIONAL AWARDS TO JSI RESEARCHERS

Dr. Zrinka Abramović

L'Oréal-UNESCO fellowship, 'For Women in Science' award for 2008

Wu Aiyang, Paula M. Vilarinho, Andrei Kholkin, Dr. Janez Holc, Prof. Marija Kosec

Excellent Paper Award for contribution at the International Materials Research Conference (MRS), 9 Jun. 2008

Prof. Sašo Džeroski

ECCAI fellow - ECCAI award. Awarded by European Coordination Committee for Artificial Intelligence

Saša Kovačič

L'Oréal-UNESCO fellowship, 'For Women in Science' award for 2008

Prof. Igor Križaj

Elected to the post of Secretary of the European Section of the International Society on Toxinology (EIST) and a member of the Council of the IST

Prof. Igor Mekjavić

BORELLI medal for his Original Contribution to Space Medicine, granted by 2nd University of Napoli, Italy

Prof. Igor Muševič

Samsung-Mid-Career Award, Južna Koreja, International Liquid Crystal Society



The winners of the Jožef Stefan Golden Emblem Prize and their mentors

Prof. Danilo Suvorov

Inauguration: Academician of the World Academy of Ceramics, The Council of the World Academy of Ceramics

Inauguration: Fellow of the American Ceramic Society, Board of Directors of the American Ceramic Society

Hana Uršič

Certificate of Award for Encouragement of Research in Materials Science for the contribution "Effect of Processing for CSD-derived LNO Seeding Layer on Electrical Properties of PZT Thin Film", The IUMRS International Conference in Asia 2008

Asja Veber

Award for the best poster on conference YUCOMAT 2008, Herceg Novi, Montenegro, Awarding Committee of the YUCOMAT 2008 Conference
The Thickness, Morphology and Structure of Sol-Gel Bi_{1-x}SiO₂ thin films.

Asst. Prof. Primož Zihertl

Outstanding Referee (American Physical Society, 2008)

The award "European Regional Environment Champion 2008" was awarded to the **Environmental Technologies Excellence Centre** by the European Regional Champions Award Expert Panel.

AWARDS TO JSI RESEARCHERS BY SLOVENIAN INSTITUTIONS

Kristina Eleršič

Best poster award, 3rd European School in Materials Science of Complex Metallic Alloys, Surface and Coatings, "Damages and surface modification on bacteria Escherichia coli caused by plasma treatment" Ljubljana, Slovenia

Ita Junkar

Best poster award, Conference MIDEM, 44th International Conference on Microelectronics, Devices and Materials with the workshop on Advanced Plasma Technologies
Improvement of polymer properties by plasma treatment

Boštjan Kaluža

Faculty Prešeren award, Faculty of Computer and Information Science, Ljubljana, Bachelor thesis: Analysis of pathological models of minimax and Pearl's game.

Katja Koenig

3rd Best Poster Award, HOT NANO TOPICS 2008, Workshop "Functional nanostructures and particles"
Influence of the suspension stability on the electrophoretic deposition of nanosized alumina and silica

Prof. Marija Kosec

Acknowledgement from Chamber of Craft and Small Business of Slovenia for extraordinary effort in the integration of science and business

Dr. Tadeja Kosec

Trimo research award for Ph.D. thesis 2008

Alja Kupec

Students Prešeren Award, B. Sc. thesis
Insulation of electrically conductive fibres

Aljoša Maglica

Award for the best lecture presentation among fellow researchers in the group for inorganic materials, 1st International Conference on Materials and Technology, sponsored by IUVESTA and FEMS

Prof. Slavko Pečar

Minarikovo acknowledgment, Slovenian Pharmacy Association

Asst. Prof. Uroš Petrovič

Lapanje prize of the Slovenian Biochemical Society for outstanding achievements in biochemical sciences

Katarina Rade

3rd Best nanoArt Contribution at the HOT NANO TOPICS 2008, for the nanoArt photo of the Hydroxyapatite precipitated from simulated body fluid on bio-glass substrate.
Hungry Bacteria Was Here

Dr. Jerica Sabotič

Krka Award for Ph. D. thesis
Characterisation of mycocypins from selected basidiomycete species using genetic and protein engineering

Dr. Srečo D. Škapin

Award for the poster presentation, Hot Nano Topics 08, Portorož Slovenia,
Photocatalytic undoped and doped nanotitanium for building applications

Janja Zupančič

Student Prešeren Award for B. Sc. Thesis
Development and usage of gene construct for expression of heterologous proteins by using lactic bacteria

Prof. Nataša Vaupotič

The Silver Sign of the University of Maribor, University of Maribor, for the successful leadership of the Department of Physics, for innovative and successful work in the field of physics education and for top achievements in scientific research at the Faculty of Natural Science and Mathematics at the University of Maribor.

Moja Žnidaršič

Award for the best contribution of young researchers, 1st International Conference on Materials and Technologies, Portorož, Awarding Committee of the Conference
The structural and electrical properties of a solid solution based on Na_{0.5}Bi_{0.5}TiO₃-K_{0.5}Bi_{0.5}TiO₃

Jožef Stefan Institute and Špica International d. o. o.

Award for placement among 30 selected innovations in 2008, Ljubljana, 3rd Slovenian Forum of Innovations, Public Agency of the Republic of Slovenia for Entrepreneurship and Foreign Investments
Device for intelligent entry control

REVIEW OF PUBLICATIONS

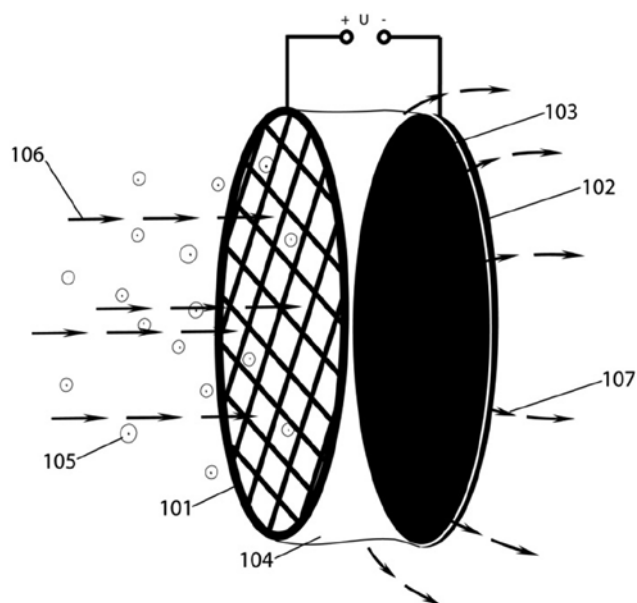
FOR 2008

Department	Original Articles*	Books	Patent Appl. and Grants	Theses
Department of Theoretical Physics (F-1)	86	2		3
Department of Low and Medium Energy Physics (F-2)	52	4		
Department of Thin Films and Surfaces (F-3)	19			
Department of Surface Engineering and Optoelectronics (F-4)	58		3	
Department of Solid State Physics (F-5)	135	5	8	3
Department for Complex Matter (F-7)	35	2	1	2
Department of Reactor Physics (F-8)	49			
Department of Experimental Particle Physics (F-9)	117	8		1
Department of Inorganic Chemistry and Technology (K-1)	40		2	
Department of Physical and Organic Chemistry (K-3)	27			2
Electronic Ceramics Department (K-5)	55		3	2
Engineering Ceramics Department (K-6)	20	1		1
Department for Nanostructured Materials (K-7)	59		1	1
Department for Synthesis of Materials (K-8)	30			
Department for Advanced Materials (K-9)	16			3
Department of Biochemistry, Molecular and Structural Biology (B-1)	35		1	2
Department of Molecular and Biomedical sciences (B-2)	15			4
Department of Biotechnology (B-3)	55		3	1
Department of Environmental Sciences (O-2)	95	2		5
Department of Automation, Biocybernetics and Robotics (E-1)	45	1	1	
Department of Systems and Control (E-2)	49	1		2
Laboratory for Open Systems and Networks (E-5)	27			
Department of Communication Systems (E-6)	45			2
Department of Computer Systems (E-7)	23	1		
Department of Knowledge Technologies (E-8)	66	3		2
Department of Intelligent Systems (E-9)	53	1		2
Department of Reactor Engineering (R-4)	60	2		3
Centre for Networking Infrastructure (CNI)		1		
Energy Efficiency Centre (EEC)	12			
Milan Čopič Nuclear Training Centre (ICJT)	7			1
Radiation Protection Unit (SVPIS)	9			1
Technology Transfer Office (U-9)	6			
TOTAL	1318	30	20	43

* Articles in Journals and Conference proceedings, and Chapters in books

PATENTS GRANTED

1. Processing of dense ceramics based on alkaline niobates and tantalates
Janez Holc, Janez Bernard, Barbara Malič, Marija Kosec
SI Patent No. 22380
2. Lead-perovskite-based thick-film structures on reactive ceramics and methods of production
Janez Holc, Silvo Drnovšek, Marija Kosec
SI Patent No. 22401
3. Scanning projection field emission microscope designed to study flat broad-area field emission cathodes
Vincenc Nemanič, Marko Žumer, Bojan Zajec, Mihael Kocmur
Patent No. 22425
4. Procedure for the synthesis of threadlike tungsten oxide W_5O_{14}
Maja Remškar, Marko Viršek, Miha Kocmur, Adolf Jesih
SI Patent No. 22445
5. Polarisation-enhanced double-channel NQR/NMR detection of solid and liquid explosives with multi pulse sequences
Robert Blinc, Zvonko Trontelj, Janko Lužnik, Tomaž Apih, Janez Seliger, Gojmir Lahajnar
SI Patent No.22459
6. Polyester material with surface having antithrombogenic properties and a method for preparation
Simona Strnad, Tea Indest, Janne Laine, Karin Stana-Kleinschek, Alenka Vesel, Renate Dworcak
SI Patent No. 22467
7. A process for the synthesis of nanotubes and fullerene-like nanostructures of dichalcogenides transition metals
Aleš Mrzel, Maja Remškar, Adolf Jesih, Marko Viršek
SI Patent No. 22485
8. Procedure of synthesis of amidines and their derivatives
Kristina Nadrah, Marija Sollner Dolenc, Slavko Pečar
SI Patent No. 22487
9. Metamaterials and resonant materials based on liquid crystal dispersions of colloidal particles and nanoparticles
Igor Muševič, Miha Škarabot, Slobodan Žumer, Miha Ravnik
SI Patent No. 22508
10. Process for Applying Adhesion Coating to a Substrate
Tomaž Kosmač, Kristoffer Krnel, Andraž Kocjan, Peter Jevnikar
SI Patent No. 22527
11. Procedure of preparation of magnetic nanocomposites with high content of nanoparticles dispersed in polymer matrix
Darko Makovec, Sašo Gyergyek, Miroslav Huskič, Miha Drofenik
SI Patent No. 22539
12. Processing of alumina porcelain for electrotechnics
Martina Oberžan, Janez Holc, Marjan Buh, Vlasta Imperl
SI Patent No. 22541
13. High Contrast, Wide Viewing Angle LCD Light-Switching Element
Janez Pirš, Matej Bažec, Sivija Pirš, Bojan Marin, Andrej Vrečko
Patent No. EP 1625445, US patent US 7,420,631
14. Tool for measuring magnetic properties at high temperatures
Paul J. McGuinness, Gregor Geršak, Spomenka Kobe
Patent US7368906 B2



Nanoparticles in air form nuclei for liquid condensation in a previous process. The droplets enter a dielectric field of a capacitor changing its capacitance and forming an electric signal. The method is suitable for detection of aerosols in a wide range of their concentration in air and is not specific for a shape or a chemical composition of nanoparticles.

Title of patent application: Method and capacitance apparatus for aerosol nanoparticle counting

*Inventors: Maja Remškar, Ivan Iskra, Marko Viršek (JSI), Mark Pleško, Damjan Golob (Cosylab, d. d.)
(published with permission of the authors)*

CENTRES OF EXCELLENCE

Research Centres of Excellence, a concept developed by the Ministry of Higher Education, Science and Technology and co-financed by the European Regional Development Fund, are a new form of cooperation between research institutes, academic institutions, and industry. Their main goal is the development of an innovative environment to facilitate the transfer, management, and development of new technologies in various priority areas of research and technology. For the period 2004-2006, the Jožef Stefan Institute has been chosen as the coordinator of four Centres of Excellence, with twenty R&D projects.

Nanoscience and Nanotechnology

Head: Prof. Dragan Dragoljub Mihailović

Project Activity Group (projects are cofunded by European Union):

1. Project for encouraging innovation, Measure 1.1.
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: LPFK, d.o.o., Zgornje Jezerško; Belinka Belles, d.o.o., Ljubljana; Iskra Feriti, d.o.o., Ljubljana; Keko Oprema, d.o.o., Žužemberk; MS Production, Bled; Iskra Mehanizmi, d.d., Kropa; Lek, d.d., Ljubljana; Acroni, d.o.o., Jesenice; Iskra Kondenzatorji, d.d., Semič; Eta Cerčno, d.o.o., Cerčno; Steklarna Hrastnik, d.d., Hrastnik; Steklarna Rogaška, d.d., Rogaška Slatina; HYB, d.o.o., Šentjernej; Balder, d.o.o., Ljubljana; Cinkarna Celje, d.d., Celje; AET, d.o.o., Tolmin; Kolektor Pro, d.o.o., Idrija; Atotech, d.d., Podnart; Iskra Tela, d.d., Ljubljana; Predilnica Litija, d.o.o., Litija; Termo, d.d., Škofja Loka; Mo6, d.o.o., Ljubljana; National Institute of Chemistry, Ljubljana
2. Synthesis of 1D Inorganic Nanostructures, Bionanostructures and Preparation of Composites
Project leader: Aleš Mrzel
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: Termo, d.d., Škofja Loka; Mo6, d.o.o., Ljubljana
3. Nanomaterials in Electrochemical Systems
Project leader: Janez Jamnik
Leading institution: National Institute of Chemistry, Ljubljana
Cooperating partners: Atotech, d.d., Podnart; Iskra Tela, d.d., Ljubljana; Predilnica Litija, d.o.o., Litija; Jozef Stefan, Ljubljana; University of Ljubljana, Faculty of chemistry, Ljubljana; University of Maribor, Faculty of mechanical engineering, Maribor
4. Nanostructured Surfaces and Interfaces
Project leader: Igor Muševič
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: HYB, d.o.o., Šentjernej; Balder, d.o.o., Ljubljana; Cinkarna Celje, d.d., Celje; AET, d.o.o., Tolmin; Kolektor Pro, d.o.o., Idrija; HIPOT-RR, d.o.o., Šentjernej; University of Nova Gorica, Nova Gorica
5. Characterisation on a Nanometric Scale
Project leader: Miran Čeh
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: Lek, d.d., Ljubljana; Acroni, d.o.o., Jesenice; Iskra Kondenzatorji, d.d., Semič; Eta Cerčno, d.o.o., Cerčno; Steklarna Hrastnik, d.d., Hrastnik; Steklarna Rogaška, d.d., Rogaška Slatina; Institute of Metals Tehnology, Ljubljana; National Institute of Chemistry, Ljubljana
6. Synthesis of Nanoparticles and Nanocomposites
Project leader: Darko Makovec
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: Belinka Belles, d.o.o., Ljubljana; Institute of Metals and Technology, Ljubljana; National Institute of Chemistry, Ljubljana; Keko Oprema, d.o.o., Žužemberk; MS Production, Bled; Iskra Mehanizmi, d.d., Kropa; KOLEKTOR MAGMA, d.o.o., Ljubljana
7. Nanoelectronics and Nanotechnology Facilities
Project leader: Dragan Mihailović
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: LPKF Laser & Elektronika, d.o.o., Zgornje Jezerško; University of Nova Gorica
8. The Development of the Research Infrastructure of The Center of Excellence and Nanotechnology (CE NS and NT), Measure 1.4.
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: LPKF Laser & Elektronika, d.o.o., Zgornje Jezerško; National Institute of Chemistry, Ljubljana

Materials for Electronics of Next Generation and Other Emerging Technologies

Head: Prof. Marija Kosec

Project Activity Group:

1. Magnetic Materials and Intermetallic Alloys
Project leader: Spomenka Kobe
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: Institute of Metals and Technology, Ljubljana; Magneti, d. d., Ljubljana; Kolektor Magma, d. o. o., Ljubljana; Kolektor, d.o.o., Idrija.
2. Microstructures and Microsystems
Project leader: Janez Trontelj
Leading institution: University of Ljubljana, Faculty of Electrical Engineering, Ljubljana
Cooperating partners: Iskra Tela, d. d., Ljubljana; Iskra Avtoelektrika, d. d., Nova Gorica
3. New generation of Elements and Devices for Protection Against Transient Surges
Project leader: Slavko Bernik
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: Milan Vidmar Electric Power Research Institute, Ljubljana; Zavod TC SEMTO, Ljubljana; VARSI, d. o. o., Ljubljana; Iskra Zaščite, d. o. o., Ljubljana; University of Ljubljana, Faculty of Electrical Engineering, Ljubljana; Iskra Tela, d. d., Ljubljana
4. Hybrid Materials and Structures
Project leader: Janez Holc
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: HIPOT-RR, d. o. o., Šentjernej; HYB, d. o. o., Šentjernej
5. Complex Materials for New Technologies: From Soft Matter to Hard Coatings
Project leader: Slobodan Žumer
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: Gorenje, d. d., Velenje; Balder, d. o. o., Ljubljana; University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana; Institute for Mathematics, Physics and Mechanics in Ljubljana, Laboratory for NQR and weak magnetic fields, Ljubljana

Environmental Technologies

Head: Prof. Milena Horvat

Project Activity Group:

1. Biological Methods of Wastewater Treatment
Leading institution: University of Ljubljana, Faculty of Civil Engineering and Geodesy, Ljubljana
Cooperating partners: University of Ljubljana, Biotechnical Faculty; University of Ljubljana, Faculty of Medicine; University of Nova Gorica; National Institute of Biology, Ljubljana; Inštitut za vodarstvo, d.o.o., Ljubljana; National Institute of Chemistry, Ljubljana; Komunalno podjetje Velenje, d. o. o., Velenje; Esotech, d. d., Velenje; RACI d.o.o., Ljubljana; LIMNOS – Company for Applied Ecology, d. o. o., Ljubljana; Lek farmacevtska družba d.d., Ljubljana, Fructal živilska industrija d.d., Ajdovščina; Javno podjetje Okolje Piran, d.o.o., Piran; Helios Domžale d.d., Domžale; Euroinvest, d.o.o., Nova Gorica; Salonit Anhovo gradbeni materiali, d.d., Anhovo; Cinkarna Celje, d.d., Celje.
2. Ecoremediation Technologies
Leading institution: University of Ljubljana, Biotechnical faculty, Ljubljana
Cooperating partners: Institute of Physical Biology, Grosuplje; University of Ljubljana; Slovenian Forestry Institute, Ljubljana; GSF – National Research Center for Environment and Health, Institut for Soil Ecology, Neuherberg, Germany; Community of Celje, Celje; ERICo, Environmental Research & Industrial Co-operation Institute, Velenje; Limnos – Company for Applied Ecology, d. o. o., Ljubljana, Nuclear Power Plant Krško, d.o.o., Krško; PV Invest, d.o.o., Velenje; Javno komunalno podjetje Cankova, d.o.o., Cankova; Komunalno podjetje Velenje, d. o. o., Velenje; Javno podjetje Centralna čistilna naprava Domžale-Kamnik, d.o.o., Domžale;
3. Recycling and Use of Waste
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: University of Maribor, Faculty of Chemistry, Maribor; Esotech, d. d., Velenje; National Institute of Biology, Ljubljana; Domžale – Kamnik Wastewater Treatment Plant, d. o. o., Domžale; National Institute of Chemistry, Ljubljana; TKI Hrastnik, d.d., Hrastnik; TANIN Sevnica, Industry of Chemistry, d.d., Sevnica, Radenska d.d., Radenci.

Advanced Control Technologies

Head: Prof. Stanko Strmčnik

Project Activity Group:

1. Advanced Control Methods
Leading institution: University of Ljubljana, Faculty of Electrical Engineering, Ljubljana
Cooperating Partners: Jožef Stefan Institute, Ljubljana; Robotina d.o.o., Koper; Metronik, d.o.o., Ljubljana; Liko Pris, d.o.o., Vrhnika; Lek, d.d., Ljubljana; Domžale – Kamnik Wastewater Treatment Plant, d.o.o., Domžale
2. Automatic On-line Supervision of Processes and Product Quality Control
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: Domel, d.d., Železniki; Telem, d.o.o., Maribor; FDS Research, d.o.o., Trzin;
3. Technologies of Distant and Distributed Control
Leading institution: University of Maribor, Faculty of Electrical Engineering and Computer Science, Maribor
Cooperating partners: Jožef Stefan Institute, Ljubljana; University of Ljubljana, Faculty of Electrical Engineering, Ljubljana; Inea, d. o. o., Ljubljana; Spica International, d. o. o., Ljubljana; Telem, d. o. o., Maribor
4. Decision Support for Control in Production
Leading institution: Jožef Stefan Institute, Ljubljana
Cooperating partners: University of Ljubljana, Faculty of Electrical Engineering, Ljubljana; University of Maribor, Faculty of Electrical Engineering and Computer Science, Maribor; Inea, d. o. o., Ljubljana; Metronik, d. o. o., Ljubljana; Synatec, d. o. o., Idrija.
5. Product Information Management through Complete Lifecycle
Leading institution: University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana
Cooperating partners: Domel, d. d., Železniki; Alpina, d. d., Žiri
6. Project Control in System of Orders
Leading institution: University of Ljubljana, Faculty of Mechanical Engineering, Ljubljana
Cooperating partners: Eti Elektroelement, d. d., Izlake; Liv Plastika, d. o. o., Postojna

KNOWLEDGE TRANSFER

The JSI pay 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.

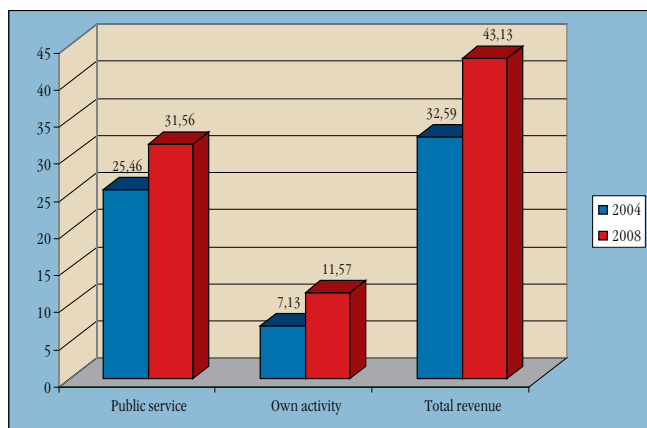
R & D PROJECT PARTNERS

1. Agenda, d. o. o., Maribor
2. Alpineon, d.o.o., Ljubljana
3. Amebis, d. o. o., Kamnik
4. ARAO, Ljubljana
5. ATR, Computational Neuroscience Laboratories, Hikoridal, Seika-cho, Japan
6. Balder, d. o. o., Ljubljana
7. Bioiks, d. o. o., Ljubljana
8. CEA - Commissariat à l'Énergie Atomique, Gif-Sur-Yvette, France
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10. Cinkarna Celje, d. d., Celje
11. Dartmouth College, Hanover, USA
12. DESY - Deutsches Elektronen Synchrotron, Hamburg, Germany
13. Droga Kolinska, d. d., Ljubljana
14. Elgo - line, d. o. o., Cerknica
15. EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
16. ESF - European Science Foundation, Strasbourg, France
17. ESOTECH, d. d., Velenje
18. European Commission, Brussels, Belgium
19. European Commission-Directorate General JRC, Brussels, Belgium
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21. Gen, d. o. o., Krško
22. Health Insurance Institute of Slovenia, Ljubljana
23. Heraklith Consulting & Engineering GmbH, Ferndorf, Austria
24. HFSPo- International Human Frontier Science Program Organization, Strasbourg, France
25. Hyb Proizvodnja hibridnih vezij, d. o. o., Šentjernej
26. IAEA - International Atomic Energy Agency, Vienna, Austria
27. Induktio, d. o. o., Ljubljana
28. INEA, d. o. o., Ljubljana
29. Institute of Oncology, Ljubljana
30. Instrumentation Technologies, d. d., Solkan
31. INTAS - International Association for the promotion of co-operatin with scientists from the New Independent States of the former Soviet Union, Brussels, Belgium
32. Interdent, d. o. o., Celje
33. IRMM - Institute for Reference Materials and Measurements, Geel, Belgium
34. Iskra Kondenzatorji Industrija kondenzatorjev in opreme, d. d., Semič
35. Iskra Zaščite, d. o. o., Ljubljana
36. JAPTI-Public Agency of the Republic of Slovenia for Entrepreneurship and Foreign Investments, Ljubljana
37. ARRS-Slovenian Research Agency, Ljubljana
38. Joanneum Research Forschungsgesellschaft mbH, Graz, Austria
39. Kolektor group, d. o. o., Idrija
40. Korea Basic Science Institute, Daejeon, South Korea
41. Kovinos, d. o. o., Horjul
42. Laboratory for Protection and Physiology, Empa, Materials Science and Technology, St. Gallen, Switzerland
43. LEK farmacevtska družba, d. d., Ljubljana
44. Leniko, bvba, Antwerp, Belgium
45. L'OREAL - Moyens Communs Comptabilité Antenne G
46. Ministry of the Economy, Ljubljana
47. Ministry of Defence, Administration for Civil Protection and Disaster Relief, Ljubljana
48. Ministry of Environment and Spatial Planning, Environmental Agency, Ljubljana
49. Ministry of Environment and Spatial Planning, Slovenian Nuclear Safety Administration, Ljubljana
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53. Ministry of Higher Education, Science and Technology, Metrology Institute of the Republic of Slovenia, Ljubljana
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55. Ministry of Health, Chemicals Office of the Republic of Slovenia, Ljubljana
56. Ministry of Health, Slovenian Radiation protection, Ljubljana
57. Municipality of Ljubljana, Ljubljana
58. National Institute of Biology, Ljubljana
59. Nanotesla Institut Ljubljana, Ljubljana
60. NATO Public Diplomacy Division, Brussels, Belgium
61. Nederlands Normalisatie-instituut, Delft, Netherlands
62. Nevron, d. o. o., Ljubljana
63. Nuklearna elektrarna Krško, Krško
64. Österreichische Energieagentur - Austrian Energy Agency, Vienna, Austria
65. PAROC group oy AB, Vantaa, Finland
66. Phos, d. o. o., Sečovelje
67. PHOTONIS Netherlands B.V., Roden, Netherlands
68. PlasmaBull Engineering GmbH, Lebring, Austria
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72. RŽV, d. o. o., Gorenja vas
73. SCRI - The Scottish Crop Research Institute, Living Technology, Dundee, United Kingdom
74. Simt, d. o. o., Grosuplje
75. Sincrotrone Trieste S.C.p.A., Bazovica, Italy
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81. Termoelektrarna Toplarna Ljubljana, d. o. o., Ljubljana
82. The United Nations Environment Programme, Nairobi, Kenya
83. Trimo, d. d., Trebnje
84. TÜV Rheinland Immissionsschutz und Energiesysteme GmbH (TIE), Köln, Germany
85. Università degli Studi di Trieste, Trieste, Italy
86. Universität Bayreuth, Bayreuth, Germany
87. University of Ljubljana, Faculty of Electrical Engineering, Ljubljana
88. Urban Planning Institute RS, Ljubljana
89. USNRC - United States Nuclear Regulatory Commission, Washington, USA
90. Varsi, d. o. o., Ljubljana
91. WSL - Swiss Federal Research Institute, Birmensdorf, Switzerland

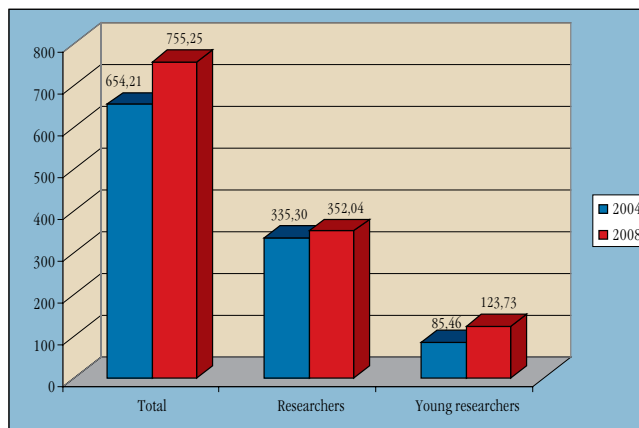
INSTITUTE IN NUMBERS

2004-2008

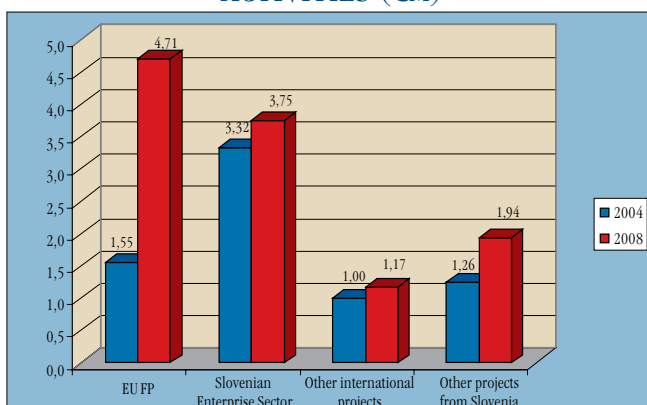
COMPARISON OF REVENUES (€M)



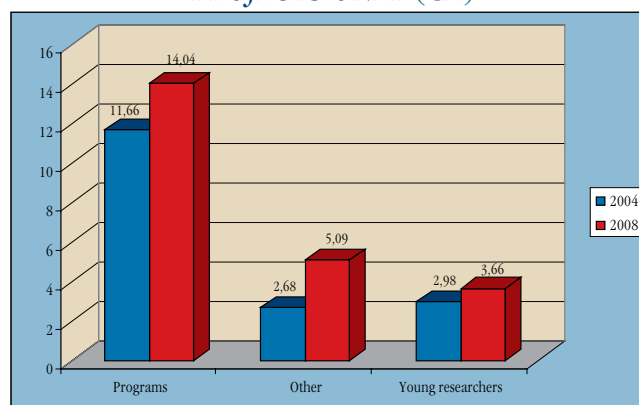
EMPLOYEES (FTE)



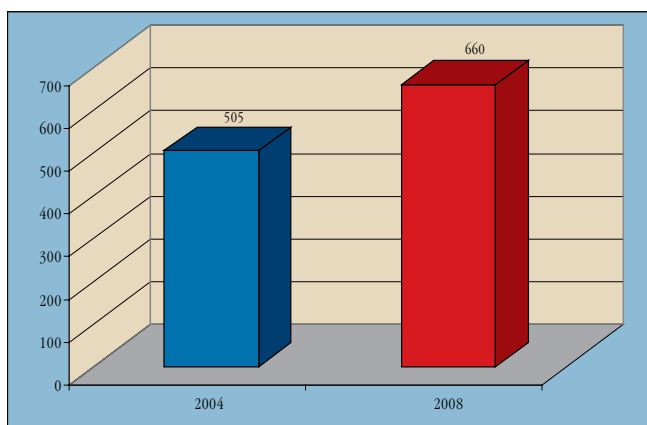
REVENUES FROM MARKET-BASED ACTIVITIES (€M)



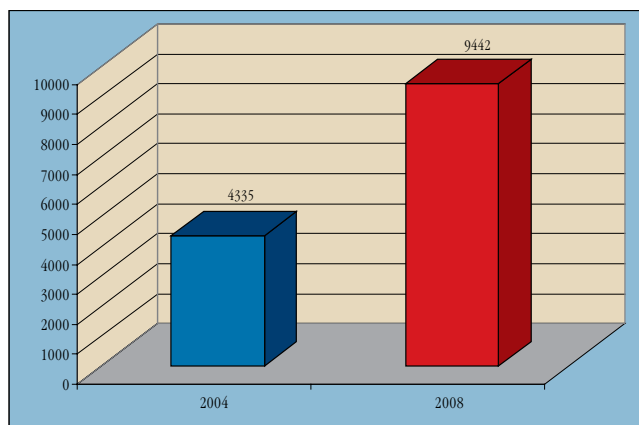
REVENUES FROM PUBLIC SERVICES - PROJECTS ONLY (€M)



NUMBER OF PUBLICATIONS IN THE WEB OF SCIENCE



NUMBER OF CITATIONS



RESEARCH DEPARTMENTS

DEPARTMENT OF THEORETICAL PHYSICS

F-1

The research program of the Department of Theoretical Physics is focused on the theory of condensed-matter physics, statistical physics, the physics of nuclei, particles and fields, as well as biophysics and soft condensed-matter physics. The department also maintains its own high-performance computing facility, for which it develops the necessary software. These studies are carried out in close collaboration with several experimental groups at the Jožef Stefan Institute as well as with local and foreign universities and institutes. The department is also involved in various international projects.

The group of Theoretical Physics of Nuclei, Particles and Fields has investigated the structure of hadrons, the effective theories of weak and electromagnetic mesonic decays, the unified theory of elementary interactions, the relativistic theory of membranes and precise calculations of the properties of three-body systems in atomic physics.



Head:
Prof. Svjetlana Fajfer

We have derived a method for calculating the multi-channel K matrix applicable to a broad class of models in which mesons linearly couple to the quark core. A good agreement with experiment has been achieved for pion scattering in the energy region of the low-lying P11 and P33 resonances, assuming that the two-pion decay proceeds through the intermediate pion-Delta and sigma-nucleon channels.

The only hadronic states that have been confirmed beyond doubt are baryons, composed of three quarks, and mesons, composed of a quark and an antiquark. There are several strong indications that the observed light scalar resonances might be non-conventional tetraquark states, composed of two valence quarks and two antiquarks. However, our lattice QCD simulations at $m_{\text{ud}} > 40$ MeV give no indication of the existence of light scalar tetraquark states.

We have analyzed models of “beyond the Standard Model” physics, respecting the minimal flavour violation hypothesis in the effective theory approach. We have explored possible signals at the B and K meson factories, derived bounds on new physics contributions from existing measurements and gave suggestions for future experiments. In addition we have analyzed and emphasized the rare semileptonic decay $B \rightarrow D\tau\nu$, which is sensitive to possible new-physics contributions and can be put under theoretical control with the combined application of heavy-quark effective theories, chiral theories and lattice QCD simulations. Therefore, it is suitable for precise studies at the LHCb experiment.

Recently, B-factories have published new results on the $B \rightarrow K\eta\gamma$ decays, being inspired by the theoretical suggestion to search for new physics in B meson decays to two pseudoscalar mesons and a photon. Using heavy-meson chiral perturbation theory we found a mechanism that governs the amplitude in parts of the Dalitz plot where either K or η mesons are soft. The dominant contributions in these cases come from the nonresonant decay modes. We also discuss the $B \rightarrow K\eta'\gamma$ Dalitz plot. Our partially integrated rates are in agreement with the experimental findings.

Together with our collaborators we have written a review article for Rev. Mod. Phys. on the searches for new physics at the future Super Flavor Factory. We have shown that even in two-body hadronic decays one can arrive at precise predictions for the interesting observables – we have shown this for the case of time-dependent asymmetries in the decays of neutral B mesons into a neutral kaon and a neutral pion. We have shown that the ratio of the Higgs production cross-section with a cut on the Higgs particles transverse momentum and the inclusive cross-section can be precisely predicted in the Standard Model. This is an interesting observable for light-resonance searches. We have also shown that with a two-component dark-matter model we can explain the large annihilation cross-sections indicated by the results of PAMELA and ATIC experiments.

We have, in a model-independent approach, analyzed bounds and proposed signals of minimal flavour violating new-physics models at present and future experiments probing the flavour transitions of quarks.

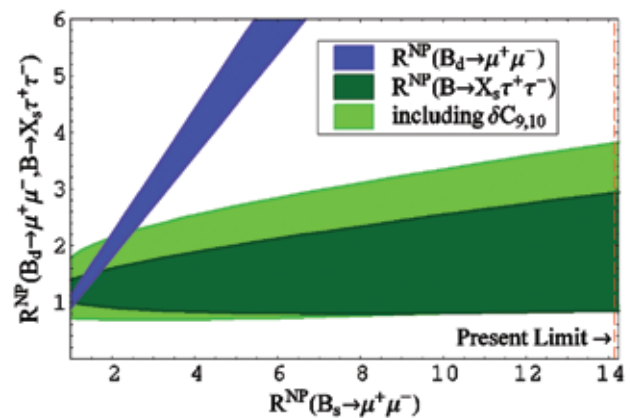


Figure 1: Bounds on the parameter space of the Two-Higgs-Doublet model type II from B meson factory measurements: rare decays $B \rightarrow \tau\nu$ (blue shaded area), $B \rightarrow D\tau\nu$ (gray shaded area); allowed projected measured deviation of the second decay with respect to the Standard Model prediction.

We have constructed a supersymmetric model without gauge singlets that spontaneously breaks both supersymmetry and gauge symmetry. We have shown that the minimal supersymmetric unified SO(10) model can describe all fermion masses and mixings, if the sfermions are much heavier than the gauginos. The solution found implies a fast $d=6$ proton decay and a 13-neutrino mixing angle of 5 degrees.

We have investigated the unification of fundamental interactions and particles within the framework of a 16-dimensional space whose tangent space is the Clifford algebra $Cl(1,3)$. The latter space is a vector space, whose elements can be rotated into each other by the action of the group $SO(8,8)$, and over which we can generate a higher dimensional Clifford algebra $Cl(8,8)$. A subspace of $Cl(8,8)$ is the Lie algebra of the exceptional group E_8 , a possible unification group.

Using the quasilinearization method (QLM) for differential equations we calculated the energies of the harmonic oscillator with a power-type singular term (spiked oscillator) for small and large values of the spike coefficient. In this case even perturbation theory works with, at most, limited precision and only for certain values of the coefficient, while QLM yielded 20 significant digits with a few iterations.

The group for Solid-State Theory and Statistical Physics has been investigating the properties of relaxor ferroelectrics, complex networks and self-organised structures, thermodynamic and transport properties of spin systems, nanosystems and quantum dots as well as models of strongly correlated electrons that are relevant to novel materials.

Two types of relaxation processes occurring in dipolar glasses and relaxor ferroelectrics have been discussed. The first of these is based on the analogy with supercooled glass-forming liquids and involves cooperative reorientation of the dipolar degrees of freedom. The relaxation time diverges at the Kauzmann temperature, where the extrapolated entropy tends to zero. This process is applicable to dipolar glasses. The second process is due to the growth and percolation of polar nanoregions in relaxor ferroelectrics. In both cases the relaxation time diverges according to the Vogel-Fulcher law.

We have continued with our study of the statistical physics of complex systems and networks, and have applied the theory of networks to study the structure of nanoparticle films and its influence on the single-electron conductivity. We have also studied the collective dynamical behaviour and stability of complex networks using the coupled chaotic maps and have developed appropriate algorithms for the detection of “weighted” subgraphs in modular (computer-generated and real-data) networks.

We have continued our investigation of the dynamical properties of 1D spin systems, in particular of the spin and thermal transport in such systems. With the application of numerical methods it was shown for the anisotropic Heisenberg model with random local fields that interaction does not destroy localization and the absence of transport within the ground state. On the other hand, at finite temperatures all the systems reveal normal dissipative transport. The effects of localization were also observed using the t-DMRG method. Prior to any realization is the development of the novel DMRG method for the dynamical properties of correlated systems at finite T . We studied the consequences of Dzyaloshinsky-Moriya interactions on the spin-spin correlations in the $S=1/2$ Heisenberg model on the Kagome lattice. We found that the out-of-plane $Dz/J > 0.1$ component spontaneously breaks the $U(1)$ symmetry and stabilizes the coplanar configurations of the spins. The application to the $ZnCu_3(OH)_6Cl_2$ compound was discussed. We also examined in simulations the ground-state configurations of dimeric and trimeric systems, which are realized on square and triangular lattices, when either two or three macro-ions are trapped in each external potential minimum. The bipartite orders of the checkerboard or stripe types were reported together with more complex quadripartite orderings.

Solutions of the models with correlated electrons coupled to lattice degrees of freedom represent one of the fundamental unsolved problems of modern solid-state physics. We have developed a new numerical method for calculating the physical properties of spin-lattice polaron in the t-J-Holstein model. Using this model in the strong electron-phonon coupling limit we were able to describe spectral properties of oxide superconductors in the low-doping regime. We have also analysed recent experimental data on inelastic neutron scattering in these compounds at low doping. In this regime the resonant peak is absent but another phenomenon, the E/T-scaling, is observed in a wide energy (E) and temperature (T) region. We

We explained why in nanostructures, e.g., oscillating molecules, the conductance can be drastically reduced simultaneously, with by a drastic increase of the Kondo temperature.

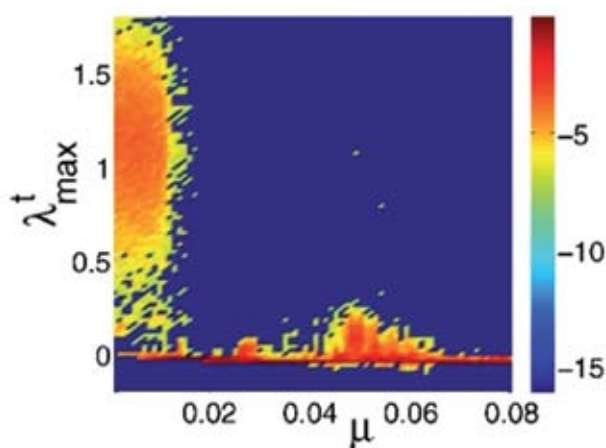


Figure 2: Finite-time Lyapunov exponent as a function of the coupling strength.

have shown that the E/T -scaling is a direct consequence of the overdamped nature of excitations, accompanied by the freezing of the spin dynamic, which is manifested in the saturation of spin-spin correlations at low T . We continued the study of the Luttinger sum rule in correlated systems. On a convenient example of 1D spinless fermions it was shown that the sum rule is broken within the Mott-Hubbard insulator, whereby the deviation is diminishing in the vicinity of the metal-insulator transition.

Quantum-dot cellular automaton (QCA) is a processing platform based on interacting quantum dots. We presented a study that introduces adiabatic switching into the ternary QCA and employs the adiabatic approach to successfully solve the issues of elementary ternary QCAs. This opens up the possibility for a realistic design of logical gates. The transport of electrons through a system consisting of metallic electrodes bridged by a single molecule was investigated. The system is described by the two-channel Anderson model where the oscillations of the molecule around the midpoint between the electrodes modulate the overlap integrals and thereby influence the transport. We found that the central position is energetically favourable only for minor electron-phonon coupling; for strong coupling the molecule is attracted to one of the leads. As a result, the conductance is suppressed and the Kondo temperature is enhanced. We investigated the stability and electronic properties of different molybdenum chalcogenide nanowires, $\text{Mo}_6\text{S}_x\text{I}_{9-x}$ ($x = 0$ to 9). Isolated, as well as several crystalline, arrangements of the nanowires were considered. In this way we were able to identify different contributions to the binding energy. The results were compared to the properties of nanowires, measured in the Department of Complex Matter of the JSI.

The group of Theoretical Biophysics and Soft Matter Physics focused on polyelectrolytes, liquid crystals, colloids, and phospholipid and biological membranes

Our efforts in the field of the physics of intermolecular interaction in biological systems are focused on studies of electrostatic and van der Waals forces. We investigated the effects of screening in dilute Na-DNA solutions. We showed that due to the electrostatic interactions, DNA molecules may collapse and form clusters. We analyzed the electrostatic interactions in the strong coupling limit in the presence of dielectric inhomogeneities, the weak and strong limits of electrostatic interaction between asymmetrically charged planar surfaces, ionic-cloud distribution close to a charged surface in the presence of salt, and the disorder and collapse of like-charged macroions. We also studied the van der Waals forces between carbon nanotubes and the packing of RNA in viral capsids.

We explored the phase diagram of colloidal molecular crystals and identified macroscopic structures stabilised by the internal molecular degrees of freedom. We studied the phonon spectra of 2D colloidal crystals and evaluated the wave-vector dependence of friction, which is caused by hydrodynamic interactions. We studied the bilayer structure in bent-core liquid crystals using both theoretical and experimental methods. We showed that the bilayer structure may result either from an asymmetric structure of the constituent molecules or from the general tilt structure.

We studied the structure of aggregates of simple cells and we showed that cell elasticity strongly affects the aggregate topology, simplifying it considerably in the moderate adhesion regime. We investigated the effect of the shape of a cell doublet on the formation of multicellular aggregates of red blood cells. We found that the rouleaux formation is expected whenever the outer doublet surfaces are either concave or flat, whereas in the strong-adhesion regime where the outer doublet surfaces are convex the cells should form rounded clump-like aggregates. We also explored the structure of layered tissues such as epithelia. We developed the equilibrium model of single-layer epithelia, whose three distinct solutions – disordered, hexatic, and hexagonal phase – are all observed experimentally. In a chapter in the monograph *The Golgi Apparatus – State of the art 110 years after Camillo Golgi's discovery* we discussed the geometry of organelles of the secretory pathway.

We used the model of airway smooth-muscle contraction to study the enzyme Rho kinase's action on calcium-dependent force development. In the model, explicit consideration of the mutual interaction between enzymes Rho kinase and myosin light-chain phosphatase was taken into account. We simulated the effect of the Rho kinase blockade and we showed

We proposed a theory of packing of DNA in bacteriophages and a theory of the self-assembly of RNA viruses.

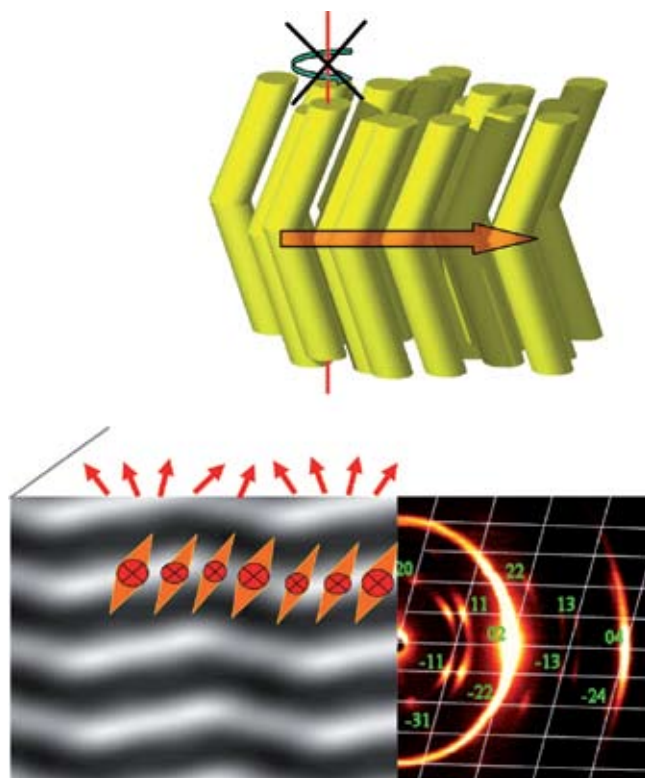


Figure 3: X-ray diffraction image of bent-core liquid crystals reveals a modulated bilayer structure found to be consistent with the tilted SmC_G

that the enzyme blocker acts as a phosphatase activator, which leads to the relaxation of muscles during a cholinergic stimulation. This important conclusion was verified experimentally by our collaborators from Bordeaux.

Our work included experimental and theoretical studies of physical phenomena that may improve the teaching practice in elementary and high schools. In particular, we explored two examples of everyday phenomena that can make school children more interested in science: the three-dimensional caustic networks, which can easily be observed in water, and the lenseless sharpening of sight.

Some outstanding publications in the past three years

Theoretical Physics of Nuclei, Particles and Fields

1. Borut Bajc, Miha Nemevšek, and Goran Senjanović, Probing seesaw at LHC, *Phys. Rev. D*, 76, 055011 (2007).
2. Svjetlana Fajfer, and Jernej Fesl Kamenik, Chiral loop corrections to strong decays of positive and negative parity charmed mesons, *Phys. Rev. D*, 74, 074023 (2006).

Solid-State Theory and Statistical Physics

1. Bosiljka Tadić, "From Microscopic Rules to Emergent Cooperativity in Large-Scale Patterns", Chapter 12 in the book "Systems Self-Assembly: Multidisciplinary Snapshots", Eds. N. Krasnogor et al., Elsevier (2008).
2. Janez Bonča, Rok Žitko, Enhanced conductance through side-coupled double quantum dots, *Phys. rev., B, Condens. matter mater. phys.*, 73, 035332 (2006).

Theoretical Biophysics and Soft Matter Physics:

1. Y. S. Jho, M. Kanduč, A. Naji, R. Podgornik, M. W. Kim in P. A. Pincus: Strong-Coupling Electrostatics in the Presence of Dielectric Inhomogeneities, *Phys. Rev. Lett.* 101, 188101 (2008).
2. S. El Shawish, J. Dobnikar in E. Trizac: Ground states of colloidal molecular crystals on periodic substrates, *Soft Matter* 4, 1491 (2008).

Awards and appointments

1. Prof. Dr. Nataša Vaupotič, The Silver Sign of the University of Maribor, University of Maribor, for the successful leadership of the Department of Physics, for innovative and successful work in the field of physics education and for top achievements in scientific research at the Faculty of Natural Science and Mathematics at the University of Maribor.
2. Asst. Prof. Primož Zihlerl, Outstanding Referee (American Physical Society, 2008)

Organization of conferences, congresses and meetings

1. Few-Quark States and the Continuum, Bled, Slovenia 15–22 Sept. 2008

INTERNATIONAL PROJECTS

1. Minimal Grand Unified Theory
MUST
Marie Curie
6. FP, MIF1-CT-2006-040907
EC
Asst. Prof. Borut Bajc
2. Novel Magnetic-mode Heat Transport for Thermal Management in Microelectronics
NOVMAG
6. FP, 032980
EC; Dr. Christian Hess, Leibniz Institute for Solid State and Materials Research Dresden, Institute for Solid State Research, Dresden, Germany
Prof. Peter Prelovšek
3. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries
MULTICERAL
6. FP, NMP3-CT-2006-032616
EC; Prof. Andrei Kholkin, University of Aveiro, Department of Ceramics & Glass Engineering, Aveiro, Portugal
Prof. Raša Pirc, Prof. Robert Blinc, Prof. Marija Kosic, Dr. Janez Holc
4. Fundamentals of Nanoelectronics
RTNNANO
6. FP, MRTN-CT-2003-504574
EC; Lancaster University, Lancaster, Great Britain
Prof. Anton Ramšak
5. Unifying Principles in Non-equilibrium Pattern Formation
PATTERNS
6. FP, MRTN-CT-2004-005728
EC; The University of Nottingham, Nottingham, Great Britain
Prof. Bosiljka Tadić
6. Emergent Behaviour in Correlated Matter
COST P16
EC
Prof. Peter Prelovšek
7. Colloidal Molecular Crystals
Cristaux colloïdaux moléculaires
PROTEUS 2008 – 2009
BI-FR/08-09-PROTEUS-012
Prof. Emmanuel Trizac, Laboratoire de Physique Théorique et Modèles Statistiques, Université Paris-Sud, Orsay Cedex, France
Dr. Jure Dobnikar

8. Hubbard, Computational Approach to Doped Mott-Hubbard Insulators
BI-JP/08-10-002
Prof. Takami Tohyama, Institute for Materials Research, Kyoto University, Kyoto, Japan
Prof. Peter Prelovšek
9. Properties of Baryons in Chiral Soliton Models
BI-PL/08-09-007
Prof. Wojciech Broniowski, Institute of Nuclear Physics, Kraków, Poland
Prof. Bojan Golli
10. Quark Models for Meson Electroproduction
Modelos de quarks para electroproducao de mesoes
BI-PT/08-09-012
Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
Prof. Bojan Golli, Asst. Prof. Simon Širca
11. Nucleon Resonances in Chiral Models
BI-PT/06-07-010
Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
Prof. Bojan Golli, Asst. Prof. Simon Širca
12. Simulations and Analysis of Complex Networks in Planetary Dynamics, Algorithms and Applications
Simulacija i analiza kompleksnih mreža u planetarnoj dinamici, algoritmi i aplikacije
BI-RS/08-09-047
Prof. Aleksandar Bogojević, Institut za fiziku, Beograd-Zemun, Serbia
Prof. Bosiljka Tadić
13. Physics of Heavy Mesons
BI-RS/08-09-029
Prof. Veljko Dmitrašinović, Institute for Nuclear Sciences "Vinca", Laboratory 010, Belgrade, Serbia
Prof. Sveltana Fajfer
14. Electronic Properties of Quantum Dots and Nanodevices
BI-UA/07-08-006
Dr. Sergei Kruchinin, Bogolyubov Institute for Theoretical Physics, Kiev, Ukraina
Prof. Janez Bonča
15. Continuum and Discrete Theory of Smectic Liquid Crystals
BI-US/08-10-028
Dr. Brigita Urbanc, Department of Physics, Boston University, Boston, MA, USA
Prof. Mojca Čepič
16. Effective Theories for LHC
BI-US/08-10-021
Prof. Ira Rothestei, Department of Physics, Carnegie Mellon University, Pittsburgh, PA, USA
Asst. Prof. Jure Zupan
17. Novel States of Correlated Electron Systems
BI-US/08-10-002
Dr. Daniel Batista, Los Alamos National Laboratory, Los Alamos, NM, USA
Prof. Janez Bonča
18. Novel Phases of Correlated Electron Systems
BI-US/06-07-010
Dr. James Gubernatis, Los Alamos National Laboratory, Los Alamos, NM, USA
Prof. Janez Bonča

R & D GRANTS AND CONTRACTS

1. Carbon nanotube based spin qubits
Prof. Anton Ramšak
2. Quantum many-body dynamics in nanostructures and quantum information
Dr. Kristjan Haule
3. Novel ground states of frustrated spin systems under doping
Dr. Samir El Shawish

RESEARCH PROGRAMS

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

VISITORS FROM ABROAD

1. Dr. George Giavaras, Department of Physics, Lancaster University, Lancaster, Great Britain, 7 Jan. to 26 Apr. 2008
2. Marija Mitrović, B.Sc., Institute for Physics, Belgrade, Serbia, 16 Jan. to 15 Feb. 2008; 10-24 May 2008; and 10 Sept. to 8 Nov. 2008
3. Jelena Grujić, B. Sc., Institute for Physics, Belgrade, Serbia, 16 Jan. to 15 Feb. 2008; 10-24 May 2008; and 10-24 Sept. 2008
4. Dr. Alejandro Ibarra, DESY Deutsches Elektronen Synchrotron, Hamburg, Germany, 3-5 Feb. 2008
5. Dr. Emile Grgin, Independent researcher, New York, USA, 13-15 Feb. 2008
6. Prof. Dr. John Jefferson, QinetiQ, Great Malvern, Great Britain, 13-16 Feb. 2008
7. Dejan Stokić, M.Sc., COSY, Medical University of Vienna, Vienna, Austria, 15-25 Feb. 2008
8. Alexis Metavitsiadis, B.Sc., University of Iraklion, Iraklion, Greece, 10-23 Feb. 2008 and 5-18 Oct. 2008
9. Prof. Dr. Jan Eeg, Physics Department, Oslo University, Oslo, Norway, 26 Feb. to 13 Mar. 2008
10. Dr. Franziska Mattheus, Heidelberg University, Heidelberg, Germany, 24 Feb. to 1 Mar. 2008
11. Prof. Dr. Takami Tohyama, Yukawa Institute of Theoretical Physics, Kyoto University, Kyoto, Japan, 9-13 Apr. 2008 and 21-26 Jul. 2008
12. Dr. Shigetoshi Soto, Yukawa Institute of Theoretical Physics, Kyoto University, Kyoto, Japan, 9-13 Apr. 2008
13. Mag. Jelena Živković, Faculty of Science Radboud, Nijmegen University, Nijmegen, Netherlands, 5-10 Apr. 2008
14. Dr. Oktay Yilmaz, Mersin University, Çiftlikköy-Mersin, Turkey, 16 Mar. to 16 Sept. 2008
15. Prof. Dr. Vyatcheslav Priezzhev, Bogolyubov Laboratory JINR, Dubna, Russia, 3-11 Apr. 2008
16. Prof. Dr. Damir Bečirević, Laboratoire de Physique Théorique, Université Paris-Sud, Centre d'Orsay, Orsay, France, 6-19 Apr. 2008
17. Dr. Francesco Caravaghios, Milano University, Milan, Italy, 5-9 May 2008
18. Prof. Dr. Veljko Dmitrašinović, Institute for Nuclear Research Vinča, Belgrade, Serbia, 5-15 May 2008 and 1-8 Sept. 2008
19. Prof. Dr. Victor Mandelzweig, Racah Institute of Physics, Hebrew University, Jerusalem, Israel, 15-17 Jun. 2008
20. Olli Nik Punkkinen, Laboratory of Physics, Helsinki University, Helsinki, Finland, 2-8 Jun. 2008
21. Prof. Dr. Peter Horsch, Max-Planck Institute, Stuttgart, Germany, 3-6 Jun. 2008
22. Prof. Dr. Masayuki Imai in Yuka Sakuma, Ochanomizu University, Tokyo, Japan, 15-21 Jun. 2008
23. Prof. Dr. Sergei Kruchinin, Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine, 15-22 Jun. 2008 and 18-20 Sept. 2008
24. Prof. Dr. Vikram Soni, National Physical Laboratory, New Delhi, India, 7-12 Jul. 2008
25. Prof. Dr. Vladimir Hinkov, MPI für Festkörperforschung, Stuttgart, Germany, 13-15 Jul. 2008
26. Prof. Dr. Altug Ospineci, Middle East Technical University, Ankara, Turkey, 15-17 Jul. 2008
27. Prof. Dr. Bernhard J. Morkross, Department of Applied Condensed Matter Physics, University of Postdam, Postdam, Germany, 22-25 Jul. 2008
28. Prof. Dr. Emmanuel Trizac, Laboratoire de Physique Théorique et Modèles Statistiques, Université Paris-Sud, Paris, France, 21-28 Sept. 2008
29. Hong Li Zeng, B.Sc., Nanjing University of Aeronautics and Astronautics, Nanjing, China, 9 Oct. to 8 Nov. 2008
30. Prof. Dr. Valentin Vikhnin, Ioffe Institute, St. Petersburg, Russia, 2 Nov. to 14 Dec. 2008
31. Dr. Kerim Suruliz, The Abdus Salam ICTP, Trieste, Italy, 4-6 Nov. 2008
32. Prof. Dr. Elzbieta Zipper, Institute of Physics, Katowice, Poland, 10-13 Nov. 2008

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1. Asst. Prof. Borut Bajc
2. Dr. Osor Slaven Barišić
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13. Dr. Matej Pavšič

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 18. Prof. Anton Ramšak*
 19. Dr. Tomaž Rejec*
 20. Dr. Igor Sega
 21. Prof. Saša Svetina*
 22. Prof. Bosiljka Tadić
 23. Prof. Nataša Vaupotič*
 24. Asst. Prof. Darko Veberič*
 25. Dr. Igor Vilfan
 26. Asst. Prof. Primož Zihertl*
 27. Dr. Jure Zupan*
 28. Prof. Boštjan Žeks*, left 21 Nov. 2008
- Postdoctoral associates**
29. Dr. Samir El Shawish

30. Dr. Jernej Fescl Kamenik
 31. Dr. Kristjan Haule
 32. Dr. Anita Prapotnik Brdnik*
 33. Dr. Mihael-Matjaž Zemljčič*

Postgraduates

34. Tilen Čadež, B. Sc.
 35. Jure Drobnak, B. Sc.
 36. *Anna Elżbieta Gorczyca, M. Sc., left 1. Jun. 2008*
 37. Ana Hočevar, B. Sc.
 38. Matej Kanduč, B. Sc.
 39. Jure Kokalj, B. Sc.

40. Nejc Košnik, B. Sc.
 41. *Zoran Levnajič, M. Sc., left 1 Sept. 2008*
 42. Jernej Mravlje, B. Sc.
 43. Miha Nemevšek, B. Sc.
 44. Lev Vidmar, B. Sc.

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45. Nevenka Hauschild

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59. Primož Žiherl, Saša Svetina, "Membrane elasticity molds aggregates of simple cells", *Soft matter*, vol. 4, no. 10, pp. 1937-1942, 2008.
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REVIEW ARTICLES AND CHAPTERS IN BOOKS

- G. Buchalla, Jure Zupan, (136 authors), "B, D and K decays", *The European physical journal. C*, vol. 57, no. 1/2, pp. 309-492, 2008.
- Jure Derganc, Alexander A. Mironov, Saša Svetina, "The geometry of organelles of the secretory pathway", In: *The Golgi Apparatus - State of the art 110 years after Camillo Golgi's discovery*, Alexander A. Mironov, ed., Margit Pavelka, ed., Wien, New York, Springer, cop. 2008, pp. 314-330.
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PUBLISHED CONFERENCE PAPERS

Invited Papers

- Bosiljka Tadić, Zoran Levnajić, "Robust dynamical effects in traffic and chaotic maps on trees", In: *Proceedings of the Conference and Workshop on Perspectives in Nonlinear Dynamics 2007: (a satellite conference to STATPHYS 23, Genova): International Centre for Theoretical Physics, Trieste, Italy, 16-27 July 2007*, (Pranama, vol. 70, no. 6, spec. issue, 2008), Bangalore, Indian Academy of Sciences, 2008, vol. 70, no. 6, pp. 1099-1108, 2008.
- Danilo Zavrtanik, Darko Veberič, "Cosmic rays at extreme energies: status and recent results of the Pierre Auger Observatory", In: *Very high energy cosmic ray interactions: proceedings of the XIV International Symposium on Very High Energy Cosmic Ray Interactions, Shandong University, Weihai, China, 15-22 August 2006*, (Nuclear

physics B, Proceedings supplements, Vol. 175/176), Kwong Sang Cheng, Amsterdam [etc.], Elsevier, cop. 2008, vol. 175/176, pp. 213-220, 2008.

- Boštjan Žekš, "Nagovor predsednika na posvetu o slovenskem jeziku, SAZU, 15. maja 2007", In: *Zbornik prispevkov na posvetu 15. maja 2007*, Tone Pavček, ed., Ljubljana, Slovenska akademija znanosti in umetnosti, 2008, pp. 7-8.

Regular papers

- J. Allen, Darko Veberič, (16 authors), "The Pierre Auger Observatory offline software", In: *International Conference on Computing in High Energy and Nuclear Physics (CHEP'07): 2-7 September 2007, Victoria, British Columbia, Canada*, (Journal of physics. Conference series, vol. 119, 2008), Bristol, Institute of Physics Publishing, 2008, vol. 119, 10 pp., 2008.
- Mojca Čepič, "Why underwater caustic network appears on the vertical walls?", In: *Frontiers of physics education: selected contributions*, Rajka Jurdana-Šepič, ed., Rijeka, Zlatni rez, 2008, pp. 301-305.
- Mojca Čepič, "Energija, da li je razumijemo?", *Zb. pred. - Semin. nastav. prof. fiz.*, no. 7, pp. 27-37, 2008.
- Mojca Čepič, Katarina Susman, "Evrodifuzija", In: *Sodobni pouk skozi cilje trajnostne vzgoje*, Ida Kavčič, ed., Peter Šabec, ed., Ljubljana, Center šolskih in obšolskih dejavnosti, 2008, pp. 80-85.
- Bojan Golli, Simon Širca, "Pion electro-production in dynamical model including quasi-bound three-quark states: [presented at Mini-Workshop Few-Quark States and the Continuum, Bled, Slovenia, September 15-22, 2008]", *Blejsk. delavn. fiz.*, let. 9, no. 1, pp. 87-92, 2008.
- Jernej Kamenik, Damir Bečirević, Svjetlana Fajfer, "Chiral behavior of the heavy meson mixing amplitudes in the standard model and beyond: [presented at Europhysics Conference on High Energy Physics 19-25 July 2007, Manchester, England]", *Journal of physics, Conference series*, vol. 110, no. 5, pp. 052025-1-052025-3, 2008.
- Vida Kariž Merhar, Mojca Čepič, Gorazd Planinšič, "Konstruktivistična metoda poučevanja - različne možnosti preverjanja znanja", *Sodob. pedagog.*, vol. 59, posebna izd., pp. 218-229, 2008.
- Jernej Mravlje, Anton Ramšak, Rok Žitko, "Vibrational effects on low-temperature properties of molecular conductors: [presented at International Conference on Strongly Correlated Electron Systems held in Houston, Texas, USA, 13-18 May 2007]", *Phys., B Condens. matter*, 403, pp. 1484-1486, 2008.
- Jerneja Pavlin, Katarina Susman, Mojca Čepič, "Plavam, plavaš, plava ali pa tudi ne ...", In: *Sodobni pouk skozi cilje trajnostne vzgoje*, Ida Kavčič, ed., Peter Šabec, ed., Ljubljana, Center šolskih in obšolskih dejavnosti, 2008, pp. 159-164.
- Saša Prelovšek, "Searching for tetraquarks on the lattice: [presented at Mini-Workshop Few-Quark States and the Continuum, Bled, Slovenia,

September 15-22, 2008]", *Blejsk. delavn. fiz.*, let. 9, no. 1, pp. 93-97, 2008.

- Saša Prelovšek, "Simulations of light scalar mesons on the lattice and related difficulties", In: *SCADRON70: Workshop on Scalar Mesons and Related Topics, Honoring Michael Scadron's 70th Birthday, IST, Lisbon, Portugal, 11-16 February 2008*, (AIP conference proceedings, v. 1030), George Rupp, ed., Melville, American Institute of Physics, cop. 2008, pp. 311-316.
- Katarina Susman, Nada Razpet, Mojca Čepič, "Modeling the water transport in tall trees", In: *Frontiers of physics education: selected contributions*, Rajka Jurdana-Šepič, ed., Rijeka, Zlatni rez, 2008, pp. 306-312.
- Gregor Veble, Rudolf Podgornik, "Self-consistent inhomogeneous dielectric response profiles from nonlocal continuous Lifshitz formulation of van der Waals interactions", In: *Interfacial Nanostructures in Ceramics: a multiscale approach: 28 May-1 June 2007, Strasbourg, France*, (Journal of physics. Conference series (Online), vol. 94, 2008), Bristol, Institute of Physics Publishing, 2008, vol. 94, pp. 012003-1-012003-8, 2008.
- Saša Zihrel, Jerneja Pavlin, Mojca Čepič, "Verižni eksperiment", In: *Sodobni pouk skozi cilje trajnostne vzgoje*, Ida Kavčič, ed., Peter Šabec, ed., Ljubljana, Center šolskih in obšolskih dejavnosti, 2008, pp. 188-191.

TEXTBOOKS AND LECTURE NOTES

- Andrej Dobovišek, Nataša Vaupotič, *Osnovna merjenja: računanje z napakami in risanje diagramov: navodila za izvedbo eksperimentalnih vaj*, Maribor, Univerza v Mariboru, Fakulteta za naravoslovje in matematiko, Oddelek za fiziko, 2008.
- Anita Prapotnik Brdnik, *Mali fizikalni priručnik*, Zgornja Poljskava, [A. Prapotnik Brdnik], 2008.

THESES

Ph. D. Theses

- Mihael-Matjaž Zemljič, *Transport and spectral properties of strongly correlated electrons in cuprates: doctoral thesis: doktorska disertacija*, Ljubljana, [M.M. Zemljič], 2008.

B. Sc. Theses

- Tilen Čadež, *Vpliv sklopitve Dydzaloshinskii-Moriya na kvantno prepletenost dveh elektronov: B. Sc. Thesis*, Ljubljana, [T. Čadež], 2008.
- Jure Drobnak, *Fizika onkraj standardnega modela v dvoeleptonskem razpadu top kvarka: B. Sc. Thesis*, Ljubljana, [J. Drobnak], 2008.

DEPARTMENT OF LOW AND MEDIUM ENERGY PHYSICS

F-2

The F-2 department conducts basic and applied research in low- and medium-energy physics. The low-energy physics relates to our atomic physics research, while the nuclear physics studied at the department can be classified as intermediate-energy physics. The third research field of the department is radiological environmental protection, which includes monitoring nuclear objects and environmental radioactivity. The department also operates the Ecological Laboratory with a mobile unit as a specialized civil protection unit.



Head:
Asst. Prof. Matej Lipoglavšek

In the A1 Collaboration at MAMI, Mainz, Germany, we have performed the second part of the measurements of the electric form-factor of the neutron during large momentum transfers. A polarized ^3He target was used and a double-polarization asymmetry was measured. The asymmetry is proportional to the interference of the poorly known electric, and the relatively better known magnetic, form-factor. A part of the experimental program has been devoted to the measurement of charged-pion electro-production in the vicinity of the threshold. The purpose of these experiments is a precise extraction of the axial form-factor of the proton. We have been developing a prototype Cherenkov counter for the KAOS spectrometer, based on an aerogel radiator. In the initial test measurements the absorption and scattering length were examined, as well as the various options for the internal geometries of the detector.

At the Jefferson Laboratory, in the framework of the Hall A Collaboration, we have performed a first set of experiments on neutral-pion electro-production at the threshold. The measurement is expected to deliver vital information in the $E0+$ and $L0+$ electro-production s-wave amplitudes and the corresponding partial cross-sections, which at low energies and low momentum transfers represent an important testing ground for the effective theory of quantum chromodynamics, the chiral perturbation theory. In the Hall C Collaboration, the measurements of the ratio of electric-to-magnetic proton form-factor have been extended to momentum transfers of up to 10 GeV^2 . The focal-plane polarimetry technique has been used to determine the ratio of the elastic recoil proton polarization components. We have performed a measurement of the transverse polarized (quark) structure functions in the neutron by using a transversely polarized ^3He target (polarization perpendicular to the scattering plane). Numerous data analyses from previous years have been completed. Selected results are given in the papers R.Subedi et al. (Hall A Collaboration), *Science* 320 (2008) 1476; E. Geis et al. (BLAST Collaboration), *Phys. Rev. Lett.* 101 (2008) 042501; P. Janssens et al. (A1 Collaboration), *Eur. Phys. J. A* 37 (2008) 1.

Work in the low-energy physics part of the F-2 department was mainly driven by the research programme "Study of atoms, molecules and structures with photons and particles" (P1-0112) and two projects which are running within the frame of the Slovenian Fusion Association (EUROATOM-MHEST). Basic and applied research was performed at home, mainly at the Microanalytical Infrastructure Center (MIC), and abroad, most frequently at different synchrotron labs in Europe, where we have conducted research on our own projects and done some work in collaborations, too.

In collaboration with the group of prof. P. Lambropoulos from IESL, Heraklion, Crete, we have modelled the two-photon inner-shell ionization of noble gases. We have also calculated the electron spectra that are emitted upon the photoexcitation of the metastable He states $1s2s\ ^1S$ in the region of doubly excited states below the $N=2$ ionization threshold. With the group of prof. Paripas from the Physics Department at University of Miskolc and the Institut Atomki in Debrecen, Hungary, we have measured interference effects in the $(e,2e)$ reaction close to the Ar $2p$ threshold.

At the XAFS beamline (Elettra) we have measured the absorption spectra of some simple molecules and performed high-resolution x-ray spectrometry to determine the Coster-Kronig coefficients for the decay of the Xe $2p_{1/2}$ and $2s_{1/2}$ holes. At ID26, the ESRF beamline, we measured high-resolution x-ray spectra in April 2008 for three weeks. We have employed our own high-resolution spectrometer, optimized for the study of low-density targets to record the

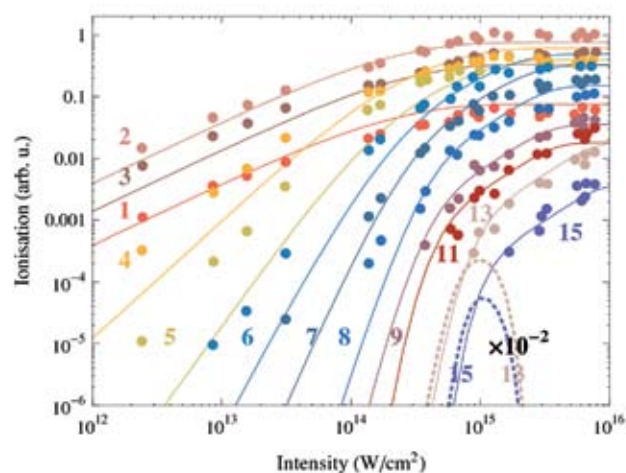


Figure 1: Calculated (solid lines, M.G. Makris, P. Lambropoulos and A. Mihelič) and measured (points, Sorokin et al., *Phys. Rev. Lett.* 99, 213002, 2007) averaged ionisation signal produced by exciting ground-state xenon atoms with a 10 fs free-electron laser pulse with photon energy of 93 eV. The signal pertaining to different ionic species Xe^{i+} , is labelled with i . The unaveraged single-atom signal is plotted with dashed lines.

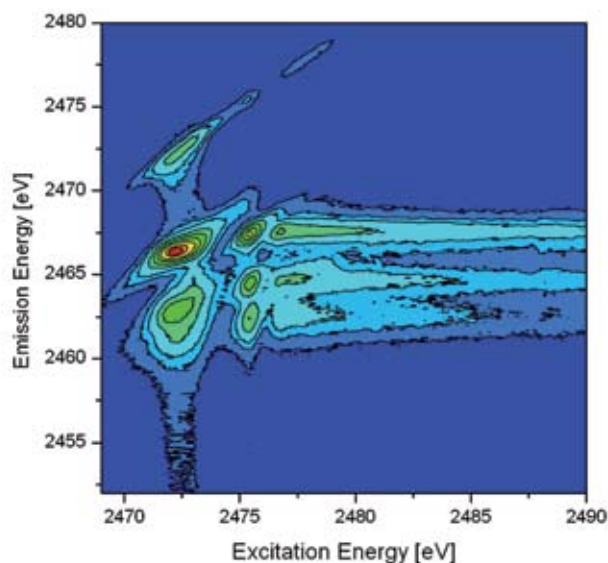


Figure 2: Inelastic x-ray resonant Raman map of H_2S at room temperature recorded in the vicinity of the sulphur K edge (excitation) in the energy region of the $K\beta$ line (emission). The measurement was made at the ID26 beamline of the European Synchrotron Radiation Facility in Grenoble.

high-resolution x-ray resonant Raman spectra in the vicinity of S and Cl K -thresholds for simple molecules (HCl , H_2S), liquids ($CuSO_4 \cdot 5 H_2O$) and solid targets (S-containing minerals, $BaVS_3$ crystals).

With its successful projects, the Laboratory for X-Ray Absorption Spectroscopy gained collaboration beamtime at three synchrotron facilities: synchrotron Elettra, Trieste (beamline XAFS, 18–22 March), ESRF in Grenoble (beamline BM29, 30 Sept. to 10 Oct.) and HASYLAB, DESY Hamburg (beamline C, 13–20 Oct.). Within the allotted beamtime we provided access to advanced analytic technologies with synchrotron light to a number of collaborating laboratories in Slovenia and abroad. In the 3-year project “XAS analysis of transition metals in lead-free piezoelectric thin films and in catalysts based on porous silicates” (II-20080058 EC) at HASYLAB we performed structural analyses of new, mesoporous catalysts, doped with the transition metal Mn, and Ti, and of the ferroelectric materials $K(Ta_{0.6}Nb_{0.4})O_3$, $Pb(Mg_{0.33}Nb_{0.67})O_3$ and thin films $CaCu_3Ti_4O_{12}$, together with their precursors, in collaboration with groups from the Institute of Chemistry, Ljubljana, and from the K-5 department of the JSI, respectively. In another multilateral collaboration with the Faculty of Biotechnology of the University of Ljubljana, the Universidad Autonoma de Barcelona, Spain, and Université de Louvain, Belgium, the binding of the metals Cd, Zn and Pb in the hyperaccumulating plant *Thlaspi praecox* was studied at ESRF. A similar bioavailability study of As and Pb in the contaminated soil from the region of Mežica was carried out in a collaboration with the

Institute of Chemistry. At Elettra, an *in-situ* x-ray absorption study of the structural and valence changes during the charging and discharging of new, nanostructured cathode materials, $Li_2Fe_xMn_{1-x}SiO_4$ and $Li_2Fe_xMn_{1-x}TiO_4$, for Li-ion batteries was implemented, to elucidate the electrochemistry of batteries and to optimize their capacity. The cathode materials were also studied *in-situ* using Moessbauer spectroscopy.

In 2008, several studies were completed with publications, among them most notably the absolute determination of the K-edge atomic absorption in monatomic iodine vapour, with the analysis of the thermal dissociation of I_2 at temperatures up to 950°C; and the XAS analysis of nanostructured manganese-zinc ferrite spinels, demonstrating the effect of the nanoparticle dimensions on the crystal structure.

In surface physics we have studied the ultrafast charge-carrier dynamics and excited charge delocalisation at hybrid organic interfaces – PTCDA/Au, Cu-phthalocyanine/Au and hybrid PTCDA/CuPc sandwiched layers – relevant for photovoltaics and molecular electronics. This has been studied with X-ray absorption and resonant photoemission at the ALOISA beamline (Elettra synchrotron, D.Cvetko, Elettra beamtime proj. ID. 2008401). The identity of the occupied wavefunctions at the Fermi level of the hybrid PTCDA/Au interface has been determined, which evidenced the metallic nature of the monolayer PTCDA/Au film. Also, the spontaneous self-assembly process of L-methionine aminoacid molecules on weakly interacting substrates like Ag and Au(111) has been studied and observed to proceed via the zwitterionic coupling into dimers with lateral H-bonding to form extended linear chains, capable

of mesoscopic 2D organisation into tunable biomolecular nanogratings. The deprotonation of carboxylic and the protonation of amino functional groups represent the key molecular-recognition mechanism in the case of a negligible functional interaction with the substrate. The detailed chemical, long-range order and orientational geometry properties have been examined on Ag, Au and Cu(111) substrates.

We continued our work on the development of the spectrometer of vibrationally excited hydrogen molecules, with an emphasis on the extraction system of negative ions and published a paper about its operation. With the ERDA ion method we measured the depth profile of hydrogen in tungsten, tantalum and copper during controlled exposure of the samples to hydrogen atoms at different sample temperatures. The vibrational temperature of the excited molecules H_2 and D_2 produced in the recombination of H and D atoms on a cold tungsten surface was determined and new data about the dissociative electron attachment to H_2 and D_2 in the ground state were obtained.

A measuring station with a high-energy focused ion beam has been reconstructed and long measuring cycles were performed with micro-

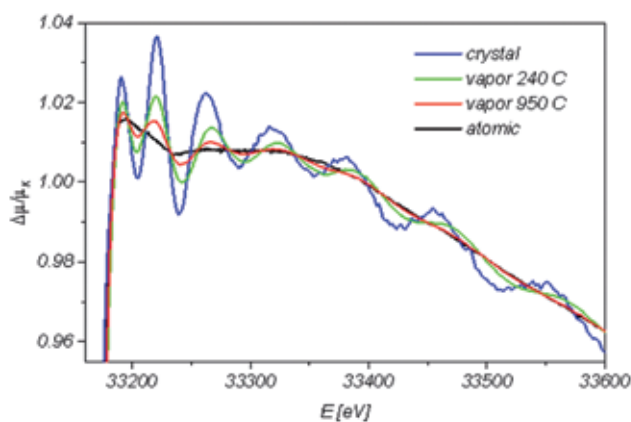


Figure 3: X-ray absorption spectra of iodine in the K-edge energy region: solid (blue), low-T vapour (green) and high-T vapour (red), together with the derived signal of the atomic absorption (black). The decrease in the structural EXAFS signal as a result of the thermal dissociation of the I_2 molecules is clearly visible.

PIXE and STIM for the analysis of the elemental distributions in plant and animal tissues. In collaboration with the Laboratory for Plant Physiology of the Biotechnical Faculty, University of Ljubljana (UL) and prof. Herrman Bothe from the University of Cologne, the elemental distribution in roots of *Viola Calaminaria* and *Viola Westfalica* were measured and the results were accepted for publication in the book *Symbiotic Fungus: Principles and Practice* by Springer-Verlag. Research on wound recovery in tree tissue has been completed in collaboration with the Dept. of Wood Science and Technology, UL. The intake of nanoparticles in animal tissue and the uptake of heavy metals in cereals were studied together with the Biotechnical Faculty, UL. A study of the uranium uptake in plant tissues was initiated and started together with the Belgian Nuclear Research Centre, Mol. In the frame of a bilateral collaboration with Tohoku University, Sendai, Japan, micro-PIXE was used to study the aerodynamic separation of atmospheric nanoparticles and the studied aerosol samplers were tested in a working environment with an increased concentration of nanoparticles. We have published our results about the 3D imaging of an aerosol sample with the confocal micro-PIXE method. In collaboration with an industrial partner, micro-ERDA with a focused ^7Li beam was used to measure the hydrogen concentration in titanium alloys.

Some outstanding publications in the 2008

1. P. Lambropoulos, L.A. Nikolopoulos, M.G. Makris, A. Mihelič, "Direct versus sequential double ionization in atomic systems", *Phys. Rev. A* 78, 055402 (2008)
2. M. Žitnik, M. Kavčič, K. Bučar A. Mihelič, "X-ray resonant Raman scattering from noble gas atoms and beyond", *Nucl. Instrum. Meth. B* (2008), doi: 10.1016/j.nimb.2008.10.074.
3. J. Padežnik Gomilšek, I. Arčon, S. de Panfilis, A. Kodre, "X-ray absorption coefficient of iodine in the K edge region", *J. Phys. B: At. Mol. Opt. Phys.* 41 (2008) 025003
4. S. Markelj, Z. Rupnik and I. Čadež, "An extraction system for low energy hydrogen ions formed by electron impact", *Int. J. Mass Spectrom.* 275 (2008) 64-74].
5. K. Vogel-Mikuš, J. Simčič, P. Pelicon, M. Budnar, P. Kump, M. Nečemer, J. Mejasz-Przybyłowicz, W.J. Przybyłowicz, M. Regvar, "Comparison of essential and non-essential element distribution in leaves of the Cd/Zn hyperaccumulator *Thlaspi praecox* as revealed by micro-PIXE". *Plant cell environ.* 31, 1484-1496 (2008)

Organization of conferences, congresses and meetings

1. Dr. Mark Pleško, Cosylab d.d., Ljubljana, Slovenia: Cosylab Co.: spin-off of IJS, international Co., Seminar on IJS, 13 Mar. 2008
2. Prof. Zdeněk Herman, J. Heyrovský Institute of Physical Chemistry, Prague, Czech Republic: Interaction of slow ions with surfaces, 3 Apr. 2008
3. Mag. Dušan Peček, Globalvision d.o.o., Prostorsko informacijski sistemi: Introduction of S3FAST system, 2 Oct. 2008
4. Dr. Marc Simon, Université Pierre et Marie Curie, Paris, France: RIXS on Chlorinated Molecules in the Tender X-ray Region, 9 Oct. 2008

INTERNATIONAL PROJECTS

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. Application of Ion Beam Analytical Methods to the Studies of Plasma Wall Interaction Studies
1.4.3.-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC, RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Asst. Prof. Primož Pelicon 2. Hydrogen/Deuterium Molecule Wall Interaction - 1.4.1.-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC, RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Iztok Čadež, Dr. Milan Čerček 3. Fusion Expo Activities under an EFDA
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC, RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Sabina Markelj, B. Sc., Melita Lenošek, B. Sc., Dr. Igor Lengar, Asst. Prof. Saša Novak Krmpotič, Štefan Kolenko 4. GammaGuru - Efficiency and True Coincidence Summing Corrections Calculation in Gamma Ray Spectrometry of Environmental Samples | <p>Benchmarking Calibration for Low-Level Gamma Spectrometric Measurements of Environmental Samples
14894
IAEA, Vienna, Austria
Dr. Tim Vidmar</p> <ol style="list-style-type: none"> 5. Holder for Annular Source, including Pure Sn Collimator, to fit a Si(Li) Detector
RAF0023-92830L
IAEA, Vienna, Austria
Dr. Peter Kump 6. Improvement of the XRF Quantification and Enhancement of the Combined Applications by EDXRF and Micro PIXE
13858/RBF, RO, R1
IAEA, Vienna, Austria
Dr. Peter Kump 7. Optimization of Portable X-ray Fluorescence Analyzer (XRFA) System and Procedures for In situ Analysis of Environmental Samples and Archaeological Objects
BI-AL/08-09-003
Asst. Prof. Civič Nikolla, Institute of Nuclear Physics, Tirana, Albania
Dr. Peter Kump 8. Material Analysis of the Objects of Cultural Heritage from the Slovenian and Albanian Area
BI-AL/06-08-001
Prof. Aferdita Vevecka-Priftaj, Polytechnic University Tirana, Tirana, Albania
Prof. Žiga Šmit |
|---|--|

9. Novel Detection Techniques in pulsed Coincidence Experiments
BI-FR07-PROTEUS-010
PROTEUS
Dr. Francis Penent, Lab de chimie physique matiere et rayonnement CNRS, Unite UMR, Paris Cedex, France
Asst. Prof. Matjaž Žitnik
10. Convention de mise a disposition
Contract between CNRS and JSI, dated 27.5.2004
Letter N/REF: NS/MD/CONV/04FRE2681JS/2004, dated 8.9.2004
Dr. Paul Indelicato, Laboratoire Kastler-Brossel (LKB - UMR 8552), Ecole normale superieure, Paris Cedex, France
Dr. Iztok Čadež
11. XAS Studies of Ti, V, Mn and Fe Local Environment in Hierarchical Porous Catalysts
ELETTRA Project Number 2007356
Luca Olivi, Sincrotrone ELETTRA, Trieste, Italy
Prof. Iztok Arčon
12. Application of Ion Beam Technology to Environmental Research
BI-JPN/07-09-02
Dr. Ishii Keizo, Department of Quantum Science and Energy Engineering, Tohoku University, Sendai, Japan
Asst. Prof. Primož Pelicon
13. Calculation of Efficiencies and True Coincidence Summing Corrections for Environmental Gamma-ray Spectrometry
BI-HU/07-08-005
Dr. Sándor Sudár, University of Debrecen, Institut za eksperimentalno fiziko, Debrecen, Hungary
Prof. Andrej Likar
14. Development and support of Java applications for use in DESY accelerator control
Attachment #7
Dr. M. Clausen, DESY (Deutsches Elektronen Synchrotron), Hamburg, Germany
Dr. Mark Pleško, Asst. Prof. Matej Lipoglavšek
15. Optimalna digitalna analiza spektroskopskih sunkov
Hi-Light Agreement
Hi-Light, Opto Electronics BV, Tolbert, The Netjerlands
Dr. Matjaž Vencelj
16. Quark Models for Meson Electroproduction
Modelos de quarks para electroproducao de mesoes
BI-PT/08-09-012
Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
Asst. Prof. Simon Širca, Prof. Bojan Golli
17. Nucleon Resonances in Chiral Models
BI-PT/06-07-005
Prof. Manuel Fiolhais, Physics Department, University of Coimbra, Coimbra, Portugal
Asst. Prof. Simon Širca, Prof. Bojan Golli
18. Quantum Mechanics of Nuclear Radiative Capture Models based on Optical Potential
BI-SK/05-07-003
Asst. Prof. Emil Betak, Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovakia
Prof. Andrej Likar
19. Electron induced Fragmentation of Organic Molecules and Small Hydrocarbons
Fragmentacija organskih molekula i malih ugljovodonika uzrokovana elektronskim udarom
BI-RS/08-09-028
Dr. Aleksandar Milosavljević, Institut za fiziku, Zemun, Serbia
Dr. Iztok Čadež
20. Studies of Parity Violation in H/He and Electromagnetic Structure of the Deuteron
BI-US/06-07-048
Gilad Shalev, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA
Asst. Prof. Simon Širca
6. Natural and man-made gamma- and beta- ray emitters in uderground waters in Slovenia
Dr. Matjaž Aleš Korun
7. Natural hydrochemical backgrounds and dynamics of Slovenian groundwaters.
Dr. Jasmina Kožar Logar
8. Inventory of Secovlje saltpan flora and optimisation of growth of autochtonus
Salicornia species
Dr. Marijan Nečemer
9. Dating of Waters by H-3 and Pb-210: groundwater dynamics and vulnerability of deep aquifers
Dr. Jasmina Kožar Logar
10. Application of x-ray analytical techniques
Dr. Peter Kump
11. Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
Prof. Darko Makovec, Dr. Darko Hanžel
12. Age, origin and dynamics of deep aquifer's groundwaters of Ljubljansko barje
Dr. Jasmina Kožar Logar
13. Tracing of tritium in the in the environment around the Krško NPP
Dr. Matjaž Aleš Korun
14. Determination of geographical and botanical origin of honey
Dr. Marijan Nečemer
15. Quality and authenticity of honey on Slovenian market
Dr. Marijan Nečemer

RESEARCH PROGRAMS

1. Structure of hadronic systems
Asst. Prof. Simon Širca
2. Studies of atoms, molecules and structures with photons and particles
Asst. Prof. Matjaž Žitnik
3. Parallel and distributed systems
Asst. Prof. Roman Trobec
4. Mobile archaeological heritage: archaeological and archaeometric investigations
Prof. Žiga Šmit

NEW CONTRACTS

1. Monitoring of central LILW storage facility at Brinje 2008
Agency of Radwaste Management
Dr. Marijan Nečemer
2. Radionuclide content in building material for high constructions in Slovenia
Ministry for Environment and Spatial Planning
Dr. Tim Vidmar
3. Ecology laboratory with mobile unit 2008
Ministry of Defence
Asst. Prof. Matej Lipoglavšek
4. Digital Pulse Processor
Instrumentation Technologies, d. d., Solkan
Asst. Prof. Primož Pelicon
5. Dosimetrical service
Oncological Institute Ljubljana
Boštjan Črnič, B. Sc.
6. Monitoring of radioactivity in the living environment
Ministry for Environment and Spatial Planning
Dr. Benjamin Zorko
7. Radiological monitoring in Slovenia 2008-2010
Krško Nuclear Power Plant
Asst. Prof. Matej Lipoglavšek
8. Monitoring of radioactivity of drinking water 2008
Ministry of Health
Asst. Prof. Matej Lipoglavšek
9. Maintenance of measurement traceability of reference standards
Ministry of Higher Education, Science and Technology
Matjaž Mihelič, M. Sc.
10. Monitoring of radioactivity in RŽV 2008
RŽv, d. o. o., Gorenja Vas
Asst. Prof. Matej Lipoglavšek

R & D GRANTS AND CONTRACTS

1. Electron screening in metals and alloys
Asst. Prof. Matej Lipoglavšek
2. Fusion relevant research of plasma interactions with surfaces
Prof. Milan Čerček, Asst. Prof. Primož Pelicon
3. Development of the diagnostics for certain parameters of the edge plasma in fusion devices
Prof. Milan Čerček, Dr. Iztok Čadež
4. Novel, enviromental friendly, high energy density materials for use in Li-ion batteries
Dr. Robert Dominko, Dr. Darko Hanžel
5. Mapping in tokamak walls and inside biological cells
Asst. Prof. Primož Pelicon

VISITORS FROM ABROAD

1. Miss. Julia Jungmann, Kernfysisch Versneller Instituut, University of Groningen, Netherlands, 07 Jan. to 6 Mar. 2008
2. Prof. Shigeo Matsuyama, Department of Quantum Science and Energy Engineering, Tohoku University, Sendai, Japan, 8–12 Jan. 2008
3. Prof. Zdeněk Herman, J. Heyrovský Institute of Physical Chemistry, Prague, Czech Republic, 1–4 Apr. 2008
4. Prof. Miodrag Čolić, VMA, Belgrade, Serbia, 7 May 2008
5. Prof. Ilir Vullkaj, Polytechnical University Tirana in Edlira Duka, doctor student, University in Draču, Albania, 9–12 Jun. 2008
6. Dr. Aleksandar Milosavljević, Institute of Physics, Belgrade, Serbia, 1–30 Sept. 2008
7. Dr. Marc Simon, Universite Pierre et Marie Curie, Paris, France, 7–10 Oct. 2008
8. Prof. Shigeo Matsuyama, Department of Quantum Science and Energy Engineering, Tohoku University, Sendai, Japan, 5–11 Nov. 2008
9. Mr. Dimosthenis Sokaras, Institut Demokritos, Athens, Greece, 17–28 Nov. 2008
10. Dr. Nele Horemans, SCK-CEN, Biosphere Impact Studies, Boeretang, Belgium, 26–27 Nov. 2008

11. M. Sc. Sanja Tosić and B. Sc. Jelena Maljković, Institute of Physics, Belgrade, Serbia, 1–10 Dec. 2008

12. Prof. Keizo Ishii, Tohoku University, Sendai, Japan, 14–19 Dec. 2008

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DEPARTMENT OF THIN FILMS AND SURFACES

F-3

The main field of research of the Department of Thin Films and Surfaces is the development, deposition and characterization of hard protective PVD coatings, while research is done also on 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, as well as the study of processes during heat treatment. In the applied research different coatings are developed for the protection of tools for various production processes in industry.

The main event of the past year was the purchase of new equipment for hard-coating deposition: the CemeCon CC800/9 sinOx. It is the most modern apparatus of its type, and enables magnetron sputtering in three different regimes: (i) classical DC deposition, (ii) pulsed deposition at medium frequencies and (iii) pulsed deposition at high power. By applying a suitable combination of process parameters we can deposit various so-called supernitride coatings, which have a fine-grained microstructure, excellent adhesion on the substrate and low internal stresses. Using pulsed deposition we can also deposit non-conductive thin films (e.g., Al_2O_3), or classical films at low substrate temperatures. New possibilities are available with the high-power pulsed magnetron sputtering (HPPMS). Its main feature is a pulsed power supply, which generates pulses with a peak power of around one megawatt, but with a duration of only a few tens of microseconds. At such a high power density, the target material is almost completely ionized, which enables the formation of a nanocrystalline microstructure and superb adhesion. A millisecond-long pause follows the pulse, and therefore the substrate temperature remains relatively low.

The first major achievement with the new system is the deposition of blue-coloured coatings. These are based on TiAlN, and as with many similar, well-established coatings they do not provide any advantage from the wear-resistance point of view. However, the major colour difference substantially improves the ability to detect tool wear, which is not the case with classical coatings that tend to be a metallic-grey colour.

We continued work on other topics related to hard coating development, where an important emphasis was given to the study of defects. Micrometer-sized defects increase friction, and cause pitting corrosion and material build-up on the tool's surface. Based on measurements with a large series of depositions we determined the dependence of the defect density on the deposition parameters: deposition rate, bias voltage, substrate-surface orientation, location in the vacuum chamber, rotation geometry, substrate type and cleaning procedures. A novel method of defect study was the application of 3D-profilometry and scanning electron microscopy in combination with a focused ion beam (FIB). Using this knowledge we are now ensuring better film purity on those substrates where a low defect density is a key property. We also continued with the development of corrosion-resistant coatings based on Al-W for the protection of aluminium alloys, where we concentrated on tungsten's influence on the microstructural properties.

To better understand the sputtering rates of composite targets, we constructed an experiment equivalent to the camera obscura used in optics. We succeeded to record a "picture" of the target through a small pinhole. By measuring the transparency of the coating deposited on glass and by measuring the film thickness we calculated the deposition rates of various target components.

The department intensively collaborates with Slovenian industry. In addition to the protection of tools with hard coatings, we performed several advanced analyses of tool protection, chose the appropriate technology and solved specific problems. In 2008 we made analyses for the companies PHOS, d. o. o., Kovinos, d. o. o., and Kolektor, d. d.

We actively collaborate in three European projects. Within the Network of Excellence "Complex metallic alloys" (CMA) we analysed the diffusion processes in the thin-film structures Al/Cr, Al/Fe and Cr/Fe, where we revealed the decisive mechanisms for diffusion. In the same network we are leading the preparation of a subproject for the combinatorial analysis of thin films with a lateral compositional gradient. The recently started EU 7FP project "Development of wear resistant coatings based on complex metallic alloys for functional applications" (AppliCMA) is to an extent a continuation of the existing Network of Excellence. In this project we will develop applications for these alloys over the next three years. There are 17 partners from eight countries



Head:
Dr. Peter Panjan



Figure 1: New apparatus for the deposition of hard coatings, CemeCon CC800/9 sinOx



Figure 2: Blue TiAlN-based coating, deposited on punches for the pharmaceutical industry

We developed TiAlN-based supernitride coatings that ensure the better wear resistance of tools, enhanced adhesion and lower internal stresses compared to classical nitride coatings. These coatings have been successfully tested in industrial production.

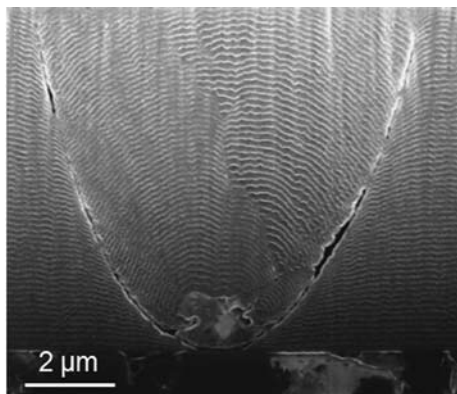


Figure 3: Cross-section of a defect in the TiAlN/CrN multilayer structure, prepared by the focused-ion-beam (FIB) method

involved in the project. From the Institute the Departments for Solid State Physics (F-5), for Engineering Ceramics (K-6), and for department for Advanced Materials (K-9) are collaborating, in addition to our department. In the ERA-NET project “Hydrogen-impermeable nanomaterial coatings for steels” (Hy-Nano-Im) we are developing coatings with a low hydrogen permeability. The project partner from Austria is Joanneum Research, Laser Center Leoben; from the Institute, in addition to our department, there are the Department for Nanostructured Materials and the Department for Surface Engineering and Optoelectronics. For this project we have so-far deposited films of diamond-like carbon.

Among the other international projects, ITER takes first place, where our task is the synthesis of various deposits of hydrogenated carbon, which should be as similar as possible to the impurities in the fusion reactor. We have long-established bilateral collaborations with the Institute for Nuclear Sciences Vinča, Serbia, on the laser treatment of surfaces and subsequent analysis, the University of Zagreb, Croatia, on the depth-profile analysis of multilayer structures, and Joanneum Research, Laser Center Leoben, Austria, on the deposition of diamond-like carbon films by anode layer source. In addition, we are developing coatings for architectural structures for the Australian company Bluescope Steel. In order to study the influence of ion etching on depth profiling we deposited several bi- and multilayer structures (Cr/Si, Ni/C, W/Nb). This research was done in collaboration with the Department of Surface Engineering and Optoelectronics, and the Research Institute for Technical Physics and Materials, Budapest, Hungary.

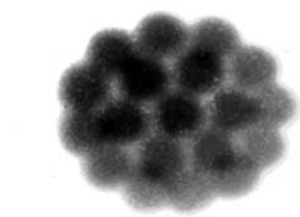
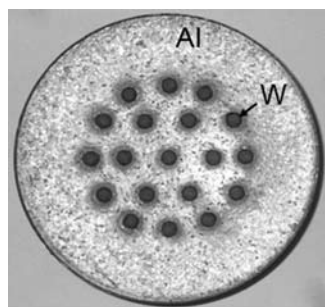


Figure 4: Composite target Al-W (above) and the “picture” of this target on a glass substrate, prepared by the camera obscura technique

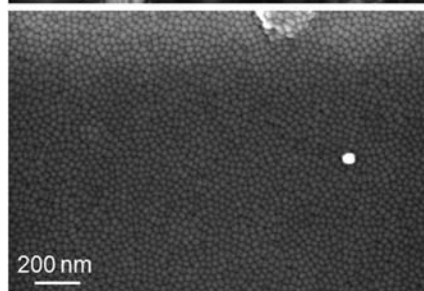
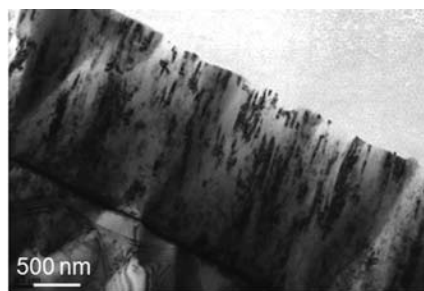


Figure 5: Nanostructured coating Al-W in cross-section by transmission electron microscopy (above), and top-view of the surface by scanning electron microscopy (below)

Some outstanding publications in the past three years

1. P. Panjan, D. Kek Merl, F. Zupanič, M. Čekada, M. Panjan, SEM study of defects in PVD hard coatings using focused ion beam milling, *Surf. Coat. Technol.*, 202 (2007) 2302–2305
2. M. Panjan, S. Šturm, P. Panjan, M. Čekada, TEM investigation of TiAlN/CrN multilayer coatings prepared by magnetron sputtering, *Surf. Coat. Technol.*, 202 (2007) 815–819
3. M. Panjan, M. Čekada, P. Panjan, A. Zalar, T. Peterman, Sputtering simulation of multilayer coatings in industrial PVD system with three-fold rotation, *Vacuum* 82 (2007) 158–161
4. M. Čekada, P. Panjan, J. Dolinšek, A. Zalar, Z. Medunič, M. Jakšič, N. Radič, Diffusion during annealing of Al/Cu/Fe thin films, *Thin Solid Films* 515 (2007), 7135–7139
5. D. Kek Merl, P. Panjan, M. Panjan, M. Čekada, The role of surface defects density on corrosion resistance of PVD hard coatings, *Plasma Proces. Polym.* 4 (2007) s613

INTERNATIONAL PROJECTS

- Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
appliCMA
7. FP, 214407
EC; Susanne Fuchs, Austrian Research Centers GmbH - ARC, Functional Materials, Seibersdorf, Austria
Dr. Miha Čekada, Prof. Janez Dolinšek, Dr. Kristoffer Krnel, Dr. Srečo D. Škapin
- Plasma Deposition of H: C-metal Coatings - 1.4.5.-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Peter Panjan
- Complex Metallic Alloys
CMA
6. FP, NMP3-CT-2005-500140
EC; Centre National de la Recherche Scientifique, Paris, France
Dr. Peter Panjan, Prof. Janez Dolinšek, Prof. Spomenka Kobe
- Hydrogen Impermeable Nano-material Coatings for Steels
Hy - Nano - IM
MNT ERA NET
Dr. Miha Čekada, Dr. Paul McGuinness, Dr. Vincenc Nemanič
- Improvement of Resurfacing Hip Implants with DLC, TiO₂ and DLC-p-h Nanocomposite Coatings
RHSI-DLC-NanoComp
MATERA ERA NET
ORTON Research Institute, Helsinki, Finland
Dr. Darinka Kek Merl, Dr. Ingrid Milošev
- Characterization of Composition and Mechanical Properties of PVD Ceramic Coatings
BI-HR/07-09-001
Dr. Lidija Čurković, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia
Dr. Peter Panjan
- Characterization of the Selected Coatings
Dr. Rainer Cremer, CemeCon AG, Coatings, Technology & Processes, Wüerselen, Germany
Dr. Peter Panjan

- Modification of Tungsten and Titanium based Thin Films with Conventional Thermal and Laser Annealing
Promene karakteristika tankih slojeva na bazi volframa i titana izazvane klasičnim termičkim i laserskim delovanjem
BI-SC/08-09-012
Dr. Biljana Gaković, Institute for Nuclear Sciences "Vinca", Belgrade, Serbia
Dr. Peter Panjan

R &D GRANTS AND CONTRACTS

- Development of measuring platform PowerQ4
Dr. Peter Panjan
- Study of plasma parameters for conditioning of the inner surfaces of a fusion reactor
Asst. Prof. Miran Mozetič, Dr. Peter Panjan
- PVD hard coatings as an alternative for corrosion protection of Fe- and Al-alloys
Dr. Darinka Kek Merl
- Smart functional coatings for improvement of structures and components used in defensive purpose
Dr. Peter Panjan

RESEARCH PROGRAM

- Thin film structures and plasma surface engineering
Prof. Anton Zalar, Dr. Peter Panjan

NEW CONTRACTS

- PVD hard coatings as an alternative for corrosion protection of Fe- and Al-alloys
Phos d. o. o., Sečovelje
Dr. Darinka Kek Merl
- Development of nanolayered PVD hard coatings
Kovinos d. o. o., Horjul
Dr. Peter Panjan

VISITORS FROM ABROAD

- dr. Rainer Cremer, dr. Christoph Schieffers, CemeCon AG, Wüerseln, Germany, 10-11 Jan. 2008
- dr. Biljana Gaković, dr. Suzana Petrović, dr. Milan Trtica, Institute for nuclear sciences "Vinča", Belgrade, Serbia, 7-11 Jul. 2008
- dr. David Nolan, Bluescope Steel, Port Kembla, Australia, 29-30 Sept. 2008
- dr. Rainer Cremer, dr. Christoph Schieffers, CemeCon AG, Wüerseln, Germany, 21-22 Oct. 2008
- dr. Suzana Petrović, mag. Jelena Stašić, Institute for nuclear sciences "Vinča", Belgrade, Serbia, 24-28 Nov. 2008
- dr. Wolfgang Waldhauser, mag. Markus Kahn, Joanneum Research, Laser Center Leoben, Leoben, Austria 11 Dec. 2008
- mag. Đurđica Gorščak, Končar Alati d.d., Zagreb, Croatia, 25-28 May 2008

STAFF

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- Dr. Miha Čekada
- Dr. Darinka Kek Merl
- Dr. Peter Panjan, Head**

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- Matjaž Panjan, B. Sc.
- Srečko Paskvale, B. Sc.

Technical officers

- Dr. Marijan Maček*, left 1 Apr. 2008

Technical and administrative staff

- Joško Fišer
- Damjan Matelič
- Andrej Mohar
- Tomaz Širnik

Note:

* part-time JSI member

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ORIGINAL ARTICLES

- Lidija Čurković, Vera Rede, Peter Panjan, Mirjana Fudurić-Jelača, Mario Lalić, "Mikrostruktura toplinski nagrižene aluminij oksidne keramike", *Kem. ind.*, vol. 57, no. 12, pp. 549-553, 2008.
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- Markus Kahn, Miha Čekada, R. Berghauser, Wolfgang Waldhauser, C. Bauer, Christian Mitterer, E. Brandstätter, "Accurate Raman

spectroscopy of diamond-like carbon films deposited by an anodelayer source", In: *Proceedings of the DIAMOND 2007, 18th European Conference on Diamond, Diamond-Like Materials, Carbon, Nanotubes, and Nitrides : 09-14 September 2007, Berlin, Germany*, (Diamond & related materials, vol. 17, no. 7/10, 2008), edited by J. Robertson ... [et al.], Oxford, Elsevier, 2008, vol. 17, no. 7/10, pp. 1647-1651, 2008.

- Julien Malherbe, Beatriz Fernández, Hervé Martínez, Patrick Chapon, Peter Panjan, Olivier F. X. Donard, "In-depth profile analysis of oxide films by radiofrequency glow discharge optical emission spectrometry

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5. Matjaž Panjan, Sašo Šturm, Peter Panjan, Miha Čekada, "The influence of rotation during sputtering on the stoichiometry of $TiAlN/CrN_x$ ", In: *Proceedings of the International Conference on Metallurgical Coatings and Thin Films, San Diego, California, April 28-May 2, 2008*, (Surface & coatings technology, vol. 203, no. 5/7, 2008), Y. Pauleau, ed., Lausanne, 2008, vol. 203, no. 5/7, pp. 554-557, 2008.
 6. Matjaž Panjan, Anton Zalar, Janez Kovač, Miha Čekada, Peter Panjan, "Določanje koncentracijskih profilov in difuzijskih parametrov v tankoplastnih strukturah s profilno analizo in modelom MRI", *Vakuumist*, vol. 28, no. 1/2, pp. 19-29, 2008.
 7. Peter Panjan, Miha Čekada, Janez Dolinšek, B. Vrtič, Anton Zalar, Darja Kek-Merl, "Diffusion processes during heat treatment of Al-Cr-Fe thin films", In: *Proceedings of the 11th joint vacuum conference (JVC-11): Prague, Czech Republic, 24-28 September 2006*, (Vacuum, Vol. 82, Issue 2, 2007), Vladimír Matolín, ed., Oxford, New York, Pergamon Press, 2007, vol. 82, no. 2, pp. 286-289, 2008.
 8. Peter Panjan, Darja Kek-Merl, Franc Zupanič, Miha Čekada, Matjaž Panjan, "SEM study of defects in PVD hard coating using focused ion beam milling", In: *Protective coatings & thin films -07: E-MRS spring meeting: Strasbourg, France, 28 May - 01 June 2007*, (Surface and coatings technology, Vol. 202, Issue 11, 2008), Christoph Eisenmenger-Sittner, ed., Amsterdam ... [etc.], Elsevier, 2008, vol. 202, no. 11, pp. 2302-2305, 2008.
 9. Aleš Petek, Bojan Podgornik, Karl Kuzman, Miha Čekada, Wolfgang Waldhauser, Jože Vižintin, "The analysis of complex tribological system of single point incremental sheet metal forming - SPIF", *Stroj. vestn.*, vol. 54, no. 4, pp. 266-273, 2008.
 10. S. Petrović, Biljana Gaković, Dalibor Peruško, Milan Trtica, Bojan Radak, Peter Panjan, Š. Miljanić, "Surface modification of a WTi thin film on Si substrate by nanosecond laser pulses", *Appl. surf. sci.*, vol. 254, no. 13, pp. 4013-4017, 2008.
 11. Anton Zalar, Janez Kovač, Borut Praček, Peter Panjan, Miran Čeh, "Ion sputtering rates of W-, Ti- and Cr-carbides at different Ar^+ ion incidence angles", *Appl. surf. sci.*, vol. 254, no. 20, pp. 6611-6618, 2008.
 12. Tadeja Kosec, Darja Kek-Merl, Ingrid Milošev, "Impedance and XPS study of benzotriazole films formed on copper, copper-zinc alloys and zinc in chloride solution", *Corrosion science*. Vol. 50, no. 7 (2008), pp. 1987-1997.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Marijan Maček, Miha Čekada, "Energy and mass spectroscopy of ions and neutrals in cold plasma", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 57-62.

Regular papers

1. Milan Bizjak, Ladislav Kosec, Janez Kovač, Anton Zalar, Peter Panjan, "Characterization of iron oxide layers on electromagnetic sheets using auger electron spectroscopy", In: *Metalni i nemetalni materijali: proizvodnja, osobine, primjena: zbornik radova: production, properties, application: proceedings*, VII naučno-stručni simpozij sa međunarodnim učešćem Metalni i nemetalni materijali = 7th Scientific-Research Symposium with International Participation Metallic and Nonmetallic Materials, Zenica, 22.-23. May 2008., Zenica, Fakultet za metalurgiju i materijale, = Faculty of Metallurgy and Materials Science, 2008, pp. 333-338.
2. Lidija Čurković, Vera Rede, Peter Panjan, Mirjana Fudurić-Jelača, Mario Lalić, "Analiza mikrostrukture aluminij oksidne keramike", In: *Zbornik radova*, MATRIB 2008, Vela Luka, otok Korčula, Hrvatska, 26.-28. lipnja/June 2008, Krešimir Grilec, ed., Gojko Marić, ed., Suzana Jakovljević, ed., Zagreb, Hrvatsko društvo za materijale i tribologiju, 2008, 59-66.
3. Janez Kovač, Anton Zalar, Peter Panjan, "Ion sputtering yields measured on amorphous Si and polycrystalline Nb layers", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 183-186.
4. Peter Panjan, Đurdica Gorščak, Lidija Čurković, Matjaž Godec, Miha Čekada, Darja Kek-Merl, Matjaž Panjan, Srećko Paskvale, "Influence of conventional and powder metallurgy cold work tool steel substrates on microstructural and tribological properties of PVD hard coatings", In: *Zbornik radova*, MATRIB 2008, Vela Luka, otok Korčula, Hrvatska, 26.-28. lipnja/June 2008, Krešimir Grilec, ed., Gojko Marić, ed., Suzana Jakovljević, ed., Zagreb, Hrvatsko društvo za materijale i tribologiju, 2008, pp. 255-261.

DEPARTMENT OF SURFACE ENGINEERING AND OPTOELECTRONICS

F-4

The main activities of the Department of Surface Engineering and Optoelectronics are oriented towards surface engineering, surface, interface and thin-film characterization, plasma applications, the synthesis of nano- and biomedical materials, vacuum optoelectronics, ultra-high-vacuum techniques and technologies. The department collaborates with other groups at the Institute as well as with other Slovenian and foreign institutes, universities and industry. The group is also active in the field of the education of students at two Slovenian universities and at the Jožef Stefan International Postgraduate School.



Head:
Prof. Anton Zalar

Surface analytical techniques are indispensable for the characterization of the surfaces and interfaces of bulk materials, layered structures and nanomaterials. In the department Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy (XPS) and atomic force microscopy (AFM) have been used successfully, all for basic research and for the characterization of technological samples. Our research group is recognized world wide for the depth profiling of thin films and multilayers at a high depth resolution.

To study the ion sputtering rates of W-, Ti- and Cr-carbides, trilayer structures comprising C/WC/W, C/TiC/Ti and C/Cr₃C₂/Cr were sputter deposited onto smooth silicon substrates. Their precise structural and compositional characterization by transmission electron microscopy (TEM), AES and XPS revealed that the WC and Cr₃C₂ layers were amorphous, while the TiC layer had a polycrystalline structure. The ion sputtering rates of all three carbides, amorphous carbon and polycrystalline Cr, Ti and W layers were determined by means of Auger electron spectroscopy depth profiling as a function of the angle of incidence of two symmetrically inclined 1 keV Ar⁺ ion beams in the range between 22° and 82°. The sputtering rates were calculated from the known thicknesses of the layers and the sputtering times necessary to remove the individual layers. We found that the sputtering rates of the carbides, C-graphite and metals were strongly angle dependent. For the carbides in the range between 36° and 62° the highest ion sputtering rate was found for Cr₃C₂ and the lowest for TiC, while the values of the sputtering rates for WC were intermediate. The normalized sputtering yields calculated from the experimentally obtained data for all three carbides followed the trend of the theoretical results obtained from calculations of the transport of ions in solids by the SRIM code. The sputtering yields we also presented in terms of atoms/ion (Figure 1). The influence of the ion-induced surface topography on the measured sputtering yields was estimated from atomic force microscope (AFM) measurements at the intermediate points of the corresponding layers on the crater walls formed during depth profiling.

In order to introduce our work and methods to the wider community, we built a new teaching model of the atomic force microscope (AFM) in collaboration with prof. Planinšič from the Faculty of Physics and Mathematics at the University of Ljubljana. The AFM model is intended as an introduction to nanophysics for high-school students. The AFM model was presented in a very well received article in the journal *Physics Education*, as shown in Figure 2. The teaching model of the AFM can be assembled by students themselves in a very simple way from components that are easily found. The model can demonstrate the contact and oscillating modes of operation of the AFM microscope, how the AFM image is created as well as some basics principles that limit the resolution of the method.

Using X-ray photoelectron spectroscopy (XPS) we investigated the reasons for the weak adhesion of electrical contacts in solar cells. We analyzed the multilayer structure Ag/NiV/Ti on a Si substrate, prepared at the Faculty of Electrical Engineering, University of Ljubljana. After a thermal treatment at 400 °C the multilayer structures have a weak adhesion to the silicon substrate. We found that a very thin amorphous Ti-Si phase was grown at the Ti/Si interface, which failed at the required mechanical loads. Our research is helping to optimize the technological process to improve the adhesion.

Using XPS and AFM methods we investigated thin organic coatings, prepared from hybrid, polyhedral oligomeric-silan-based precursors (POSS) by the sol-gel process at the National Institute of Chemistry, Ljubljana. The

A teaching model of the atomic force microscope (AFM) for an introduction to nanoscience was assembled and presented in a very well received article in the journal *Physics Education*.

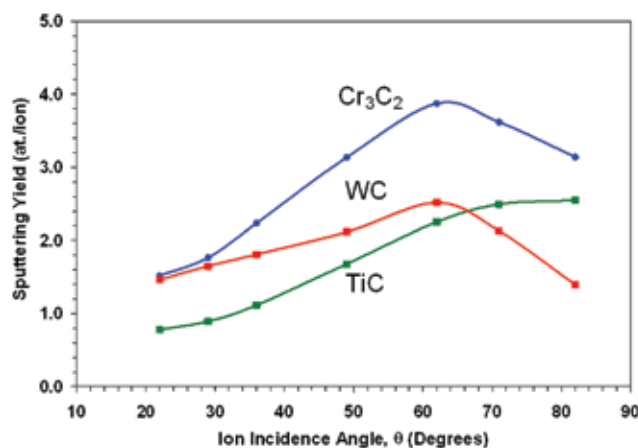


Figure 1: Sputtering yields (atoms/ion) of Cr₃C₂, WC and TiC as a function of the ion incidence angle for 1 keV Ar⁺ ions.



Figure 2: The cover page of the journal *Physics Education* showing the teaching model of the atomic force microscope (AFM), which was built in collaboration with the Faculty of Physics and Mathematics at University of Ljubljana (*Physics Education*, 43 (2008), 29-36).

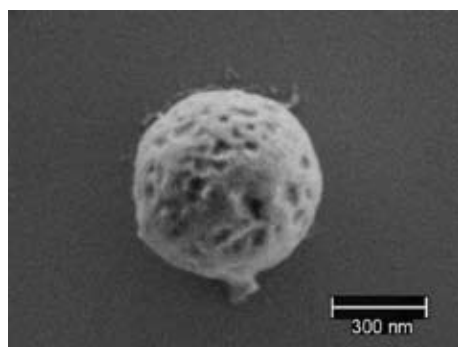


Figure 3: A SEM image of the *Staphylococcus aureus* bacterium after treatment with O atoms for 300 s.

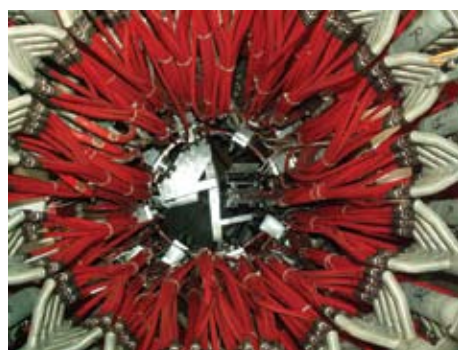


Figure 4: Central part of TJ-II stellarator at LNF, Madrid, Spain

coatings were intended for the corrosion inhibition of aluminium alloys. Our measurements show the formation of very thin, self-assembled and compact coatings with thicknesses of only 40 nm, which provide very good corrosion protection of aluminium alloys.

Systematic research on the interaction of neutral oxygen atoms in the ground state with bacteria has been performed. Bacteria *Staphylococcus aureus* have been investigated in detail in order to obtain valuable data on the efficiency of the removal of different segments. Experiments were performed in an afterglow chamber made from borosilicate glass. The source of the oxygen atoms was a remote, inductively coupled RF oxygen plasma. The density of atoms at the samples was 8×10^{20} atom/m³. The treatment was performed at room temperature. The first effect was the removal of the dried capsule. The capsule on exposed parts of bacteria was removed after receiving a dose of 6×10^{23} atom/m², while the parts of the capsule filling the gaps between the bacteria were removed after receiving a dose of 2.4×10^{24} atom/m². After removing the capsule the degradation continued as etching of the bacterial cell wall. The etching was rather non-uniform as holes with a diameter of several 10 nm were observed (Figure 3). The cell wall was removed after receiving a dose of about 7×10^{24} atom/m². The results were explained by the different compositions of the capsule and the cell wall.

The interaction of gaseous plasma with ITER-relevant materials has been investigated in close collaboration with partners from the European Fusion Development Agreement (EFDA) association. Experiments on the behaviour of materials treated with plasma under different conditions have been performed at our laboratories as well as at the National Fusion Laboratory, Madrid, Spain (Figure 4), the National Institute for Laser, Plasma and Radiation Physics, Bucharest, Romania, the PROMES Laboratory, Font Romeu, France, and the Laplace Laboratory, University Paul Sabatier, Toulouse, France. Reduction of thin oxide films on the surface of stainless-steel samples was performed at PROMES with a highly reactive hydrogen plasma and the results showed that the removal of the passive oxide film causes the sublimation of manganese from the samples even at a temperature of about 500 °C. The technique is therefore suitable for the removal of oxide thin films, but causes a weak depletion of manganese. The removal of hydrogenated carbon films, on the other hand, was performed using a highly reactive oxygen or nitrogen plasma at laboratories in Bucharest and Toulouse. The results of systematic research on the treatment of deposits with an oxygen plasma showed that the removal rate was below 1 nm/s at room temperature, reached about 10 nm/s at a temperature of 300 °C and increased to over 100 nm/s for temperatures above 500 °C. Similar results were obtained with an atmospheric nitrogen plasma torch, except that this technique is more suitable for the removal of deposits from small samples.

Systematic research on the functionalization of organic materials revealed the strong influence of plasma parameters on the type and concentration of specific functional groups on the surface of different polymers. The modification of the surface properties of the following polymers was studied: polyethyleneterephthalate (PET), polyethersulphone (PES), polyphenylenesulfide (PPS), nylon 6 polyamide (PA6), polytetrafluoroethylene (PTFE), polystyrene (PS), polypropylene (PP) and cellulose (ink-jet paper and textile). The polymer samples were treated in an oxygen plasma (the glow region as well as early afterglow) at a pressure of 75 Pa, where the O-atom density is the highest. The appearance of the functional groups on the surface of the samples was monitored by high-energy-resolution X-ray photoelectron spectroscopy (XPS). The results showed that oxygen-plasma treatment was an effective tool for surface modification. On all the polymer surfaces an increased concentration of oxygen was detected. The high resolution C 1s peaks indicated the formation of several new oxygen-containing functional groups. On all the polymers groups like C-O, C=O and O=C-O are observed. However, in some cases, more complex groups were found as well. The concentration of these functional groups depended on the type of polymer and the time of the plasma treatment. The highest increase of oxygen by the polymer was found for cellulose, and the lowest was found for polypropylene. The only exception was the PTFE polymer, where practically no chemical changes were observed after the plasma treatment.

The safe operation of future fusion reactors and their decommissioning after their operational lifetime sets some questions that are not completely answered. For the ITER project, the main source of radioactivity is caused by high-energy neutron capturing as well as by tritium retention, since not all the applied fuel is spent in fusion. The most affected area is the first wall (i.e., tungsten, beryllium), but there is a large surface area of stainless-steel vacuum chamber exposed to gaseous tritium after the plasma ignition. The prediction of tritium retention is today mainly calculated from data taken in a small system using similar parameters as expected for

the ITER. Deuterium provides valuable and complementary data on its retention in metals, as usually taken by tritium. We investigated the kinetics of deuterium absorption and desorption in selected ITER-grade metals, such as tungsten, beryllium and stainless steel, at the prescribed low pressures and high temperatures (Figure 5). Working at a very low concentration of deuterium required us to improve and refine the existing setup, which was a time-consuming task. As a result, we obtained some new data on the kinetics of evolution and absorption as well as the amount of retained deuterium. Isotope exchange with residual hydrogen in the bulk represents the reaction channel, which decreases the accuracy of the measured data.

The field-emission (FE) characterization of nanowires, together with two-terminal current-voltage measurements, was conducted inside a transmission electron microscope (TEM) equipped with a scanning-tunnelling microscope (STM) sample holder. The nanowires were manipulated by the electron-beam-induced deposition (EBID) of amorphous carbon (a-C) fixed to a W tip inside the TEM. Preliminary field-emission characterization and two-terminal current-voltage measurements followed. In order to get an additional insight into the characteristics of the nanowires, a second experimental setup, a classical field-emission microscope with a diode configuration designed for a point-to-plane geometry, was applied. Current-voltage relations, current field-emission microscopy imaging, and the FE current stability and reduced angular current density distribution were obtained. We found that the investigated inorganic nanowires represent a very bright point electron source comparable to carbon nanotubes.

It has been reported that relatively smooth nanocrystalline diamond films exhibit an intense electron emission at low-to-moderate applied electric fields, which was in the past attributed exclusively to nanotips and nanotubes. The spatial distribution of the emission sites that originate from the surface of nanocrystalline diamond films was determined. To characterize the relation of the emission sites over the whole surface, a triode concept has been developed, which employs a pulsed voltage to the mesh and a DC potential applied to the luminescent screen to display the emission site distribution across the 20-mm-diameter substrates. Besides this method, a novel, scanning field-emission microscope was constructed, where the applied field at the surface of the sample is uniform, and the electron emission from individual emission sites is projected onto the phosphor screen. In this way, the emission current versus the voltage for individual emitting sites was observed and characterized. This provided a fundamental insight into the relation of the materials' properties and the emission characteristics.

One of our group members spent nine months at Uppsala University in Sweden as a postdoctoral fellow. A major part of his research work consisted of measurements of heavy-ion-induced desorption yields. A rotational sample holder with various samples (flat and tubular) is shown in Figure 6. The investigated samples were made from metals such as stainless steel, copper, tantalum, etc., which are the most promising candidates for the beam pipe elements of the SIS 100/300 heavy-ion accelerator at GSI, Germany. The grazing incidence of ions exhibited a significant increase in the measured desorption yield. The experiments were conducted at the beam line of the heavy ion accelerator at The Svedberg Laboratory in Uppsala.

Some outstanding publications in the past three years

1. A. Zalar, J. Kovač, B. Praček, P. Panjan, M. Čeh, Ion sputtering rates of W-, Ti- and Cr-carbides studied at different Ar⁺ ion incidence angles, *Applied Surface Science*, 254 (2008), 6611-6618
2. S. Hofmann, J. Y. Wang, A. Zalar, Backscattering effect in quantitative AES sputter depth profiling of multilayers, *Surface and Interface Analysis*, 39 (2007), 787-797
3. U. Cvelbar, K. Ostrikov, A. Drenik, M. Mozetič, Nanowire sensor response to reactive gas environment, *Applied Physics Letters*, 92 (2008), 133505-1-133505-3
4. U. Cvelbar, K. Ostrikov, M. Mozetič, Reactive oxygen plasma-enabled synthesis of nanostructured CdO: tailoring nanostructures through plasma-surface interactions, *Nanotechnology (Bristol)*, 19 (2008), 405605-1-405605-7

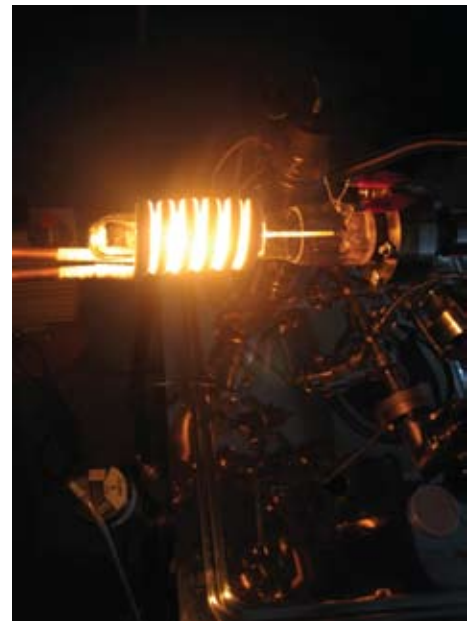


Figure 5: Deuterium-retention studies with metals relevant for the ITER fusion reactor run in the temperature range from 250 to 1000 °C.

A precise method for determining the O-atom reaction probability on the surface of delicate organic samples has been developed.

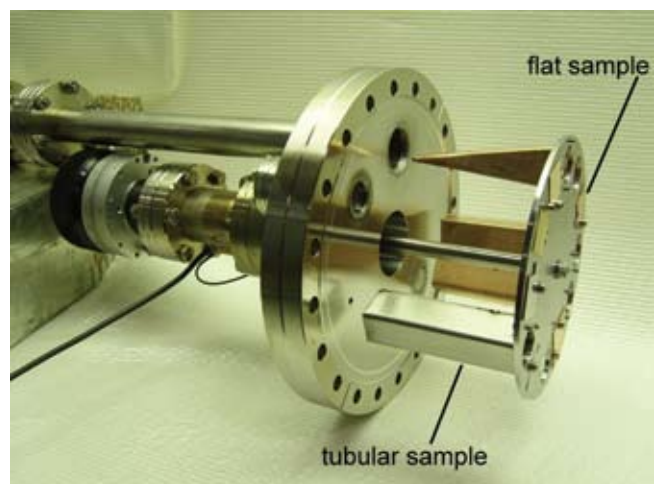


Figure 6: Rotational sample holder together with various samples intended for the determination of the heavy-ion-induced desorption yield.

5. M. Remškar, J. Kovač, M. Viršek, M. Mrak, A. Jesih, A. Seabaugh, W_5O_{14} nanowires, *Advanced Functional Materials*, 17 (2007), 1974-1978
6. V. Nemanič, M. Žumer, B. Zajec, Deuterium retention in ITER-grade austenitic stainless steel, *Nuclear Fusion*, 48 (2008), 115009-1-115009-8
7. M. Žumer, V. Nemanič, B. Zajec, M. Wang, J. Y. Liu, L.M. Peng, The field-emission and current-voltage characteristics of individual W_5O_{14} nanowires, *The Journal of Physical Chemistry*, 112 (2008), 5250-5253.

Patents granted

1. Polyester material with surface having antithrombogenic properties and a method for preparation
Simona Strnad, Tea Indest, Janne Laine, Karin Stana-Kleinschek, Alenka Vesel, Renate Dworczak
SI Patent No. 22467
2. Scanning projection field emission microscope designed to study flat broad-area field emission cathodes
Vincenc Nemanič, Marko Žumer, Bojan Zajec, Mihael Kocmur
SI Patent No. 22425

Awards and Appointments

1. Kristina Eleršič: Best poster award, 3rd European School in Materials Science of Complex Metallic Alloys, Surface and Coatings, "Damages and surface modification on bacteria Escherichia coli caused by plasma treatment" Ljubljana, Slovenia
2. Ita Junkar: Best poster award, Conference MIDEM, 44th International Conference on Microelectronics, Devices and Materials with the workshop on Advanced Plasma Technologies, "Improvement of polymer properties by plasma treatment", Fiesa, Slovenia.

Organization of conferences, congresses and meetings

1. 15. International meeting on vacuum science and techniques, Varaždin, Croatia 4 Jun. 2008
2. 44th International Conference on Microelectronics Devices and Materials and the Workshop on Advanced Plasma Technologies, Fiesa, Slovenia 17-19 Sept. 2008

INTERNATIONAL PROJECTS

1. Atmospheric Plasmas for Nanoscale Industrial Surface Processing
PlasmaNice
7. FP
EC; Dr. Johanna Lahti, Tampere University of Technology, Department of Energy and Process Engineering, Paper Converting and Packaging Technology, Tampere, Finland
Dr. Janez Kovač
2. Report on the Determination of Fuel Retention Properties of ITER Metallic Materials (Be, W and Stainless Steel 316L) under Gas Exposure in ITER-like Conditions (TW6-TTP-RETMET) - T2-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
TW6-1.3R3-TW6-G05, 3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Vincenc Nemanič
3. Removal of Deposits by Neutral Oxygen and Nitrogen Atoms - 1.4.2.-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Asst. Prof. Miran Mozetič
4. Deuterium Retention and Release from Metal Surfaces - 1.4.4. - FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Vincenc Nemanič
5. Sensitive and Differential Blood and Cerebrospinal Fluid Test for Neurodegenerative Dementia Diagnosis
Innovation Projects Under the Sixth Framework Programme of the European Community
NeuroScreen
6. FP
EC; Elodie Girardet, HLP Développement SA, Paris, France
Asst. Prof. Miran Mozetič
6. Vascular Graft Interfaces
VaGrint
MNT ERA NET
3211-07-000024
University of Maribor, Faculty of Mechanical Engineering, Maribor, Slovenia
Asst. Prof. Miran Mozetič
7. Hydrogen Impermeable Nano-material Coatings for Steels
Hy - Nano - IM
MNT ERA NET
Dr. Vincenc Nemanič, Dr. Paul McGuinness, Dr. Miha Čekada
8. Treatment of Fusion relevant Materials in Hydrogen Plasma at Extreme Conditions
Traitement de matériaux pour les réacteurs de fusion sous plasma d'hydrogène en conditions extremes
PROTEUS 2008 - 2009
BI-FR/08-09-PROTEUS-003
Dr. Marianne Balat - Pichelin, PROMES-CNRS, Laboratory for Processes, Materials and Solar Energy (PROMES)-French National Centre for Scientific research (CNRS), Odeillo-Font Romeu, Francija
Dr. Alenka Vesel
9. Determination of the Density of Nitrogen and Hydrogen Atoms in Plasma created in mixture of both Gases
Détermination des densités locales d'atomes d'azote et d'hydrogène dans deux types de décharges plasmas
PROTEUS 2008 - 2009
BI-FR/08-09-PROTEUS-009
Prof. Freddy Gaborian, LAPLACE (Laboratoire Plasma et Conversion d'Energie), CNRS-Université Paul Sabatier, Toulouse, France
Asst. Prof. Miran Mozetič
10. Cleaning and Functionalization of Biocompatible Polymer Materials with Atmospheric Pressure Plasma
PROTEUS
BI-FR07-PROTEUS-002
Dr. Belmonte Thierry, Laboratoire de Science et Génie des Surfaces, Unité Mixte de Recherche CNRS, Nancy, Francija
Dr. Uroš Cvelbar

11. Planar Cold Cathodes Composed of Inorganic Nanowires
BI-CN/07-09-008
Dr. Lian-Mao Peng, Institute of Physical Electronics, Peking University, Department of Electronics, China
Dr. Vincenc Nemanič
 12. Research of Bacteria Damages after Plasma Radical Interaction
BI-SC/06-07-001
Asst. Prof. Dragan Laušević, Institut za zdravlje Crne Gore, Podgorica, Montenegro
Asst. Prof. Miran Mozetič
 13. Simulations and Analysis of Complex Networks in Planetary Dynamics, Algorithms and Applications
Sinteza, modifikacija jonskim zračenjem i karakterizacija višeslojnih struktura na nanometarskoj skali
BI-RS/08-09-031
Prof. Momir Milosavljević, Institute for Nuclear Sciences "Vinca", Belgrade, Serbia
Prof. Anton Zalar
- Metal Oxide Nanowire/Nanotube Arrays for Electrochemical Energy Conversion Applications
BI-US/08-10-030
Prof. K. Mahendra Sunkara, University of Louisville, Department of Chemical Engineering, Louisville, KY, USA
Asst. Prof. Uroš Cvelbar
- Large Scale Synthesis and Dispersions of Metal Oxide Nanowires
BI-US/06-07-002
Prof. K. Mahendra Sunkara, University of Louisville, Department of Chemical Engineering, Louisville, KY, USA
Asst. Prof. Miran Mozetič
14. Microscopic Characterization of Field Emission Sites on Nanostructured Carbon Films
BI-US/06-07-023
Prof. Robert Nemanich, North Carolina State University (NCSU), Department of Physics, Raleigh, NC, USA
Dr. Vincenc Nemanič

R & D GRANTS AND CONTRACTS

1. Fusion relevant research and plasma surface interaction
Prof. Milan Čerček, Asst. Prof. Miran Mozetič
2. Development of diagnostics for some edge plasma parameters in fusion
Prof. Milan Čerček, Asst. Prof. Miran Mozetič
3. Electron field emission from flat nanostructured cathodes
Dr. Vincenc Nemanič
4. Polymer nanocomposites for chemical sensors
Asst. Prof. Miran Mozetič
5. Development of treatment and procedures for improvement of hemocompatibility of polyethylenetereftalate surfaces
Asst. Prof. Miran Mozetič
6. Study of the plasma parameters for conditioning of the inner surfaces of a function reactor
Asst. Prof. Miran Mozetič
7. Printed passive electronic components for smart packaging
Asst. Prof. Alenka Vesel

8. Investigation of gaseous discharges for introduction of a new environmentally friendly technology for semimanufactures functionalization at capacitors production
Asst. Prof. Miran Mozetič
9. Plasma sterilization and functionalization of biocompatible materials
Asst. Prof. Miran Mozetič
10. Electron beam writer with nanometric resolution
Dr. Vincenc Nemanič
11. Research of the integrated surge protective system
Dr. Vincenc Nemanič
12. Oxidation of metals by reactive oxygen plasma
Asst. Prof. Miran Mozetič
13. Field emission cathode from nanomaterials for THz miniature klystron
Dr. Bojan Zajec
14. Self cleaning photocatalytic paints and coatings
Asst. Prof. Miran Mozetič
15. Smart functional coatings for improvement of structures and components used in defensive purpose
Dr. Peter Panjan, Asst. Prof. Janez Kovač
16. Industrial intellectual rights as an instrument for economy development
Asst. Prof. Uroš Cvelbar

RESEARCH PROGRAMS

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

NEW CONTRACTS

1. Oxidation of metals by reactive oxygen plasma
Kolektor Group d. o. o., Idrija
Asst. Prof. Miran Mozetič
2. Plasma sterilization and functionalization of biocompatible materials
Induktio d. o. o., Ljubljana
Asst. Prof. Miran Mozetič
3. Development of treatments and procedures for improvement of hemocompatibility of polyethylenetereftalate surfaces
Bioiks d. o. o., Ljubljana
Asst. Prof. Miran Mozetič
4. Study of the plasma parameters for conditioning of the inner surfaces of a fusion reactor
Induktio d. o. o., Ljubljana
Asst. Prof. Miran Mozetič
5. Investigation of gaseous discharges for introduction of a new environmentally friendly technology for semimanufactures functionalization at capacitors production
Iskra Kondenzatorji Industrija Kondenzatorjev in Opreme d. d., Semič
Asst. Prof. Miran Mozetič

VISITORS FROM ABROAD

1. Dr. Slobodan Milošević, Nino Čutić, Nikša Krstulović, Institute of Physics, Zagreb, Croatia, several times in the year
2. Dr. Primož Eiselt, Plasmabull, Lebring, Austria, several times in the year
3. Zoran Vratnica in Danijela Vujošević, Institute for health of Montenegro, Podgorica, Montenegro, several times in the year
4. Dr. Jiang Yong Wang, Max-Planck-Institute for Metals Research, Stuttgart, Germany, 13–19 May 2008
5. Prof. dr. Kostya Ostrikov, University of Sydney, Australia, 5 Jun. to 20 Sept. 2008
6. Dr. Momir Milosavljević, dr. Velimir Milinović and dr. Davor Peruško, Institut za nuklearne nauke Vinča, Beograd, Serbia, 30 June to 4 Jul. 2008
7. Dr. Marianne Balat-Pichelin, Font Romeu, France, 15–20 Sept. 2008
8. Prof. dr. Thierry Belmonte, Université du Nancy, Nancy, France, 16–20 Sept. 2008
9. Prof. dr. Mahendra K. Sunkara, University in Louisville, Louisville, USA, 16–21 Sept. 2008
10. Prof. dr. Wang Jingyun, prof. dr. Xuelei Liang and dr. Min Gao, University of Beijing, Beijing, China, 27 Sept. to 6 Oct. 2008
11. Prof. dr. Freddy Gaboriau, University Paul Sabatier, Toulouse, France, 25–30 Oct. 2008
12. Dr. Shigeki Katom, High Energy Accelerator Research Organization (KEK), Tsukuba, Japan, 25–30 Nov. 2008

STAFF

Researchers

1. Asst. Prof. Janez Kovač
2. Asst. Prof. Miran Mozetič
3. Dr. Vincenc Nemanič
4. Asst. Prof. Alenka Vesel
5. Dr. Bojan Zajec

6. Prof. Anton Zalar, Head

Postdoctoral associates

7. Asst. Prof. Uroš Cvelbar

Postgraduates

8. Aleksander Drenik, B. Sc.

9. Kristina Eleršič, B. Sc.
10. Ita Juncar, B. Sc.
11. Borut Praček, B. Sc.
12. Tjaša Vrlinič, B. Sc.
13. Marko Žumer, B. Sc.

Technical and administrative staff

14. Ružica Bolte
15. Tatjana Filipič, B. Sc.
16. Mihael Kocmur
17. Janez Trtnik

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. N. Bundaleski, S. Petrović, Dalibor Peruško, Janez Kovač, Anton Zalar, "Composition of the sputter deposited W-Ti thin films", *Appl. surf. sci.*, vol. 254, no. 20, pp. 6390-6394, 2008.
2. Alciwiadis-Constantinos Cefalas, Janez Kovač, Evangelia Sarantopoulou, Goran Dražič, Zoe Kollia, Spomenka Kobe, "Growth and adhesion of biphasic crystalline-amorphous Sm/Fe-Ta-N magnetic nanospheroids on a Ta surface", In: *The 12th European conference on applications of surface and interface analysis: Brussels, Belgium, 9-14 September 2007: ECASIA'07*, (Surface and interface analysis, Vol. 40, Issues 3-4), Wiley, 2008, Heyden & Son, vol. 40, no. 3/4, pp. 364-367, 2008.
3. Zhiqiang Chen, Uroš Cvelbar, Miran Mozetič, Jiaqing He, Mahendra K. Sunkara, "Long-range ordering of oxygen-vacancy planes in $\alpha - Fe_2O_3$ nanowires and nanobelts", *Chem. mater.*, vol. 20, no. 9, pp. 3224-3228, 2008.
4. Uroš Cvelbar, Zhiqiang Chen, Mahendra K. Sunkara, Miran Mozetič, "Spontaneous growth of superstructure $\alpha - Fe_2O_3$ nanowire and nanobelt arrays in reactive oxygen plasma", *Small (Weinb., Print)*, vol. 4, no. 10, pp. 1610-1614, 2008.
5. Uroš Cvelbar, Kostya Ostrikov, Aleksander Drenik, Miran Mozetič, "Nanowire sensor response to reactive gas environment: [selected as a topical article for the April 14, 2008 issue of Virtual journal of nanoscale science & technology (ISSN 1553-9644, published by the American Institute of Physics and the American Physical Society)]", *Appl. phys. lett.*, vol. 92, no. 13, pp. 133505-1-133505-3, 2008.
6. Uroš Cvelbar, Kostya Ostrikov, Miran Mozetič, "Reactive oxygen plasma-enabled synthesis of nanostructured CdO tailoring nanostructures through plasma-surface interactions", *Nanotechnology (Bristol)*, vol. 19, no. 40, pp. 405605-1-405605-7, 2008.
7. I. Denysenko, Kostya Ostrikov, Uroš Cvelbar, Miran Mozetič, Nikolai Alekseevich Azarenkov, "Carbon nanofiber growth in plasma-enhanced chemical vapor deposition", *J. appl. phys.*, vol. 104, no. 7, pp. 073301-1-073301-9, 2008.
8. Aleksander Drenik, Uroš Cvelbar, Kostya Ostrikov, Miran Mozetič, "Catalytic probes with nanostructured surface for gas/discharge diagnostic: a study of a probe signal behaviour", *J. phys., D, Appl. phys.*, vol. 41, no. 11, pp. 115201-1-115201-7, 2008.
9. Aleksander Drenik, Alenka Vesel, Miran Mozetič, Peter Panjan, Miha Čekada, "Odstranjevanje amorfnih hidrogeniziranih ogljikovih tankih plasti s kisikovimi atomi", *Vakuumist*, vol. 28, no. 1/2, pp. 8-11, 2008.
10. Nina Hauptman, Marta Klanjšek Gunde, Alenka Vesel, Matjaž Kunaver, "Spremembe površine praškastega premaza zaradi jedkanja s kisikovo plazmo", *Vakuumist*, let. 28, no. 1/2, pp. 4-7, 2008.
11. Boštjan Japelj, Angela Šurca Vuk, Boris Orel, Lidija Slemenik Perše, Ivan Jerman, Janez Kovač, "Preparation of a TiMEMO nanocomposite by the sol-gel method and its application in coloured thickness insensitive spectrally selective (TISS) coatings", *Sol. energy mater. sol. cells*, vol. 92, no. 9, pp. 1149-1161, 2008.
12. Ivan Jerman, Angela Šurca Vuk, Matjaž Koželj, Boris Orel, Janez Kovač, "A structural and corrosion study of triethoxysilyl functionalized POSS coatings on AA 2024 alloy", *Langmuir*, vol. 24, no. 9, pp. 5029-5037, 2008.
13. Irena Kozjek-Škofic, Janez Kovač, Nataša Bukovec, "The ion-storage capacity and surface characterization of Ce/Cu thin films", *Acta chim. slov.*, vol. 55, no. 4, pp. 897-903, 2008.
14. Zlatko Kregar, Nikša Krstulović, Slobodan Milošević, Klemen Kenda, Uroš Cvelbar, Miran Mozetič, "Inductively coupled RF oxygen plasma studied by spatially resolved optical emission spectroscopy", *IEEE trans. plasma sci.*, vol. 36, no. 4, pp. 1368-1369, 2008.
15. Danjela Kuščer, Janez Kovač, Marija Kosec, Ronn Andriesen, "The effect of the valence state of titanium ions on the hydrophilicity of ceramics in the titanium-oxygen system", *J. Eur. Ceram. Soc.*, vol. 28, no. 3, pp. 577-584, 2008.
16. Igor Levchenko, Kostya Ostrikov, Uroš Cvelbar, "Simulation and visualization of self-assembled nanodevice networks synthesized via plasma-surface interaction", *IEEE trans. plasma sci.*, vol. 36, no. 4, pp. 866-867, 2008.
17. I. Levchenko, Kostya Ostrikov, M. Keidar, Uroš Cvelbar, "Model of nanotube growth in plasmas and reasons for single-walled structure", *J. phys., D, Appl. phys.*, vol. 41, no. 13, pp. 132004-1-132004-6, 2008.
18. M. Mafra, Thierry Belmonte, A. Maliska, A. S. da Silva Sobrinho, Uroš Cvelbar, F. Poncin-Eppailard, "Argon - oxygen post-discharge treatment of hexatriacontane: heat transfer between gas phase and sample", *Key eng. mater.*, vol. 373/374, pp. 421-425, 2008.
19. Miran Mozetič, Uroš Cvelbar, Alenka Vesel, Nikša Krstulović, Slobodan Milošević, "Interaction of oxygen plasma with aluminium substrates", *IEEE trans. plasma sci.*, vol. 36, no. 4, pp. 868-869, 2008.
20. Vincenc Nemanič, Marko Žumer, Bojan Zajec, "Deuterium retention in ITER-grade austenitic stainless steel", *Nucl. fus.*, vol. 48, no. 11, pp. 115009-1-115009-8, 2008.
21. Vincenc Nemanič, Marko Žumer, Bojan Zajec, "Visualization of individual emission sites on flat broad-area field emission cathodes", *Ultramicroscopy*, vol. 108, pp. 69-73, 2008.
22. Vincenc Nemanič, Marko Žumer, Bojan Zajec, Dragan Mihailović, Damjan Vengust, Boštjan Podobnik, "Deuterium influence on the field emission from inorganic nanowires", *J. appl. phys.*, vol. 103, no. 9, pp. 094310-1-094310-5, 2008.
23. Jana Padežnik Gomilšek, Alojz Kodre, Iztok Arčon, Vincenc Nemanič, "X-ray absorption in atomic potassium", *Nucl. instrum. methods phys. res., B Beam interact. mater. atoms*, 266, pp. 677-680, 2008.
24. Matjaž Panjan, Anton Zalar, Janez Kovač, Miha Čekada, Peter Panjan, "Določanje koncentracijskih profilov in difuzijskih parametrov v tankoplastnih strukturah s profilno analizo in modelom MRI", *Vakuumist*, vol. 28, no. 1/2, pp. 19-29, 2008.
25. Peter Panjan, Miha Čekada, Janez Dolinšek, B. Vrtič, Anton Zalar, Darja Kek-Merl, "Diffusion processes during heat treatment of Al-Cr-Fe thin films", In: *Proceedings of the 11th joint vacuum conference (JVC-11): Prague, Czech Republic, 24-28 September 2006*, (Vacuum, Vol. 82, Issue 2, 2007), Vladimír Matolín, ed., Oxford, New York, Pergamon Press, 2007, vol. 82, no. 2, pp. 286-289, 2008.
26. Dalibor Peruško, M. Milosavljević, V. Milinović, B. Timotijević, Anton Zalar, Janez Kovač, Borut Praček, C. Jeynes, "High fluence nitrogen implantation in Al/Ti multilayers", In: *Proceedings of ECCART9, 9th European Conference on Accelerators in Applied Research and Technology, Florence, Italy, Concitto della Calza, September 3-7, 2007*, (Nuclear instruments & methods in physics research, B, vol. 266, no. 10), Mariaelena Fedi, ed., Novella Grassi, ed., Pier Andrea Mandó, ed., Amsterdam, Elsevier, 2008, vol. 266, no. 10, pp. 2503-2506, 2008.
27. Gorazd Planinšič, Janez Kovač, "Nano goes to school: a teaching model of the atomic force microscope", *Phys. Educ.*, 43, pp. 37-45, 2008.
28. Drago Resnik, Janez Kovač, Danilo Vrtačnik, Slavko Amon, "Structural investigation of direct current magnetron sputtered Ti/NiV/Ag layers on n+Si substrate", *Thin solid films*, vol. 516, no. 21, pp. 7497-7504, Sep. 2008.
29. Evangelia Sarantopoulou, Janez Kovač, Zoe Kollia, Ioannis Raptis, Spomenka Kobe, Alciwiadis-Constantinos Cefalas, "Surface modification of polymeric thin films with vacuum ultraviolet light", In: *The 12th European conference on applications of surface and interface analysis: Brussels, Belgium, 9-14 September 2007: ECASIA'07*, (Surface and interface analysis, Vol. 40, Issues 3-4), Wiley, 2008, Heyden & Son, vol. 40, no. 3/4, pp. 400-403, 2008.
30. Evangelia Sarantopoulou, Janez Kovač, Stergios Pispas, Spomenka Kobe, Zoe Kollia, Alciwiadis-Constantinos Cefalas, "Self-assembled ferromagnetic and superparamagnetic structures of hybrid Fe block copolymers", In: *E-MRS 2007 symposium K-nanoscale self-assembly and patterning: spring meeting 2007, Strasbourg, France, May 28th - June 1st, 2007*, (Superlattices and microstructures, Vol. 44, Issue 4-5, 2008), Isabelle Berbezier, ed., London, Academic Press, 2008, issue 4-5, vol. 44, pp. 457-467, 2008.
31. Marc Schroeder, Enrico Fatarella, Janez Kovač, Georg M. Gübitz, Vanja Kokol, "Laccase-induced grafting on plasma-pretreated polypropylene", *Biomacromolecules*, 9, 10, pp. 2735-2741, 2008.
32. Brigita Tomšič, Barbara Simončič, Boris Orel, Lidija Černe, Petra Forte-Tavčer, Mateja Zorko, Ivan Jerman, Aljaž Vilčnik, Janez Kovač, "Sol-gel coating of cellulose fibres with antimicrobial and repellent properties", *J. sol-gel sci. technol.*, vol. 47, no. 1, pp. 44-57, 2008.
33. Alenka Vesel, Ita Junkar, Uroš Cvelbar, Janez Kovač, Miran Mozetič, "Surface modification of polyester by oxygen-and nitrogen-plasma treatment", *Surf. interface anal.*, vol. 40, no. 11, pp. 1444-1453, 2008.
34. Alenka Vesel, Miran Mozetič, Aleksander Drenik, Nina Hauptman, Marianne Balat-Pichelin, "High temperature oxidation of stainless steel AISI316L in air plasma", *Appl. surf. sci.*, vol. 255, issue 5, Part 1, pp. 1759-1765, 2008.
35. Alenka Vesel, Miran Mozetič, Anton Zalar, "XPS characterization of PTFE after treatment with RF oxygen and nitrogen plasma", In: *The 12th European conference on applications of surface and interface analysis: Brussels, Belgium, 9-14 September 2007: ECASIA'07*, (Surface and interface analysis, Vol. 40, Issues 3-4), Wiley, 2008, Heyden & Son, vol. 40, no. 3/4, pp. 661-663, 2008.
36. Alenka Vesel, Miran Mozetič, Anton Zalar, "XPS study of oxygen plasma activated PET", In: *Proceedings of the 11th joint vacuum conference (JVC-*

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37. Anton Zalar, Janez Kovač, Borut Praček, Peter Panjan, Miran Čeh, "Ion sputtering rates of W-, Ti- and Cr-carbides at different Ar^+ ion incidence angles", *Appl. surf. sci.*, vol. 254, no. 20, pp. 6611-6618, 2008.
38. Marko Žumer, Vincenc Nemanič, Bojan Zajec, Mingsheng Wang, J. Y. Wang, Yang Liu, Lian-Mao Peng, "The field-emission and current-voltage characteristics of individual W_5O_{14} nanowires", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 112, no. 14, pp. 5250-5253, 2008.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Uroš Cvelbar, "Selective etching of micro and nanocomposites by oxygen plasma: the case of graphite/PPS polymer composite", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDE - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 47-50.
2. Uroš Cvelbar, Miran Mozetič, "Quantification of neutral atoms in processing plasmas", In: *International Conference and Exhibition on Analysis & Testing of Materials: Beijing, 4 November 2007*, (Metallurgical analysis, vol. 28, suppl. 1, 2008), Beijing, Yejinbu Gangtie Yanjiu Zongyuan, 2008, vol. 28, suppl. 1, pp. 540-546, 2008.
3. Alenka Vesel, "Surface functionalization of organic materials by plasma treatment", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDE - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 41-46.

Regular papers

1. Marianne Balat-Pichelin, H. Vandevivère, B. Boyez, L. Charpentier, Alenka Vesel, "Hydrogen atoms recombination on ceramics and metals in the temperature range 300-1600K", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDE - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 195-200.
2. Milan Bizjak, Ladislav Kosce, Janez Kovač, Anton Zalar, Peter Panjan, "Characterization of iron oxide layers on electromagnetic sheets using Auger electron spectroscopy", In: *Metalni i nemetalni materijali: proizvodnja, osobine, primjena: zbornik radova: production, properties, application: proceedings*, VII naučno-stručni simpozij sa međunarodnim učešćem Metalni i nemetalni materijali = 7th Scientific-Research Symposium with International Participation Metallic and Nonmetallic Materials, Zenica, 22.-23. May 2008., Zenica, Fakultet za metalurgiju i materijale, = Faculty of Metallurgy and Materials Science, 2008, pp. 333-338.
3. Aleksander Drenik, Uroš Cvelbar, Alenka Vesel, Dušan Babič, Igor Poberaj, Miran Mozetič, "Characterization of weakly ionised plasma with catalytic probes", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDE - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 201-204.
4. Kristina Eleršič, Ita Junkar, Janez Kovač, Uroš Cvelbar, Aleksander Drenik, Miran Mozetič, "Investigation of damages on bacteria *Escherichia coli* caused by afterglow plasma treatment", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDE - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 231-233.
5. José Marija Fonte Ferreira, Francisco Tabarés, Alenka Vesel, Miran Mozetič, "Characterization of helium plasma created in an asymmetric DC normal glow discharge with a single Langmuir probe", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies*, September 17. - September 19. 2008, Fiesa, Slovenia, Slavko Amon, ed., Miran Mozetič, ed.,

- Iztok Šorli, ed., Ljubljana, MIDE - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 189-192.
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PATENT APPLICATIONS

1. Miran Mozetič, Alenka Vesel, Ita Junkar, Uroš Cvelbar, Simona Strnad, *Method and device for the modification of implants and synthetic blood vessels: patentna prijava no. PCT/SI2008/000050*, Ljubljana, Urad RS za intelektualno lastnino, 2008.

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 the one hand, 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 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 the Jožef Stefan Institute is performed in close collaboration with the Department of Physics at the Faculty of Mathematics and Physics of the University of Ljubljana, the Institute of Mathematics, Physics and Mechanics and the Jožef Stefan International Postgraduate School. In 2008, the research was performed within three research programs:

- NMR and Dielectric Spectroscopy of Condensed Matter: Smart New Materials and Translational Symmetry Breaking,
- Physics of Soft Matter, Surfaces and Nanostructures,
- Experimental Biophysics of Complex Systems.

Research programme “Magnetic Resonance and Dielectric Spectroscopy of Condensed Matter: Smart New Materials and Translational Symmetry Breaking”

The program group was 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 the investigations was to discover the basic laws of physics governing the behaviour of these systems, which represent a link between perfectly ordered crystals, on the one hand, and amorphous matter, soft condensed matter and living systems, on the other. This knowledge provides the key to the understanding of the macroscopic

The group has investigated important open questions in the physics of spin liquids, and it has discovered the principal reason for the giant electromechanical response of ferroelectric relaxors in the vicinity of the critical point. It has determined the physical and chemical properties of selected nanomaterials and discovered the thermal memory effect in quasicrystalline intermetallic compounds.

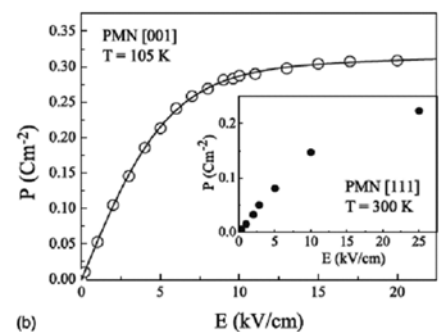
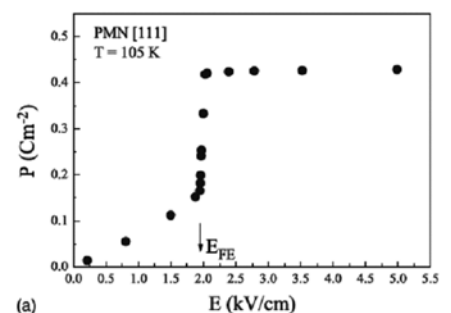


Figure 1: Anisotropy in the polarization electric-field dependence as observed in PMN [111] (a) and PMN [001] (b) single crystals. (Z. Kutnjak et al.)

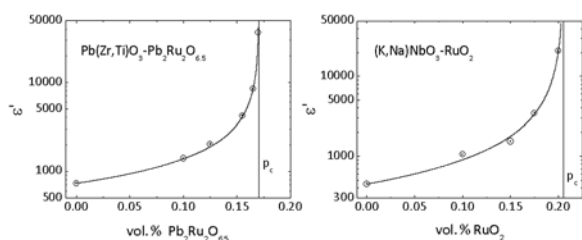


Figure 2: Real part of the dielectric constant versus the conductive filler volume concentration, measured at RT and 1 kHz in all-ceramic percolative composites. The solid lines represent the fit of the experimental data to the theoretical predictions, while vertical lines indicate the percolation threshold. (V. Bobnar et al.)

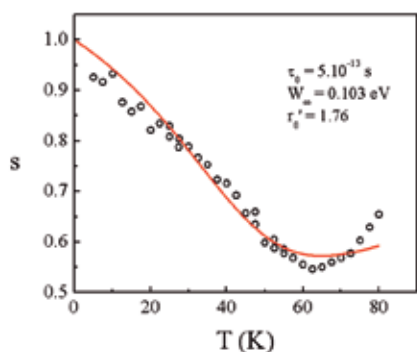


Figure 3: Temperature dependence of the UDR parameter s in magnetolectric $K_3Fe_5F_{15}$. The solid line represents the fit of the experimental data to a model for small polaron tunnelling. (R. Blinc, A. Levstik et al.)

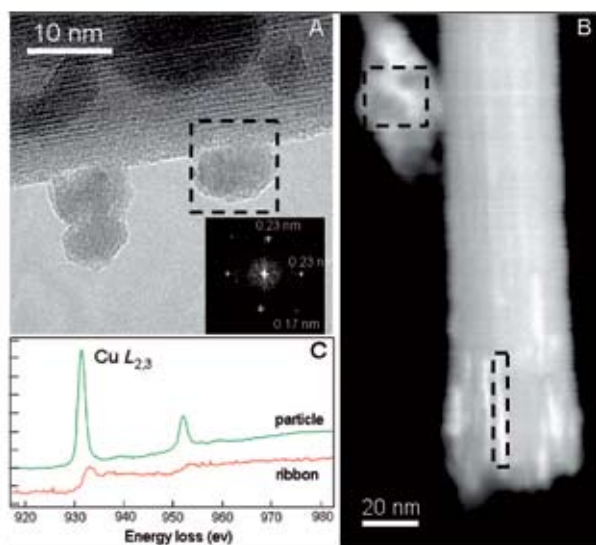


Figure 4: Characterization of doped titanium nanoribbons by the method *ex situ* using electron microscopy (HRTEM (a) and HAADF-STEM (b)) and electron spectroscopy (EELS (c)). (P. Umek et al.)

properties of these systems and is an important condition for the discovery and development of new, multifunctional materials and nanomaterials for new applications. In 2008, the members of the program group published their research in **51 original publications** in international scientific journals. The investigations were directed to:

Giant electromechanical response of relaxor ferroelectrics.

The electric field-temperature phase diagram was calculated for perovskite ferroelectric relaxors in the vicinity of the critical point where the giant electromechanical response is observed. It was shown that the PMN single crystal exhibits remarkable anisotropy, in contrast to previous views that this system is an isotropic relaxor glass. We also confirmed the existence of the critical point in the [111] axis in PMN and its absence in the [001] axis. These findings are important for understanding the giant electromechanical response and for the future engineering and production

of sensors and actuators on the basis of these materials. Relevant publications: M. Iwata, Z. Kutnjak, Y. Ishibashi, R. Blinc, *J. Phys. Soc. Jpn.* 77, 034703-1 (2008); Z. Kutnjak, B. Vodopivec, R. Blinc, *Phys. Rev. B* 77, 054102-1 (2008); M. Iwata, Z. Kutnjak, Y. Ishibashi, R. Blinc, *J. Phys. Soc. Jpn.* 77, 065003-1 (2008); Z. Kutnjak, *Ferroelectrics* 369, 198 (2008); Z. Kutnjak, *Ferroelectrics* 369, 133 (2008).

Synthesis and characterization of newly developed all-ceramic percolative composites.

In a collaboration between researchers from the Condensed Matter Physics Department and the Electronic Ceramics Department of the JSI, the first all-ceramic percolative composites (comprising a conductive filler in a dielectric matrix) have been developed. Until now only organic percolative composites and inorganic systems, comprising metal particles within an insulator, have been developed. The structural analysis revealed an almost ideal structure - conductive ceramic grains uniformly distributed in a dielectric ceramic matrix. Thus, in the lead-based PZT- $Pb_2Ru_2O_{6.5}$ and in the lead-free KNN- RuO_2 systems, the dielectric response follows the predictions of the percolation theory. The dielectric constant actually diverges on approaching the percolation threshold (values as high as 40,000 were detected) and the critical exponents and percolation points agree reasonably well with the theoretically predicted values. The electromechanical properties further demonstrated the potential for use as high-dielectric-constant materials in various applications. Published in: V. Bobnar, M. Hrovat, J. Holc, M. Kosec, *Appl. Phys. Lett.* 92, 182911 (2008).

Polarons in magnetolectric $K_3Fe_5F_{15}$. In the past decade, the number of investigations of magnetolectrics has grown rapidly, as they are promising materials for new types of memory elements. We discovered a new magnetolectric, i.e., $K_3Fe_5F_{15}$. We showed from the measured ac electric conductivity that the charge transport is governed by a thermally activated process at high temperatures, while at low temperatures the tunnelling of small polarons prevails. We were the first to show that polarons play an important role as a charge-transport mechanism in $K_3Fe_5F_{15}$, which could provide a clue for understanding the magnetolectric effect in this system. Published in: R. Blinc et al., *J. Appl. Phys.* 103, 074114 (2008); A. Levstik, C. Filipič, V. Bobnar, G. Tavčar, and B. Žemva, *Europhys. Lett.* 83, 27001 (2008).

Synthesis and characterization of titanate and MnO_2 nanostructures

An important achievement was the synthesis of Cu^{2+} -doped titanate nanostructures by *in situ* and *ex situ* methods and the determination of the accumulation sites for Cu^{2+} ions with electron microscopy and electron paramagnetic resonance. The results represent joint work with the group from Université Paris Sud, France. The results were published in *Journal of Physical Chemistry C*. The accumulation sites for the Cu^{2+} ions in the sample of titanate nanoribbons doped *ex situ* with Cu^{2+} are shown in figure 4. The Cu^{2+} ions accumulate on the surface of the nanoribbons in the form of CuO nanoparticles (figure 4A) and between the titanate layers, where they exchange the Na^+ ions (the bright contrast in figure 4B).

(Non)existence of a nematic phase for the 12CB

The first homologues of the *n*-acyl cyanobipheyl family of liquid crystals (*n*-CB) were synthesised more than 30 years ago. Their stability and electro-optical properties at room temperature have made them attractive materials for display technology. Higher homologues ($n = 8-14$) of the same family were studied extensively using various techniques, such as differential

scanning calorimetry (DSC), high-resolution calorimetry, light scattering, dielectric spectroscopy and X-rays, and phase diagrams have been constructed. In spite of this intensive research, several important questions have remained unresolved, among them being the possibility of the existence of a nematic phase for 12CB. We have employed high-resolution calorimetric techniques to investigate the unresolved issue of the existence of a nematic phase for the 12CB. Various heating and cooling runs were performed on 12CB samples of different origin; these revealed no signature of a nematic phase, which was further supported by optical polarising microscopy. The research was also focused on the preparation of mixtures of ferroelectric liquid crystals (FLCs) and anisotropic magnetic nanoparticles (NPs), as well as the study of phase ordering due to FLC-NP coupling. By measuring the magnetic response, a finite FLC-NP coupling effect was observed for a mixture of weakly anisotropic magnetic NPs and the FLC phase, suggesting that such systems could be used as soft magnetoelectrics.

Liquid crystalline elastomers and emulsions. Studies of liquid crystalline elastomers (LCEs) are of interest because of their potential applicability as biologically inspired actuators or artificial muscles. They exhibit exceptional mechanical properties, such as an elastic modulus comparable to that of human skeletal muscles and a giant anisotropic deformation (up to 400%) at the phase transition between the ordered and the disordered liquid-crystalline phase. We demonstrated, using *ac*-calorimetry and nuclear magnetic resonance of deuterium, that by increasing the crosslinking density in a LCE the thermodynamic response of the system changes from below-critical to supercritical. Accordingly, the thermomechanical response at the phase transition becomes more gradual, and can thus be tuned by selecting an appropriate crosslinking density. This result was obtained for the side-chain and the main-chain LCEs and is an indication that the link between the crosslinking density and the criticality of the phase transition is universal. We investigated the applicability of photoactive LCEs for their use in photonics. We found that information could be stored in these systems by “optical writing”, thus creating tunable optical gratings. We employed spectroscopic NMR imaging in our investigations of the solubility of nanoscopic micelles in a nematic liquid crystal. The expulsion of micelles from the nematic phase was visualized at the onset of the isotropic-to-nematic phase transition, which results in the phase separation of the micelle-poor nematic phase and the micelle-rich isotropic phase. This process is driven by the elastic forces of the nematic director field caused by the incompatible spherical shape of the micelles. Our investigation ruled out the assumptions of other groups about the formation of a thermodynamically stable “transparent nematic phase”. Published in *Phys. Rev. E* 78, 031707 (2008).

Strongly correlated electron systems. We focused on certain fulleride salts as a model system. In particular, we were interested in systems with a greatly expanded unit cell as we expected that in these systems electronic correlations will gain in importance. We demonstrated in our magnetic resonance experiments that $(\text{CH}_3\text{NH}_2)_\text{K}_3\text{C}_{60}$ has an insulating antiferromagnetic ground state with a Neel temperature $T_N=46$ K. The work was published in *J. Am. Chem. Soc.* and *Phys. Rev. B*. We were the first to find the antiferromagnetic resonance in this model system and simulations of ^1H and ^2H NMR spectra enabled us to determine the exact antiferromagnetic structure. In our studies of Li_4C_{60} we focused on the phase diagram and demonstrated that Li_4C_{60} is a metallic cubic system with a very small unit cell at high temperature.

Nanomaterials. We focused on titanate nanostructures and their possible applications. A very important study was published in *Adv. Funct. Mat.*, where we reported on a pulsed EPR study of sol-gel titanate structures and their charge excitation upon UV-light illumination. These results are relevant for the development of novel solar cells and we propose an alternative structure to Grätzel cells. Considerable effort was devoted to the doping of semiconducting titanate nanostructures with transition-metal elements. The basic idea of these activities was to prepare semiconducting ferromagnetic structures, which are potentially interesting for future spintronic devices. We demonstrated that in copper-doped titanate nanotubes, Cu^{2+} intercalates into the structure as anticipated. However, we also found that a large amount of copper forms CuO nanoparticles (typical dimensions of 5 nm) that grow on the outer surface of the titanate nanotubes.

Magnetic systems. We studied the magnetic properties of low-dimensional antiferromagnetic systems and discovered an antiferromagnetic resonance in layered $\text{Ni}_3(\text{TeO}_3)_4\text{Br}_2$ and explained this resonance with a microscopic spin model. We have also studied the magnetic properties of hollandite structures with a typical frustrated antiferromagnetic triangular lattice. We found that some vanadium ions change their valence because of electron doping (a non-stoichiometry that appears during the synthesis) and that this may be responsible for a three-dimensional antiferromagnetic ordering at low temperatures.

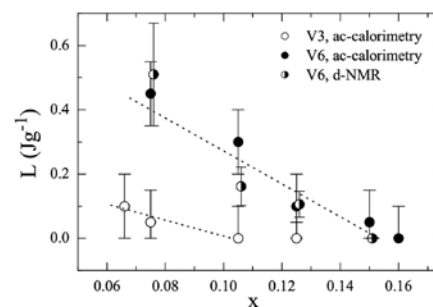


Figure 5: Experimentally observed onset of criticality (disappearance of the latent heat L) by increasing the crosslinking density (x) in conventional LC elastomer structures with side chains. (B. Zalar; A. Lebar et al.).

We have synthesised coaxial MoS_2 nanotubes and “mama-tubes”, where MoS_2 nanospheres are encapsulated in the nanotubes during the growth.

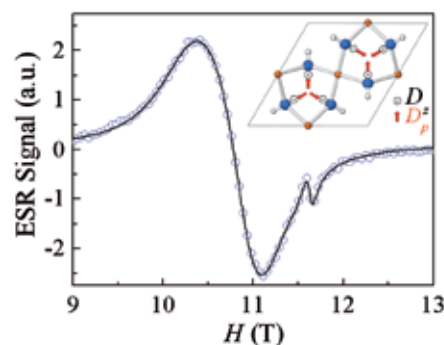


Figure 6: Room-temperature ESR spectrum of $\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$, measured at 326.4 MHz. The fit (solid line) corresponds to two Lorentzians. Inset shows the kagome lattice of copper $S = 1/2$ spins (orange circles) and a corresponding pattern of Dzyaloshinsky-Moriya vectors. (A. Zorko et al.).

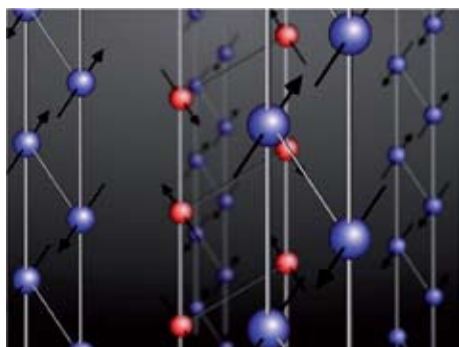


Figure 7: Magnetic ladders in $\text{CuBr}_4(\text{C}_5\text{H}_{12}\text{N})_2$ (M. Klanjšek et al.)

Geometrically frustrated spin lattices. We studied two novel realizations of a *kagomé spin lattice* as part of our investigations of geometrically frustrated spin lattices, in which all pairwise exchange interactions cannot be simultaneously minimized. Both spin lattices are lacking any signs of magnetic instabilities, at least down to 20 mK. In the case of the classical-spin compound $\text{Nd}_3\text{Ga}_5\text{SiO}_{14}$ we demonstrated the existence of a spin-liquid state, in which an applied magnetic field strongly affects the spin fluctuations (A. Zorko et al., *Phys. Rev. Lett.* 100, 147201 (2008)). In the quantum-spin system $\text{ZnCu}_3(\text{OH})_6\text{Cl}_2$, on the other hand, we determined the symmetry and magnitude of the magnetic anisotropy – the Dzyaloshinsky-Moriya interaction – which can crucially affect the spin-liquid ground state and explain the absence of a spin gap in this system (A. Zorko et al., *Phys. Rev. Lett.* 101, 026405 (2008)).

Luttinger spin liquids. In collaboration with the NMR group from the Grenoble High Magnetic Field Laboratory we have studied $\text{CuBr}_4(\text{C}_5\text{H}_{12}\text{N})_2$, a system of magnetic Cu^{2+} atoms arranged to form parallel ladders. We have shown that its magnetic behaviour at low temperatures can be perfectly described by the general “Luttinger liquid” theory, which is assumed to describe

any 1D microscopic system, including the magnetic ladder. Our work represents the first quantitative demonstration of this powerful theory. Published in Klanjšek et al., *Phys. Rev. Lett.* 101, 137207 (2008).

New methods for the detection of solid explosives. Despite its relatively low sensitivity, the ^{14}N NQR detection of solid explosives is still promising among the many technologies used for the detection of buried antipersonnel landmines and improvised explosive devices. The reason is its characteristic response, which results in a very small false-alarm rate. In 2008 we obtained two major results:

- we determined some important TNT NQR properties,
- we developed a new detection technique, without polarization enhancement, which is able to detect a small amount of the explosive TNT, ~ 70 g in less than 1 min.

Hydrogen-storage materials. The transition of our society towards a “hydrogen economy” will require that we find a way to store hydrogen. Intermetallic alloys of rare earths and transitional metals represent a promising class of hydrogen-storage materials. In particular, alloys with a quasicrystalline structure have been shown to exhibit a high density of hydrogen interstitial sites. We used fast field cycling relaxometry to study the hydrogen dynamics in partially quasicrystalline alloy $\text{Zr}_{69.5}\text{Cu}_{12}\text{Ni}_{11}\text{Al}_{7.5}$. We have demonstrated that this method is superior to classical NMR and allows us to distinguish various models of hydrogen binding. We were able to determine the distribution of hydrogen activation energies, and, in combination with our previous diffusion measurement, the hopping distance between the interstitial sites.

Setting of dental cements The dynamics of the setting of dental cements is important information for both designing new cements and for a comparison of different cements. Also, the cement paste is very sensitive to the fluids in the mouth during the early stages of the setting reaction. NMR relaxation is a well-established method for following the setting reaction of ordinary Portland cements, where the hydration lasts for as long as 28 days. We have successfully applied this technique to follow the setting reaction of dental glass-ionomer cements, which set in the course of several minutes. The method allows us to qualitatively and quantitatively compare the setting dynamics of various dental cements.

Quasicrystals and complex metallic alloys. One of our important achievements was the synthesis, structure determination and thermoelectric properties of boron-doped $\text{Ba}_8\text{Al}_{14}\text{Si}_{31}$ clathrate phases. The structure of boron-doped $\text{Ba}_8\text{Al}_{14}\text{Si}_{31}$ is shown in figure 10. Using the solid-state MAS and MQMAS NMR techniques we proved the incorporation of boron into the framework structure. This work is an important step towards an efficient thermoelectric material, containing light elements, which are advantageous for transportation applications. The results represent joint work with the Max-Planck Institute for Chemical Physics of Solids in Dresden and the Department of Chemistry from the University of California. Published in *Inorganic Chemistry* 47, 8204 (2008) (P. Jeglič et al.).

As part of our research on complex metallic alloys we have investigated the Y-Al-Ni-Co approximant phase to the decagonal quasicrystal. We determined the spatially anisotropic physical properties (magnetic, electrical and thermal conductivity, thermoelectric power, Hall coefficient) along three orthogonal crystalline directions. The transport coefficients were theoretically simulated by an *ab-initio* calculation, showing that the origin of the anisotropy is the anisotropic Fermi surface, as a consequence of the stacked-layer structure of the crystalline lattice. The anisotropic Fermi surface of the Y-Al-Ni-Co phase is shown in figure 11. The investigation was published in: A. Smontara, I. Smiljanič, J. Ivkov, D. Stanič, O. Barišič, Z. Jagličič, P. Gille, M. Komelj, P. Jeglič, M. Bobnar, J. Dolinšek, *Phys. Rev. B* 78, 104204(2008).

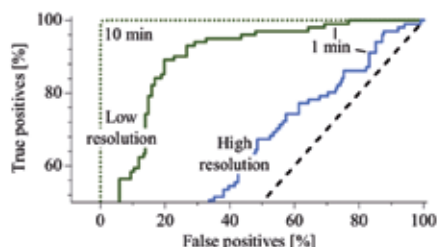


Figure 8: Sensitivity of the new “low-resolution” detector with a detection time of 1 min (green solid curve) and 10 min (dotted green curve). For comparison the sensitivity of a conventional “high-resolution” detector is shown as well (solid blue curve). (T. Apih, A. Gregorović et al.)

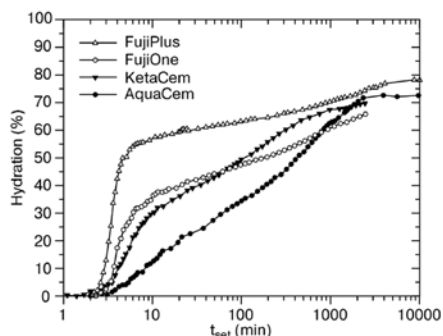


Figure 9: NMR relaxation enables us to follow the hydration dynamics of fast-setting glass-ionomer cements. (T. Apih et al.)

Memory effect in complex metallic alloys. A new type of complex metallic alloys, known as the Taylor phases, exhibit a memory effect, where the thermal history of the crystal can be stored by pure temperature manipulation. The crystal “knows” the temperature where the cooling was temporarily stopped and for how long it was stopped. The information is stored in the local magnetic order of magnetically frustrated electronic spins. The stored information can be read by measuring the electronic magnetization in a small magnetic field. We have successfully thermally written one byte of eight bits of digital information, so that the Taylor-phase crystal represents a thermal memory cell. This discovery represents the introduction of a new kind of memory element, where the digital information is stored by pure temperature manipulation in the absence of any external static electrical or magnetic field or electromagnetic radiation (J. Dolinšek et al., *Phys. Rev. B* 77, 064430(2008)).

Development of novel double-resonance methods; study of phase transition in organic ferroelectric; analysis of NQR parameters ^{17}O in P=O and P-O-H bonds

The ^1H - ^{14}N nuclear quadrupole double resonance using magnetic field cycling between high and low magnetic fields and the solid effect in a low magnetic field was analyzed in detail. The transition probabilities per unit time for the solid-effect transitions were calculated. The double resonance spectra were calculated in the limiting cases of fast and slow nitrogen spin-lattice relaxation. The double resonance spectra were measured in histamine and quinolinic acid. The experimental spectra were analyzed and the ^{14}N NQR frequencies were, for the first time, determined in both substances. The sensitivity of Slusher and Hahn’s nuclear quadrupole double resonance technique was calculated in general for an arbitrary nuclear spin S of the quadrupole nuclei and for an arbitrary transition between the quadrupole energy levels. The nuclear spin $S = 5/2$ (^{17}O , ^{25}Mg) was treated in detail. The influence of the cross-relaxation rate between the quadrupole nuclei and the protons on the sensitivity of the double resonance was discussed. The results of the theoretical analysis were applied in the analysis of the ^1H - ^{17}O nuclear quadrupole double resonance spectra in p-toluenesulfonamide and 2-nitrobenzoic acid. The ^{17}O nuclear quadrupole resonance frequencies from a sulphonamide group were determined for the first time. The proton-oxygen cross-relaxation rates were experimentally determined from the nuclear quadrupole double resonance spectra.

European projects in 2008. The above research was partially supported by the EU FP6 project MULTICERAL (principal Slovenian investigator, R. Blinc), and by the EU FP6 Network of Excellence project “Complex Metallic Alloys” (principal Slovenian investigator, J. Dolinšek), which is the cover project for the annual *European School in Materials Science*, conducted in Ljubljana, Slovenia. Since 1 December 2008 we have been involved in the EU FP7 project “AppliCMA” (principal Slovenian investigator, J. Dolinšek). The research was also supported by numerous bilateral, industrial and national defence projects.

Guest Editorial in the journal Ferroelectrics. Four volumes of the journal *Ferroelectrics* were published in 2008, which include the proceedings of the 11th European Meeting on Ferroelectricity (EMF-2007, Bled, Slovenia). The guest editors of these volumes were dr. Vid Bobnar and dr. Boštjan Zalar.

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 the structural and dynamic 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. A special emphasis is given to possible electro-optic and medical applications.

A substantial part of our research in 2008 was devoted to the field of *nematic colloids*. We demonstrated that the symmetry of the elastic interaction between the dipolar and quadrupolar colloidal particles in the nematic liquid crystal leads to a novel variety of 2D nematic “binary” colloidal crystals, which have so far not been observed in any colloidal system. The dipolar-quadrupolar interaction is highly anisotropic and shows a power-law dependence when the particles approach each other along the director field. This work was published in the paper “2D Interactions and

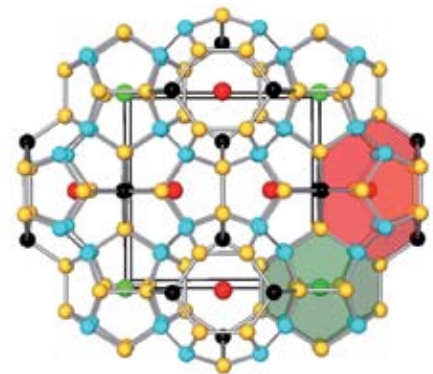


Figure 10: Illustration of the type-I clathrate unit cell (Ba: $2a$ = green and $6d$ = red, Si/Al/B: $6c$ = black, $16i$ = cyan, and $24k$ = orange, P. Jeglič et al.)

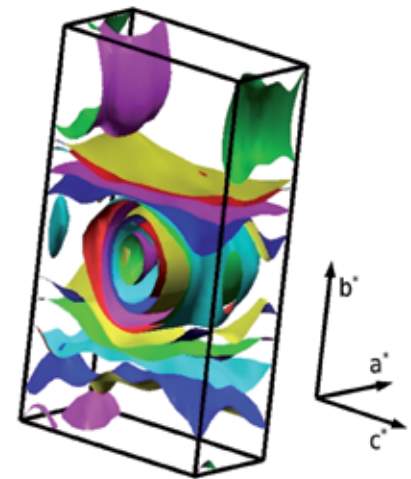


Figure 11: Anisotropic Fermi surface of the YAl-Ni-Co approximant to the decagonal quasicrystal (J. Dolinšek et al.)

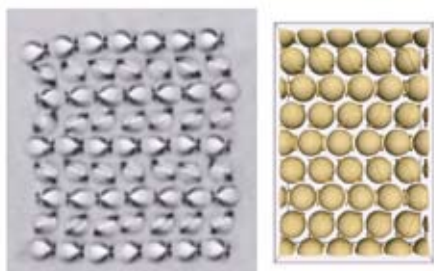


Figure 12: Microscopic images of mixed dipolar-quadrupolar 2D lattice micron-sized particles in a nematic liquid crystal (left) together with computer simulation using the Landau-de Gennes theory. (A. Nych and M. Ravnik)

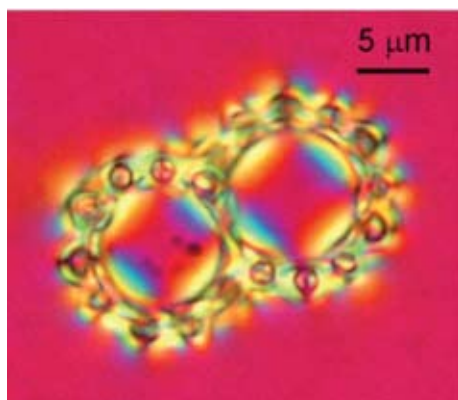


Figure 13: Smaller colloidal particles are trapped into the topological defect loop, twisting around a larger colloidal pair. (M. Škarabot)

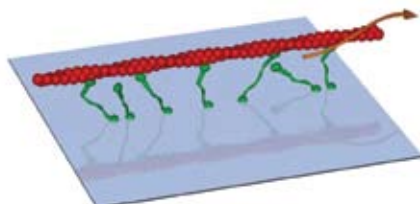


Figure 14: Myosin motors acting on an actin filament with a right-handed structure induce a left-handed helical motion. (A. Vilfan)

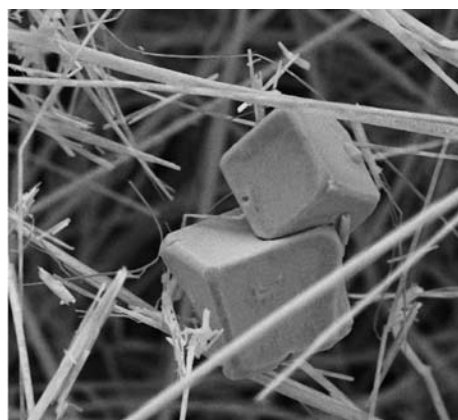


Figure 15: Scanning electron micrograph of MoS₂ cubes, surrounded by coaxial MoS₂ nanotubes. Awarded the first prize in the NanoArt competition in the frame of the international conference Hot Nano Topics 08, organized in collaboration with the Department for Complex Matter. (Maja Remškar)

Binary Crystals of Dipolar and Quadrupolar Nematic Colloids”. *Phys. Rev. Lett.* **100**, 217803 (2008). We have also shown that colloidal superstructures could be assembled in mixtures of large and small colloidal particles dispersed in a nematic liquid crystal. Using the elastic interaction of small colloidal particles with the disclination lines we have succeeded in decorating, with small particles, a topological matrix of defect rings and loops formed by an array of large colloidal particles. Later, we presented the first experimental analysis of the topological properties of a nematic liquid crystal in the vicinity of small cylindrical micro-rods dispersed in a nematic liquid crystal and found that our results are in good agreement with previous theoretical predictions. Related to this topic is the problem of the alignment of carbon nanotubes immersed in a liquid crystal. Combining the mesoscopic approaches of Doi and Landau-De Gennes, we derived the structure of the coupling terms favouring the parallel alignment of the liquid crystal and the carbon nanotubes, and then estimated the phase separation tendencies.

Using the proton NMR relaxometry technique, we completed our study of molecular dynamics in **dendrimer systems** of zero order with different terminal mesogenic groups. The study was carried out in collaboration with the groups of Professors Sebastiao in Lisbon, Portugal, and Mehl in Hull, United Kingdom. It turned out that the microsegregation of the dendrimer molecules gives rise to strong orientational director fluctuations as the siloxane entities prevent the coupling between mesogenic layers. On the other hand, a slowing down of the internal molecular reorientations takes place. A theoretical study of **topological defects** in the nematic phase, based on the Landau-De Gennes approach, revealed the detailed structure of a nematic boojum, which is qualitatively different from previous predictions. We also demonstrated the strong memory effects in the domain structure of a nematic liquid crystal under the influence of a random field type disorder using a simple Lebwohl-Lasher semimicroscopic approach. A phenomenon of particular interest is the **stochastic resonance in ferroelectric liquid crystals**. We were the first to analyse systematically the combined influence of static and dynamic disorder in stochastic resonance for short- and long-range interactions in these systems.

In the field of **molecular motors** we have investigated the collective properties of motors (myosin molecules) interacting with helical filaments (actin). We have shown that motors can induce a left-handed twirling motion of actin, even though the latter has a right-handed helical structure. The period of rotation depends on the sliding velocity and increases for high, as well as for very low, velocities. Furthermore, we have started to investigate more complex structures involving bundles of microtubules, maintained by motor proteins that play an important role in cell division. In collaboration with the group of Professor Igor Poberaj we have used the findings of our past research to design biomimetic concepts of biomimetic microfluidic pumps and mixers driven by a magnetic field.

In the **Laboratory for inorganic nanotube synthesis** we optimized the synthesis of hybrid nanostructures based on MoS₂ nanotubes. Besides “mama-tubes”, i.e., nanotubes with in-situ grown encapsulated MoS₂ nanospheres, we succeeded in growing coaxial nanotubes with tube walls split into several cylinders, and also MoS₂ cubes (Fig. 4). In cooperation with the Faculty for Mechanical Engineering, University of Ljubljana, we have performed the first testing of our hybrid nanotubes mixed with synthetic oils. We also started the mixing of the materials with polymers (in collaboration with the Universities in Madrid and Lisbon). We applied for PCT protection of the method for the synthesis of these unique nanostructures. Such hybrid materials are promising for tribology, solar-energy conversion, and for smart polymer composites. In the field of the **detection of nanoparticles in air** we applied for a patent for a new detection method and built – in collaboration with the company CosyLab d.d – a new generation of a prototype for a cheap, portable detector.

In 2008, the Laboratory for low-temperature ultra-high vacuum **scanning-tunnelling microscopy, spectroscopy and single-atom manipulation** focused on improvements to the home-made instrumentation and its application, which includes, in particular, the surface manipulation of single adatoms and molecules, an investigation of phenomena like surface electronic standing waves, and single-atom spectroscopy. After a series of successful manipulation experiments with surface copper adatoms on different single-crystal substrates, we succeeded in 2008 for the first time to clearly demonstrate our ability to measure completely reproducible spectroscopy spectra on individual Cu adatoms and even the Kondo effect, i.e., the interaction of an individual magnetic atom, in our case Co, with the free electrons of a non-magnetic substrate (Fig. 5). We also continued to study experimentally and theoretically the structure and related

properties of certain low-dimensional compounds like intercalated Nb_3Te_4 single crystals, and the charge density waves, stabilized by different intercalants. Apart from the low-temperature scanning-tunnelling microscopy and spectroscopy, we also used low-energy electron diffraction, Auger spectroscopy, and transmission electron microscopy.

Applications of liquid crystals. The applied research in the field of light modulation by means of a fast LC light shutter was focused on an analysis of light transition through thin layers of ordered nematic. The computer-modelling software, on the basis of the Berreman method, was upgraded to also allow for a Poincaré sphere analysis. A number of high-tech processes for soft as well as for rigid substrates were developed in order to allow for the small-series production of novel LC light-protective filters. The research results were published in *Appl. Optics* 47, 12(2008), and two international patents were granted (EP 1625445, US 7,420,631) as well as transferred to the small-series production in the spin-off company of IJS Balder Ltd. The new method as well as the prototype equipment for measuring the light sensitivity of the optical protective filters for the new international ISO standard was accepted by the Task Groups ISO/TC94/SC6/WG2 and WG4 on the occasion of the conference ISO/TC94/SC6 group for Eye Protection in Sydney, Australia.

The results of our research programme in 2008 appeared in 22 articles in peer-reviewed journals (including Physical Review Letters and Nano Letters), one monograph contribution, 10 papers in conference proceedings, and led to two patent applications. Members of the program group have given 11 invited talks at international conferences (San Jose, Odessa, Philadelphia, New London, Manchester, Erice, Jeju (2x), Boulder (2x), Ljubljana) and organized 3 scientific meetings (in Portorož, Podčetrtek, and Erice). It is worth mentioning that our group was the only one in Slovenia to obtain, in 2008, an award from the Human Frontiers Science Program organization, which was founded years ago by the G7 and the EU to speed up the basic research on complex processes in living organisms. The head of our program group, Professor Slobodan Žumer, was elected as President of the International Liquid Crystal Society (ILCS) for the next four-year term of office. ILCS is the main society worldwide in the field of liquid crystals and has over 900 members that elect the president. Professor Igor Muševič is the first recipient of the new, mid-career ILCS award for outstanding achievements in the field of liquid crystals. He was awarded at the ILCS conference at Jeju in Korea in July this year.

Research programme “Experimental Biophysics of Complex Systems”

Within the program “Experimental Biophysics of Complex Systems” we explore the processes and structures of various complex systems (from model systems to the structures in living cells, tissues and even small animals) including the effects of various bioactive molecules on these systems. One of the aims is to investigate the structural properties of different membrane structures, such as membrane domains, membrane proteins and the glycosaccharide matrix as well as their interactions with other cell parts at different pathogenic states. These activities will improve our understanding of cell signalling and signal transduction in biomembranes, which in turn will enable a better insight into complex cell responses. In addition, research in different fields is conducted, for example, in vivo oxymetry studies on live animals for the optimization of medical treatment in tumor therapies, magnetic resonance imaging techniques and mathematical modelling of thrombolysis, magnetic resonance microscopy for application in forestry and wood science, studies of constrained diffusion as well as food processing by magnetic resonance imaging. Another important part of our activities is the development of spectroscopic methods of electron paramagnetic resonance, magnetic resonance imaging and combined fluorescence microspectroscopy. The latter will broaden the range of the molecular spectroscopies used in the group within the nanometre spatial and nanosecond time scale and the coupling of the molecular spectroscopies with the microscopic analysis, with the aim being to detect the interdomain interactions in living cells.

Within the **biomembrane characterization** we focus on solving the **membrane domain paradox**, a consequence of the characterization mismatch of different microscopies and spectroscopies of these supramolecular structures mediating the activities of membrane receptors, channels and pump. To solve this problem, we started to develop a combined experimental approach based on electron paramagnetic resonance (EPR) and fluorescence microspectroscopy. The main connection between these three techniques is the so-called double probes, possessing a nitroxide group and fluorophore at the same time. In such a way we couple the microscopical image describing the partitioning of the probes among cell structures with a resolution of 150 nm on a millisecond time-scale and a molecular image derived by EPR and fluorescence spectroscopy with nanometre resolution on a nanosecond time-scale. The properties of membrane domains have been modified by

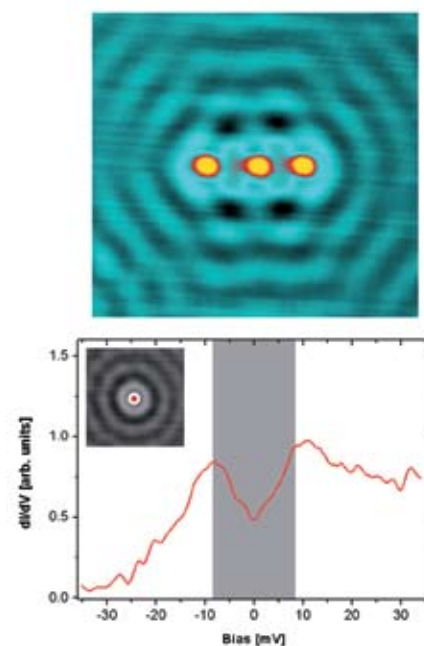


Figure 16: STM image of three atoms of Co, positioned in a chain on Cu(111) surface at 9K. The spectrum of differential tunnelling conductivity, measured on a single Co atom on the Cu(111) surface at 9K (shown in the inset). The Kondo system is characterized by a Fano-type of spectrum (grey region) at the Fermi level E_F (Erik Zupanič).

Using our scanning-tunnelling microscope at low temperatures we have manipulated individual atoms and assembled artificial nanostructures. The spectra of the electron tunnelling current through individual atoms have been studied.



Figure 17: Multiple conformations of membrane protein: combination of structural modeling and SDSL-EPR spectroscopy (J.Štrancar, A.Kavalenka).

various chemical substances, including alkyl-phospholipids, representing a strong potential in cancer treatment. The electron spin resonance (EPR) method was therefore used to investigate the interaction between liposomes composed of alkylphospholipid (OPP) and cholesterol, the potential anticancer drugs, with breast cancer cells. We found that the interaction depends strongly on the liposome **membrane domain** structure, which is determined by the cholesterol content in the liposomes. The rapid release of the liposome entrapped hydrophilic substance into the cell, which is supposed to be the consequence of membrane fusion, coincides with the presence of domains with a highly disordered alkyl-chain motion that disappears at 50 mol% of cholesterol. We proposed that these highly fluid domains are responsible for membrane fusion. These results suggest that the micelles are not the only reason for the cytotoxic effect of OPP formulations, but the liposomes with less than 45 mol% cholesterol also contribute to the cytotoxicity of these formulations. EPR was also used to investigate the formation of vesicles from the most simple amphiphilic system—decanoic acid-sodium decanoate – which is important for understanding the processes, which led to the formation of membranes and protocells during early evolution. We have found that the vesicles are formed from micelles in a well-defined pH region between pH 6.5 and pH 7.8. In this interval the micelles remain in coexistence with vesicles.

Within the activities dedicated to **protein structure characterization**, where classical high-resolution techniques are not so successful, we determined the structure of the major coat protein as well as its conformational dependence on membrane biochemical composition. In addition we characterized the temperature-induced structural degradation of a protein complex of the N-terminal end of a measles virus nucleoprotein and its biological partner phosphoprotein. This represents the first characterization ever determined dedicated to structures stable for not more than a few nanoseconds and still being physiologically active. Finally, we also characterized the structure of one terminal end of the photosystem protein CP29 and compared the differences with better-known photosystem proteins.

We have optimized the deposition of **titanate nanomaterials for application in the maintenance of clean surfaces**, to increase their photocatalytic antimicrobial activities on predefined surfaces, chosen according to applications in the food-processing industry. Special care was taken to increase the efficiency of the method to prevent bacterial growth of those bacteria that are adapted to grow at lower temperatures. At the same time we continued to work in the field of **oxymetry**. The sensitivity of the L-band EPR spectrometer was increased by an order of magnitude. In this way the measurements of radicals in tooth enamel, which are formed during ionizing radiation in hydroxyapatite of tooth enamel at the doses of about 2 Gy. In this way the possibility of applying the EPR method for biodosimetry in in-vivo conditions on the human population is greatly increased.

The moisture content of wood can also be determined by NMR. In the past year our group for MRI discovered a method for moisture determination by NMR, which has, in comparison to other presently known methods for moisture-content determination, the advantage of greater accuracy and instantaneous response. The method is currently in the process of a patent registration and a scientific paper, where the method presented is already accepted in *Holzforschung*, a well-renowned scientific journal in the field of wood science. The paper got very positive critiques from all the reviewers.

The MRI group at the JSI was also scientifically active in the field of **thrombolysis**. Experiences with diffusion imaging gained over the years were combined with those in the field of thrombolysis. This resulted in a new protocol that could help improve thrombolytic treatment. Namely, we discovered that the apparent diffusion coefficient (ADC) images are more accurate in the prediction of clot regions that are susceptible to thrombolysis than the currently used T2 mapping method. We determined a relation between the NMR parameters ADC and T2 and the success rate of the thrombolysis. The group was also active in studies of diffusion in porous materials. The group discovered a new method for the measurement of diffusion spectra. The method excels in its high accuracy and wide frequency range. The method was used in the discovery of the anomalous diffusion behaviour of water at low frequencies in comparison to other liquids. The measured diffusion spectra indicate that water forms clusters of molecules that slow down diffusion in the low-frequency range. Another discovery of the group is an improved RARE method that enables auxiliary phase encoding. The method was demonstrated with electric current density imaging. Namely, the original RARE method cannot be used with auxiliary phase encoding and the discovered modification of the method has overcome this problem and can be used whenever auxiliary phase encoding and imaging speed are needed.

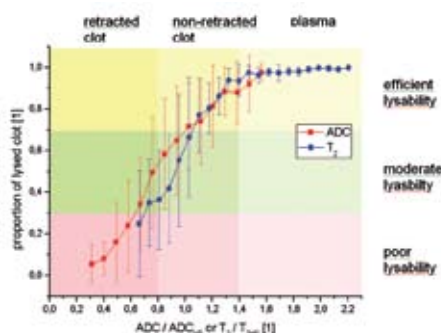


Figure 18: The observed proportion of the lysed clot after two hour thrombolysis as a function of normalized ADC values (squares) and normalized T2 values (circles).

The above research has been supported by a number of international projects financed by the European Union within the 5FP and 6FP, as well as by NATO. It was also supported within the bilateral Slovenia–USA, Slovenia–German and Slovenia–Greece projects and other scientific cooperations.

We also have international cooperations with:

- The high magnetic field centers in Grenoble, France, and Nijmegen, The Netherlands,
- The high magnetic field center 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 Saarbrücken 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, 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 Delbrück Center for Molecular medicine in Berlin, Germany,
- The Dartmouth Medical School, Hanover, NH, USA,
- The Mayo Clinic, Rochester, USA.

Some outstanding publications in 2008

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8. A. Vilfan. Myosin V passing over Arp2/3 junctions: branching ratio calculated from the elastic lever arm model. *Biophys. J.* 94, 3405(2008).
9. G. Wollny, E. Bründermann, Z. Arsov, L. Quaroni, M. Havenith. Nanoscale depth resolution in scanning near-field infrared microscopy. *Opt. Express* 16, 7453(2008).
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Some outstanding publications in 2007

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Some outstanding publications in 2006

1. Zdravko Kutnjak, Jan Petzelt, and Robert Blinc, The giant electromechanical response in ferroelectric relaxors as a critical phenomenon, *Nature (Lond.)* 441, 956-959 (2006).
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5. I. Muševič, M. Škarabot, U. Tkalec, M. Ravnik, S. Žumer, Two-dimensional nematic colloidal crystals self-assembled by topological defects, *Science* 18, 954-958 (2006).
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Some outstanding publications in 2005

1. M. Remškar, A. Mrzel, A. Jesih, J. Kovač, New composite $\text{MoS}_2\text{C}_6\text{O}$ crystals, *Adv. mater.* 17, 911(2005)
2. R. Blinc, B. Zalar, V. V. Laguta, m. Itoh, Order-disorder component in the phase transition mechanism of O-18 enriched strontium titanate, *Phys. Rev. Lett.* 94, 47601(2005)
3. B. Zalar, A. Lebar, J. Seliger, R. Blinc, V. V. Laguta, M. Itoh, NMR study of disorder in BaTiO_3 and SrTiO_3 , *Phys. Rev. B* 71, 064107(2005).
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6. T. Apih, V. Bobnar, J. Dolinšek, L. Jastrow, D. Zander, U. Koster, Influence of the hydrogen content on hydrogen diffusion in the $\text{Zr}_{69.5}\text{Cu}_{12}\text{Ni}_{11}\text{Al}_{7.5}$ metallic glass, *Solid State Communications* 134, 337(2005).
7. M. Škarabot, I. Muševič, B. Helgee, L. Komitov, Direct evidence of the molecular switching in electrically commanded surfaces for liquid-crystal displays, *J. Appl. Phys.* 98, 046109 (2005).
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9. B. Blanc, D. Svenšek, S. Žumer, M. Nobili, Dynamics of nematic liquid crystal disclinations: the role of the backflow, *Phys. Rev. Lett.* 95, 097802 (2005)

Patents granted

1. Procedure for the synthesis of threadlike tungsten oxide W_5O_{14}
Maja Remškar, Marko Viršek, Miha Kocmur, Adolf Jesih
SI Patent no. 22445
2. Polarisation-enhanced double-channel NQR/NMR detection of solid and liquid explosives with multi pulse sequences
Robert Blinc, Zvonko Trontelj, Janko Lužnik, Tomaž Apih, Janez Seliger, Gojmir Lahajnar
SI Patent no.22459

3. A process for the synthesis of nanotubes and fullerene-like nanostructures of dichalcogenides transition metals
Aleš Mrzel, Maja Remškar, Adolf Jesih, Marko Viršek
SI Patent no. 22485
4. Procedure of synthesis of amidines and their derivatives
Kristina Nadrah, Marija Sollner Dolenc, Slavko Pečar
SI Patent no. 22487
5. Metamaterials and resonant materials based on liquid crystal dispersions of colloidal particles and nanoparticles
Igor Muševič, Miha Škarabot, Slobodan Žumer, Miha Ravnik
SI Patent no. 22508
6. High Contrast, Wide Viewing Angle LCD Light-Switching Element
Janez Pirš, Matej Bažec, Sivija Pirš, Bojan Marin, Andrej Vrečko
Patent no. EP 1625445, US patent US 7,420,631

Awards and appointments

1. Denis Arčon: ZOIS award, Ljubljana, Ministry of Higher Education, Science and Technology, 24 Nov. 2008
2. Zrinka Abramović: Foundation L'Oreal-UNESCO "For woman in science", Jan. 2008
3. Robert Blinc: ZOIS award for life achievement, Ljubljana, Ministry of Higher Education, Science and Technology, 24 Nov. 2008
4. Igor Muševič: Samsung-Mid-Career Award, Južna Koreja, International Liquid Crystal Society, 4 Jul. 2008
5. Slavko Pečar: Minarikovo acknowledgment, Ljubljana, Slovenian Pharmacy Association
6. Rok Žitko: Golden Emblem of JSI, Ljubljana, JSI, 26 Mar. 2008

Organization of conferences, congress and meetings

1. 6th Physics Conference in Basic Research, Podčetrtek, Slovenia, 7 Nov. 2008
2. 15th Workshop Liquid Crystal Phases and Nano-Structures, Erice, Italy, Co-organiser, 27 Oct. to 1 Nov. 2008
3. Slovenia-Korea Symposium on Hydrogen-Storage Materials, Ljubljana, Slovenia, 30 Oct. 2008
4. Hot Nano Topics 2008, Portorož, Slovenia, Co-organiser, 23–30 May 2008
5. 2nd Security technologies for the 21st century: Advanced techniques for the detection of plastic and liquid explosives – Emphasis on application of optical magnetometers, Bled, Slovenia, 10–12 Jun. 2008
6. 3rd European School in Materials Science, MONS, Ljubljana, Slovenia, 26–31 May 2008
7. F5 Department Brainstorming Day, Bistra, Slovenia, 17 Sept. 2008

INTERNATIONAL PROJECTS

- | | |
|---|---|
| <ol style="list-style-type: none"> 1. Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
appliCMA
7. FP, 214407
EC; Susanne Fuchs, Austrian Research Centers GmbH - ARC, Functional Materials, Seibersdorf, Austria
Prof. Janez Dolinšek, Dr. Miha Čekada, Dr. Kristoffer Krnel, Dr. Srečo D. Škapin 2. Hierarchical Assembly in Controllable Matrices
HIERARCHY
7. FP, 215851, PITN-GA-2008-215851
EC; Harry Rullmann, Radboud University Nijmegen, Faculty of Science, Finance and Economic Affairs, Nijmegen, The Netherlands
Prof. Igor Muševič 3. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries
MULTICERAL
6. FP, NMP3-CT-2006-032616
EC; Prof. Andrei Kholkin, University of Aveiro, Department of Ceramics & Glass Engineering, Aveiro, Portugal
Prof. Robert Blinc, Prof. Marija Kosec, Dr. Janez Holc, Prof. Raša Pirc 4. Reliable, Tuneable and INexpensive Antennas by collective fabrication processes
RETINA
6. FP, AST4-CT-2005-516121
EC; Dr. Volker Ziegler, EADS Deutschland GmbH, Corporate Research Centre, Dept. LG-ME, München, Germany
Dr. Vid Bobnar, Prof. Marija Kosec, Asst. Prof. Barbara Malič | <ol style="list-style-type: none"> 5. Complex Metallic Alloys
CMA
6. FP, NoE, NMP3-CT-2005-500140
EC; Centre National de la Recherche Scientifique, Paris, France
Prof. Janez Dolinšek, Dr. Peter Panjan, Prof. Spomenka Kobe 6. Safe Production and Use of Nanomaterials
NANOSAFE2
6. FP, NMP2-CT-2005-515843
EC; Frederic Schuster, Commissariat a l'Energie Atomique, Grenoble, France
Asst. Prof. Maja Remškar 7. Fullerene-based Opportunities for Robust Engineering: Making Optimised Surfaces for Tribology
FOREMOST
6. FP, 515840-2
EC; Alberto Alberdi, Fundacion Tekniker, Eibar, Spain
Asst. Prof. Maja Remškar, Marko Žumer, B. Sc. 8. Improving the Understanding of the Impact of Nanoparticles on Human Health and the Environment
IMPART
6. FP, 013968
EC; Mark Pullinger, Chalex Research Ltd., Torquay, Great Britain
Asst. Prof. Maja Remškar 9. Optical Micro-manipulation by Nonlinear Photonics
COST MP0604
EC
Prof. Igor Muševič 10. Advanced Paramagnetic Resonance Methods in Molecular Biophysics
COST P15
EC
Asst. Prof. Janez Štrancar |
|---|---|

11. Conditioning of Drinking Water with Constructed Wetlands
WETPUR
EUREKA
Limnos Ltd., Brezovica at Ljubljana, Slovenia
Asst. Prof. Janez Strancar
12. Multidisciplinary Frontiers of Magnetic Resonance
EMAR
ESF - European Science Foundation, Strasbourg, France
Prof. Janez Dolinšek
13. Structure and Mechanism of Cytoplasmic Dynein
HFSP RGP0009/2008-C
HFSP - International Human Frontier Science Program Organisation, Strasbourg, France
Asst. Prof. Andrej Vilfan
14. EPR Analysis of Formula from L'OREAL
C080643
Anne-Laure Bernard, L'OREAL - Moyens communs, Chevilly-Larue, France
Dr. Marjeta Šentjurs
15. Microscopy and Magnetic Resonance Study of Derivatized One-dimensional Titanate-based and Carbon Nanostructures and Their Adsorption Potential Toward NO₂
PROTEUS
BI-FR07-PROTEUS-007
Dr. Alexandre Gloter, Laboratoire de Physique des Solides CNRS UMR 8502, Université Paris-Sud, Laboratoire de physique des Solides, CNRS UMR, Orsay, France
Dr. Polona Umek
16. Complex Metallic Alloys
BI-HR/07-08-010
Dr. Ana Smontara, Institute of Physics, Zagreb, Croatia
Prof. Janez Dolinšek
17. Manifestation of Gigantic Electrical/magnetic Response Near the Phase Boundary in Complex Oxides
BI-JP/08-10-001
Prof. Mitsuru Itoh, Tokyo Institute of Tehnology, Materials and Structures Laboratory, Tokyo Institute of Technology, Yokohama, Japan
Prof. Robert Blinc
18. Nanoscale Characterization and Origin of Polar States in Ferroelectric Relaxors
BI-PT/08-09-014
Dr. Andrei Kholkin, Centro de Investigacao em Materiais Ceramicos e Compositos, Aveiro, Portugal
Prof. Robert Blinc
19. Fast Field-Cycling NMR Relaxometry Studies in Chiral Liquid Crystals
Estudos de relaxometria por RMN de Campo Ciclico Rapido em cristais liquidos quirais
BI-PT/08-09-005
Prof. Pedro Sebastiao, Centro de Fisica da Materia Condensada da Universidade de Lisboa, Lisbona, Portugal
Asst. Prof. Tomaž Apih
20. NMR Study of Collective Orientational Fluctuations in the Smectic Phases
BI-PT/06-07-003
Prof. Pedro Sebastiao, Centro de Fisica da Matéria Condensada da Universidade de Lisboa, Lisbona, Portugal
Prof. Marija Jamšek Vilfan
21. Organizing Carbon Nanotubes with Liquid Crystals
BI-RO/08-09-001
Prof. Vlad Popa-Nita, Fakulteta za fiziko, Univerza v Bukarešti, Faculty of Physics, University of Bucharest, Bucharest, Romania
Prof. Samo Kralj
22. Mechanical Characteristics of Molybdenum-and Tungsten-Disulfide Nanotubes and Nanowires
BI-RS/08-09-030
Prof. Milan Danmjanovič, Faculty of Physics, University of Belgrade, Belgrade, Serbia
Asst. Prof. Maja Remškar
23. Transition Metals Dichalcogenide Nanotubes: Theoretical and Experimental Investigations of Mechanical and Electro-optical Properties
BI-CS/06-07-007
Prof. Milan Danmjanovič, Faculty of Physics, University of Belgrade, Belgrade, Serbia
Asst. Prof. Maja Remškar
24. EPR Investigation of Surface Active Antidepressant Drug - Membrane Interactions
BI-TR/05-08-001
Prof. Maral Sünnetçioğlu, Hacettepe University, Department of Physics Engineering, Beytepe-Ankara, Turkey
Dr. Marjeta Šentjurs
25. The Incommensurate Structure Dynamics in Conditions of Strong Pinning in Dielectric Crystals
BI-UA/05-06-006
Dr. Sergiy Sveleba, Faculty of Electronics, Lviv Ivan Franko National University, Lviv, Ukraine
Prof. Igor Muševič
26. Photonic Liquid Crystals
BI-UA/07-08-002
Vassili Nazarenko, Institute of Physics, National Academy of Science of Ukraine, Kyiv, Ukraine
Prof. Igor Muševič
27. The Incommensurate Structure Dynamics in Conditions of Strong Pinning in Dielectric Crystals
BI-UA/07-08-006
Dr. Sergiy Sveleba, Faculty of Electronics, Lviv Ivan Franko National University, Lviv, Ukraine
Asst. Prof. Tomaž Apih
28. High Throughput-Low Cost Biologically Base Triage for Radiation Exposure Based on EPR Measure
407, HR0011-08-C-0023; 412, HR0011-08-C-0022
Shelagh Eastridge, Dartmouth College, Hanover, NH, USA
Dr. Pavel Cevc
29. Spintronics in Artificially Grown Nanostructures
BI-US/08-10-017
Prof. Saw-Wai Hla, Department of Physics and Astronomy, Ohio University, Athens, OH, USA
Prof. Igor Muševič
30. Optical and Electrical Properties of MoS₂ and WS₂ Hybrid Nanomaterials
BI-US/08-10-016
Prof. Alan Seabaugh, University of Notre Dame, Electrical Engineering, Notre Dame, IN, USA
Asst. Prof. Maja Remškar
31. Applications of MoS₂ and WS₂ Nanotubes
BI-US/06-07-016
Prof. Alan Seabaugh, University of Notre Dame, Electrical Engineering, Notre Dame, IN, USA
Asst. Prof. Maja Remškar
32. Magneto-resonance Study of New Porous Materials for Electrodes in Li-based Batteries
BI-US/06-07-037
Brunel Louis Claude, National High Magnetic Field Laboratory, Tallahassee, FL, USA
Dr. Andrej Zorko

R & D GRANTS AND CONTRACTS

1. Patterns, structural self-assembly and multiferroic states in mixtures of nanoparticles and liquid crystals
Prof. Samo Kralj
2. Physico - chemical processes involved in formation of radioactive nano aerosols
Asst. Prof. Janja Vaupotič, Asst. Prof. Maja Remškar
3. Carbon nanotube based spin qubits
Prof. Anton Ramšak, Dr. Rok Žitko
4. Active devices - dispersion force based nanoactuators
Asst. Prof. Andrej Vilfan
5. MRI research of wood as a material and as a live tissue
Dr. Mojca Urška Mikac
6. Selforganization of molecular nanomagnets in nanotubes
Dr. Polona Umek
7. Novel nanostructured materials with giant electromechanical response, soft elasticity and unusual physical properties: thermal, dielectric, transport and selforganization studies
Prof. Zdravko Kutnjak
8. Elaboration and evaluation of a toxicity test for engineered nanoparticles with terrestrial isopods
Asst. Prof. Maja Remškar
9. Organic and inorganic percolative composites with giant dielectric constant
Asst. Prof. Vid Bobnar
10. Self-assembly of nanoparticles in 2D nematic colloidal crystals: photonic crystals and metamaterials
Prof. Igor Muševič
11. Ecotechnological 1D nanomaterials: Synthesis and characterisation of 1D titanate nanomaterials doped with transition metal ions
Dr. Polona Umek
12. Study of the structure and the dynamics of blood clot dissolution: mathematical modeling supported by magnetic resonance experiments
Asst. Prof. Igor Serša
13. Formulation and characterization BF fuzogenic nanoparticles for efficient drug delivery
Dr. Marjeta Šentjurs
14. NQR - nondestructive method for study of polymorphism in pharmacy
Dr. Tomaž Apih
15. Applications of nanoparticle-macromolecule complexes for the formulation of biological drugs
Prof. Igor Muševič
16. Wire-less Network of Networks with Radio over Fiber
Prof. Jurij Franc Tasič
17. Numerical detection of nanoparticles in air
Asst. Prof. Maja Remškar
18. Analysis, computer modeling and optimization of the storage of explosives
Dr. Janez Pirš
19. Selfcleaning materials for antimicrobial protection of surface of vechicles and equipment
Asst. Prof. Janez Štrancar
20. Biodosimetry by magnetic resonance methods
Dr. Marjeta Šentjurs
21. Rapid two-channel NQR/NMR detection of solid and liquid explosives
Dr. Tomaž Apih
22. Development of super-hard PA composites
Asst. Prof. Denis Arčon
23. Smart functional hard coatings for increased durability of defence-related equipment
Dr. Peter Panjan, Prof. Janez Dolinšek
24. Thermally stable antioxidants and food stability
Dr. Marjeta Šentjurs

25. Antimicrobial surfaces for safety production of food
Asst. Prof. Janez Strancar
26. Complex Metallic Alloys - Novel materials for the Future
Dr. Peter Jeglič
27. Preparation of Supported Lipid Membranes with Enzymes for Development of Biosensors
Dr. Zoran Arsov
28. Magnetism in Geometrically Frustrated Two-Dimensional Spin Systems
Dr. Andrej Zorko

RESEARCH PROGRAMS

1. Experimental biophysics of complex systems
Asst. Prof. Janez Strancar

2. Physics of soft matter, surfaces and nanostructures
Prof. Slobodan Žumer
3. NMR and dielectric spectroscopy condensed matter: smart new materials and translational symmetry breaking
Prof. Rober Blinc

NEW CONTRACT

1. Expert analysis of the state-of-the-art LCD active light filters
Balder, optoelectronic elements and measuring systems, Ltd.
Dr. Janez Pirš

VISITORS FROM ABROAD

1. Aleh Kavalenka, Belorussian State University Work, Systems Analysis Department, Minsk, Belarus, 1 Jan. to 31 Dec. 2008
2. Dr. Alexander Gloter, Universite Paris Sud, Pariz, France, 9–11 Jan. 2008 and 9–13 Jun. 2008
3. Dr. Roland Roth, Max-Planck Institut fuer Metallforschung, Stuttgart, Germany, 14–16 Jan. 2008
4. Prof. Dr. Alexandra Carvalho, Escola Superior de Tecnologias da Sude de Lisboa, Lisabon, Portugal, 25–28 Feb. 2008
5. Jelena Buha, Universitaet Potsdam, Math.-Nat. Fakultae, Golm, Germany, 16–20 Mar. 2008
6. Prof. Dr. Danielle Pinotello, Kent State University, Kent, Ohio, USA, 31 Mar. to 5 Apr. 2008
7. Prof. Dr. Erwin Frey, Ludwig Maximilian University, Munich, Germany, 12–13 May 2008
8. Dr. George Cordoyiannis, Katholieke Universiteit Leuven, Fysica en Sterrenkunde Department, Laboratorium voor Akoestiek en Thermische Fysica (ATF), Leuven, Belgium 15–20 May 2008 and 5–9 Sept. 2008
9. Prof. Dr. Valentin Laguta, Ukrainian Academy of Science, Institute for Problems of Materials Science, Department of Oxides Materials, Kiev, Ukraine, 1 Jun. to 15 Jul. 2008
10. Prof. Dr. Uichiro Mizutani, University of Nagoya, Nagoya, Japan, 29 May 2008
11. Dr. Magdalena Wencka, Polish Academy of Sciences, Institute of Molecular Physics, Poznan, Poland, 1–7 Jun. 2008 and 27 Sept. to 24 Dec. 2008
12. Dr. Lise Lyngsnes Randeberg, Norwegian University of Science and Technology, Department of Electronics and Telecommunications, Trondheim, Norway, 2–4 Jun. 2008
13. Dr. Daniele Biglino, Max-Planck Institute for Bioinorganic Chemistry, Mülheim, Germany, 10 Jun. to 31 Dec. 2008
14. Prof. Dr. Michael V. Romalis, Princeton University, New Jersey, USA, 13 Jun. 2008
15. Prof. Dr. Pedro Sebastiao and Prof. Dr. Maria Helena Godinho, Instituto Superior Tecnico, Departamento de Fisica, Lisbon, Portugal, 10–18 Jul. 2008
16. Ivan Katerinchuk, Yuriy Pankivsky and Ostap Semotyuk, Lviv Ivan Franko National University, Faculty of Electronics, Lviv, Ukraine, 18–25 Aug. 2008
17. Prof. Dr. Vlad Popa Nita, University of Bucurest, Faculty of Physics, Bucharest, Romania, 3–17 Sept. 2008
18. Prof. Dr. Horst Böhm, University of Mainz, Mainz, Germany, 18–25 Sept. 2008
19. Dr. N. Guyen and Dr. Anne-Laure Bernard, L'Oreal, Chevilly-Larue, France, 9–10 Sept. 2008
20. Prof. Dr. George Nounesis and Prof. Dr. Vassilios Tzitzios, National Center for Scientific Research "Demokritos", Institute of Materials Science, Athens, Greece, 14–21 Sept. 2008
21. Bojana Višić, University of Belgrade, Faculty of Physics, Belgrade, Serbia, 24–26 Sept. 2008 and 6–20 Dec. 2008
22. Dr. Rita Rosentveig, Weizmann Institute, Department of Materials and Interfaces, Rehovod, Israel, 2–3 Oct. 2008
23. Dr. Carla Bittencourt, Universite de Mons-Hainaut, LGIA-Materia Nova, Mons, Belgium, 11–14 Oct. 2008
24. Dr. Andriy Nych and Assist. Prof. Uliana Ognysta, National Academy of Science of Ukraine, Institute of Physics, Kyiv, Ukraine, 12 Oct. to 12 Nov. 2008
25. Dr. Maral Sunnetcioglu, Hacettepe University, Ankara, Turkey, 26–31 Oct. 2008
26. Dr. Sang Sup Han, Dr. Seong Hyun Hong, Dr. Hae Jin Kim, KIER, KIMM, KBSI, Daejeon, Korea, 29 Oct. to 1 Nov. 2008
27. Prof. Dr. Milan Damnjanović and Prof. Dr. Ivanka Milošević, Faculty of Physics, University of Belgrade, Belgrade, Serbia, 1–8 Nov. 2008
28. Dr. Dmitry Kiselev, Universidad de Aveiro, Aveiro, Portugal, 1–15 Nov. 2008
29. Dr. Andrei Kholkin, Universidad de Aveiro, Aveiro, Portugal, 3–6 Nov. 2008
30. Prof. Dr. Valentin S. Vikhniin, Russian Academy of Sciences, A. F. Ioffe Physical Technical Institute, St. Petersburg, Russia, 2 Nov. to 14 Dec. 2008
31. Dr. Fani Milia, National Center for Scientific Research "Demokritos", Institute of Materials Science, Athens, Greece, 16–25 Nov. 2008
32. Prof. Dr. Maya Glinchuk, Ukrainian Academy of Sciences, Institute for Material Science, Kiev, Ukraine, 25 Nov. to 14 Dec. 2008
33. Dr. Saw Wai Hla, University of Ohio, Department of Physics and Astronomy, Athens, Ohio, USA, 22–31 Dec. 2008

STAFF

Researchers

1. Asst. Prof. Tomaž Apih
2. Asst. Prof. Denis Arčon*
3. Prof. Robert Blinc
4. Asst. Prof. Vid Bobnar
5. Asst. Prof. Pavel Cevc
6. Prof. Janez Dolinšek*
7. Dr. Cene Filipič
8. Prof. Marija Jamšek Vilfan
9. Dr. Peter Jeglič
10. Dr. Martin Klanjšek
11. Prof. Samo Kralj*
12. Prof. Zdravko Kutnjak
13. Prof. Gojmir Lahajnar
14. Prof. Adrijan Levstik
15. Dr. Mojca Urška Mikac
16. **Prof. Igor Mušević*, Head**
17. Prof. Slavko Pečar*
18. Dr. Janez Pirš
19. Asst. Prof. Dušan Ponikvar*
20. Prof. Albert Prodan
21. Asst. Prof. Maja Remškar
22. Prof. Janez Seliger*
23. Asst. Prof. Igor Serša
24. Prof. Janez Stepišnik*
25. *Dr. Marjeta Šentjurc, retired 31 Dec. 2008*
26. Dr. Miha Skarabot
27. Asst. Prof. Janez Strancar
28. Prof. Jurij Franc Tasič

29. Dr. Polona Umek
30. Dr. Herman Josef Petrus van Midden
31. Asst. Prof. Andrej Vilfan
32. Prof. Boštjan Zalar
33. Prof. Aleksander Zidanšek
34. Dr. Andrej Zorko
35. Prof. Slobodan Žumer*
- Postdoctoral associates**
36. Dr. Zoran Arsov
37. Dr. Marjetka Conradi
38. Dr. Alan Gregorovič
39. Dr. Tilen Koklič
40. Dr. Andrija Lebar
41. Dr. Rok Žitko
- Postgraduates**
42. *Dr. Zrinka Abramović, left 9 Apr. 2008*
43. Franci Bajd, B. Sc.
44. Matej Bobnar, B. Sc.
45. *Goran Bobojevič, M. Sc., left 1 Jul. 2008*
46. *Dr. Iztok Dogša, left 1 Mar. 2008*
47. Maja Garvas, B. Sc.
48. Anton Gradišek, B. Sc.
49. Matjaž Humar, B. Sc.
50. Bojan Marin*, M. Sc.
51. Anton Potočnik, B. Sc.
52. Matej Pregelj, B. Sc.
53. Brigita Rožič, B. Sc.
54. Uroš Tkalec, B. Sc.
55. Jernej Vidmar, B. Sc.

56. Marko Viršek, B. Sc.
 57. Dr. Andrej Vrečko, left 1 Nov. 2008
 58. Stanislav Vrtnik, B. Sc.
 59. Blaž Zupančič, B. Sc.
Technical officers
 60. Andreja Berglez, B. Sc.
 61. Ivan Iskra, B. Sc.
 62. Dr. Orest Jarh*
 63. Sandra Kure, B. Sc.
 64. Ivan Kvasič, B. Sc.
 65. Bojan Ložar, B. Sc.
 66. Milan Rožmarin, B. Sc.
 67. Dr. Janez Slak*
 68. Marta Vidrih, B. Sc., left 2 Jul. 2008

69. Erik von Zupanič, B. Sc.
Technical and administrative staff
 70. Dražen Ivanov
 71. Davorin Kotnik
 72. Silvano Mendizza
 73. Marjanca Nemec, retired 27 Jul. 2008
 74. Iztok Ograjenšek
 75. Silvija Pirš
 76. Ana Sepe, B. Sc.
 77. Marjetka Tršinar
 78. Veselko Tihidrag Žagar, B. Sc.

Note:
 * part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

- Zrinka Abramović, Urška Šuštaršič, Karmen Teskač, Marjeta Šentjunc, Julijana Kristl, "Influence of nanosized delivery systems with benzyl nicotinate and penetration enhancers on skin oxygenation", *Int. j. pharm.*, vol. 359, no. 1-2, pp. 220-227, 2008.
- Tomaž Apih, Pavel Cevc, Robert Blinc, Peter Jevnikar, Nenad Funduk, "Proton spin-lattice relaxation study of the setting reaction in conventional and resin-modified glass-ionomer dental cements", *Appl. magn. reson.*, vol. 33, no. 3, pp. 323-332, 2008.
- Denis Arčon, Alexey Yu. Ganin, Yasuhiro Takabayashi, Matthew Rosseinsky, Kosmas Prassides, "Magnetic properties and phase transitions in $(\text{CH}[\text{sub}3]\text{NH}[\text{sub}2])\text{K}[\text{sub}3]\text{C}[\text{sub}60]$ fulleride: an 1H and 2H NMR spectroscopic study", *Chem. mater.*, vol. 20, no. 13, pp. 4391-4397, 2008.
- Denis Arčon, Matej Pregelj, Andrej Zorko, Alexey Yu. Ganin, Matthew Rosseinsky, Yasuhiro Takabayashi, Kosmas Prassides, Hans van Tol, Louis Claude Brunel, "Antiferromagnetic resonance in methylaminated potassium fulleride $(\text{CH}_2\text{NH}_2)\text{K}_3\text{C}_{60}$ ", *Phys. rev., B, Condens. matter mater. phys.*, vol. 77, no. 3, pp. 035104-1-035104-6, 2008.
- Denis Arčon, Andrej Zorko, M. Mazzani, Maria Belli, D. Pontiroli, M. Ricco, Serena Margadonna, "The structural and electronic evolution of Li_4C_{60} through the polymer-monomer transformation", *New journal of physics*, vol. 10, pp. 033021-1-033021-17, 2008.
- Zoran Arsov, Marjanca Nemec, Milan Valter Schara, Henrik Johansson, Ūlo Langel, Matjaž Zorko, "Cholesterol prevents interaction of the cell-penetrating peptide transport with model lipid membranes", *J. pept. sci.*, vol. 14, no. 12, pp. 1303-1308, 2008.
- Zoran Arsov, Luca Quaroni, "Detection of lipid phase coexistence and lipid interactions in sphingomyelin/cholesterol membranes by ATR-FTIR spectroscopy", *Biochim. biophys. acta, Biomembr.*, vol. 1778, no. 4, pp. 880-889, 2008.
- Andrej Babič, Stanislav Gobec, Christine Gravier-Pelletier, Yves Le Merrer, Slavko Pečar, "Synthesis of 1-C-linked diphosphate analogues of UDP-N-Ac-glucosamine and UDP-N-Ac-muramic acid", *Tetrahedron*, vol. 64, no. 38, pp. 9093-9100, 2008.
- Andrej Babič, Slavko Pečar, "Synthesis of novel bicyclic nitroxides using partial Favorskii rearrangement", *Synlett*, no. 8, pp. 1155-1158, 2008.
- Andrej Babič, Slavko Pečar, "Synthesis of protected hydroxyethylamine transition-state analogs of N-Ac-muramyl-L-alanine", *Synth. commun.*, vol. 38, no. 18, pp. 3052-3061, 2008.
- Andrej Babič, Slavko Pečar, "Total synthesis of uridine diphosphate-N-acetylmuramoyl-L-alanine", *Tetrahedron: asymmetry*, vol. 19, no. 19, pp. 2265-2271, 2008.
- Valerie Belle, Janez Štrancar, (8 authors), "Mapping α -helical induced folding within the intrinsically disordered C-terminal domain of the measles virus nucleoprotein by site-directed spin-labeling EPR spectroscopy", *Proteins*, issue 4, vol. 73, pp. 973-988, 2008.
- Robert Blinc, "Magnetoelektriki", *Obz. mat. fiz.*, vol. 55, no. 1, pp. 25-28, 2008.
- Robert Blinc, Valentin V. Laguta, Boštjan Zalar, Mitsuru Itoh, H. Krakauer, " ^{17}O quadrupole coupling and the origin of ferroelectricity in isotopically enriched BaTiO_3 and SrTiO_3 ", *J. phys., Condens. matter*, vol. 20, no. 8, pp. 085204-1-085204-6, 2008.
- Robert Blinc, Valentin V. Laguta, Boštjan Zalar, Blaž Zupančič, Mitsuru Itoh, " ^{17}O and ^{93}Nb NMR investigation of magnetoelectric effect in $\text{Pb}(\text{Fe}_{1/2}\text{Nb}_{1/2})\text{O}_3$ ", *J. appl. phys.*, vol. 104, no. 8, pp. 084105-1-084105-4, 2008.
- Robert Blinc, Dimitrij Najdovski, Sadik Bekteshi, Skender Kabashi, Ivo Šlaus, Aleksander Zidanšek, "How to achieve a sustainable future for Europe?", *Therm. sci.*, vol. 12, no. 4, pp. 19-25, 2008.
- Robert Blinc, Gašper Tavčar, Boris Žemva, Darko Hanžel, Pavel Cevc, Cene Filipič, Adrijan Levstik, Zvonko Jagličič, Zvonko Trontelj, Naresh S. Dalal, Vasanth Ramachandran, Saritha Nellutla, James Floyd Scott, "Weak ferromagnetism and ferroelectricity in $\text{K}_3\text{Fe}_5\text{F}_{15}$ ", *J. appl. phys.*, vol. 103, no. 7, pp. 074114-1-074114-4, 2008.
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- Slavko Čeru, Saša Jenko, Sabina Rabzelj, Miha Škarabot, Ion Gutierrez-Aguirre, Nataša Kopitar-Jerala, Gregor Anderluh, Dušan Turk, Vito Turk, Eva Žerovnik, "Size and morphology of toxic oligomers of amyloidogenic proteins: a case study of human stefin B", *Amyloid (Carnforth)*, vol. 15, no. 3, pp. 147-159, 2008.
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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 and biomolecules to superconductors and nanowires. The experimental methods used are suitably diverse, from synthetic chemistry to biomedicine and femtosecond laser spectroscopy and magnetometry. Last year's research achievements are thus quite diverse, but we are able to report on breakthroughs 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:

Ultrafast studies of electron dynamics in correlated systems.

The field of the research of relaxation processes of photo-excited electrons in strongly correlated electron systems remains one of our main research topics. Several experimental studies of carrier-relaxation phenomena in strongly correlated electron systems have been performed using femtosecond time-resolved techniques. The aim of the ongoing research is to gain additional information about the nature of the low-lying excitations in these materials, and to explore the nature and strength of the interactions of electrons with other low-lying excitations. Femtosecond spectroscopy has been instrumental in elucidating the nature of the electronic excitations in superconductors, since it allows us to distinguish the different components by their lifetimes. Moreover, the relaxation kinetics can yield valuable information on the mechanism for superconductivity.

As an important contribution to the understanding of the nature of high-temperature superconductivity we should mention our study of the relaxation processes in the cuprate superconductor $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$. We studied the photo-induced phase transition from the superconducting to the normal state. The absorbed energy density required to suppress the superconductivity was found to be an order of magnitude higher than the thermodynamically measured condensation energy. The implication of this result is that in cuprates charge carriers have by far the strongest interaction with phonons. This work has been published in *Physical Review Letters* 101, 227001 (2008).

The recent discovery of high-temperature superconductivity in iron-based pnictides has attracted a great deal of attention, partly because of their high critical temperatures, but more fundamentally because they appear to have some similarities and important differences compared to cuprate superconductors, which raises the question of the superconductivity mechanism. Particularly pertinent are the questions regarding the existence of a pseudogap precursor state, which is believed by many to be essential for high-temperature superconductivity and is attributable to pre-formed pair formation above the T_c .

We are the first group in the world to investigate the quasiparticle relaxation and low-energy electronic structure in a near-optimally doped pnictide superconductor, $\text{SmFeAsO}_{0.8}\text{F}_{0.2}$ with $T_c = 49.5$ K. Multiple relaxation processes are evident, with distinct superconducting state quasiparticle recombination dynamics exhibiting a T-dependent superconducting (SC) gap, and a clear "pseudogap" (PG)-like feature with an onset around 200K, indicating the existence of a temperature-independent gap of magnitude $\Delta_{\text{PG}} = 61 \pm 9$ meV above the T_c . Both the SC and PG components show saturation as a function of fluence. This work has been submitted to *Physical Review Letters*.

The first systematic studies of photo-induced charge density wave (CDW) – metal phase transition have been performed on the prototype quasi one-dimensional CDW system $\text{K}_{0.3}\text{MoO}_3$. The photo-induced phase transition is found to be non-thermal and takes place on the 100 fs timescale. The recovery of the electronic subsystem is found to be extremely fast, on the sub-ps timescale. The fact that several folded phonons, characteristic for the modulated ground state, are observed at fluences far above the phase transition threshold implies that on a timescale of several 100 fs after the photo-excitation the lattice remains in its unperturbed state. We believe that this could be the reason for an extremely fast order-parameter recovery in this class of systems. The paper is currently under review in *Physical Review Letters*.

The coupling of phonons with collective modes and single-particle gap excitations associated with one- (1D) and two-directional (2D) electronically driven CDW ordering in metallic RTe_3 is investigated as a function of rare-

Laboratory experiments investigating the evolution of the universe rely on investigating the evolution of single-particle and collective excitations in analogue systems, such as liquid helium ^3He . In a new type of cosmic-quench experiment we have proposed investigating the mechanisms for domain-wall anti-wall recombination processes on the ultra-fast timescale in a model electronically ordered system.

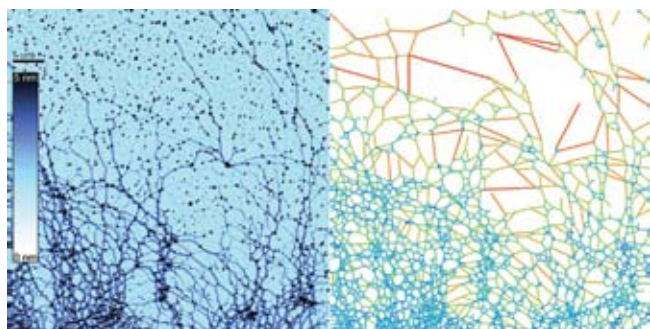


Figure 1: Molecular-scale artificial network of MoSI wires and gold nanoparticles.

earth ion chemical pressure (R=Tb, Dy, Ho) using femtosecond pump-probe spectroscopy. From the T dependence of the CDW gap and the amplitude mode (AM) we find that while the transition to a 1D-CDW ordered state at T_{c1} initially proceeds in an exemplary mean-field (MF) like fashion, below T_{c1} , the CDW gap is depressed and departs from the MF behaviour. The effect is apparently triggered by resonant mode-mixing of the AM with a totally symmetric phonon at 1.75 THz. At low temperatures, when the state evolves into a 2D-CDW ordered state at T_{c2} in the DyTe₃ and HoTe₃, additional, much weaker, mode-mixing is evident, but no soft mode is observed. The paper has appeared recently in *Physical Review Letters*.

A new method of three-pulse ultrafast optical spectroscopy was introduced and used for the investigation of the phase-transition dynamics from the disordered state to the ordered CDW state in TbTe₃. We found that the local CDW gap develops on a significantly faster timescale than the long-range coherent order. The paper reporting these results is currently in the final stage of preparation.

We also continued with measurements and analyses of the magneto-optical Kerr effect in (Pr,Ca)MnO₃ thin films. Some of the results were published in *Applied Physics Letters* 93, 042512 (2008). Another part of the results was submitted to *Europhysics Letters*.

The temperature and fluence dependence of the time-resolved photo-induced optical reflectivity in a decagonal Al_{71.9}Ni_{11.1}Co_{17.0} quasicrystal was also measured. We found no evidence for the relaxation of a hot thermalized electron gas, as observed in metals. Instead, a quick diffusion of the hot, non-thermal carriers ~40 nm into the bulk is detected, enhanced by the presence of a broad pseudogap. From the relaxation dynamics we found evidence for the suppression of the electronic DOS at the Fermi energy, with respect to the electronic DOS at ~13 meV away from the Fermi energy, which is consistent with recent theoretical calculations. The manuscript is currently under review in *Physical Review Letters*.

Ultrafast studies of electron dynamics in low-dimensional systems.

We studied the equilibrium and non-equilibrium optical properties of Mo₆S₃I₆ nanowires using a range of different laser wavelengths from 0.5 to 2.8 μm. The absorption of oriented thin films of MoSI nanowires shows good qualitative agreement with density functional theory calculations (in collaboration with the department F-1). The broad features indicate the large density of the interpenetrating electron sub-bands as well as the damping of transitions and disorder in the bulk. The electron relaxation from a non-equilibrium situation was explored with femtosecond pump-probe spectroscopy. We found a cascade relaxation involving three distinct states determined the lifetimes of these states, which cover the ranges from a few hundred fs to a few ns. We are currently examining the electronic nature of these states with further spectroscopic methods, such as electromodulation. Some of these results are already published in *Phys. Stat. Sol. B* 245, 2098 (2008).

Organic semiconductors show a strong potential for new technological applications. The applications include photodiodes, light-emitting diodes (OLEDs), and photovoltaics (OPVs). To successfully utilize organic semiconductors in these technologies it is important to understand both the nature and the relaxation dynamics of the photogenerated carriers. By performing systematic time and spectrally resolved studies of the relaxation processes in pentacene and tetracene we have shown that relaxation phenomena strongly depend on the sample's morphology. In single crystals the main relaxation channel for the above gap excitation was found to be singlet-triplet exciton fission. In thin films, where the density of defects is considerably higher, this process is strongly suppressed. This work has been accepted for publication in *Physical Review Letters*.

In conjugated polymers, in particular polyfluorenes, which are the preferred polymer family for blue polymer LEDs or the blue component of organic displays, we used femtosecond spectroscopy in combination with a modulated electric field, which yields additional information on the electronic structure of photo-excited states. We showed that the Stark effect, and the nonlinear optics related to it, is not only seen in transitions involving the ground state, but also in transitions between two excited states. This opens up broad opportunities for switchable, nonlinear, optical properties and has been published in *Phys. Rev. Lett.* 100, 057401 (2008). A further consequence of this effect is the non-linear bimolecular relaxation of excited states and hence their lifetime can be modulated by an electric field (*Phys. Rev. B* 78, 045207 (2008)).

Nano-bio-sensors are currently a very hot topic in nanotechnology, with potential applications in medicine, the environment and for the detection of explosives. MoSI molecular wires have been found to be unique in providing a substrate for the attachment of antibodies and aptamers for the ultra-sensitive specific electrochemical detection of proteins. The sensor was found to have universal application for the detection of femtomolar concentrations of proteins.

Theoretical studies on the nanoscale.

We developed the theory of the proximity effect for a clean superconductor-to-metal interface. We have shown that contrary to the dirty limit the order parameter decreases in normal metal as a power law of the distance from the interface. We also predicted that there exists a characteristic temperature, which is dependent on the size of the sample, at which the decay of the order parameter becomes exponential. (*Physical Review B*, 78, 132510 (2008)).

After the reports of observations of the de Haas–van Alphen oscillations in underdoped high- T_c superconductors we have developed the theory of quantum oscillations in doped antiferromagnetic semiconductors. We have shown that the presence of magnetization axes leads to the strong anisotropy of the amplitude of oscillations, which allows the detection of the antiferromagnetic order on the basis of quantum-oscillation measurements. We also investigated the appearance of mixed frequencies in the Shubnikov-de Haas effect in the case of quasi-2D materials with complex Fermi surfaces. (*Physical Review B*, 77, 075434 (2008), *ibid* 77, 132403 (2008)).

We have developed the analytical kinetic theory of the relaxation of hot electrons photo-excited by the laser pulse in metals. In the regime of weak perturbation we were able to linearize the kinetic equations and reduce them to differential form. As a result the problem was reduced to the so-called Calogero-Sutherland equations, which have exact analytical solutions. An analysis of the solution shows that the two-temperature model, commonly used for the analysis of the relaxation in metals, is qualitatively incorrect and predicts shorter relaxation times than exact theory (*Physical Review B*, 78, 174514 (2008)).

Nanotubes and nanomaterials.

Two major breakthroughs were reported in the area of nano-biosensors using $\text{Mo}_6\text{S}_9\text{I}_x$ nanowires. In the first report, which appeared in *Chem. Materials*, $\text{Mo}_6\text{S}_3\text{I}_6$ nanowire networks of interest are found to change their resistance in response to the presence of analyte vapors. This vapour-sensing behaviour is quantitatively described very well phenomenologically in terms of the concentration of adsorbed analyte molecules in the contact tunnelling junctions, and an expression is derived for the dynamics and sensor resistance in terms of the analyte vapour pressure. The time response of the sensor is observed to follow simple adsorption-desorption kinetics. The network sensor shows a very clear selectivity, whereby the response is related to the dipole moment of the analyte. The response function favours rapid detection of small analyte concentrations. The work has opened the way to an entirely new type of olfactory sensor, which can be tailored to have recognitive detection of small molecules and is sensitive over a wide range, and has a linear response. Intensive efforts are now continuing in this direction to produce a prototype e-nose sensor.

In the second report, this time in collaboration within the DESYGN-IT project, “Bioassembled Nanocircuits of $\text{Mo}_6\text{S}_9\text{I}_x$ Nanowires for Electrochemical Immunodetection of Estrone Hapten” are reported. We demonstrated a novel and highly sensitive electrochemical detection of estrone based on an immunosensor platform, composed of bio-assembled nanocircuits of $\text{Mo}_6\text{S}_9\text{I}_x$ nanowires (MoSI NWs) covalently connected to anti-estrone antibodies. The one-step, label-free, and quantitative detection of estrone is realized by employing the $[\text{Ru}(\text{NH}_3)_6]^{3+/2+}$ redox ions to sense anti-estrone antibody and estrone interactions. The MoSI NWs/antiestrone antibody nanocircuit architectures provide an amplification and conductive pathway for the specific electrochemical sensing of estrone hapten. A detection limit of $1.4 \text{ pg} \cdot \text{mL}^{-1}$ was achieved, in contrast to previous electrochemical techniques in which the sensitivity was limited to the nanomolar range. The report was published in *Analytical Chemistry*.

$\text{Mo}_6\text{S}_9\text{I}_x$ are semi-metallic nanowires that have already been tested with others as molecular-scale connectors, bio- and chemo-sensors, electrodes for Li-ion batteries, and field-emission tips. Due to their particularly low interaction with each other and their environment (hence their application also in lubricants), they are currently the “most one-dimensional” material we know. One of their key advantages is solubility in a number of common solvents, like acetone, ethanol or water, without the need for surfactants or chemical functionalisation (which was one of the big show stoppers for carbon nanotubes). In such solutions they are usually present as bundles of diameters, varying from 1 nm to 1 micron, depending on the procedure and concentration. We showed how we can rapidly centrifugate such a dispersion into fractions with different diameters and find a clear correlation between the bundle size and the optical absorption spectrum. Therefore, we can easily determine the diameter distribution by a simple optical measurement, which enormously speeds up the preparation and characterization of such dispersions.

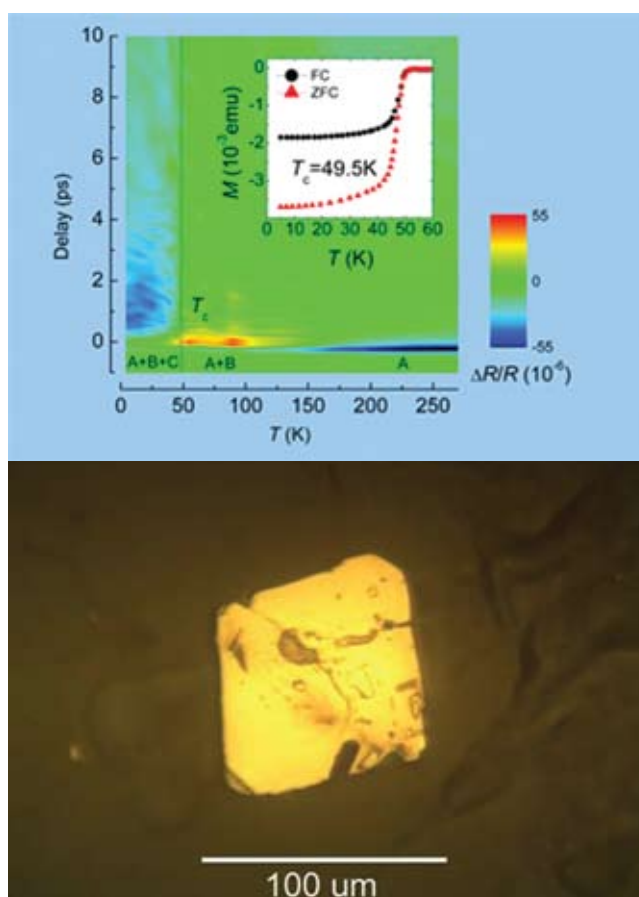


Figure 2: Ultrafast optical response in a single crystal of the new pnictide superconductors with the critical temperature $T_c = 49.5 \text{ K}$. A pseudogap response was discovered below $\sim 180 \text{ K}$.

Iron-based pnictide high-temperature superconductors discovered in 2008 have generated a lot of interest, both from the fundamental point of view and applications for potentially reducing energy-transport losses. We have performed the first measurements investigating the electronic structure, and particularly the band extrema, using femtosecond pump-probe experiments, which indicate the existence of a low-energy pseudogap in the electronic spectrum. This observation has important fundamental consequences for the mechanism of high-temperature superconductivity in the pnictides.

We discovered a method for growing vertically aligned bundles of $\text{Mo}_6\text{S}_9\text{I}_x$ ($4.5 < x < 6$) nanowires, perpendicular with respect to the substrate. In this efficient method, a one-step synthesis direct from molybdenum, sulphur and iodine in temperature-gradient conditions is used. The bundles with similar lengths and diameters could be grown on quartz or conductive materials like molybdenum foil at a temperature of around 1040 K. X ray diffraction (XRD), scanning electron spectroscopy (SEM) and transmission electron microscopy (TEM) were used to characterize the obtained bundles of nanowires. Due to the similar lengths of the aligned bundles and the ease of dispersion in some polar solvents, this material could also be potentially used for some applications, for example, as the building blocks in nanodevices.

Electron dynamics in biological macromolecules.

In 2008 we have continued our study of the electronic transitions in M-DNA, a new form of DNA where divalent metal cations are incorporated into the DNA structure by replacing one of the hydrogens from the hydrogen bonds in the interior of the double helix. Our intention was to complement previous results, which we have obtained with optical spectroscopy methods, with electron spin resonance (ESR) measurements. For this purpose we needed dry samples of M-DNA, which would be extracted from a buffered solution. Because M-DNA complexes are very sensitive to pH, temperature and salt concentration, the only suitable method for sample drying was lyophilisation (freeze drying). In the lyophilisation process we first freeze a buffered solution of M-DNA with liquid nitrogen and then we connect it to a vacuum system. During lyophilisation the solution always stays in the frozen state and the vacuum system pumps out water molecules directly from the ice. After approximately 24 hours the process is completed. The result is a white, waterless powder consisting mostly of dried Tris buffer and metal chloride (ZnCl_2). The percentage of M-DNA complex in a dry sample is approximately 5%, which is still much greater than in solution with a DNA concentration of 100 $\mu\text{g}/\text{ml}$. For the ESR measurements we used from 20 to 40 mg of sample. At room temperature the M-DNA ESR signal is wide (~ 1000 G) and inhomogeneously broadened – the ESR signal's line shape deviates significantly from the Lorentz curve, which is characteristic for homogeneously broadened ESR line shapes. When we cool the system we observe two features: i) the ESR line gets narrower and ii) the resonant field strongly decreases (from 3400 G to 2400 G). The sole detection of a strong ESR signal has led us to an important discovery: Zn^{2+} ions, if trapped in a dry DNA, reduce to their monovalent state Zn^+ , which is paramagnetic and produces a strong ESR signal. This is only the second known example of a stable zinc monocation in the solid state. The other known example, Zn^+ trapped in zeolite changes, was discovered five years ago. From the width and the position of the ESR line we can conclude that the unpaired electrons are mobile at room temperature and localized at low temperatures. The electron dynamics at room temperature is faster than the ESR time-scale 100 ps (10 GHz). This suggests that dry M-DNA could be an effective electron conductor. If so, it would be a major step forward in the development of molecular electronics, where a poor DNA conductance is still a major obstacle.

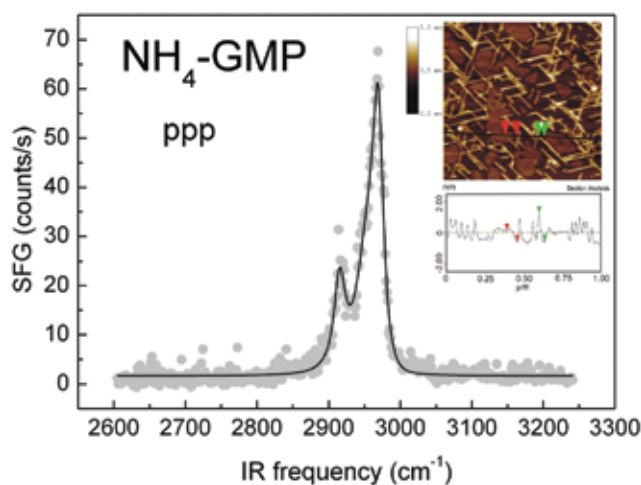


Figure 3: SFG spectrum of a thin film of Guanosine 5'-monophosphate deposited on a mica substrate. The inset shows the AFM image of the surface topography. Typical wire-like structures can be observed, which are a consequence of the self-assembly of the guanosine molecules.

In the **Light and Matter** research group we continued our interdisciplinary studies of the interaction of light and matter and its use in research and applications in different fields.

Soft Matter.

Magneto-optical tweezers were used to study nematic colloids. In such systems, the interactions between colloidal particles are long ranged, due to the elastic deformations in the liquid crystal's director field. We measured this interaction between two spherical particles under the influence of the confining surfaces. Our results show that there is a significant cross-over in the force versus particle separation dependence: the power law, which is expected due to the symmetry of the elastic deformations, holds only for separations up to approximately the thickness of the cell. At larger separations, the interparticle force decays exponentially, with the characteristic decay length being proportional to the sample thickness. We found an excellent agreement with a theoretical model made at the University of Ljubljana, Department of Physics, and corroborated the results by an analogy from classical electrostatics. The results are presented in a paper that was published in *Physical Review Letters*, 101, 237801 (2008).

In cooperation with the Faculty of Physics at the University of Vienna we continued investigations of the diffraction properties of holographic polymer-dispersed liquid crystals (HPDLCs). The effect of the phase and amplitude modulation on the angular dependence of the diffraction efficiency of 1D transmission gratings was analyzed. The results were published in *Optics Express*, 16, 6528-6536 (2008). We studied the effects of ageing, which occur after photopolymerization of the HPDLC gratings, on their structural and diffractive properties. The results show that most of the so-called “dark modifications” of the structure, which take place several days after the termination of the illumination, are associated with the phase-separation process. This investigation was reported in a paper published in *Applied Physics, B Laser Opt.*, 91, 11-15 (2008). A new series of optical gratings with different grating periodicities was fabricated and a comparative study of their diffraction properties for cold neutrons was performed. The results show that the amplitude of the modulation of coherent scattering-length density for cold neutrons strongly decreases with a decreasing grating periodicity. The results are reported in a manuscript accepted for publication in *Journal of Optics A*, (2009).

We continued with investigations of 2D composite photonic structures from polymers and liquid crystals. With the use of an interference pattern of four coherent laser beams that were mixed on the sample with the help of a glass pyramid, we fabricated 2D photonic lattices with four-fold rotational symmetry. The role of the nematic-isotropic phase transition and the effect of an external electric field on the structural and diffraction properties of the lattices were investigated. The results of this work are reported in a manuscript accepted for publication in *Journal of Optics A*, (2009). In cooperation with TEDA College, Nankai University, P.R. China, we investigated the phenomenon of coherent back-scattering in polymer-dispersed liquid crystals (PDLCS).

In cooperation with the Department for Condensed Matter Physics at the Jožef Stefan Institute and the National institute for Chemistry in Ljubljana we started to investigate the process of optical holographic patterning in light-sensitive liquid-crystal elastomers (LCEs). We demonstrated a large range of reversible tunability for the grating period of 1D transmission gratings made from this material by modification of the strain and the temperature of the medium. These features have a large potential for applications in optical sensors and various optical diffractive devices.

We continued to upgrade our experimental setup for the optical spectroscopy of surfaces and interfaces based on the nonlinear frequency mixing of IR and visible radiation (IR-Vis SFG). The technique was used to investigate the surface properties of Langmuir and Langmuir-Blodgett (LB) films of various organic molecules: heptadecanoic acid, guanosine 5' monophosphate (GMP), different lipophilic guanosine derivatives, etc. Structural data on surface adsorbates deduced from the SFG measurements were evaluated in comparison to the structural information attained by the use of atomic force microscopy (AFM). We found that on the mica surface the ammonium salt of GMP makes much more homogeneous and ordered films than sodium GMP. The results of the comparative SFG/AFM study are reported in a paper that is accepted for publication in *Chemical Physics Letters*, (2008).

Our cooperation with the laser company Fotona d.d. was focused on the further development of computer-simulation methods for determining the optical field in unstable laser resonators. The main part of the work was devoted to resonators with Gaussian mirrors and to investigations of the self-Q-switching effect in ruby lasers.

Using dynamic light scattering we have studied suspensions of ferrimagnetic maghemite ($\gamma\text{-Fe}_2\text{O}_3$) nanoparticles in n-decane. The measurements in the suspensions of different concentrations ranging from 0.21 to 25.8 wt % have been compared in zero external field and in a magnetic field of 270 mT. In all samples a well-defined relaxation process was observed. In the absence of an external field the suspensions were homogeneous, while in the magnetic field more concentrated suspensions undergo a phase separation in needle-like islands of a very dense suspension surrounded by a dilute suspension. The dynamical behaviour in the phase-separated samples is found to be anisotropic. In the direction parallel to the external field it keeps the free diffusion behaviour, but it is enhanced. In the perpendicular direction the diffusion is anomalous. The mean-squared displacement grows faster than linearly with time and the dependence of the relaxation rate on the scattering vector q is not quadratic. In this direction the system behaves like a repulsive glass close to dynamic arrest.

Nonlinear optics.

In the Nonlinear Optics Laboratory we study new materials and their interaction with laser light. We study new concepts of compact laser sources on the basis of the nonlinear optical conversion of Nd:YAG lasers.



Figure 4: Experimental setup for non-linear optical spectroscopy (IR-VIS SFG) of Langmuir films of biomolecules on the surface of water.

In the second half of 2008 our new femtosecond laser system for the optical spectroscopy of surfaces started operation. The system is based on the nonlinear frequency mixing of infrared and visible radiation (IR-VIS SFG) and will be used for investigations of thin films of organic molecules on liquid and solid substrates.

We are interested in compact laser sources in the eye-safe wavelength region of 1550 nm and the challenging THz region. We cooperated with Fotona from Ljubljana and with the National Institute for Materials Science in Tsukuba, Japan, studying the optical properties of domain-engineered LiTaO_3 crystals with Mg doping and various degrees of stoichiometry. In addition, we studied the nonlinear conversion in KTP (Potassium Titanyl Phosphate) monolithic crystals. In cooperation with ETH, Zurich, a new topic is THz generation with difference frequency mixing. In an optical parametric oscillator we produce pulses with two frequency components with a prescribed frequency difference. These pulses are then sent to a nonlinear optical crystal where they generate a pulse of THz waves.

Biomedical optics.

We have developed a laboratory system for non-contact measurements of laser-induced temperature profiles in strongly scattering tissues using pulsed photo-thermal radiometry (PPTR), and investigated its potential for the characterization of vascular lesions in human skin. We have developed an original approach to the computation of the optimal effective absorption coefficient from the spectral properties of the tissue and the IR radiation detector. Using systematic measurements in agar models of soft tissue and detailed numerical simulations, we have determined the optimal IR spectral band for radiometric signal acquisition. A comparison of the results with magnetic resonance imaging demonstrated the unprecedented accuracy and spatial resolution of our PPTR system. (Performed in part in collaboration with the Beckman Laser Institute, University of California at Irvine).

We have collaborated with the Clinical Center Ljubljana (Department for Plastic Surgery and Burns) and Fotona d.d., Ljubljana, in clinical trials of dermatologic laser therapy, primarily of port-wine-stain birthmarks and keloid scars, using various laser systems and dynamic cryogen cooling. A quick and objective evaluation of the therapeutic efficacy in these trials was provided by measurements of skin colour with a tri-stimulus colorimeter, supported with a custom PC application.

Biological systems.

We continued our research on biomimetic systems. We are now able to generate the directed motion of two particles in thin cells with an isotropic liquid by applying an external magnetic field. We expanded our research to similar systems and discovered a large variety of so-called artificial swimmers. A paper is in preparation. We also studied the hydrodynamics around a regular array of artificial cilia. They are composed of individual superparamagnetic spheres, held together by an external magnetic field. An additional component of the magnetic field is used to rotate them and due to the asymmetry in the rotation, there exists a net flow above the ciliated surface. We measured the velocity profile as a function of distance from the sample surface and studied the influence of the rotation parameters (tilt angle, frequency) on the flow. A paper is in preparation.

Some outstanding publications in 2008

1. Roman.V. Yusupov, Tomaz Mertelj, J.-H. Chu, I.R. Fisher, Dragan Mihailović. Single-particle and collective mode couplings associated with 1- and 2-directional electronic ordering in metallic RTe_3 ($R = \text{Ho, Dy, Tb}$). *Phys. rev. lett.*, 2008, 101, issue 24, 246402.
2. Mojca Vilfan, Natan Osterman, Martin Čopič, Miha Ravnik, Slobodan Žumer, Jurij Kotar, Dušan Babič, Igor Poberaj. Confinement effect on interparticle potential in nematic colloids. *Phys. rev. lett.*, 2008, 101, pp. 237801-1-237801-4.
3. Primož Kušar, Viktor V. Kabanov, Jure Demšar, Tomaž Mertelj, Sunji Sugai, Dragan Mihailović. Controlled vaporization of the superconducting condensate in cuprate superconductors by femtosecond photoexcitation. *Phys. rev. lett.*, 2008, vol. 101, no. 22, pp. 227001-1-22700-4.
4. Christoph Gadermaier. Stark spectroscopy of excited-state transitions in a conjugated polymer. *Phys. rev. lett.*, 2008, vol. 100, no. 4, pp. 057401-1-057401-4.
5. Nijuan Sun, Martin McMullan, Pagona Panakonstantinou, Hui Gao, Xinxiang Zhang, Dragan Mihailović, Meixian Li. Bioassembled nanocircuits of $\text{Mo}_6\text{S}_{(9-x)}\text{I}_x$ nanowires for electrochemical immunodetection of estrone hapton. *Anal. chem.* (Wash.). [Print ed.], 2008, vol. 80, no. 10, pp. 3593-3597.
6. Miha Devetak, Boštjan Berčič, Marko Uplaznik, Aleš Mrzel, Dragan Mihailović. $\text{Mo}_6\text{S}_3\text{I}_6$ nanowire network vapor pressure chemisensors. *Chem. mater.* [Print ed.], 2008, vol. 20, no. 5, str. 1773-1777.
7. Martin Fally, Mostafa A. Ellabban, Irena Drevnšek Olenik. Out-of-phase mixed holographic gratings : a quantitative analysis. *Opt. express*, 2008, vo. 16, no. 9, str. 6528-6536.
8. Matija Milanič, Boris Majaron, J. Stuart Nelson. Spectral filtering for improved pulsed photothermal temperature profiling in agar tissue phantoms. *J. biomed. opt.*, 2008, vol. 13, no. 6, pp. 064002-1-064002-9.

Patent granted

1. A process for the synthesis of nanotubes and fullerene-like nanostructures of dichalcogenides transition metals
Aleš Mrzel, Maja Remškar, Adolf Jesih, Marko Viršek
SI Patent no. 22485

Organization Of Conferences, Congresses And Meetings

1. Hot nano topics 2008 : incorporating SLONANO 2008, 3 overlapping workshops on current hot subjects in nanoscience, Portorož, Slovenia, coorganizer, 23–30 May 2008.
2. COST MP0802 (Self-assembled guanosine structures for molecular electronic devices) – Kick-off meeting, Jožef Stefan Institut, Ljubljana, 21 Nov. 2008.

INTERNATIONAL PROJECTS

1. Electronic Response of Single Inorganic Nanowires
ERESIN
7. FP, 230975, PERG03-GA-2008-230975
EC
Prof. Dragan Mihailović
2. Electronic Response of Molybdenum-based Nanowires
EREMON
6. FP, MEIF-CT-2006-040958
EC
Prof. Dragan Mihailović
3. Controlling Mesoscopic Phase Separation
COMEPHS
6. FP, NMP4-CT-2005-517039
EC; Prof. E. Liarokapis, National Technical University of Athens, Zografou, Athens, Greece
Prof. Dragan Mihailović
4. Design, Synthesis and Growth of Nanotubes for Industrial Technology
DESYGN-IT
6. FP, NMP4-CT-2004-505626
EC; Grace Dempsey, The Provost Fellows and Scholars of the College of the Holy and Undivided Trinity of Queen Elizabeth near Dublin, Dublin, Ireland
Prof. Dragan Mihailović
5. Ultrafast Processes in Low-Dimensional Nanomaterials
NATO Reintegration Grant
PDD (CD)-(EAP.RIG 981425)
Dr. F. Pedrazzini, NATO, Public Diplomacy Division, Collaborative Programmes Section, Brussels, Belgium
Asst. Prof. Jure Demšar
6. Processes in Biophysical Matter Studied with Optical Tweezers
NATO Reintegration Grant
PDD (CD)-(EAP.RIG 981424)
Dr. F. Pedrazzini, NATO, Public Diplomacy Division, Collaborative Programmes Section, Brussels, Belgium
Dr. Mojca Vilfan
7. Self-assembled Guanosine Structures for Molecular Electronic Devices
COST-Workshop-MP0802-01830
Dr. Caroline Whelan, Milena Stoyanova, COST Office, Brussels, Belgium
Asst. Prof. Lea Spindler
8. Photonic Structures from Polymer-Liquid Crystal Composites
BI-AT/07-08-004
Asst. Prof. Martin Fally, Faculty of Physics, University of Vienna, Vienna, Austria
Prof. Irena Drevenšek Olenik
9. Guanosine-based Nanodevices on Polymeric Templates
PROTEUS
BI-FR07-PROTEUS-015
Dr. Günter Reiter, CNRS, Institut de Chimie des Surfaces et Interfaces, Mulhouse, France
Dr. Martin Čopič
10. Surface Structure of Guanosine Derivatives on Solid Substrates
BI-IT/05-08-008
Prof. Paolo Mariani, Facoltà di Scienze, Università Politecnica delle Marche, Ancona, Italy
Prof. Irena Drevenšek Olenik
11. Fabrication and Characterization of New Ultraviolet Nonlinear Optic Materials
BI-CN/07-09-024
Guoquan Zhang, College of Physics Science, Nankai University, Tianjin, China
Prof. Marko Zgonik
12. Organic Materials for Newly Emerging Photonic Technologies
BI-CN/07-09-024
Jingjun Xu, Key Laboratory of Weak-Light Nonlinear Photonics, Ministry of Education of China, Nankai University, Tianjin, China
Prof. Irena Drevenšek Olenik
13. Crystal Growth and Time-domain Spectroscopy Investigations of the Superconducting State of the Cuprate Superconductors
BI-CN/07-09-003
Prof. Xin Yao, Department of Physics, Shanghai Jiao Tong University, Shanghai, China
Asst. Prof. Viktor Kabanov
14. Ultrafast Electronic and Structural Dynamics in thin Films of Charge Density Wave Compounds
BI-RO/08-09-017
Dr. Mihailescu Ion, National Institute for Lasers, Plasma and Radiation Physics, NILPRP, Magurele, Ilfov, Romania
Asst. Prof. Jure Demšar
15. Structure and Dynamics of Confined Bent-core Liquid Crystals
BI-US/08-10-029
Noel A. Clark, Department of Physics, University of Colorado, Boulder, CO, USA
Prof. Martin Čopič

R &D GRANTS AND CONTRACTS

1. Dynamics of Complex Functional States
Prof. Dragan Dragoljub Mihailović
2. Synthesis and characterization of novel nanostructures on the basis of transition metal
Dr. Aleš Mrzel
3. Polymeric nanocomposites
Prof. Majda Žigon, Boštjan Berčič

RESEARCH PROGRAMS

1. Dynamics of Complex Systems
Prof. Dragan Dragoljub Mihailović, Prof. Dragan Dragoljub Mihailović
2. Theory of condensed matter and statistical physics
Prof. Janez Bonča, Boštjan Berčič
3. Light and Matter
Prof. Martin Čopič

VISITORS FROM ABROAD

1. Prof. dr. Andras Kis, Laboratory of Nanoscale Electronics and Structures, School of Engineering, Lausanne, Switzerland, 03 Jan. 2008.
2. Prof. dr. Wilfried Schranz, Universitaet Wien, Institut für Experimentalphysik, Vienna, Austria, 28–30 Jan. 2008. Department seminar: Glass transition dynamics in nanostructured media studied by Dynamic Mechanical Analysis.
3. Dr. Francesco Federiconi, University of Ancona, Ancona, Italy, 27 Jan. to 16 Feb. 2008.
4. Prof. dr. Gian Piero Spada, Dipartimento di Chimica Organica A. Mangini, Università di Bologna, Bologna, Italy, 2–4 Feb. 2008.
5. Prof. dr. Romano A. Rupp, Universitaet Wien, Nonlinear Physics in Condensed Matter Sciences, Vienna, Austria, 15–22 Mar. 2008.
6. Prof. dr. Ion N. Mihailescu, dr. Carmen Ristoscu and dr. Gabriel Socol, National Institute for lasers, plasma and radiation Physics, Bucharest, Romania, 17–21 May. Department seminars: Advanced pulsed laser technologies for synthesis of biomaterials nanostructures: applications to implantology (Prof. dr. Mihailescu), Nanostructured metal oxides thin films for optical gas sensing (Dr. Ristoscu).
7. Dr. Damir Dominko, Institute of Physics, Zagreb, Croatia, 19–21 May 2008.
8. Dr. Lise Lyngnes Randeberg, Department of Electronics and Telecommunications, Norwegian University of Science and Technology, Trondheim, Norway, 2–4 Jun. 2008.

9. Prof. dr. Gregory Goltsman, Moscow State Pedagogical, University of Moscow, Moscow, Russia, 9–11 Jun. Department seminar: Terahertz range hot-electron bolometers, mixers, and infra-red photon counters based on non-equilibrium phenomena in ultrathin superconducting films.
10. Prof. dr. Martin Frenz, Institute of Applied Physics, University of Bern, Switzerland, 17–20 Jun. 2008.
11. Dr. Valentin Alek Dediu, Istituto per lo Studio dei materiali Nanostrutturati - sezione Bologna, Consiglio Nazionale delle Ricerche, Bologna, Italy, 7–8 Aug. 2008.
12. Prof. dr. Guoquan Zhang in prof. Xinzheng Zhang, Faculty of Physics, Applied Physics School, TEDA College, Nankai University, Tianjin, China, 20–25 Sept. 2008. Department seminar: Slow and fast lights with moving and stationary gratings (Prof. dr. Guoquan Zhang)
13. Dr. Goran Pichler, Institute of Physics, Zagreb, Croatia, 13 Nov. 2008. Department seminar: Velocity selection by accumulation effects of the optical frequency comb.
14. Dr. Mostafa Ellaban, Universitaet Wien, Vienna, Austria, 8–13 Dec. 2008

STAFF

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1. Prof. Martin Čopić*
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4. Dr. Christoph Gadermaier
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10. Asst. Prof. Tomaž Mertelj
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16. Dr. Mojca Vilfan
17. Prof. Marko Zgonik*

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18. Dr. Damjan Dvoršek, left 1 Mar. 2008
19. Dr. Roman Yusupov

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20. Miha Devetak, B. Sc.
21. Klemen Kunstelj, B. Sc.
22. Dr. Primož Kušar, left 1 Jul. 2008
23. Mathieu Lu-Dac, B. Sc.
24. Dr. Matija Milanič
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26. Jure Strle, B. Sc.
27. Andrej Tomelj, B. Sc.
28. Marko Uplaznik, B. Sc., left 1 Dec. 2008

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29. Boštjan Berčič, B. Sc.
30. Alessandro Lukan, B. Sc.
31. Tamara Matevc, B. Sc., left 22 Sept. 2008
32. Damjan Vengust, B. Sc.

Technical and administrative staff

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34. Martina Knavs, B. Sc.
35. Marko Koren, B. Sc., left 30 May 2008

Note:

* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. A. S. Alexandrov, Viktor V. Kabanov, "Low-temperature proximity effect in clean metals with repulsive electron-electron interaction", *Phys. rev., B, Condens. matter mater. phys.*, vol. 78, no. 13, pp. 132510-1-132510-4, 2008.
2. Miha Devetak, Boštjan Berčič, Marko Uplaznik, Aleš Mrzel, Dragan Mihailović, " $Mo_6S_3I_6$ nanowire network vapor pressure chemisensors", *Chem. mater.*, vol. 20, no. 5, pp. 1773-1777, 2008.
3. Mostafa A. Ellabban, Irena Drevenšek Olenik, R. A. Rupp, "Huge retardation of grating formation in holographic polymer-dispersed liquid crystals", *Appl. phys., B Lasers opt.*, vol. 91, no. 1, pp. 11-15, 2008.
4. Martin Fally, Mostafa A. Ellabban, Irena Drevenšek Olenik, "Out-of-phase mixed holographic gratings: a quantitative analysis", *Opt. express*, vol. 16, no. 9, pp. 6528-6536, 2008.
5. Christoph Gadermaier, Primož Kušar, Damjan Vengust, Dragan Mihailović, "Femtosecond pump-probe spectroscopy on MoSI nanowires", In: *Molecular nanostructures*, (Physica status solidi, B, vol. 235, no. 10, 2008), IWEPNM 2008, XXII International Winterschool on Electronic Properties of Novel Materials, 1-8 March, 2008, Kirchberg, Tirol, Austria, Berlin, Akademie-Verlag, 2008, vol. 235, no. 10, pp. 2098-2101, 2008.
6. Christoph Gadermaier, (8 authors), "Electric field effect on energy transfer monitored by bimolecular annihilation", *Phys. rev., B, Condens. matter mater. phys.*, vol. 78, no. 4, pp. 045207-1-045207-5, 2008.
7. Christoph Gadermaier, (8 authors), "Stark spectroscopy of excited-state transitions in a conjugated polymer", *Phys. rev. lett.*, vol. 100, no. 4, pp. 057401-1-057401-4, 2008.
8. Toru Iijima, et al. (23 authors), "Studies of a proximity focusing RICH with aerogel radiator for future Belle upgrade", In: *RICH 2007, Proceedings of the Sixth International Workshop on Ring Imaging Cherenkov Detectors, 15-20 October 2007, Trieste, Italy*, (Nuclear instruments & methods in physics research, section A, vol. 595, no. 1, 2008), A. Bressan, ed., Amsterdam, Elsevier, 2008, vol. 595, no. 1, pp. 92-95, 2008.
9. Viktor V. Kabanov, A. S. Alexandrov, "Electron relaxation in metals: theory and exact analytical solution", *Phys. rev., B, Condens. matter mater. phys.*, vol. 78, no. 17, pp. 174514-1-174514-8, 2008.
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11. Klemen Kunstelj, Lea Spindler, Francesco Federiconi, Mischa Bonn, Irena Drevenšek Olenik, Martin Čopić, "Sum-frequency generation spectroscopy of self-assembled structures of Guanosine 5'-monophosphate on mica", *Chem. Phys. Lett.*, vol. 467, no. 1/3, pp. 159-163, 2008.
12. Primož Kušar, Viktor V. Kabanov, Jure Demšar, Tomaž Mertelj, Sunji Sugai, Dragan Mihailović, "Controlled vaporization of the superconducting condensate in cuprate superconductors by femtosecond photoexcitation", *Phys. rev. lett.*, vol. 101, no. 22, pp. 227001-1-22700-4, 2008.
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14. Djordje Mandrino, Daniel Vrbanić, Monika Jenko, Dragan Mihailović, Stane Pejovnik, "AES and XPS investigations of molybdenum-sulfur-iodine-based nanowire-type material", *Surf. interface anal.*, vol. , no. , pp., 2008.
15. Tomaž Mertelj, Roman V. Yusupov, Marco Filippi, W. Prellier, Dragan Mihailović, "Magnetic properties of the insulating ferromagnetic phase in strained $Pr_{0.6}Ca_{0.4}MnO_3$ thin films", *Appl. phys. lett.*, issue 4, vol. 93, pp. 042512-1-042512-3, 2008.
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17. Joaquin Gabriel Miranda Mena, Viktor V. Kabanov, "Coulomb frustrated first order phase transition and stripes", In: *Proceedings of*

the workshop on fluctuations and phase transitions in superconductors: Nazareth Ilit, Israel, 10-14 June 2007, (Physica. C, Superconductivity, Vol. 468, Issue 4, 2008), Jorge Berger, ed., Amsterdam, North Holland, 2007, vol. 468, no. 4, pp. 358-361, 2008.

18. Miha Mlinar, Rok Klasinc, Martina Knavs, "Zaščitne arheološke raziskave na Mostu na Soči leta 2001: najdišča Maregova guna, Štulčev kuk in Plac", *Arheol. vestn.*, [Letn.] 59, pp. 189-208, 2008.
19. Vincenc Nemanič, Marko Žumer, Bojan Zajec, Dragan Mihailović, Damjan Vengust, Boštjan Podobnik, "Deuterium influence on the field emission from inorganic nanowires", *J. appl. phys.*, vol. 103, no. 9, pp. 094310-1-094310-5, 2008.
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REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Dragan Mihailović, Primož Kušar, "Lattice and magnetic excitations in relation to pairing and the formation of Jahn-Teller polaron texture in cuprates", In: *High T_{sub}c superconductors and related transition metal oxides: special contributions in honor of K. Alex Müller on the occasion of his 80th birthday*, Annette Bussmann-Holder, ed., Hugo Keller, ed., Berlin, New York, Springer, cop. 2007, pp. 243-251.
2. Mojca Vilfan, Irena Drevenšek Olenik, Martin Čopič, "Dynamical processes in confined liquid crystals", In: *Time-resolved spectroscopy in complex liquids*, Renato Torre, ed., New York, London, Springer, 2008, pp. 185-216.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Viktor V. Kabanov, A. S. Alexandrov, "De Haas-van Alphen oscillations in antiferromagnetic metals", In: *Sbornik trudov, Tret'ja Mežnarodna Konferencija "Fundamental'n'ie Problemi v'isokotemperaturnoj Sverhprovodivosti"*, FPS'08, 13-17 Okmjabrja 2008 goda, Zvenigorod = 3rd International Conference "Fundamental Problems of High Temperature Superconductivity", FPS'08, October 13-17, 2008, Zvenigorod, Moscow, Lebedev Physical Institute of the Russian Academy of Science, pp. 69-70.

Regular papers

1. D. Dominko, et al. (12 authors), "Growing thin films of charge density wave system $Rb_{0.3}MoO_3$ by pulsed laser deposition", In: *Functionalized nanoscale materials, devices and systems: [proceedings of the NATO Advanced Study Institute on Functionalized Nanoscale Materials, Devices and Systems for Chem.-bio Sensors, Photonics, and Energy Generation and Storage, Sinaia, Romania, 4-15 June 2007]*, (NATO science for peace and security series, seria B, Physics and biophysics), Ashok Vaseashta, ed., Ion N. Mihailescu, ed., Dordrecht, London, Springer, 2008, pp. 399-402.
2. Christoph Gadermaier, Primož Kušar, Damjan Vengust, Dragan Mihailović, "Equilibrium and non-equilibrium spectroscopy on $Mo_6S_9-xI_x$ nanowires", *Journal of physics, Conference series*, vol. 29, pp. 012043-1-012043-4, 2008.
3. Mathieu Lu-Dac, Viktor V. Kabanov, "Dynamics in mesoscopic superconducting rings: relaxation process and vortex-antivortex pairs: [Dubna-nano 2008, International Conference on Theoretical Physics, July 7-11, 2008, Dubna, Russia]", *Journal of physics, Conference series*, vol. 129, pp. 012050-1-012050-4, 2008.
4. Katarina Susman, Jure Bajc, Jelmer Renema, Kees Herbschleb, Irena Drevenšek Olenik, Celia Voetmann, "Physics shows in Europe", In: *Frontiers of physics education*, GIREP - EPEC Conference 2007, Rijeka, August 2008, Rijeka, Zlatni rez, 2008, 5 pp.

TEXTBOOKS AND LECTURE NOTES

1. Martin Čopič, *Fizika II*, Ljubljana, Fakulteta za matematiko in fiziko, Oddelek za fiziko, 2007-.
2. Irena Drevenšek Olenik, Boštjan Golob, Igor Serša, *Naloge iz fizike za študente tehniških fakultet*, (Zbirka izbranih poglavij iz fizike, 38), 2. natis, Ljubljana, DMFA - založništvo, 2008.

THESES

Ph. D. Theses

1. Matija Milanič, *Development and evaluation of pulsed photothermal radiometry for temperature profiling in biological tissues: doctoral thesis: doktorska disertacija*, Ljubljana, [M. Milanič], 2008.
2. Janez Žabkar, *Optična parametrična pretvorba Nd:YAG laserja v očem varno območje spektra: doktorska disertacija*, Ljubljana, [J. Žabkar], 2008.

PATENT APPLICATIONS

1. Aleš Mrzel, Maja Remškar, Adolf Jesih, Marko Viršek, *A process for the synthesis of nanotubes and fullerene-like nanostructures of transition metal dichalcogenides, quasi one-dimensional structures of transition metals and oxides of transition metals: EP - patent application WO2008121081 (A2)*.

DEPARTMENT OF REACTOR PHYSICS

F-8

During the past year we have focused mainly on:

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

Our research in reactor physics has been oriented mostly to new methods for power and research-reactor calculations, where special attention has been given to the calibration and benchmarking of nuclear data and to computational methods. We have linked theoretical and practical reactor physics by participating in a project to evaluate older, critically safety experiments, which is hosted by the Idaho National Laboratory. With the use of advanced Monte Carlo techniques, we evaluated the criticality and uncertainties of the nuclear-powered ship Otto Hahn propulsion reactor, which has all the characteristics of a pressurized water-reactor. We have focused attention on Monte Carlo neutron, photon and electron-transport and nuclear-data processing for transport calculations, and on advanced nodal methods aimed at a detailed power-distribution reconstruction. The results of this basic research have been published in a number of papers, both in scientific journals and conference proceedings. We have developed detailed physical models of the TRIGA research reactor, aimed at the characterization of important operating parameters, mainly the neutron flux and spectrum distribution. The power peaking in mixed TRIGA cores was also studied. The results were applied to two research projects aimed at the irradiation of SiC and organic specimens. The SiC specimens were studied together with the Department for Nanostructured Materials in order to characterize first-wall fusion-reactor materials. Our target is to identify materials with as low as possible activation. The materials were irradiated and then analysed using gamma spectrometry. A second experiment dealt with the irradiation of teeth in order to explore the use of biological specimens for the received-dose determination

In the field of plasma physics the research was directed into several areas. We continued the study of the potential formation in front of a negative electron-emitting electrode immersed in a two-electron temperature plasma. We used a fluid and a kinetic model of the bounded plasma system. For the kinetic model we have shown that the regular numerical solutions of the Poisson equation correspond to physically possible potential states in the diode and that the shooting method for the determination of the second boundary condition of the Poisson equation can be used as a criterion for which states are possible and which are not. This is particularly useful when one wishes to determine whether the Bohm potential drop in front of the electrode is determined by the hot or by the cool electrons. A similar result is also found in the fluid model. A kinetic model of a plasma diode and a PIC simulation using the XPDP1 code were also used for the analysis of the potential formation in a plasma with two positive ion species. Our interest was focused on the boundary-ion concentrations, where the Bohm criterion becomes determined by the lighter or the heavier ion species. We have started to develop a method for the measurements of the electron temperature with an elongated emissive probe. The longer wire of the emissive probes means a larger voltage drop across the wire, and this makes possible the measurement of the electron temperature. Modelling of the entire current-voltage characteristics of the emissive probe, also taking into account space-charge effects, is also progressing very well. We have initiated the computer simulations of the current-voltage characteristics of various types of probes using a two-dimensional XOOPIC code. At present we are still dealing with the bugs of the code itself. Using a fluid model we studied the formation of a pre-sheath in front of a negative electrode immersed in a plasma with an oblique magnetic field. The results of the model were compared to the computer simulations using the BIT1 code. We have developed a simple and original method for normalizing the length of the simulated system to the system length predicted by the model. This enabled us to make quantitative



Head:

Prof. Bogdan Glumac

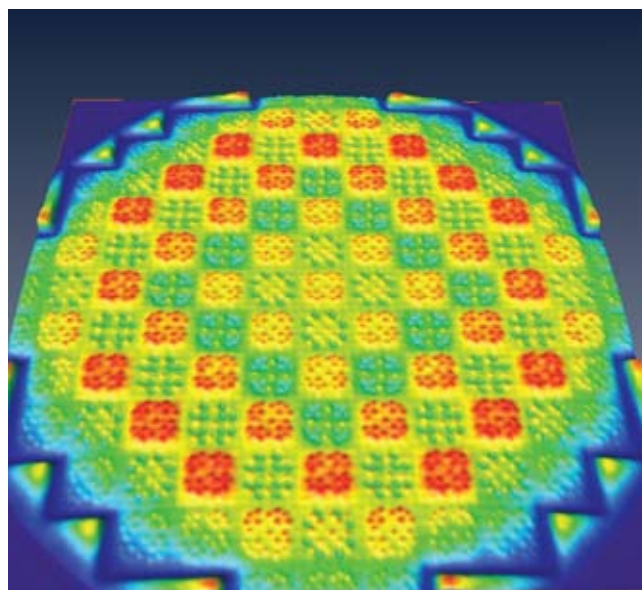


Figure 1: Radial thermal flux distribution in the Krško nuclear power plant reactor core, calculated with the MCNP Monte Carlo code.

comparisons of the model with the simulations. The agreement was relatively satisfactory. Within the Slovenian Fusion Association we have successfully continued with the work in the field of fusion-energy development. The research was carried out in the frame of 14 projects, with more than 50 collaborators from 6 departments of the Institute. Most of the projects are from the field of plasma-wall interactions, and besides 5 projects of several years we have won this year two additional preferentially supported EFDA projects. This year collaborators from the Department for Reactor Engineering have joined the Association. In collaboration with Forschungs Zentrum Karlsruhe they work on the development of a helium-cooled divertor for the demonstration fusion reactor. The researchers from our department who are dealing with nuclear data research have acquired a grant from the Joint Undertaking for ITER in Barcelona. Within two projects in a consortia consisting of several institutions from the EU they are developing the breeding-blanket module for the fusion reactor. The collaborators from the Institute who are dealing within the association with public information activities have acquired an EFDA project, within which they have to organize, in 18 months, 16 FUSION EXPOS in EU countries. They have already successfully set up an exposition as part of the European City of Science fair in Paris on the occasion of the French presidency of the EU.

The collaboration with JET (the Joint European Torus), the largest fusion reactor in the world, was intensified, especially in the field of neutron-transport calculations. Co-workers of the reactor physics division collaborated on the beryllium-wall upgrade project and predicted future changes in the neutron and γ fields during longer visits at the institute, which is situated in the UK. The response of the neutron detectors was modelled with the Monte Carlo method and the sensitivity of the response with regards to the changes of some components in the torus was estimated. It was found that the diagnostics is relatively insensitive to changes in the torus configuration.

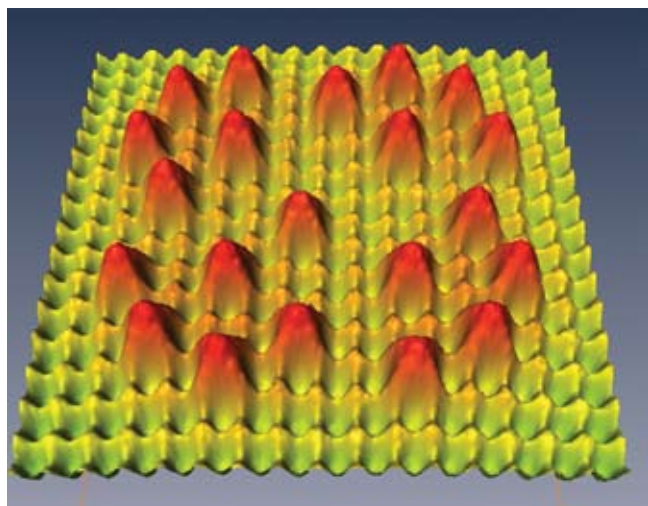


Figure 2: Radial thermal flux distribution in a typical Krško nuclear power-plant fuel element, calculated with the MCNP Monte Carlo code. Areas with a high thermal flux in the control rod and the instrumentation channels (filled with water) are clear

Another topic was the modelling of an irradiation probe response and the experimental results were successfully interpreted using transport calculations. Besides this, the differential distribution of the γ rays was calculated, as was their influence on the profile monitors response. In the frame of the Gamma-Ray Cameras Upgrade Project the neutron attenuation in the planned shields for the γ cameras and the neutron field around the cameras were calculated. Activation of the SiC/SiC composite, a material developed for the first wall of future fusion reactors by the Department for Nanostructured materials, was calculated. The activation is dependent mainly on impurities, which are needed for the sintering process. Neutron transport and activation calculations were coupled and the results show that in the case of a deuterium-deuterium plasma the activation in the first wall is dominated by thermal neutrons and irradiations in the TRIGA reactor fairly well resemble the conditions in a fusion reactor. In the case of a deuterium-tritium plasma, the conditions change and predictions on-hand of fission reactor irradiations, become difficult. It has also been established that the activation of a compound is the sum of the activations of the individually irradiated elements. Additional modelling of the activation detectors used within JET and the possibility of their use in ion-energy-loss measurements within the torus was also performed.

In the domain of semiconductor physics we performed an investigation of the metalA/organic semiconductor/metalB/ structures for radiation sensors the investigators have determined, based upon the published measurements of the electric current through the ITO/PPV(200 nm)/Al organic structure, an archetype for (shallow) trap-controlled space-charge-limited conduction characteristics, that the theoretical basis of the Mott-Gurney derivation of the spatial distribution of the internal electric characteristics, like the internal electric field, the (free and trapped) charge density, and the electric potential within the organic semiconductor is based on an erroneous assumption. In contrast to the expectations governed by the usual space-charge-limited current results, it was determined that these quantities are all linearly distributed throughout the above structure, instead. The breakdown of the Mott-Gurney approach was assigned to the usual, but an inappropriate, assumption of the boundary condition at the hole-injecting metal/organic junction. It was explicitly shown that for the above-stated structure the electric field at the ITO/PPV boundary is non-zero and linearly increases with the forward bias voltage. The organic bulk differential capacitance is small in magnitude and exhibits a nonlinear decrease with the increasing value of the applied voltage.

Our research in the field of medical physics has been focused on three main areas: cancer-treatment assessment with biomedical imaging, radio-biological studies on zebrafish, and computer simulations of cancer growth and the response to therapy. In the cancer-treatment assessment we are using biomedical imaging, particularly positron-emission tomography (PET) using novel tracers of cellular proliferation (FLT) and hypoxia (CuATSM) to assess the biological substructure of tumors prior to and during antineoplastic therapies. We are performing experiments on

small animals (mice) and large animals (dogs with spontaneous tumors). In addition, we are involved in several human clinical trials in patients with brain, head and neck, lung, oesophagus, and prostate tumors, as well as patients with leukaemia and lymphomas. In the previous year we have completed a preclinical study on dogs with lymphomas, investigating the treatment efficacy of a novel drug, which provided the basis for the accelerated start of a human clinical trial. In patients receiving radiotherapy, chemo-radiotherapy and molecular targeted therapies we have observed large heterogeneity and variability of the pre-treatment biological substructures as well as the complex dynamics of the response. For radio-biological studies on zebrafish we have developed a new image-guided micro-irradiator, which is capable of the localized irradiation of zebrafish embryos with photon fields of less than 1 mm in diameter. This will enable radio-biological studies of localized irradiation, similar to the conditions met in external beam radiotherapy. In preliminary studies, comparing total and partial body irradiation, following up the apoptosis and inflammatory response, we observed that while apoptosis is high in both cases, the inflammatory response is significant only during partial irradiation. In computer simulations of cancer growth and the response to therapy we have developed a stochastic multi-layer model that feeds from biomedical images. In parallel we have developed a vasculature growth model. We have been able to apply the models to experimental datasets of in-vitro and in-vivo experiments. This provides a foundation for the future development of biological cancer-treatment planning.

Some outstanding publications in 2008

1. Georges Bonheure, Igor Lengar, B. Syme, Elisabeth Wieslander, Mikael Hult, Joël Gasparro, Gerd Marissens, Dirk Arnold, Matthias Laubenstein, Sergei Popovichev, "In-vessel activation monitors in JET : progress in modeling", *Rev. sci. instrum.*, 2008.
2. R. T. Flynn, S. Bowen, S. Bentzen, T.R. Mackie, Robert Jeraj, "Intensity-modulated x-ray (IMXT) versus proton (IMPT) therapy for theragnostic hypoxia-based dose painting", *Phys. Med. Biol.*, vol. 53, pp. 4153-4167, 2008.
3. Tomaž Gyergyek, Borut Jurčič-Zlobec, Milan Čerček, "Potential formation in a one-dimensional bounded plasma system containing a two-electron temperature plasma : kinetic model and PIC simulation", *Phys. plasmas*, issue 6, vol. 15, pp. 063501-1-063501-28, 2008, <http://dx.doi.org/10.1063/1.2921793>
4. Igor Lengar, Luka Snoj, Petra Rogan, Matjaž Ravnik, "Re-evaluation of the criticality experiments of the "Otto Hahn Nuclear Ship" reactor", *Kerntechnik* (1987), vol. 73, pp. 242-248, 2008.
5. Luka Snoj, Matjaž Ravnik, "Power peakings in mixed TRIGA cores", *Nucl. Eng. Des.*, vol. 238, pp. 2473-2479, 2008.
6. B. Titz, Robert Jeraj, "An imaging-based tumor growth and treatment response model : investigating the effect of tumour oxygenation on radiation therapy response", *Phys. Med. Biol.*, vol. 53, pp. 4471-4488, 2008.
7. Andrej Trkov, R. Capote, Ivan Aleksander Kodeli, L. C. Leal, "Evaluation of Tungsten nuclear reaction data with covariances", *Nucl. data sheets*, 2008, issue 12, vol. 109, p. 2905-2909

Organization of conferences, congress and meetings

1. 36th Meeting of the EFDA Steering Committee, Nuclear Training Centre Milan Čopič, Jožef Stefan Institute, Brinje, Dol near Ljubljana, 10-11 Mar. 2008 (45 participants)

INTERNATIONAL PROJECTS

1. Development of Composites with Advanced/Alternative Manufacturing Concepts - 4.1.2. FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Matjaž Ravnik, Asst. Prof. Goran Dražič
2. Ceramic Processing of Sic/Sic Composites for Functional Application - 4.1.1. FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Matjaž Ravnik, Asst. Prof. Saša Novak Krmpotič
3. Nuclear Data: Benchmark Experiments to Validate EFF/EAF Data (TW6-TTMN-002B)
T1.002B-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Asst. Prof. Andrej Trkov
4. Nuclear Data: Benchmark Experiments to validate EFF/EAF Data (TW6-TTMN-002B)
T1.002B-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
FU07-CT-2007-00016 (EFDA 07-1708)
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Asst. Prof. Andrej Trkov
5. Nuclear Data: EFF/EAF Data File Upgrade, Processing and Benchmark Analyses (TW6-TTMN-001B) - T1.001B-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
FU07-CT-2007-00016 (EFDA 07-1708)
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Asst. Prof. Andrej Trkov
6. Upgrade of Gamma-Ray Cameras: Neutron Attenuators
EFDA Task Agreement Code: JW6-TA-EP2-GRC-01, Contract No.: JW6-NEP-MHST-01,
Notification Amendment JW6-NEP-MHST-01
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Igor Lengar

7. Upgrade of Gamma-Ray Cameras: Neutron Attenuators
EFDA Task Agreement Code: JW6-TA-EP2-GRC-01, Contract No.: JW6-OEP-MHST-01, Order Amendment JW6-OEP-MHST-01A
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Igor Lengar
8. Neutron Calculation for Fusion Reactor - 3.4.2.-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Igor Lengar
9. Hydrogen/Deuterium Molecule Wall Interaction - 1.4.1.-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Milan Čerček, Dr. Iztok Čadež
10. Research Unit - Administration and Services - RU-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Prof. Milan Čerček, Asst. Prof. Saša Novak Krmpotič
11. Fusion Expo Activities under an EFDA
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Igor Lengar, Melita Lenšek, univ. dipl. ped., Sabina Markelj, univ. dipl. fiz., Asst. Prof. Saša Novak Krmpotič, Stefan Kolenko
12. Improvement of Evaluated Nuclear Data Fiels with Emphasis on Activation and Dosimetry Reactions
14914/R0
Teresa Ann Benson, IAEA - International Atomic Energy Agency, Vienna, Austria
Asst. Prof. Andrej Trkov

R & D GRANTS AND CONTRACTS

1. PET with a novel photon decetor
Prof. Peter Križan, Asst. Prof. Robert Jeraj
2. A development of low-activation material for the first wall in fusion reactor
Asst. Prof. Saša Novak Krmpotič, Luka Snoj
3. Fusion relevant research of plasma interaction with surfaces
Prof. Milan Čerček
4. Development of the diagnostics for certain parameters of the edge plasma in fusion devices
Prof. Milan Čerček
5. A study of the plasma parameters for conditioning of the inner surfaces of a fusion reactor
Asst. Prof. Miran Mozetič, Prof. Milan Čerček
6. Radiation field characterization for diagnostic and therapeutic use of radioactive isotopes
Dr. Marjeta Šentjurs, Asst. Prof. Robert Jeraj
7. On the use of benchmark experiment for improved utilization of nuclear facilities
Asst. Prof. Andrej Trkov
8. Concrete construction properties and water seeping through concrete structures
Asst. Prof. Igor Lengar
9. Prevention and reduction of the consequences of the terrorist attack on TRIGA research reactor
Prof. Matjaž Ravnik
10. Development of procedures for neutron spectrum characterization with covariance matrices for irradiation experiments
Asst. Prof. Andrej Trkov

RESEARCH PROGRAM

1. Reactor Physics
Prof. Bogdan Glumac

NEW CONTRACT

1. NEK Spent fuel container loading scheme optimization regarding maximum permissible power
Agency for Radioactive Waste, Ljubljana
Prof. Matjaž Ravnik

VISITORS FROM ABROAD

1. dr. Jörgen Kjems, director DTU Electro, Technical University of Denmark, Lyngby, Denmark, 7 Mar. 2008
2. Francesca Sinischalchi, Steven Booth, scientific coordinator, J4-Energy and Douglas Bartlett, European Commission, Brussels, Belgium, 30 Jun. 2008

3. dr. Michael Loughlin, head of the neutron calculations division for ITER, ITER Organization, St. Paul lez Durance, France, 8-11 Sept. 2008
4. Mark Pipeleers and Ana Maria Montaner-Alonso, European Commission, Brussels, Belgium, 6-7 Nov. 2008
5. Rustam Khan, MAAE fellow, Atominstitut Vienna, Austria, 10-12 Dec. 2008
6. prof. Petro Gorley and dr. Sergii Bilichuk, University Chernivci, Ukraine, 9 Dec. 2008

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* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

- Georges Bonheure, Igor Lengar, B. Syme, Elisabeth Wieslander, Mikael Hult, Joël Gasparro, Gerd Marissens, Dirk Arnold, Matthias Laubenstein, Sergei Popovichev, "In-vessel activation monitors in JET: progress in modeling", *Rev. sci. instrum.*, issue 10, vol. 79, pp. 10E504-1-10E504-4, 2008.
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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, at DESY in Hamburg and at KEK in Tsukuba. The department is also engaged in developing and applying technologically advanced particle detectors, which 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 the 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, the German centre DESY in Hamburg and the Japanese centre KEK in Tsukuba. We are taking part in three experiments, each conducted as an international collaboration:

- ATLAS at the Large Hadron Collider (LHC) at CERN (2000 researchers, 167 institutions),
- Belle at the asymmetric electron-positron collider (KEK-B) at KEK (380 researchers, 55 institutions),
- HERA-B at the HERA electron-proton collider at DESY (310 researchers, 33 institutions).

In the field of astroparticle physics we are part of the Pierre Auger collaboration (200 researchers, 55 institutions), 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 detailed report on the 2008 activities follows, focused on the contributions of our researchers:

ATLAS

The ATLAS detector will from 2009 onwards measure proton collisions at the LHC, which briefly began its operation in September 2008 (Fig. 1). Once restarted in 2009, we expect that the luminosity will increase gradually and reach the design value of 10³⁴ cm⁻²s⁻¹ in the years 2011–2012. CERN has already approved two upgrades of the beam optics system in front of the ATLAS and CMS detectors as well as the proton injectors, which each by itself can increase the luminosity by a factor of two, above the design value. In accordance with this, the development of new detector components is taking place, which will be able to function at the increased luminosity. Until 2016 the LHC luminosity should have gradually increased to 10³⁵ cm⁻²s⁻¹ (super LHC - sLHC) and subsequently at least the inner part of the ATLAS detector will need replacing. Also, an upgrade of the radiation protection of external components, especially the muon chambers, will be required.

On 10 September the Large Hadron Collider at CERN was successfully turned on in front of an audience of several hundred million people. Unluckily enough, a faulty connection between the superconducting magnets brought the collider to a temporary halt after only nine days of operation, postponing the start-up of physics measurements by nearly a year.

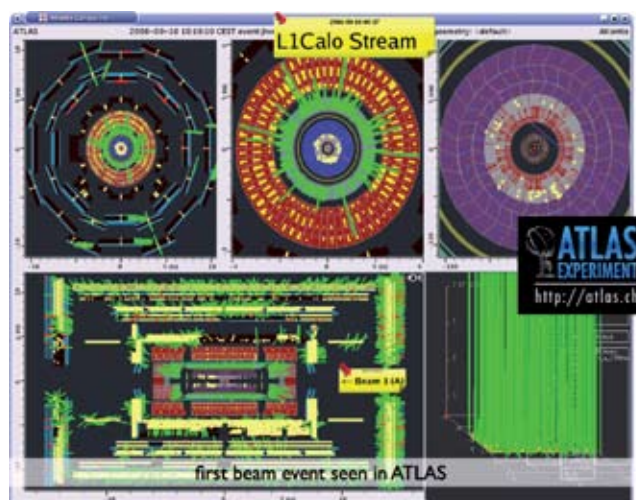


Figure 1: On 10 September the ATLAS detector recorded this first event, provoked by a 450-GeV proton bunch from the Large Hadron Collider. The protons hit a foil at a collimator 100-m upstream of the detector. The detected spray of particles consists of muons, the only particles from proton-induced interactions that penetrate the material to the detector.

We expect a very rich and relevant yield of fundamental physics results. Already the first collisions should extend our knowledge of Quantum Chromodynamics in the description of peripheral (soft) collisions at presently unattainable energies. With the growing integrated luminosity the number of observed and measured processes at higher effective energies of parton collisions (hard scattering) will increase and with it the possibility of the production of new, heavy particles, which were impossible to observe at the up-to-date colliders.

Already in the initial phase, the ATLAS detector will be able to perform much more accurate measurements of the heavy top-quark masses with respect to the present precision. It will also significantly contribute to the precision of the Standard Model parameter measurements, such as, for example, the properties of the W and Z weak bosons.

The expected discovery of the Higgs boson is highly dependent on its actual mass; in the most favourable realisation with its mass around 150 GeV it is estimated that only somewhat more than 800 pb⁻¹ is required, which could be accumulated in 2009–2010. Harder to discover are lower masses, of around 120 GeV. About 10 fb⁻¹ of integrated luminosity will be needed, which might be achievable by 2011. The discovery of the lightest supersymmetric particles also depends on their actual mass, which is only weakly bracketed by the present measurements. A total of 100 pb⁻¹ of integrated luminosity, feasible in 2009, makes it possible to unveil such particles with masses up to 750 GeV; 10 fb⁻¹ expands the discovery potential up to masses of 1.8 TeV. These measurements also require a precise understanding of the detector's response; this can, however, be calibrated only on the data itself. Nevertheless, we will be able to quickly detect any exotic particles at the TeV scale, decaying into leptons as well as possible micro-black-holes with a mass of a few TeV, which would evaporate in the detector.

To further increase the physics reach of the collider two directions are foreseen: increasing the luminosity by an order of magnitude, and doubling or even tripling the collision energy. The increased luminosity places very stringent demands to the detector's performance, and only marginally increases the predictive power (e.g., about 30% in new particle masses), but is achievable with a small investment and continuous increase of the maximum luminosity maintains the operational stability of the collider. An increase of the collision energy would be much more desirable from the perspective of physics reach and detector performance; however, the increase of energy by more than 10% requires replacing all the magnets, which practically means building a completely new collider.

The Slovenian group is actively participating in the R&D phase of the tracking-detector upgrade, particularly in radiation hardness studies of position-sensitive detectors, suitable for operation in the extreme radiation conditions of the sLHC. Measuring the charge collection in heavily irradiated silicon micro-strip detectors, anomalously high values were obtained at high detector biases, matching the non-irradiated values (Fig. 2). This is in contradiction with the previously established data on irradiation-induced charge trapping at lower fluences. The background of this phenomenon is yet to be understood, although there are some indications for avalanche multiplication in the strong electric field close to the read-out electrodes.

The ATLAS experiment will produce about a PB of data per year, corresponding to a quantity of data that can be written on 1.5 million CDs. In the full life cycle of the experiment the data quantity is expected to get 30 times larger. Thus it becomes evident that it will be impossible to store and process it within a single computing centre. The network infrastructure is thereby an additional bottleneck. We cannot expect such a quantity of data in its entirety to be sent over the internet more than once: from CERN, where the experiment will take place, into one of the computing centres, where the data will actually be stored and where particular data processing procedures and physics analyses will take place according to the needs of ATLAS collaboration.

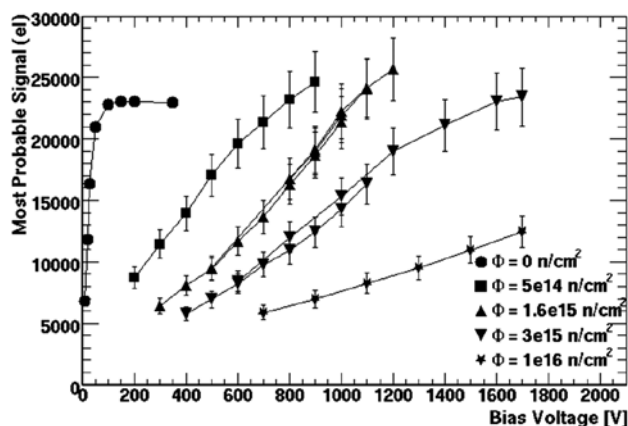


Figure 2: Measured collected charge as a function of bias voltage for un-irradiated and irradiated silicon micro-strip detectors of 300- μm thickness. The expected irradiation fluences are in the sLHC range, depending on the distance from the interaction point, between 5×10^{14} and 10^{16} n/cm².

The use of Grid technology is the only solution facilitating the fast data transfer from the collider to remote centres where such quantities of data can be stored at a sufficient rate. Due to the quantity of data and the complexity of processing it is mandatory to also use Grid technologies for data processing, since none of the research centres has enough storage and computing capacity. It is due to such huge storage and processing demands with the forthcoming experiments that the Experimental Particle Physics community exerts such a strong initiative for the development and application of Grid technologies. Subsequently, a large portion of software and standards, which are being developed in the framework of the LHC Computing Grid (LCG) project, became the basis of the EGEE (Enabling Grids for E-science) infrastructure

As ATLAS Collaboration members, our Department took part in the LHC Computing Grid and from 2003 participated in the preparation of the EGEE project. Since autumn 2003 we have been maintaining our own infrastructure and have put in to production a grid cluster named SIGNET (Slovenian Grid Network). SIGNET became the Slovenian grid infrastructure centre and is working as a part of the European grid network

and EGEE. We are participating as a fully-flagged Tier-2 computing research centre in the production and analysis part of the ATLAS experiment. From the start we have been taking part in the development of the newest technologies to make the ATLAS experiment possible and open the door to new fundamental research results in the field of particle physics. In 2008 SiNET was upgraded to a total capacity above 500 processors and 170 TBy of disk space. Due to the exemplary reliability of the system, we managed to considerably exceed our predicted share in Monte Carlo sample production for the ATLAS experiment.

The development of new computational methods in combination with distributed data processing is expected to stimulate the development in other branches of science where large computing capacities and/or computing simulations are needed (computing, informatics, meteorology, statistics), and in the final instance also significantly contribute to the development of the informatics infrastructure. As a showcase example, the world wide web (WWW) was developed at the European Laboratory for Particle Physics (CERN) for the early needs of the LHC collaborations; to the present day it has become a totally new branch of information technology. Similar expectations are also being raised for the development of the distributed computing (Grid), which is being pushed for the exploitation of the LHC project.

BELLE

The Belle experiment records data of electron-positron collisions at a centre-of-mass energy corresponding to the bound state of a beauty or b quark and an anti-b quark, $Y(4S)$. This resonance instantaneously decays into a pair of B mesons, and up to now decays of around 900 million B-meson pairs have been recorded. Furthermore, in electron-positron collisions other processes take place as well, giving rise to an abundant production of heavy particles composed of charm - c - and lighter quarks. The experimental facility thus represents a perfect environment for various studies of particles composed of heavy quarks b and c. A huge sample of recorded decays enables measurements of extremely rare processes, where we might observe unexpected effects, not included in the Standard Model (SM) of strong and electroweak interaction among elementary particles. Generally speaking, the measurements performed by the Belle collaboration represent a complementary approach (the so-called *precision frontier*) to the future experiments at the LHC (the so-called *energy frontier*). While the latter may discover the so far unknown - but long searched for - particles due to the high available energy, measurements at Belle and its successor SuperBelle, to start operation by 2013, may provide insight into various theories beyond the SM that predict such particles (for example, string theories).

The largest success of the Belle collaboration, encompassing around 370 scientists from 60 institutions worldwide, came at the end of 2008. The 2008 Nobel Prize for physics was awarded to Makoto Kobayashi and Toshihide Maskawa for their theory of the so-called CP symmetry-breaking, which was precisely confirmed and verified by the Belle experiment in numerous measurements (Fig. 3). CP violation in the B-meson system was one of the primary goals of the experiment since its start-up in 1999. CP symmetry violation reflects in the slightly different properties of particles and their anti-particles, and is one of the conditions for an almost complete domination of matter over anti-matter in the Universe.

The CP symmetry violation nevertheless hides some puzzles, which are so far not completely understood. In 2008 members of the Belle collaboration discovered a significant difference in CP symmetry violation between the decays of neutral and charged B-meson decays. The results were presented in a paper published in the prestigious journal Nature. The explanation of the observed phenomena in the framework of the SM proves to be difficult. While there are less anti- B^0 mesons (with b quark) decaying to $K\pi^+$ than B^0 mesons (with anti-b quark) decaying to $K^+\pi$, the situation is reversed for the charged B mesons: there are more B mesons (with b quark) decaying to $K\pi^0$ than B^+ mesons (with anti-b quark) decaying to $K^+\pi^0$ (see Fig. 4).

In the search of processes beyond the Standard Model, the Belle experiment in 2008 broke another precision frontier by the measurement of decays where the beauty quark decays into a strange quark and a photon. Since this process is extremely rare within the SM, it is sensitive to possible contributions of new, yet undiscovered particles. Measurements of the decay rate and of the photon energy spectrum with an unprecedented precision impose stringent constraints on values of parameters used in the theories that predict new particles.

Precise verifications of CP symmetry-breaking in the neutral B meson system, accomplished in a major part by the Belle collaboration, led to the 2008 Nobel Prize in physics for the Japanese theoretical physicists Makoto Kobayashi and Toshihide Maskawa.

KEKB と Belle に携わった全ての
人とともに、アップグレード計画の
成功を祈念しつつ。

2008年10月9日

小林 誠

Figure 3: Makoto Kobayashi (2008 Nobel Prize laureate for physics) thanks members of the Belle collaboration and wishes all the best for their future work.

Using sophisticated experimental methods that consider subtle interferences among decay products of B mesons, the Belle experiment obtained evidence for several, so-far unobserved particles. The large interest triggered by these results lies in the fact that the observed bound states are electrically charged. Hence, while their properties are similar to the properties of well-known, but electrically neutral bound states of a charm quark and its anti-particle, they cannot be placed into the existing scheme of heavy particles composed of a quark and an anti-quark.

The preparation of the upgrades of the Belle spectrometer and the KEK-B collider in Tsukuba has reached an important new phase. A major reconstruction of the collider that will allow running at luminosities exceeding, by 10–50, the present best values has become one of the priorities of the Japanese KEK laboratory. To carry out such a long-term project, a new research group was formed with scientists from US, Germany, Japan, Austria, Poland, Australia, Russia, China, Korea and Slovenia; in this group, our collaborators coordinate some essential activities. The aim of the project is to use a considerably larger data sample to investigate with high precision processes where deviations from the Standard Model predictions could be observed. These measurements will represent an important complement to the searches for physics beyond the Standard Model planned at the LHC collider.

For the upgraded Belle spectrometer, we have developed a new method for charged-particle identification. The method uses a measurement of the time of propagation (TOP) of charged particles and Čerenkov photons, emitted in a quartz bar; the method was examined under various conditions and by varying the parameters of the counter. We have continued the investigation of a proximity focusing Čerenkov counter with aerogel as a radiator, for which a new single-photon detector was developed. This detector is based on a novel type of sensor, known as a silicon photomultiplier or Geiger mode APD, and is based on the photoelectric effect in a suitably doped semiconductor. With this new detector type we have successfully carried out first tests in a test beam. We have also investigated another type of single-photon detector, a hybrid photodiode; in such a light sensor, photoelectrons gain kinetic energy in a high electric field, and are subsequently detected in a silicon counter, enclosed in the same vacuum container.

HERA-B

We have continued with the analysis of data collected with the HERA-B spectrometer at DESY in Hamburg. The following analyses were finalized and prepared for publication: cross-section measurements for the production of excited charmonium states, the production of strange baryons and the polarisation of the J/ψ mesons.

PIERRE AUGER

The Pierre Auger collaboration has constructed a huge high-energy cosmic-ray observatory in Argentina, sensitive to cosmic rays with energies above 10^{19} eV. The Auger Observatory is a “hybrid detector”, employing two independent methods to detect and study high-energy cosmic rays. One technique detects high energy particles through their interaction with water placed in surface detector tanks. The other technique tracks the development of air showers by observing ultraviolet light emitted high in the Earth’s atmosphere. An upgrade with HEAT (High Elevation Auger Telescope) is underway to extend the sensitivity to lower energies.

The main physics results in 2008 are the discovery of the correlation of the highest-energy cosmic rays with nearby active galactic nuclei and the observation of the suppression of the flux of cosmic rays above 10^{19} eV. Our group is involved in data analysis, the LIDAR system operation, the development of an offline data-analysis package and detector simulation, and calibration.

Detector development

In collaboration with CERN, University of Valencia, University of Michigan, Ann Arbor and Ohio State University we have continued with the development of the Compton camera and a novel PET apparatus, based on position-sensitive silicon detectors. Work on a high-resolution PET probe utilizing the same technology has started in the framework of MADEIRA, a EU FP 7 project. A dual-head prototype detector for a brachytherapy source locator was assembled and tested in real time at the Oncology Institute in Ljubljana.

Encouraged by successful measurements with silicon photomultipliers, we have designed, constructed and tested a novel type of detector module for position emission tomography (PET), and investigated the two important parameters, its energy and timing resolution. Such a counter seems to be an extremely interesting candidate for the dual modality medical imaging, where a PET apparatus is embedded in an MRI imager, and the light sensors have to operate in magnetic fields exceeding 2 T. This research is a part of the FP7 research project aimed at the development of novel detection methods for particle physics and medical imaging.

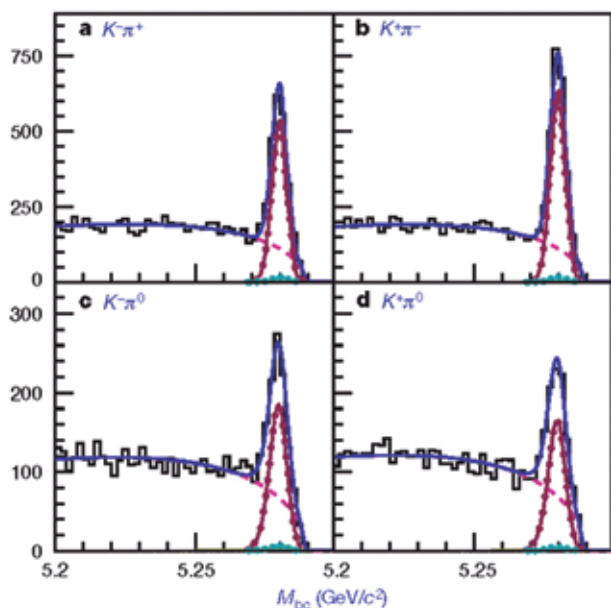


Figure 4: Top: Number of reconstructed B^0 (right) and anti- B^0 (left) decays to K and π . Bottom: Number of reconstructed B^+ (right) and B^- (left) decays to K and π . The sharp peaks are signal while the rest are background decays. Adapted from *Nature*, 452, 06827 (2008).

Some outstanding publications in the past three years

1. The Pierre Auger Collaboration, J. Abraham et al., Correlation of the Highest-Energy Cosmic Rays with Nearby Extragalactic Objects, *Science* Vol. 318. no. 5852 (2007) 938–943.
2. The Belle Collaboration, S.-W. Lin et al., Difference in direct charge-parity violation between charged and neutral B meson decays, *Nature* 452 (2008) 332–335.
3. The ATLAS Collaboration, G Aad et al., The ATLAS Experiment at the CERN Large Hadron Collider, 2008 JINST 3 S08003.

Awards and appointments

1. Prof. Peter Križan, Zois award, Ministry of Higher Education, Science and Technology, Ljubljana, Research field of experimental particle physics

Organization of conferences, congress and meetings

1. 12. Workshop of RD 50: Radiation hard semiconductor devices for very high luminosity colliders, Jožef Stefan Institute, Ljubljana, Slovenia, 2–4 Jun. 2008
2. Workshop RD42: Development of Diamond Tracking Detectors for High Luminosity Experiments at the LHC, Jožef Stefan Institute (F-9), Ljubljana, Slovenia, 19–20 Sept. 2008

INTERNATIONAL PROJECTS

1. Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and Their Digital Resources
MONDILEX
7. FP, 211938
EC; Institute of Mathematics and Informatics of the Bulgarian Academy of Science, Sofia, Bulgaria
Jan Jona Javoršek, B. Sc., Asst. Prof. Tomaž Erjavec
2. Marie Curie Training Network on Particle Detectors
MC-PAD
7. FP, 214560, PITN-GA-2008-214560
EC; Seamus Hegarty, CERN, Geneva, Switzerland
Prof. Peter Križan
3. Joint Research on Various Types of Radiation Dosimeters
RADDOS
7. FP, 207122
EC; University College Cork, National University of Ireland, Tyndall National Institute, Cork, Ireland
Dr. Gregor Kramberger
4. Enabling Grids for E-science III
EGEE-III
EGEE-SA1, EGEE-NA2, EGEE-NA4
7. FP, 222667
EC; Dr. Bob Jones, Anna Cook, CERN IT-EGE, Geneva, Switzerland
Prof. Marko Mikuž
5. Minimizing Activity and Dose with Enhanced Image Quality by Radiopharmaceutical Administrations
MADEIRA
7. FP – EURATOM, 212100
EC; GSF - Forschungszentrum für Umwelt und Gesundheit GmbH, München Neuherberg, Germany
Prof. Marko Mikuž
6. Image-based Navigation in Multimedia Archives
IMAGINATION
6. FP, 034626
EC; Clemens van Dinther, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc., Prof. Marko Mikuž
7. Semantic Web Services Interoperability for Geospatial Decision Making
SWING
6. FP, 026514
EC; Arne J. Berre, SINTEF - Stiftelsen for Industriell OG Teknisk Forskning Ved Norges Tekniske Hoegskole, Trondheim; SINTEF ICT, Oslo, Norway
Prof. Marko Mikuž, Asst. Prof. Dunja Mladenič, Marko Grobelnik, Mitja Jermol, M. Sc.
8. Enabling Grids for E-science II
EGEE-II
EGEE-NA1, EGEE-NA2, EGEE-NA3, EGEE-NA4
6. FP, 031688
EC; Dr. Bob Jones, CERN IT-EGE, Geneva, Switzerland
Prof. Marko Mikuž
9. Safe Production and Use of Nanomaterials
NANOSAFE2
6. FP, NMP2-CT-2005-515843
EC; Commissariat à l'Énergie Atomique, Grenoble, France
Andrej Detela, B. Sc., Asst. Prof. Maja Remškar, Marko Žumer, B. Sc., Prof. Boris Turk
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Asst. Prof. Borut Paul Kerševan
11. Collaboration HERA-B
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Prof. Peter Križan
12. Collaboration ATLAS
Prof. Peter Jenni, CERN, Geneva, Switzerland
Prof. Marko Mikuž
13. Collaboration CERN RD-39
Dr. Jaako Haarkonen, HIP, Finland
Dr. Zheng Li, BNL, USA
Prof. Marko Mikuž
14. Collaboration CERN RD-42
Prof. Peter Weilhammer, CERN, Geneva, Switzerland
Prof. Marko Mikuž
15. Collaboration CERN RD-50
Prof. Mara Bruzzi, University of Florence, Florence, Italy
Dr. Michael Moll, CERN, Geneva, Switzerland
Prof. Marko Mikuž
16. Collaboration Belle
Prof. Masanori Yamauchi, KEK, Tsukuba, Japan
Prof. Peter Križan
17. Collaboration CIMA
Cameras for Imaging in Medical Applications
Prof. Peter Weilhammer, CERN, Geneva, Switzerland
Prof. Marko Mikuž
18. Study of Top Events produced at the LHC for the Commissioning of the ATLAS Detector
BH-T/05-08-003
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Asst. Prof. Borut Paul Kerševan
19. Measurement of Properties of Charmed Hadrons
SLO-JPN
BIJP/07-09/C-002
Prof. Fumihiko Takasaki, High Energy Accelerator Research Organization, Ibaraki ken, Japan
Asst. Prof. Tomi Živko

R & D GRANTS AND CONTRACTS

1. Construction of test beam telescope
Dr. Andrej Gorišek
2. Positron emission tomography with a novel photo-detector
Prof. Peter Križan

3. A combined method for particle identification
Asst. Prof. Samo Korpar
4. Development of high-resolution PET probe
Dr. Dejan Žontar
5. Development and Implementation of Tools for the Physics Research with the ATLAS Detector in the Grid Environment
Asst. Prof. Borut Paul Kerševan
6. New electric direct drive systems
Andrej Detela, B. Sc.
7. Verification of radioactive sources positioning during brachytherapy
Dr. Gregor Kramberger
8. Optimizing of direct drive system for electric two-wheel vehicles
Andrej Detela, B. Sc.
9. Unknown Manuscripts of Slovenian Literature of 17th and 18th century: IT Supported Register, Original Research Presentations and Analyses
Asst. Prof. Tomaž Erjavec, Jan Jona Javoršek, B. Sc.
10. Slovene Terminology Web /Portal
Jan Jona Javoršek, B. Sc.

11. Hadron collider physics
Dr. Ilija Bizjak

RESEARCH PROGRAMS

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

NEW CONTRACT

1. Verification of radioactive sources positioning during brachytherapy
Elgo - Line d. o. o., Cerknica
Dr. Gregor Kramberger

VISITORS FROM ABROAD

1. Dr. Olav Ulland, CERN, Geneva, Switzerland, 8–10 Jan. 2008
2. Aleksej Litvičenko, INFN, Padova, Italy, 12–23 May 2008

3. Prof. Dr. Črtomir Zupancič, University of Ludwig Maximilian, Munich, Germany, 1–6 Jun. 2008
4. Prof. Dr. William Trischuk, University of Toronto, Toronto, Canada, 17–19 Sept. 2008
5. Dr. Aleksandar Jakšić, Tyndall National Institute, Ireland, 3–4 Nov. 2008
6. Prof. Dr. Goran Ristić, Electrofaculty, Niš, Serbia, 3–4 Nov. 2008

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38. Erik Margan

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3. CDF Collaboration: T. Aaltonen, Ilija Bizjak, (618 authors), "Direct measurement of the W boson width in $p\bar{p}$ collisions at $\sqrt{s}=1.96$ TeV", *Phys. rev. lett.*, vol. 100, no. 7, pp. 071801-1-071801-7, 2008.
4. CDF Collaboration: T. Aaltonen, Ilija Bizjak, (617 authors), "Evidence for $D^0 - \bar{D}^0$ mixing using the CDF II detector", *Phys. rev. lett.*, vol. 100, no. 12, pp. 121802-1-121802-7, 2008.
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THESES

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DEPARTMENT OF INORGANIC CHEMISTRY AND TECHNOLOGY K-1

The Department of Inorganic Chemistry and Technology is one of the leading groups in the world in the field of synthesising new inorganic compounds containing fluorine. The main research fields of the department are reactions in superacids, 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 and ecological problems in Slovenia. The group has already been cooperating closely with Slovenian industry for more than thirty years. The group is also active in the field of educating teachers of chemistry and in the field of the promotion of natural sciences among students of colleges and elementary schools.



Head:

Asst. Prof. Tomaž Skapin

In the field of the research of new inorganic compounds containing fluorine, new coordination compounds of the type $[M^x(L)_n](AF_6^-)_x$ have been synthesized (M is a metal; A is P, As, Sb, Nb, or Ru; L is a ligand, e.g., XeF_2 , XeF_4 , HF and x is the oxidation number of the central atom).

In connection with this the synthesis and characterization of the compound $[Ba(XeF_2)_4](PF_6)_2$ should be mentioned. The molecules of XeF_2 are bonded directly to the central Ba^{2+} cation with electrostatic forces between the negatively charged F ligands of the XeF_2 molecules and the positively charged Ba^{2+} centres. The structure consists of two crystallographically independent barium atoms with the coordination numbers 10 and 12. The barium atoms and the bridging XeF_2 molecules form double layers, which are further interconnected into the 3D network by the weak $Xe \cdots F(PF_6^-)$ interactions. With Ba as the central atom, two interesting new compounds $[Ba(XeF_2)_2](AF_6^-)_2$ ($A = Ru, Nb$) were isolated and compared with analogous, already-known compounds with $A = Sb$ and As. We found that the influence of the anion on the structure diversity of these coordination compounds is small although the Lewis basicity of AF_6^- anions is different. The compounds with $A = Nb$ and Ru are the first known coordination compounds with XeF_2 as a ligand and RuF_6^- and NbF_6^- as anions. In 2008, besides the already known compound $[Cu(XeF_2)_6](SbF_6)_2$, two new coordination compounds in the system $Cu(SbF_6)_2-XeF_2$ have been isolated. These two compounds are $[Cu(XeF_2)_n](SbF_6)_2$ ($n = 2, 4$).

Until now, only the coordination compounds with the XeF_2 molecule acting as a ligand to the metal ion were known. However, in 2008 we succeeded in synthesising the first compound in which the molecule XeF_4 is connected to the Mg^{2+} ion as a ligand. We also determined the structure of this compound.

The research of the possibility of using XeF_4 as a ligand to the metal ion was continued. The first compound of this type, $[Mg(XeF_2)(XeF_4)](AsF_6)_2$, was prepared and its structure was determined. In this compound two molecules of xenon fluorides in different oxidation states (XeF_2 , XeF_4) are acting as ligands. The magnesium atom is surrounded by six fluorine atoms from four AsF_6^- units, one XeF_2 , and one XeF_4 molecule. Both xenon fluorides are non-bridging ligands, while the surrounding AsF_6^- units connect magnesium atoms (by *cis* and *trans* F bridges) forming the layers along the b axis. Our efforts to synthesize the coordination compound with only XeF_4 as a ligand have not been successful up to now.

The compounds where HF is acting as a ligand or where HF forms with an F^- anion (poly)-hydrogen-fluoride anions of the type $H_xF_{x+1}^-$ should be mentioned here. In 2008 two new compounds with HF acting as a ligand were isolated and characterized: $[Sr(HF)_3](TaF_6)_2$ and $[Sr(HF)](BF_4)_2$. In addition to the compound $Ba(H_3F_4)_2$, which was isolated and its structure determined in our laboratory in previous years, the compound $Ca(HF)_2$ represents the second known compound in which the central atom has a homoleptic environment of HF molecules. Furthermore, ribbon-like polymeric compounds of the type $(MF)_n^+$ were synthesized. These ribbons could be further connected with the HF_2^- anions in the double ribbons, e.g., $Ba_4F_4(HF_2)(PF_6)_3$ or in the infinite layers, e.g., $Pb_2F_2(HF_2)(PF_6)$.

This year, the first known compounds with mixed anions (BF_4^- , PF_6^- and AsF_6^-) were synthesized and their structures were determined: $Ba(BF_4)(PF_6)$ and $Ba_2(AsF_6)(BF_4)_2(H_3F_4)$. These types of compounds are interesting because a whole series of different AF_6^- anions ($A = Sb, Bi, Nb, Ta, Ru, Au$ etc.) could be applied.

The crystal structures of AMF_6 ($A = In, Tl; M = P, As$) were determined on single crystals. Together with the crystal structure of $InBF_4$, the crystal structures of $InPF_6$ and $InAsF_6$ represent unique examples of ternary In(I) compounds with In(I) in a solely fluorine environment.

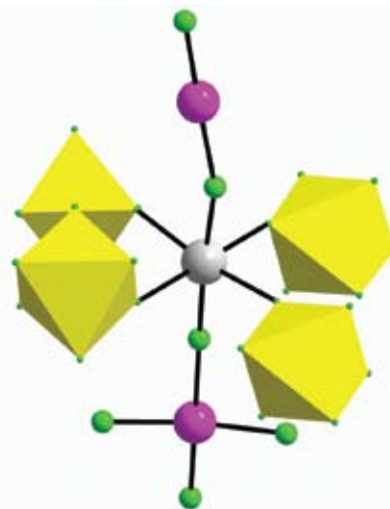


Figure 1: The coordination of ligands around the Mg^{2+} ion in the crystal structure of $Mg(XeF_2)(XeF_4)(AsF_6)_2$

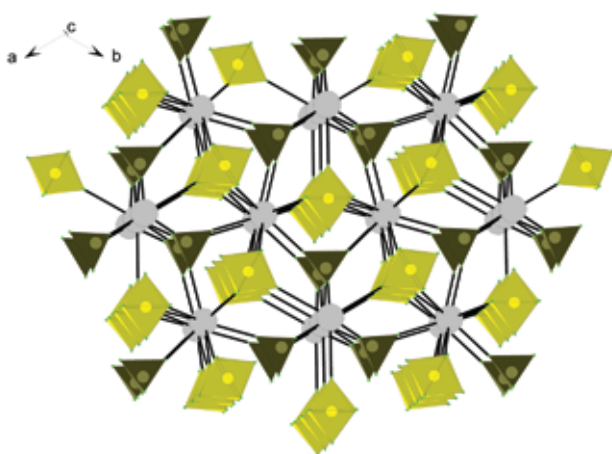


Figure 2: Packing diagram of $Ba(BF_4)(PF_6)$: the first compound containing simultaneously tetrahedral BF_4^- and octahedral PF_6^- anions

compounds. This research is very promising and will be continued.

The BF_4^- and SiF_6^- derivatives of protonated 3,5-diamino-1,2,4-triazole have been obtained and structurally investigated with X-rays. A complex system of strong hydrogen bonds was found in both compounds, the same as in the

With the Aichi Institute of Technology, Nagoya, Japan, we studied the electrochemical behaviour of natural graphite (fluorinated by ClF_3 and NF_3) in propylene-carbonate-containing solvents. Additionally, surface fluorination of the graphitized vapour grown carbon fibre (VGCF) has been performed with F_2 , $F_2 + O_2$, NF_3 and ClF_3 under mild conditions and the charge/discharge characteristics were investigated.

Together with researchers from Colorado State University, USA, and Moscow State University, Russia, we have continued our study of the selective fluorination of fullerenes and investigations of the vapour composition obtained by the thermal decompositions of different fluorides. The application of Fourier transform mid- and far-IR spectroscopy for studies of the oxo-derivatives of Ag(II) was made in cooperation with Warsaw University, Poland. With the same partner we also studied the reactivity of the potent AgF_2 oxidizer to a whole range of organic and inorganic compounds.

In cooperation with the Department of Solid State Physics (F-5) we continued our research on ferroelectric and ferromagnetic metal fluorides. Most of our research was made on $K_3Fe_5F_{15}$, which exhibited both properties. The contribution of our department was mainly in the preparation of these

[$Cu(C_2N_5H_6)_2$] SiF_6 derivative. In collaboration with the Ivan Franko National University, Lviv, Ukraine, five new copper(I) π -complexes with fluorine-containing anions have been obtained: $CuBF_4$ with 2-allylbenzotriazole and diallylcyanamide, $Cu(CF_3COO)$ with 1-allylbenzotriazole, and Cu_2SiF_6 with N-allylmorpholinium and diallylcyanamide.

The influence of different reaction conditions on the plasma polymerization was evaluated. In plasma of the gases CF_4 , C_6F_{12} , C_2F_6 and hydrogen, the polymerization rate depends strongly on the gas pressure in the reactor; by increasing the pressure in the range of 1 mbar the polymerization rate increases strongly. By increasing the pressure to a few mbar the precipitation of polymer in the form of a powder takes place. 4-amino arylsulfur pentafluoride is a product used in the syntheses and transformation of arylsulfur pentafluorides

into different products. Single-crystal X-ray diffraction revealed that the torsion angles F-S-C differ considerably from the corresponding angles in a 4-acetamidoarylsulfur pentafluoride.

We have continued with the work started within the EU project FUNFLUOS. Gallium fluoride was prepared using a modified fluoride sol-gel procedure. The focus was on the key parameters of synthesis, like temperature, concentration and ratio of reactants and the type of fluorinating agent. Gallium fluoride synthesized by this route is amorphous and has a high surface area and a high Lewis acidity. The influences of HF on the gel formation with the use of gallium isopropoxide were studied. Additionally, the temperature conditions for the additional fluorination were studied.

In the frame of the analytical laboratory, elemental analyses of some compounds synthesized in our laboratories and some technological samples were conducted. For a determination of the end point of titrations in redox systems modifications of the Gran I and Gran II methods were proposed and verified. A new method for spectro-pHmetric determination of the dissociation constants was proposed. Stabilities of the systems $Al(OH)_3 / Al_2(SO_4)_3 /$ with different fluorides used as additions for concrete were studied. In the field of thermochemistry a theoretical study of the enthalpies of formation of some complex anions consisting of a metallic cation and one or more oxyanions was conducted.

Related to the fields of process safety (industrial risks) and reliability of processes/equipment we have been engaged in consultations with local industry and the competent national authorities. For Geoplin plinovodi d.o.o. we elaborated an updated threat (risk) assessment for their natural gas distribution system. With Istrabenz plini d.o.o. we elaborated a security plan according to the provisions of the European Treaty ADR and continued the

In the frame of the Centre of Excellence for Environmental Technologies we merged expertise in the fields of mercury's environmental impact (Department O-2) and technological expertise in the field of flue-gas cleaning from high-temperature industrial processes (Department K-1), which enables a quantitative evaluation of the mercury emissions and also technological interventions needed for emission abatement.

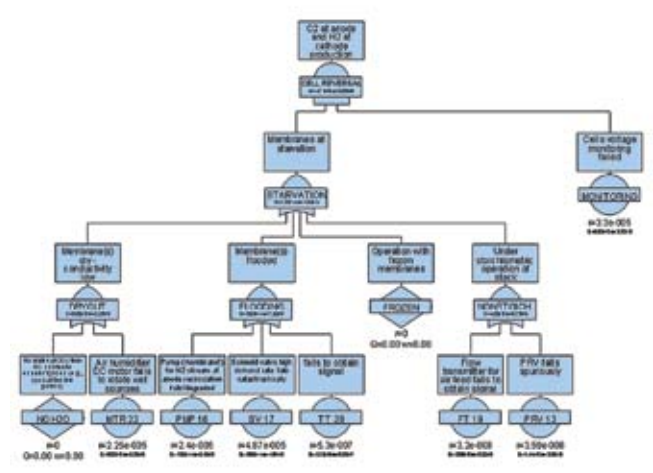


Figure 3: An example of a fault-tree detail within the process safety analysis for proton-exchange-membrane-type fuel cell (PEMFC)

consultation services related to the implementation and performance of the safety management system (in the context of the EU directive 96/82/EC, or Seveso II). In addition, we were engaged by the Ministry of the Environment and Spatial Planning of the Republic of Slovenia in updating the expert review of process-safety aspects for the project documentation for two planned LNG terminals in the Gulf of Trieste, Italy. In cooperation with another research group we finished a quantitative analysis of operational and process safety aspects of PEMFC-type fuel cells. With the company Esotech d.d. we continued work in terms of the remaining uncertainties related to comparative analyses of alternative technological processes for a wet flue-gas desulphurization process. For Geoplin plinovodi d.o.o. we started with the reliability analysis of a part of a natural gas distribution system.

The final report of the Centre of Excellence Environmental Technologies (CEET) activities for the first period has been submitted to the authorities as well as the draft program for the next period. In the framework of CEET we merged international expertise in the fields of mercury environmental impacts (Department O-2) and technological expertise in the field of flue-gas cleaning from high-temperature industrial processes (Department K-1), with the aim of understanding the processes that influence the amount of emission and emitted species. The gained knowledge enables a quantitative evaluation of the emissions and also the technological interventions needed for the abatement of these emissions.

In cooperation with the technological firm Esotech d.d. and in the frame of the development of volatile organic compounds (VOCs) removal technology from the secondary lead processing we performed technological measurements. We studied the problem of arsenic and antimony removal from the industrial waste waters of a glass factory. It was established that the classical methods of co-precipitation are not successful because As and Sb are in the form of chemically very stable ions AsF_6^- and SbF_6^- . We participated in the technological design of a flue-gas desulphurisation plant for the planned block VI (600-MW power) of the Šoštanj thermal power plant. In the same project we also cooperated during the design of a pilot plant for the preparation of boiler water based on membrane techniques.

In cooperation with S&T Slovenija and the Slovenian Army and in the frame of the Targeted Development Project for Peace, financed by the Slovenian Ministry of Defence, we developed an ammunition-categorisation system and prepared a model for the inclusion of ammunition categorisation into the overall quality-assurance information system.

In cooperation with three Belgian companies – Leniko, IRE and Tecubel – a contract financed by the European Union with the title “Improvement of the management of institutional radioactive waste in Slovenia” was obtained. The project was managed with the help of the Radiation Protection Group at the JSI in the JSI Hot Cell Facility. With this project a foundation for future cooperation in the field of radioactive-waste management was laid.

Two European projects were finished in 2008 – Form-it and PROBASE – which involved a collaboration between the JSI, the University of Ljubljana and various secondary schools. In 2008 the School of Experimental Chemistry provided 54 one-week courses of physical and chemical experiments for the students of elementary and secondary schools. The number includes attractive experiments that were performed for some special visits to our laboratories and for performances at schools all over Slovenia. We participated at the 14th Science Festival in Ljubljana, organized by the Slovenian Scientific Foundation, and in the 1st HOKUS-POKUS natural sciences festival, organised by the Youth Culture Centre Ljubljana. We were again invited to the 2008 International Science Festival in Genova, Italy.

Awards and appointments

1. The award “European Regional Environment Champion 2008” was awarded to the Environmental Technologies Excellence Centre by the European Regional Champions Award Expert Panel.

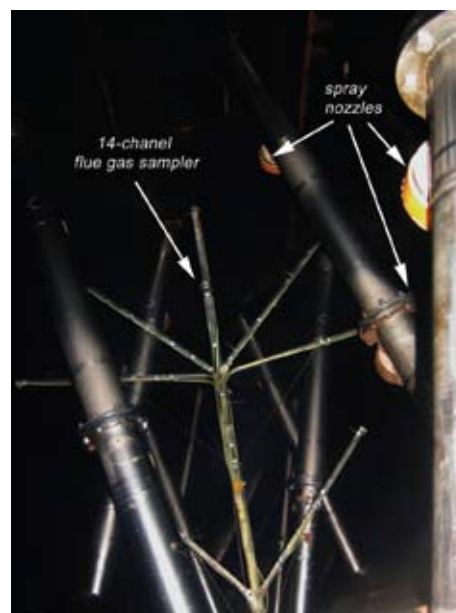


Figure 4: A view into the flue-gas absorber from above. Levels of spray nozzles can be seen with the innovative sampling system for simultaneous multi-point sampling of flue gas at 14 points on the absorber cross-section. The FGD plant in MPI Žerjav has been in operation since 2003, and the sampling system is used to measure the SO_2 concentration profiles inside the FGD absorber.

We prepared a novelised expertise on the cross-boundary environmental impact assessment from the point of view of process safety for the two planned liquid natural gas terminals in the Gulf of Trieste.



Figure 5: Disassembling of smoke detectors with americium-241, performed as part of the project “Improvement of the management of institutional radioactive waste in Slovenia”.

Some outstanding publications in 2008

1. T. Bunič, M. Tramšek, E. A. Goreshnik, B. Žemva, Synthesis and structural investigation of the compounds containing HF_2^- anions : $\text{Ca}(\text{HF}_2)_2$, $\text{Ba}_4\text{F}_4(\text{HF}_2)(\text{PF}_6)_3$ and $\text{Pb}_2\text{F}_2(\text{HF}_2)(\text{PF}_6)$, *J. Solid State Chem.*, 181 (2008) 2318-2324.
2. T. Bunič, M. Tramšek, E. A. Goreshnik, B. Žemva, Synthesis, Raman spectrum and crystal structure of $[\text{Ba}(\text{XeF}_4)(\text{PF}_6)_2]$, *Solid State Sci.*, 10 (2008) 1511-1516.
3. R. Blinc, G. Tavčar, B. Žemva, D. Hanžel, P. Cevc, C. Filipič, A. Levstik, Z. Jagličič, Z. Trontelj, N. S. Dalal, V. Ramachandran, S. Nellutla, J. F. Scott, Weak ferromagnetism and ferroelectricity in $\text{K}_3\text{Fe}_5\text{F}_{15}$, *J. Appl. Phys.*, 103 (2008) 074114-1-074114-4.
4. A. Stergaršek, M. Horvat, J. Kotnik, J. Tratnik, P. Frkal, D. Kocman, R. Jačimović, V. Fajon, M. Ponikvar, I. Hrastel, J. Lenart, B. Debeljak, M. Čujež, The role of flue gas desulphurisation in mercury speciation and distribution in a lignite burning power plant, *Fuel*, 87 (2008) 3504-3512.
5. M. Ponikvar, T. Michałowski, K. Kupiec, S. Wybraniec, M. Rymanowski, Experimental verification of the modified Gran methods applicable to redox systems, *Anal. Chim. Acta*, 628 (2008) 181-189.
6. M. Gerbec, On the process and implications of drawing up and running a security plan according to ADR in an SME-type company, *J. Loss Prev. Process Ind.*, 21 (2008) 604-612.
7. Chapter in book: M. Ponikvar, Exposure of humans to fluorine and its assessment. In: Tressaud A. (Ed.), Haufe G. (Ed.). Fluorine and health: molecular imaging, biomedical materials and pharmaceuticals. 1st ed. Amsterdam: Elsevier, 2008, 488-549.

Patents granted

1. Procedure for the synthesis of threadlike tungsten oxide W_5O_{14}
Maja Remškar, Marko Viršek, Miha Kocmur, Adolf Jesih
SI Patent no. 22445

Awards and appointments

1. European Regional Championship Award 2008 for Environment section (11 sections). Centre of Excellence for Environmental Technologies.

Organization of conferences, congress and meetings

1. PROBASA partners meeting, Celje, 31 Mar to 4 Apr. 2008

INTERNATIONAL PROJECTS

- | | |
|--|---|
| <ol style="list-style-type: none"> 1. Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related Risks
iNTeg-Risk
7. FP, 213345, NMP2-LA-2008-213345
EC; European Virtual Institute for Integrated Risk Management, Stuttgart, Germany
Asst. Prof. Marko Gerbec, Asst. Prof. Branko Kontić 2. Form-It "Take Part in Research"
Form-It
6. FP, SAS6, 042938
EC; Markus Meissner, Austrian Institute for Applied Ecology, Vienna, Austria
Tomaž Ogrin, M. Sc. 3. Functionalised Metal Fluorides
FUNFLUOS
6. FP, NMP3-CT-2004-505575
EC; Humboldt-Universität zu Berlin, Berlin, Germany
Dr. Tomaž Skapin 4. Access to Technology and Know-how in Cleaner Production in Central Europe
ACT CLEAN
Central Europe Programme
EC; Jakob Gross, Horst Pohle, Federal Environment Agency, Dessau-Roßlau, Germany
Dr. Andrej Stergaršek, Andrej Gyergyek, B. Sc., Dr. Sonja Lojen 5. Problem-based Learning in Vocational Science - Designing Activities that develop the Skills used by Scientists in the Workplace for Integration into Vocational Science Courses
PROBASE
Leonardo da Vinci Programme
HU/06/B/F/PP-170027
Lévayné Szalay Luca, Bertalan Zsolt, Petrik Lajos Két Tanítási Nyelvű Vegyipari, | <ol style="list-style-type: none"> 6. Improvement of the Management of Institutional Radioactive Waste in Slovenia
11145406-06-01-0001
Agency for Radwaste Management, Ljubljana, Slovenia; Leniko bvba, Antwerp, Belgium
Dr. Gašper Tavčar, Bogdan Pucelj, M. Sc., Bojan Huzjan, Prof. Borut Smodiš 7. Optimization of Flue Gas Desulphurization (FGD) Process in Iron Ore Sintering Plants and Lead/Zinc Smelters
BI-CN/07-09-020
Prof. Xiang Gao, State Key Laboratory of Clean Energy Utilization, Institute of Thermal Energy and Power Engineering, Zhejiang University, Zhejiang Province Hang Zhou, China
Dr. Andrej Stergaršek 8. Experimental and Theoretical Studies of Molecular Adsorption on High Surface Area Materials and Other Interaction Phenomena Relevant to Heterogeneous Catalysis
BI-MK/07-08-003
Asst. Prof. Ljupčo Pejov, Institute of Chemistry, Faculty of Natural Sciences and Mathematics, University "St. Cyril and Methodius", Skopje, The Republic of Macedonia
Dr. Tomaž Skapin 9. Synthesis and Thermal Stability Investigation of Transition and Rare-earth Metals Fluorides
BI-RU/08-09-006
Dr. Norbert Chiligarov, Moscow State University, Chemistry Department of Lomonosov, Moscow, Russia
dr. Zoran Mazej 10. Pi-complexes of Copper (I) Fluoro-ionic Salts: Syntheses and Crystal Structure Determinations
BI-UA/07-08-011
Dr. Marian Mys'kiv, Chemical Department, Ivan Franko National University, Lviv, Ukraine
Dr. Zoran Mazej |
|--|---|

- Molybdenum and Tungsten Carbides, Titanium and Zirconium Diborides: Obtained from Fluoride Melts, Structure and Properties
BI-UA/07-08-003
Dr. Viktor Malyshev, Faculty of Chemistry and Technology, National Technical University of Ukraine, "Kyiv Polytechnical Institute", Kyiv, Ukraine
Dr. Melita Tramšek
- Study of Polymerization Process in RF Plasmas
BI-CS/06-07-022
Prof. Zoran Petrović, Institut za fiziku Beograda, Zemun, Belgrade, Serbia
Dr. Adolf Jesih
- Advanced Nanocaged Fluorocarbon Materials and Their Chemical Modifications
BI-US/08-10-018
Prof. Steven Strauss, Department of Chemistry, Colorado State University, Fort Collins, CO, USA
Dr. Zoran Mazej

R & D GRANTS AND CONTRACTS

- Control of Hg and some other toxic elements emissions from TPP, cement works and other high-temperature industrial processes
Prof. Milena Horvat, Dr. Andrej Stergaršek
- Development of an ammunition categorisation system with implementation into the Quality Manager and Warehouse Management system
Asst. Prof. Robert Kocjančič
- Smart functional coatings for improvement of structures and components used in defensive purpose
Dr. Peter Panjan, Dr. Adolf Jesih

- The faith and the speciation of pollutants in the transformation of contaminated biomass into synthetic fuels and pure hydrogen
Dr. Andrej Stergaršek

RESEARCH PROGRAM

- Inorganic Chemistry and Technology
Prof. Boris Žemva

NEW CONTRACTS

- School of experimental chemistry for students of colleges in RS
Ministry of Education and Sport
Tomaž Ogrin, M. Sc.
- Expert review of cross boundary effects of LNG terminal projects in the Gulf of Trieste
Ministry of the Environment and Spatial Planning
Asst. Prof. Marko Gerbec
- Control of Hg and some other toxic elements emissions from TPP, cement works and other high-temperature industrial processes
Esotech, d. d., Velenje
Dr. Andrej Stergaršek

VISITORS FROM ABROAD

- Prof. dr. Joel F. Liebman, University of Baltimore, USA, 4–6 Feb. 2008
- Prof. dr. Mews Rüdiger, Universität Bremen, Germany, 30 Apr. to 5 May 2008
- Prof. dr. Marian Mys'kiv and dr. Oleksiy Pavlyuk, Chemical Department, Ivan Franko National University, Lviv, Ukraine, 12–19 Jun. 2008

- Igor M. Shlyapnikov, "Chemical Department, Lomonosov Moscow State University", Moscow, Russia, 18 Jun. to 17 Sept. 2008
- Dr. Norbert Chilingarov, "Chemical Department, Lomonosov Moscow State University", Moscow, Russia, 22 Nov. to 6 Dec. 2008
- Dr. Angelina Gab and dr. Dmytro Shakhnin, Faculty of Chemistry and Technology, National Technical University of Ukraine, "Kyiv Polytechnical Institute", Kiev, Ukraine, 27 Nov. to 4 Dec. 2008

STAFF

Researchers

- Asst. Prof. Marko Gerbec
- Dr. Yevheniy Horyeshnik
- Dr. Adolf Jesih
- Asst. Prof. Robert Kocjančič
- Dr. Zoran Mazej
- Asst. Prof. Maja Ponikvar
- Asst. Prof. Tomaž Skapin, Head**
- Dr. Andrej Stergaršek
- Dr. Melita Tramšek
- Prof. Boris Žemva

Postdoctoral associates

- Dr. Gašper Tavčar

Postgraduates

- Dr. Tina Bunič, left 1 May 2008
- Matic Lozinšek, B. Sc.
- Andrii Vakulka, M. Sc.

Technical officers

- Peter Frkal, B. Sc.
- Tine Oblak, B. Sc.
- Tomaž Ogrin, M. Sc.

Technical and administrative staff

- Pero Kolobarić
- Robert Moravec
- Marija Toplak, retired 11 Jul. 2008
- Mira Zupančič

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2. Maja Ponikvar, Joel F. Liebman, "Interplay of thermochemistry and Structural chemistry, the journal (volume 18, 2007) and the discipline", *Struct. chem.*, vol. 19, no. 6, pp. 849-872, 2008.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Tsuyoshi Nakajima, Takashi Achiha, X. Cheng, Jianling Li, Yoshimi Ohzawa, Boris Žemva, Zoran Mazej, Alain Tressaud, E. Durand, "Charge/discharge behavior of surface-fluorinated graphite for lithium ion battery", In: *Advanced inorganic fluorides: proceedings of ISIF-2008*, The Third International Siberian Workshop "INTERSIBFLUORINE - 2008", September 01-06, 2008, Vladivostok, Russia, Valerii IAkovlevich Kavun, ed., Vladivostok, Institute of Chemistry FEB RAS, 2008, pp. 21-24.
2. Maja Ponikvar, "Dovolj ali preveč fluora?", In: *Slovenski kemijski dnevi 2008, Maribor, 25. in 26. september 2008: [zbornik referatov]*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, Univerza v Mariboru, Fakulteta za kemijo in kemijsko tehnologijo, 2008, 8 pp.
3. Tomaž Skapin, Gašper Tavčar, Zoran Mazej, Boris Žemva, "Kovinski fluoriidi z visoko specifično površino", In: *Slovenski kemijski dnevi 2008, Maribor, 25. in 26. september 2008: [zbornik referatov]*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, Univerza v Mariboru, Fakulteta za kemijo in kemijsko tehnologijo, 2008, 6 pp.
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Regular papers

1. Marko Gerbec, Vladimir Jovan, Janko Petrovčič, "Operational reliability and safety risk assessment of fuel cell proton exchange membrane system", In: *34th ESReDA, 2nd ESReDA/ESRA Seminar on Supporting technologies for advanced maintenance information management: 13-14th May, 2008, San Sebastian, Spain*, [S. l., s. n.], 2008, 15 pp.
2. Tanja Ljubič-Mlakar, Milena Horvat, Tomaž Vuk, Andrej Stergaršek, Janja Tratnik, Vesna Fajon, "A study of mercury species and the mass balance in the process of cement clinker production indicating potentials for mercury emission control", In: *Proceedings, GCHT-7, 7th International Symposium on Gas Cleaning at High Temperatures*, June June 23rd-25th, 2008, Newcastle, Australia, Terry Wall, ed., Jianglong Yu, ed., 2008, 15 pp.
3. Tine Oblak, Gašper Tavčar, Tomaž Skapin, "Priprava in karakterizacija galijevega(III) fluorida s specifičnimi lastnostmi", In: *Slovenski kemijski dnevi 2008, Maribor, 25. in 26. september 2008: [zbornik referatov]*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, Univerza v Mariboru, Fakulteta za kemijo in kemijsko tehnologijo, 2008, 6 pp.
4. Tomaž Ogrin, Miklós Riedel, Luca Szalay, "Probase, a pilot project for practical education and training in chemistry", In: *Slovenski kemijski dnevi 2008, Maribor, 25. in 26. september 2008: [zbornik referatov]*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, Univerza v Mariboru, Fakulteta za kemijo in kemijsko tehnologijo, 2008, 5 pp.
5. Andrej Stergaršek, Milena Horvat, Jože Kotnik, Janja Tratnik, Peter Frkal, Radojko Jačimović, Vesna Fajon, Maja Ponikvar, "The role of FGD in mercury speciation and its distribution in a lignite burning power plant", In: *Proceedings, GCHT-7, 7th International Symposium on Gas Cleaning at High Temperatures*, June June 23rd-25th, 2008, Newcastle, Australia, Terry Wall, ed., Jianglong Yu, ed., 2008, 10 pp.
6. Gašper Tavčar, Matjaž Stepišnik, Bogdan Pucelj, "Decommissioning of uranium research processing facility", In: *Proceedings, International Conference Nuclear Energy for New Europe 2008, Portorož, Slovenia, September 8-11*, Stane Rožman, ed., Bojan Žefran, ed., Ljubljana, Nuclear Society of Slovenia, 2008, 7 pp.

THESES

Ph. D. Theses

1. Tina Bunič, *XeF₂ and poly(hydrogen fluoride) anions as ligands in the compounds of some metal (II) hexafluorometalates and hexafluorophosphates*, Ljubljana, [T. Bunič], 2008.

PATENT APPLICATIONS

1. Aleš Mrzel, Maja Remškar, Adolf Jesih, Marko Viršek, *A process for the synthesis of nanotubes and fullerene-like nanostructures of transition metal dichalcogenides, quasi one-dimensional structures of transition metals and oxides of transition metals: EP - patent application W02008121081 (A2)*.

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 the halogenated, in particular fluorinated, organic molecules.

Experimental research in the field of electrochemistry looks at the materials that are important in biomedical and technological applications. We have studied the passive film formed on a Ti-6Al-7Nb alloy in a simulated physiological solution. It is characterized as a dual oxide layer comprising an inner barrier layer and an outer porous layer. The resistance of the barrier layer TiO_2 is high throughout the potential range investigated, whereas that of the outer layer is low in the lower potential range but increases at higher potentials. The greater corrosion resistance and stability of the Ti-6Al-7Nb alloy compared to the Ti-6Al-4V alloy investigated in our previous study is ascribed to the incorporation of niobium oxides – NbO , NbO_2 , and primarily Nb_2O_5 – into the passive layer. This result is important for the safe long-term in-vivo application of the Ti-6Al-7Nb alloy, since niobium has the characteristics of an immunologically inert metal.

Our experimental studies of biomedical materials were focused on total hip replacements and were carried out in collaboration with the Orthopaedic Hospital Valdoltra and the Faculty of Medicine. We have developed a procedure for the isolation of nanometre-sized metal particles formed by the wear of a bearing surface made of the Co-28Cr-6Mo alloy. The composition and size of these particles were analysed using high-resolution transmission electron microscopy. Two types of particles were recognized: needle-shaped particles, ranging from 40 to 120 nm and containing both cobalt and chromium; and globular particles, ranging up to 90 nm and containing high levels of chromium and no cobalt. The composition of the isolated particles was related to the composition of the layer formed in vivo at the surface of the Co-28Cr-6Mo alloy.

In the field of corrosion protection we are interested in various ways of protecting materials – from corrosion inhibitors to surface layers. Electrochemical and electrochemical quartz microbalance measurements of BTAH and BTAOH inhibition efficiency for copper corrosion in 3%NaCl solution were analyzed. The experimental results were supplemented by molecular modelling to gain a better insight into the structural differences, electronic effects, reactivity parameters and adsorption properties of inhibitor molecules in relation to their inhibiting effectiveness. The superior inhibition effectiveness of BTAH was attributed to the interplay of the planar molecular structure, physisorption and intermolecular H-bonding, resulting in the formation of a thin and protective film on the surface (Fig. 1).

Our theoretical investigations based on quantum chemical methods were focused on the examination of the structural, spectroscopic and stability features of the halogenated methyl nitrates, which have a great atmospheric relevance (Fig. 2). The computational results demonstrate the significant structural changes of CX_3ONO_2 , $\text{CX}_n\text{Y}_{3-n}\text{ONO}_2$ ($\text{X}, \text{Y} = \text{F}, \text{Cl}$) caused by the halogen electron withdrawing effect, compared with the plain methyl analogue. A high stabilization of nitrates is achieved upon halogenation. The distinguishing spectroscopic features of the FC(O)ONO and FC(O)NO_2 isomers have been determined, which should allow these species to be identified experimentally. A comparison of the relative energetic stabilities of these isomers with those of chlorine analogues clearly demonstrates that the chlorine isomers are unstable relative to the fluorine analogues.

In the context of chemistry at silver surfaces, we investigated – by means of quantum mechanical computer simulations – the ethylene epoxidation reaction, which is one of the most important selective oxidation processes occurring on metal catalysts. We found that the catalyst's selectivity in this reaction is determined in part by the differential bonding affinity of the catalyst toward the oxygen and carbon atoms of the reaction intermediate. We believe that the concept of the differential bonding affinity of a catalyst toward the various atoms of the molecule to which it binds may also be important in determining the selectivity in other surface reactions.



Head:
Dr. Ingrid Milošev

The L'Oréal-UNESCO fellowship 'For Women in Science' award for 2008 has been presented to our young researcher Saša Kovačič. Her Ph.D. thesis was efficiently defended in time, and the results are published in 12 scientific articles, all of which are quoted in the SCI database. These articles have already been cited more than 30 times.

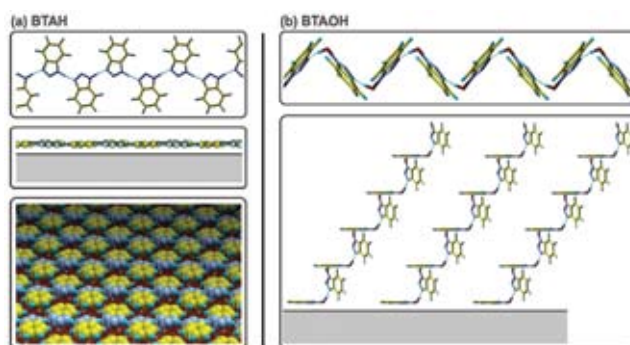


Figure 1: Tentative model of the corrosion-protection layer composed of BTAH (left) and BTAOH (right) molecules at a copper surface.

By means of a quantum mechanical computer simulation we were able to explain what determines the catalyst's selectivity in the elusive mechanism of the ethylene epoxidation reaction.

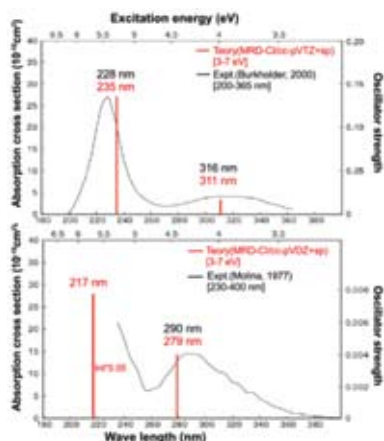


Figure 2: Calculated and experimental electronic spectra of ClONO (top) and BrONO (left).

The oxidative halogenation of organic compounds was performed by using hydrogen peroxide or air oxygen.

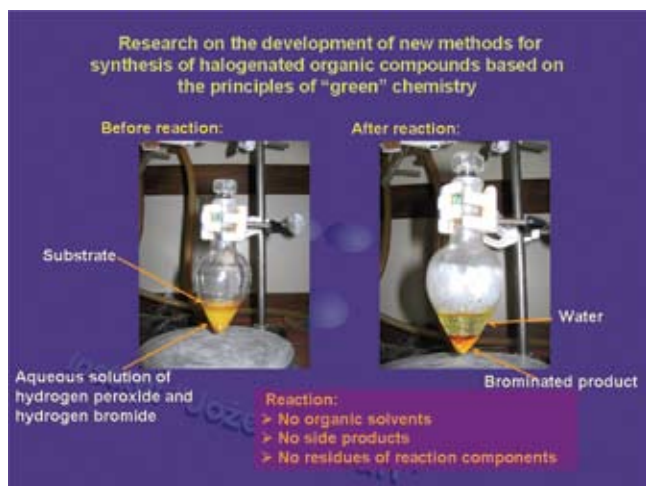


Figure 3: 'Green' halogenation of organic compounds in water.

In the field of organic and bio-organic chemistry we continued our investigation on the application of green reaction conditions to the selective halogenation of organic compounds. We developed a method for the iodination of organic compounds with elemental iodine in the presence of 30% aqueous H_2O_2 under organic solvent-free reaction conditions. We applied the method for the selective and efficient iodination of methoxy-substituted benzene derivatives and aryl alkyl ketones. We used the same reagent system

also for the iodination performed in ionic liquids and proved that this reaction media could also be used for the efficient and selective iodofunctionalisation of activated aromatics and aryl alkyl ketones. On the basis of our preliminary research performed last year we developed the aerobic oxidative iodination of organic compounds with iodide catalysed by sodium nitrite under acidic conditions. Using the reagent system KI/Na_2NO_2 (cat.)/ H_2SO_4 in polar aprotic (MeCN) or protic (EtOH) solvent we iodinated activated and moderately deactivated aromatic compounds, ketones and 1,3-ketones, alkenes and alkynes. We also established that the regioselectivity of the iodination of aryl alkyl ketones bearing a strongly activated aromatic ring could be directed with the solvent used. In acetonitrile the aromatic ring was selectively iodinated, while in ethanol α -iodo derivatives were selectively obtained. On the basis of an editorial invitation we prepared and published a review article dealing with the electrophilic iodination of organic compounds using iodine or iodide. The method of aerobic oxidative halogenation catalysed by $NaNO_2$ was also applied for the bromination of alkenes and we established that in this way the dibromination of the alkene double bond resulting in vicinal dibromides could be performed using 48% aqueous HBr. By developing these methods of oxidative halogenation using H_2O_2 or oxygen in the air as the oxidants the mimicking of related natural processes was performed, thus proving that these processes could also be successful in the case of non-enzymatic or non-metallic catalysis (Fig. 3). We developed a method for the direct fluorination of ketones with *Selectfluor*TM *F-TEDA-BF₄* in aqueous reaction media by using anionic amphiphile sodium dodecylsulfate in concentrations higher than its critical micelle concentration. In a collaboration we experimentally determined the solubility of halogens in fluorosolvents as a function of the temperature, and the data obtained complemented the theoretical calculations.

Some outstanding publications in 2008

1. I. Milošev, T. Kosec and H.-H. Strehlow, XPS and EIS study of the passive film formed on orthopaedic Ti-6Al-7Nb alloy in Hank's physiological solution, *Electrochim. Acta* 53 (2008) 3547-3558
2. A. Lesar and T. Sajevec, Structures, vibrational spectra, and relative energetics of $FC(O)ONO$ and $FC(O)NO_2$ isomers at DFT and ab initio levels, *Mol. Phys.* 106 (2008), 2301-2308
3. A. Kokalj, P. Gava, S. de Gironcoli, and S. Baroni, What determines the catalyst's selectivity in the ethylene epoxidation reaction, *J. Catal.* 254 (2008) 304-309
4. J. Iskra, S. Stavber, M. Zupan, Aerobic oxidative iodination of organic molecules activated by sodium nitrite, *Tetrahedron Lett.* 49 (2008) 893-895
5. S. Stavber, M. Jereb, M. Zupan, Electrophilic iodination of organic compounds using elemental iodine or iodine, *Synthesis* 2008, 1487-1513

Awards and appointments

1. Saša Kovačič: L'Oréal-UNESCO fellowship, 'For Women in Science' award for 2008
2. Tadeja Kosec Trimo research award for Ph.D. thesis 2008

INTERNATIONAL PROJECTS

1. Core Laboratories for the Improvement of Medical Devices in Clinical Practice from the Failure of the Explanted Prostheses Analysis (FEPA)
COST Action 537 (WG 1)
EC
Dr. Ingrid Milošev
2. A Swedish-Slovenian Nanobattery Network
SVEN-SLO-BATT
Micro-Nano-Technology MNT ERA NET
Uppsala University, Uppsala, Sweden
Dr. Anton Kokalj
3. Improvement of Resurfacing Hip Implants with DLC, TiO₂ and DLC-p-h Nanocomposite Coatings
RHSI-DLC-NanoComp
MATERA ERA NET
ORTON Research Institute, Helsinki, Finland
Dr. Ingrid Milošev
4. Investigation of Elemental Steps of Competing Radical Reactions important for Atmospheric Chemistry, especially Chlorine and Bromine Containing Compounds
BI-AT/07-08-017
Prof. Max Muehlhaeuser, Management Center Innsbruck, Innsbruck, Austria
Dr. Antonija Lesar
5. Fluorous Phases as Substitutes to Organic Solvents. Study of Solvation and Molecular Transport
PROTEUS
BI-FR07-PROTEUS-005
Dr. Margarida Costa Gomes, Laboratoire de Thermodynamique des solutions et des polymères UMR 6003 CNRS/Université Blaise Pascal, Clermont-Ferrand, Aubière, France
Dr. Jernej Iskra

6. Chemistry at Silver Surfaces: Understanding Ethylene Epoxidation and Other Popular Reactions on Silver based Catalysts
BI-T/05-08-004
Dr. Mario Rocca, Department of Physics, University of Genova, Genova, Italy
Dr. Anton Kokalj

R & D GRANTS AND CONTRACTS

1. The influence of electronic structure of corrosion inhibitors on their efficiency
Dr. Anton Kokalj
2. Survivorship of total hip replacements as a function of type of bearing surfaces
Dr. Ingrid Milošev
3. PVD hard coatings as an alternative for corrosion protection of Fe and Al alloys
Dr. Darinka Kek Merl, Dr. Ingrid Milošev
4. Smart functional coatings for improvement of structures and components used in defensive purposes
Dr. Peter Panjan, Dr. Ingrid Milošev

RESEARCH PROGRAMS

1. Bioinorganic and bioorganic chemistry
Dr. Stojan Stavber
2. Micro- and nanostructured functional materials: development, physical and chemical characterization and simulation of processes
Dr. Ingrid Milošev

STAFF

Researchers

1. Dr. Jernej Iskra
2. Dr. Anton Kokalj
3. Dr. Antonija Lesar
4. **Dr. Ingrid Milošev, Head**
5. Dr. Stojan Stavber
6. Prof. Marko-Andrej Zupan*

Postdoctoral associates

7. Dr. Tadeja Kosec, left 1 Sept. 2008

Postgraduates

8. Matjaž Finšgar, B. Sc.
9. Dr. Saša Kovačič, left 1 Jul. 2008

10. Jasminka Pavlinac, B. Sc.
11. Sebastijan Peljhan, B. Sc.
12. Ajda Podgoršek, B. Sc.
13. Dejan Vražič, B. Sc.
14. Dr. Kaja Žmitek, left 1 Dec. 2008

Technical officers

15. Edita Blažević, B. Sc., left 21 Apr. 2008
16. Barbara Kapun, B. Sc.

Note:

* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Matjaž Finšgar, Antonija Lesar, Anton Kokalj, Ingrid Milošev, "A comparative electrochemical and quantum chemical calculation study of BTAH and BTAOH as copper corrosion inhibitors in near neutral chloride solution", *Electrochim. acta*, vol. 53, no. 28, pp. 8287-8297, 2008.
2. Matjaž Finšgar, Ingrid Milošev, "Organske molekule kot korozijski inhibitorji", *Vakuumist*, vol. 28, no. 1/2, pp. 12-18, 2008.
3. Paola Gava, Anton Kokalj, Stefano de Gironcoli, Stefano Baroni, "Adsorption of chlorine on Ag(111): no subsurface Cl at low coverage", *Phys. rev. B, Condens. matter mater. phys.*, vol. 78, no. 16, pp. 165419-1-165419-15, 2008.
4. Jernej Iskra, Stojan Stavber, Marko Zupan, "Fluorination of fluorine, dibenzofuran and their open analogues with caesium fluoroxysulfate and related fluorinating reagents", *Collect. Czech. Chem. Commun.*, vol. 73, no. 12, pp. 1671-1680, 2008.
5. Jernej Iskra, Stojan Stavber, Marko Zupan, "Aerobic oxidative iodination of organic molecules activated by sodium nitrite", *Tetrahedron lett.*, vol. 49, no. 5, pp. 893-895, 2008.
6. Anton Kokalj, Paola Gava, Stefano de Gironcoli, Stefano Baroni, "Activated adsorption of ethylene on atomic-oxygen-covered Ag(100) and Ag(210): formation of an oxametallacycle", *The journal of physical chemistry. C, Nanomaterials and interfaces*, vol. 112, no. 4, pp. 1019-1027, 2008.
7. Anton Kokalj, Paola Gava, Stefano de Gironcoli, Stefano Baroni, "What determines the catalyst's selectivity in the ethylene epoxidation reaction", *J. catal.*, vol. 254, no. 2, pp. 304-309, 2008.
8. Tadeja Kosec, Darja Kek-Merl, Ingrid Milošev, "Impedance and XPS study of benzotriazole films formed on copper, copper-zinc alloys and zinc in chloride solution", *Corros. sci.*, vol. 50, no. 7, pp. 1987-1997, 2008.
9. Agnie M. Kosmas, Antonija Lesar, "Computational study of the perhalogenated methyl nitrates CX_3ONO_2 , $CX_2Y_{3-x}ONO_2$ (X, Y = F, Cl)", *Mol. Phys.*, vol. 106, no. 8, pp. 1025-1032, 2008.
10. Saša Kovačič, Jože Koller, Janez Cerkovnik, Tell Tuttle, Božo Plesničar, "Dihydrogen trioxide clusters, $(HOOH)_n$ (n = 2-4), and the hydrogen-bonded complexes of HOOH with acetone and dimethyl ether: implications for the decomposition of HOOH", *J. phys. chem., A Mol. spectrosc. kinet. environ. gen. theory*, vol. 112, no. 35, pp. 8129-8135, 2008.
11. Antonija Lesar, Tamara Sajevec, "Structures, vibrational spectra, and relative energetics of FC(O)ONO and FC(O)NO₂ isomers at DFT and ab initio levels", *Mol. Phys.*, vol. 106, no. 19, pp. 2301-2308, 2008.
12. Ingrid Milošev, "Biomedicinski materiali in njihova uporaba", *IRT 3000*, let. 3, no. 17, pp. 68-76, 2008.

13. Ingrid Milošev, Tadeja Kosec, Hans-Henning Strehblow, "XPS and EIS study of the passive film formed on orthopaedic Ti-6Al-7Nb alloy in Hank's physiological solution", *Electrochim. acta*, vol. 53, no. 9, pp. 3547-3558, 2008.
14. Jasminka Pavlinac, Kenneth K. Laali, Marko Zupan, Stojan Stavber, "Iodination of organic compounds with elemental iodine in the presence of hydrogen peroxide in ionic liquid media", *Aust. J. Chem.*, vol. 61, no. 12, pp. 946-955, 2008.
15. Jasminka Pavlinac, Marko Zupan, Stojan Stavber, "Iodination of organic compounds using the reagent system I_2 -30% aq, H_2O_2 under organic solvent-free reaction conditions", *Acta chim. slov.*, vol. 55, no. 4, pp. 841-849, 2008.
16. Ajda Podgoršek, Stojan Stavber, Marko Zupan, Jernej Iskra, A. A. H. Padua, Costa Gomes, "Solvation of halogens in fluoruous phases, Experimental and simulation data for F_2 , Cl_2 and Br_2 in several fluorinated liquids", *J. phys. chem., B Condens. mater. surf. interfaces biophys.*, vol. 112, no. 21, pp. 6653-6664, 2008.
17. Igor Pravst, Marko Zupan, Stojan Stavber, "Halogenation of ketones with N-halosuccinimides under solvent-free reaction conditions", *Tetrahedron*, vol. 64, no. 22, pp. 5191-5199, 2008.
18. L. Savio, C. Giallombardo, L. Vattuone, Anton Kokalj, M. Rocca, "Oxygen interaction at Ag(511): from chemisorption to the initial stages of oxide formation", *J. phys., Condens. matter*, vol. 20, no. 22, pp. 224006-1-224006, 2008.
19. L. Savio, C. Giallombardo, L. Vattuone, Anton Kokalj, M. Rocca, "Tuning the stoichiometry of surface oxide phases by step morphology: Ag(511) versus Ag(210)", *Phys. rev. lett.*, vol. 101, no. 26, pp. 266103-1-266103-4, 2008.
20. Gaj Stavber, Jernej Iskra, Marko Zupan, Stojan Stavber, "Aerobic oxidative iodination of organic compounds with iodine catalyzed by sodium nitrite", *Advanced Synthesis & Catalysis*, vol. 350, no. 18, pp. 2921-2929, 2008.
21. S. Virtanen, Ingrid Milošev, E. Gomez-Barrena, Rihard Trebše, J. Salo, Y.T. Konttinen, "Special modes of corrosion under physiological and simulated physiological conditions", *Acta biomaterialia*, vol. 4, no. 3, pp. 468-476, 2008.
22. Janko Žmitek, Andrej Šmidovnik, Maja Fir Milivojevič, Mirko Prošek, Katja Žmitek, Jaroslaw Walczak, Igor Pravst, "Relative bioavailability of two forms of a novel water-soluble coenzyme Q10", *Ann. nutr. metab.*, vol. 52, no. 4, pp. 281-287, 2008.
23. Janko Žmitek, Katja Žmitek, Igor Pravst, "Improving the bioavailability of coenzyme Q10", *Agro-Ind. Hi-Tech*, vol. 19, no. 4, pp. 8-10, 2008.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Stojan Stavber, Marjan Jereb, Marko Zupan, "Electrophilic iodination of organic compounds using elemental iodine or iodides", *Synthesis (Stuttg.)*, no. 10, pp. 1487-1513, 2008.
2. Y.T. Konttinen, Ingrid Milošev, Rihard Trebše, P. Rantanen, R. Linden, Veli-Matti Tiainen, S. Virtanen, "Metals for joint replacement", In: *Joint replacement technology*, (Woodhead publishing materials), Peter Allen Revell, ed., Boca Raton ... [etc.], Crc Press, Cambridge, England, Woodhead Publishing Limited, 2008, pp. 115-162.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Jernej Iskra, "'Green' halogenation reactions: Oxidative aerobic halogenation and 'on water' bromination with hydrobromic acid and hydrogen peroxide", In: *[Proceedings]*, 18th International Symposium on Fine Chemistry and Functional Polymers (FCFP-XVIII) & IUPAC 4th International Symposium on Novel Materials and Synthesis (NMS-IV), October 15-18, 2008, Zhenjiang, P. R. China, Zhenjiang, Jianguo University, 2008, pp. 62-63.

Regular papers

1. Ajda Podgoršek, Markus Jurisch, Stojan Stavber, Marko Zupan, Jernej Iskra, John A. Gladysz, "Sinteza in reaktivnost aril in perfluoroalkil jod(III) dikloridov kot obnovljivih klorirnih reagentov v dvofaznih sistemih", In: *Slovenski kemijski dnevi 2008, Maribor, 25. in 26. september 2008: [zbornik referatov]*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, Univerza v Mariboru, Fakulteta za kemijo in kemijsko tehnologijo, 2008, [1-7] pp.

THESES

Ph. D. Theses

1. Saša Kovačič, *Študij elementarnih reakcij dušikovih oksidov v atmosferskih procesih: doktorska disertacija*, Ljubljana, [S. Kovačič], 2008.
2. Katja Žmitek, *Sinteza, lastnosti in biološke aktivnosti tetraoksanov in sorodnih peroksidnih derivatov: doktorska disertacija*, Ljubljana, [K. Žmitek], 2008.

ELECTRONIC CERAMICS DEPARTMENT

K-5

The Electronic Ceramics Department is active in the research of the synthesis, properties and applications of materials for electronics, mainly complex multifunctional materials and structures. The materials of interest include ceramic piezoelectrics, ferroelectrics, relaxors, 'conductive' oxides and materials for solid-oxide fuel cells (SOFCs). The emphasis is on the creation of properties by the synthesis and the structure on the nano-, micro- and macro-levels.



Head:
Prof. Marija Kosec

Lead-free piezoceramics based on the $K_xNa_{1-x}NbO_3$ solid solution represent an environment-friendly alternative to lead-based piezoelectrics; however, not much data is available on its basic properties. X-ray diffraction measurements were used to follow the change of the unit-cell parameters of $K_xNa_{1-x}NbO_3$ ($0.4 \leq x \leq 0.6$) in the temperature range 100–800 K. At room temperature all the compositions exhibited a monoclinic metric of the unit cell with a small monoclinic distortion ($90.32^\circ \leq \beta \leq 90.34^\circ$) and not an orthorhombic structure, as found in the literature. With increasing temperature, the samples underwent first-order monoclinic–tetragonal and tetragonal–cubic transitions. No major change of the symmetry was evidenced in the investigated compositional range, which should be characteristic of the morphotropic phase-boundary region at $x \approx 0.5$, as reported in earlier papers.

We continued research on the processing of alkaline niobate-based ceramics. Our objective was to lower the sintering temperature of $K_{0.5}Na_{0.5}NbO_3$ (KNN) without diminishing its piezoelectric properties by using a novel sintering aid based on (K,Na)-germanate. (Figure 1) The KNN ceramics modified with 1 mass% of alkaline-germanate reached 96% of theoretical density after sintering at temperatures as low as 1000°C, which is approximately 100°C lower than the sintering temperature of KNN without additives. The relative dielectric permittivity and losses measured at 10 kHz are 397 and 0.02, respectively, and the piezo d_{33} coefficient is 120 pC/N, and the electromechanical coupling and mechanical quality factors (k_p , k_f , Q_m) are 0.40, 0.44, and 77, respectively. These values are comparable to the best values obtained for KNN ceramics sintered at 1115°C.

The $K_{0.5}Na_{0.5}NbO_3$ (KNN) ceramics modified with 1 mass% of alkaline-germanate as a novel sintering aid reached 96% of theoretical density after sintering at 1000°C and had piezoelectric properties comparable to the best values obtained for unmodified KNN ceramics sintered at 1115°C.

We continued research of the properties of $K_{0.5}Na_{0.5}NbO_3$ **single crystals** prepared by solid-state crystal growth (SSCG). We performed a detailed study of the chemical homogeneity and the domain structure by X-ray powder diffraction, as well as optical, scanning, and transmission electron microscopy. No compositional inhomogeneities were encountered in the crystals with monoclinic syngony. The domain pattern consists of 90°-domains that are about 100 μm across, and which contain smaller, 180° domains of up to a few hundred nm.

Lead-free **percolative all-ceramic composites** based on $K_{0.5}Na_{0.5}NbO_3$ and RuO_2 were synthesized and a dielectric permittivity of over 20,000 at 10 kHz was obtained for compositions close to the percolation threshold. Percolative composites of $Pb(Zr_{0.53}Ti_{0.47})O_3$ and conductive $Pb_2Ru_2O_{6.5}$ with permittivities over 40,000 were also fabricated.

We systematically studied the synthesis of nanoparticles with the aim of controlling the morphology and attaining a high chemical homogeneity. The research of the **solution synthesis of nanoparticles** of multicomponent oxides was focused on $La_2Zr_2O_7$. The nanometre-sized powder was prepared from dehydrated lanthanum nitrate and zirconium n-butoxide in 2-methoxyethanol and heating at 800°C. We followed the structural evolution from the sol to the amorphous powder by X-ray absorption spectroscopy (EXAFS). The La environment in both the La-nitrate solution and the $La_2Zr_2O_7$ sol is similar to that of the lanthanum nitrate hydrate. The Zr environment is populated by six Zr–O–Zr links and it remains almost unchanged in the transition from the sol to the dried and amorphous powder, heated at 500°C. The La–O–Zr links have not been established. We concluded that the reaction between individual metal-oxide species proceeds in the solid state. The solution-synthesis route ensures a very good mixing of the species at the nanometre level, which

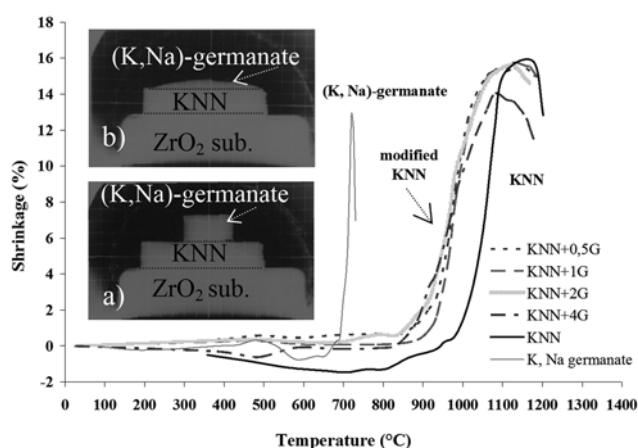


Figure 1: Shrinkage versus temperature for $K_{0.5}Na_{0.5}NbO_3$ (KNN), (K, Na)-germanate, and KNN modified with 0.5, 1, 2, and 4 mass% of alkaline germanate (KNN+0.5G, KNN+1G, KNN+2G, KNN+4G). Insets: photos of a (K,Na)-germanate pellet on top of a KNN pellet on a ZrO_2 substrate in a heating-stage microscope (a) at room temperature and (b) at 800°C, when the melted (K,Na)-germanate completely wets the surface of the KNN.

By mechanochemical activation of the mixture of constituent powders we prepared dense, chemically homogeneous $(K_{0.485}Na_{0.485}Li_{0.03})(Nb_{0.8}Ta_{0.2})O_3$ piezoelectric ceramics. Using this approach we could avoid a number of processing steps typical for classical solid-state synthesis.

enables a strongly reduced temperature of the reaction when compared to classical solid-state synthesis.

In the past year we broadened our research of the **mechanochemical synthesis** to complex systems. We prepared the $(K_{0.485}Na_{0.485}Li_{0.03})(Nb_{0.8}Ta_{0.2})O_3$ (KNLNT) solid solution by introducing mechanochemical activation of the mixture of the initial compounds. Dense and homogeneous KNLNT ceramics were obtained, which is quite difficult with the conventional solid-state synthesis route. The procedure, which allows numerous processing steps encountered

during conventional synthesis to be avoided, such as multiple calcinations with intermediate milling steps, has been patented. We found that during the activation an amorphous carbonato complex is formed, which plays a crucial role in obtaining homogeneous KNLNT ceramics.

We prepared the $0.3Pb(Fe_{0.5}Nb_{0.5})O_3-0.7Pb(Mg_{0.5}W_{0.5})O_3$ and $0.8Pb(Fe_{0.5}Nb_{0.5})O_3-0.2Pb(Mg_{0.5}W_{0.5})O_3$ multiferroic powders by mechanochemical synthesis, and by sintering we prepared dense ceramics. Colleagues at the Condensed Matter Physics Department confirmed for the first time that the materials are **magnetoelectric relaxors**.

The research of the **chemical solution deposition of ferroelectric thin films** was focused mainly on alkaline earth titanates and alkaline tantalates/niobates.

In cooperation with the partners HYB d.o.o., Šentjernej, Slovenia; EPFL, Switzerland; and Thales, France; several demonstration antennas for aeronautics (10 to 14 GHz) were fabricated in the frame of the EU 6FP project RETINA. Planar capacitors from $(Ba,Sr)TiO_3$ thin films on alumina substrates, processed in our laboratory, were integrated

into the phase shifters of a reflect-array, which makes possible electronic steering towards a telecommunications satellite.

$K(Ta,Nb)O_3$ is a structural analogue of $(Ba,Sr)TiO_3$ with an expected higher capacitance tunability and therefore possible applications in microwave phase shifters; however, due to a difficult synthesis there are only a few reports on its functional properties in both bulk and thin-film forms. $KTa_{0.6}Nb_{0.4}O_3$ thin films on polycrystalline alumina were prepared from potassium acetate and transition-metal alkoxides in 2-methoxyethanol. The films, prepared at $900^\circ C$ have a dielectric permittivity value of 1690, a dielectric loss value of 0.04 and a tunability (C_{on}/C_{off}) value of 2.6 at 1 MHz.

In the frame of the EU 6FP project CAMELIA we studied thin films with a high permittivity for microelectronics. $CaCu_3Ti_4O_{12}$ single crystals and ceramics have been reported to possess extremely high values of permittivity, but there are almost no data on thin films prepared by chemical solution deposition. We prepared the $CaCu_3Ti_4O_{12}$ films on platinumized silicon from nitrate-alkoxide based sols and after heating at $750^\circ C$ we obtained a permittivity of about 1000 at 10 kHz.

The R&D of transparent materials and their integration onto an organic substrate enable the manufacturing of flexible, large-area displays. Within the EU 6FP project MULTIFLEXIOXIDES we developed the materials and procedures for the fabrication of **thin-film transistors (TFTs)** on

polymer substrates. We prepared 2-inch $ZnO-In_2O_3-Ga_2O_3$ -based ceramic targets with a dense and homogeneous microstructure. These have been further used for RF-magnetron sputtering or the pulsed-laser ablation of amorphous thin films, acting as the electrode, and semiconductor components in TFT. Project partners from the University Nova, Lisbon, Portugal, processed the semiconducting elements of TFTs at a remarkably low temperature of $150^\circ C$, which exhibited a field-effect mobility of $55\text{ cm}^2/Vs$ and an on/off ratio of 10^8 . (Figure 2)

In_2O_3-ZnO -based liquid precursors have been developed for the chemical solution deposition of thin films or, after optimizing the viscosity, surface tension and solids content, as the inks for the shaping of different structures by ink-jet printing. Spin-coating of the precursors on polymeric substrates and heating at as low as $150^\circ C$ resulted in transparent amorphous films without any organic residues.

We studied the processing of ferroelectric **thick-film structures** based on complex lead-based perovskites such as $0.65Pb(Mg_{0.33}Nb_{0.67})O_3-0.35PbTiO_3$ (PMN-PT) and $Pb(Zr_{0.55}Ti_{0.47})O_3$ (PZT) by screen-printing and electrophoretic deposition (EPD). Chemically homogeneous, nanosized powders were synthesized by high-energy milling. With a careful control of the amount and type of additives, the pastes for screen printing and suspensions with a high absolute value of the zeta-potential in organic solvents for EPD have been prepared.

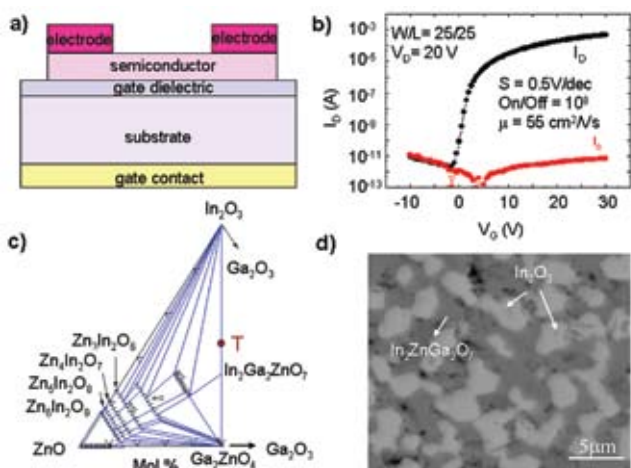


Figure 2: a) scheme and b) transfer characteristics of thin-film transistor with an $In-Zn-O$ -based source and drain electrodes and a $Ga-In-Zn-O$ semiconductor; c) $ZnO-In_2O_3-Ga_2O_3$ phase diagram; d) microstructure of the ceramics based on $ZnO-In_2O_3-Ga_2O_3$, with the composition denoted by T in the phase diagram.

We prepared homogeneous and dense ceramics from mechanochemically activated $ZnO-In_2O_3-Ga_2O_3$ -based powder. The ceramics, used as targets for the sputtering of source-drain electrodes and semiconductor layers, enabled the fabrication of thin-film transistors on transparent, flexible substrates at as low as $150^\circ C$.

Using EPD we prepared homogeneous PZT films of about 50 μm thickness with a high green density. The films, sintered at 850°C, exhibited a room-temperature dielectric permittivity of 1050, dielectric losses of 0.038, a remnant polarization of 29 $\mu\text{C}/\text{cm}^2$, a coercive field of 21 kV/cm, and a piezoelectric d_{33} coefficient of 97 pC/N.

About 50- μm -thick PMN–PT films were prepared by screen-printing. By using a suitable amount of packing powder when sintering the films, which prevented the sublimation of PbO, we obtained a room-temperature dielectric permittivity of 3600, dielectric losses of 0.036, and a d_{33} of 140 pC/N.

The structural, dielectric, ferroelectric and electrostrictive characteristics of PMN–PT thick films screen printed and sintered on different substrates, i.e., alumina, bulk PMN–PT and platinum were investigated. The results indicated that the microstructure of the films, the phase composition, i.e., the ratio between the tetragonal and monoclinic phases, and the electrical characteristics, depended on the substrates. The highest density, dielectric permittivity and piezoelectric d_{33} coefficient were obtained when using alumina substrates.

We continued work on **LTCC (Low Temperature Co-fired Ceramic)** materials that are used for multilayer hybrid circuits and 3D structures with buried channels and cavities. A number of LTCC materials have been investigated; both those containing a few percent of PbO in the glassy phase as well as lead-free formulations. Thick-film resistors on LTCC substrates, which will be used as piezoelectric pressure sensors, were realized. The sheet resistivity and temperature coefficient of resistivity of the structures increased due to interactions between the glassy phase from the LTCC substrate and the resistor materials. However, the gauge factors, which are important for the sensing characteristics, remained unchanged.

Sacrificial layers are often used to realize buried channels or cavities within 3D LTCC structures without de-lamination and/or sagging during the lamination and firing processes. We evaluated sacrificial materials based on graphite. Thermogravimetric analysis was used to optimize the filler burn-out profiles. We found that we could prepare 3D structures without cracks and deformations by heating at 850°C, with a hold at 700–720°C to allow the complete burn-out of carbon.

Based on the studies of LTCC and sacrificial materials the **ceramic micro-reactor for the reforming of fuel** for fuel cells was designed and realized in collaboration with HIPOT-RR. The reactor is composed of two evaporators, a mixing chamber and a part where the reaction takes place. This 3D structure of 50 x 30 mm² in size is assembled from eight LTCC layers and contains four buried chambers and nearly 2 m of buried channels designed on three levels. It is heated to the reaction temperature by a Pt thick-film heater. Numerical analyses of the temperature conditions in the 3D LTCC evaporator enabled the optimization of the prototype design and offered guidelines for further work. (Figure 3)

We collaborated with our partners, HIPOT-RR d.o.o and HYB d.o.o., in the development and technology transfer of **ceramic pressure sensors**. The LTCC-based pressure sensors for low pressures, i.e., up to 3 kPa, were designed and realized. The sensors are 3D LTCC structures with highly sensitive thick-film resistors as the sensing elements.

Investigations of the **phase equilibria** in the $\text{RuO}_2\text{-Bi}_2\text{O}_3\text{-SiO}_2$ system were continued in collaboration with EPFL, Switzerland. This system is important for understanding the reactions between conductive phases and the lead-free glassy phase in thick-film resistors. The results showed that $\text{Bi}_2\text{Ru}_2\text{O}_7$ is not stable when in contact with SiO_2 and, therefore, not suitable as the conductive phase in thick-film resistors.

In cooperation with the company **ETI d.d. Izlake** we studied the influence of Li_2O on **the phase composition, mechanical and thermal properties of alumina porcelains**. We found that Li_2O , introduced in the formulation as a mineral spodumene, reacted with the undesired free SiO_2 , and formed lithium aluminosilicate minerals with a larger amount of SiO_2 . The Li-modified porcelain had a lower thermal expansion coefficient, better resistance to thermal shocks and a higher mechanical strength than the standard formulation used in production. The developed material has been used for the fabrication of fuse bases in

In collaboration with ETI d.d. Izlake, we developed a new alumina porcelain with the addition of lithium minerals for the fabrication of fuse bases with a lower thermal expansion coefficient, better resistance to thermal shocks and improved flexural strength than the standard formulation. We exhibited the new material and products at the Slovenian Innovation Forum 2008 in Ljubljana, where JSI and ETI won recognition for their innovation.

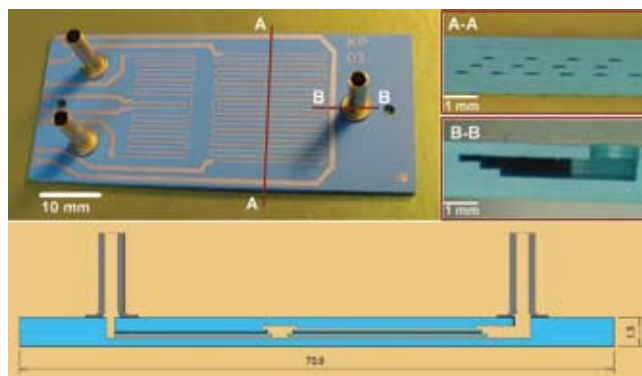


Figure 3: The ceramic micro-reactor with the dimensions 70 x 30 x 1.5 mm³ is assembled from eight LTCC layers. It contains buried channels in several layers. The width, thickness and length of the channels are 400 μm , 30 μm and nearly 2 m, respectively. Thick-film Pt-based heaters are printed and fired on the surface. The inlets for the reactants are on the left-hand side and the outlet for the reaction products is on the right-hand side. The microstructure of the cross-section of the channels (line A–A) and the cross-section of the cavity (line B–B) are shown on the right. The schematic cross-section of the micro-reactor is presented below. Collaboration JSI and HIPOT-RR.

Our postgraduate student Hana Uršič won the Young Scientist Award for Encouragement of Research in Materials Science at the IUMRS-ICA 2008 conference in Nagoya, Japan, 9–11 December 2008 for the contribution Effect of Processing for CSD-derived LNO Seeding Layer on Electrical Properties of PZT Thin Film.

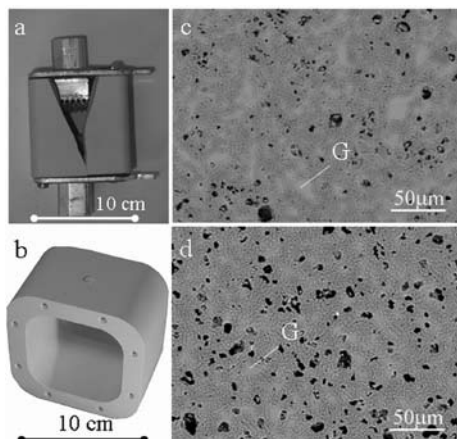


Figure 4: a) the cracked part of a fuse, produced from the standard alumina porcelain, after electrical load, b) part of a fuse produced from the newly developed alumina porcelain with a modified composition, which did not crack after the electrical load due to the improved resistance of the material to thermal shocks, c) microstructure of the porcelain used in production and, d) the microstructure of the alumina porcelain with a modified composition with a homogeneously distributed glassy phase (G). Collaboration JSI and ETI.

ETI (Figure 4). The developed materials and products were presented at the Slovenian Innovation Forum 2008 in Ljubljana, where the JSI and ETI obtained recognition for their innovation.

The department's research was conducted in the frame of the research programme "Electronic Ceramics, Nano, 2D and 3D Structures", two fundamental ARRS projects, four ARRS projects, co-financed by Slovenian industry, one post-doc project, one CRP-MIR project, one project financed by Slovenian industry and eight EU FP6 and FP7 projects.

Some outstanding publications in 2008

1. John Gerard Fisher, Andreja Benčan, Marija Kosec, Sophie Vernay, Daniel Rytz, Growth of dense single crystals of potassium sodium niobate by a combination of solid-state crystal growth and hot pressing, *J. Am. Ceram. Soc.*, 2008, 91 [5], 1503-1507.
2. Barbara Malič, Darja Jenko, Janez Holc, Marko Hrovat, Marija Kosec, Synthesis of sodium potassium niobate: a diffusion couples study, *J. Am. Ceram. Soc.*, 2008, 91 [6], 1916-1922.
3. Jenny Tellier, Barbara Malič, Brahim Dkhil, Darja Jenko, Jena Cilenšek, Marija Kosec, Crystal structure and phase transitions of sodium potassium niobate perovskites, *Solid state sci.*, 2008, doi:10.1016/j.solidstatesciences.2008.07.011.
4. Barbara Malič, Mira Mandeljc, Goran Dražič, Miha Škarabot, Igor Muševič, Marija Kosec, Strategy for low-temperature crystallization of titanium-rich PZT thin films by chemical solution deposition, *Integr. Ferroelectr.*, 2008, 100 [1], 285-296.
5. Hana Uršič, Marko Hrovat, Janez Holc, Marina Santo-Zarnik, Silvo Drnovšek, Srečo Maček, Marija Kosec, A large-displacement $65\text{Pb}(\text{Mg}_{0.33}\text{Nb}_{0.67})\text{O}_3-35\text{PbTiO}_3/\text{Pt}$ bimorph actuator prepared by screen printing. *Sens. Actuators, B, Chem.*, 2008, 133 [2], 699-704.

Patents granted

1. Processing of dense ceramics based on alkaline niobates and tantalates
Janez Holc, Janez Bernard, Barbara Malič, Marija Kosec
SI Patent No. 22380
2. Lead-perovskite-based thick-film structures on reactive ceramics and methods of production
Janez Holc, Silvo Drnovšek, Marija Kosec
SI Patent No. 22401
3. Processing of alumina porcelain for electrotechnics
Martina Oberžan, Janez Holc, Marjan Buh, Vlasta Imperl
SI Patent No. 22541

Awards and Appointments

1. Kupec Alja: Students Prešeren Award, B. Sc. thesis entitled Insulation of electrically conductive fibres
2. Wu Aiyong, Vilarinho Paula M., Kholkin Andrei, Holc Janez, Kosec Marija: Excellent Paper Award for contribution at the International Materials Research Conference (MRS)
3. Kosec Marija: Acknowledgement from Chamber of Craft and Small Business of Slovenia for extraordinary effort in the integration of science and business
4. Hana Uršič: Certificate of Award for Encouragement of Research in Materials Science for the contribution "Effect of Processing for CSD-derived LNO Seeding Layer on Electrical Properties of PZT Thin Film"

Organization of conferences, congresses and meetings

1. Conference SEMTO 2008: Sensors and Actuators, Ljubljana, Slovenia, 4-6 Jun., 2008
2. AMF-6, 6th Asian Meeting on Ferroelectrics, Taipei, Taiwan, 2-6 Aug., 2008
3. ESTC 2008, 2nd Electronics Systemintegration Technology Conference, Greenwich, Great Britain, 1-4 Sep. 2008
4. MIDEM 2008, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies, Fiesca, Slovenia, 17-19 Sep. 2008
5. 32nd International IMAPS-IEEE CPMT Poland Conference, Warsaw, Pułtusk, Poland, 21-24 Sep., 2008
6. 4th Balkan Conference on Glass Science and Technology, 16th Conference on Glass and Ceramics, Varna, Bulgaria, 27 Sep. to 1 Oct. 2008
7. IWAC03, 3rd International Workshop on Advanced Ceramics, Limoges, France, 5-8 Nov., 2008
8. IUMRS-ICA 2008, The IUMRS International Conference in Asia 2008, Nagoya, Japan, 3-12 Dec. 2008

INTERNATIONAL PROJECTS

1. Micro Fabrication Production Technology for MEMS on New Emerging Smart Textiles/Flexibles MICROFLEX
7. FP, NMP2-LA-2008-211335
EC; Dr. Steve Beeby, University of Southampton, School of Electronics and Computer Science, Hampshire, Southampton, Great Britain
Dr. Janez Holc, Prof. Marija Kosec
2. Novel Technology for High-PERformance piezoelectric Actuators HIPER-Act
CP-IP 212394, FP7-NMP-2007-LARGE-1
7. FP, EC; Anders Bjerrum, Claus Bo Andersen, Noliac A/S, Kvistgaard, Denmark
Prof. Marija Kosec, Dr. Andreja Benčan Golob
3. Monolithic above IC Ultra High Value Capacitors for Mobile and Wireless Communication Systems CAMELIA
6. FP, NMP3-CT-2006-033103
EC; Clíodhna Horan, Tyndall National Institute, Lee Maltings, Cork; University College Cork, National University of Ireland, College Road, Cork, Ireland
Asst. Prof. Barbara Malič
4. Multifunctional Ceramic Layers with High Electromagnetoelastic Coupling in Complex Geometries MULTICERAL
6. FP, NMP3-CT-2006-032616
EC; Prof. Andrei Kholkin, University of Aveiro, Dept. of Ceramics & Glass Engineering, Aveiro, Portugal
Prof. Marija Kosec, Dr. Janez Holc, Prof. Robert Blinc, Prof. Raša Pirc
5. Multicomponent Oxides for Flexible and Transparent Electronics MULTIFLEXIOXIDES
6. FP, NMP3-CT-2006-032231
EC; Prof. Rodrigo Ferrao de Paiva Martins, UNINOVA - Instituto de Desenvolvimento de Novas Tecnologias, Campus da FCT/UNL, Monte de Caparica, Portugal
Dr. Danjela Kuščer Hrovatin
6. RELiable, Tuneable and INexpensive Antennas by collective fabrication processes RETINA
6. FP, AST4-CT-2005-516121
EC; Dr. Volker Ziegler, EADS Deutschland GmbH, Corporate Research Centre, Dept. LG-ME, München, Germany
Prof. Marija Kosec, Asst. Prof. Barbara Malič
7. Multifunctional & Integrated Piezoelectric Devices MIND
6. FP, NMP3-CT-2005-515757
EC; Wanda Wolny, Ferroperm Piezoceramics A/S, Kvistgård, Denmark
Prof. Marija Kosec, Asst. Prof. Barbara Malič
8. Fuel Cell Application in a New Configured Aircraft CELINA
6. FP, AST4-CT-2005-516126
EC; Wolfgang Dressel, Airbus Deutschland GmbH, Hamburg, Germany
Prof. Marija Kosec, Dr. Danjela Kuščer Hrovatin
9. Electroceramics from Nanopowders produced by Innovative Methods ELENA
COST 539
EC
Asst. Prof. Barbara Malič

10. INVISIBLE
Sincrotrone Trieste S.C.p.A di interesse nazionale, Basovizza, Trieste, Italy
Dr. Danjela Kuščer Hrovatin
11. Processing, Structure and Properties of Advanced Electronics Ceramics BI-CN/07-09-005
Prof. Hong Wang, Xi'an Jiaotong University, Electronic Materials Research Laboratory, Key Lab of the Ministry of Education Of China, Xi'an, China
Prof. Marija Kosec
12. Novel Possibilities of Creation Three-Dimensional Structures in Low-Temperature Co-Fired Ceramics (LTCC) BI-PL/08-09-011
Prof. Andrzej Dziedzic, Politechnika Wroclawska, Wydział Elektroniki Mikrosystemów i Fotoniki, Wrocław, Poland
Dr. Marko Hrovat

R & D GRANTS AND CONTRACTS

1. Functional properties of thin films based on environment friendly complex perovskite materials: dependence on microstructure and chemical homogeneity
Asst. Prof. Barbara Malič
2. Materials and processes for shaping miniature thick film ceramic 2D and 3D structures
Dr. Marko Hrovat
3. Energy-saving ceramic pressure sensors with digital output
Dr. Marko Hrovat
4. Processing of ceramic microelectromechanical systems (MEMS) by novel technologies
Dr. Janez Holc
5. Capacitive ceramics: pressure sensors
Dr. Marko Hrovat
6. Miniaturised Ceramic Low Pressure Sensors
Dr. Marko Hrovat
7. Fuel cell systems as an auxiliary energy sources for autonomous military vehicles; Auxiliary power supply based on fuel cells
Dr. Janko Petrovčič, Dr. Danjela Kuščer Hrovatin
8. Mechanochemical synthesis of complex ceramic oxides
Dr. Tadej Rojac

RESEARCH PROGRAM

1. Electronic Ceramics, Nano-, 2D and 3D Structures
Prof. Marija Kosec

NEW CONTRACTS

1. Processing of ceramic microelectromechanical systems (MEMS) by novel technologies Hyb Hybrid Circuits and Sensors d.o.o., Šentjernej
Dr. Janez Holc
2. KeraPro - Ceramic Processor for Fuel Reforming and Cleaning of Obtained Gasses
Ministry of Defence
Dr. Marko Hrovat

VISITORS FROM ABROAD

1. Prof. Marc Lethiecq, University of Tours, Tours, France, 9 Jan. 2008
2. Dr. Miguel Alguero, Instituto de Ciencia de Materiales de Madrid, Madrid, Spain, 22- 28 Jan. 2008
3. Prof. Susan Trolrier-McKinstry, Pennsylvania State University, Pennsylvania, USA, 21-25 Aug. 2008

4. Dr. Elena Daniela Ion, National Institute for Materials Physics, Magurele, Romania, 5-7 Jun. 2008
5. Dr. Alexey Popov, University of Oulu, Oulu, Finland, 22 Sept. 2008
6. Dr. Sophie d' Astorg, Cranfield University, Cranfield, Great Britain, 23 Sept. to 4 Oct. 2008
7. Mr. Kozma Gabor, University of Szeged, Szeged, Hungary, 13-26 Oct. 2008
8. Mr. Dmitry Kiselev, University of Aveiro, Aveiro, Portugal, 1-15 Nov. 2008

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9. Dr. Andrej Degen*

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11. Dr. Jenny Julie Angeline Tellier
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13. Sebastjan Glinšek, B. Sc.
14. *Jerneja Godnjavec, M. Sc., left 1 May 2008*
15. Jurij Koruza, B. Sc.
16. Alja Kupec, B. Sc.
17. Branka Perc, B. Sc.
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25. Miha Skalar, B. Sc.

26. Tanja Urh, B. Sc.

Technical and administrative staff

27. Srečko Maček

Note:

* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Harvey Amorín, Jesús Ricote, Janez Holc, Marija Kosec, Miguel Algueró, "Homogeneous templated grain growth of $0.65\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3}\text{O}_3 - 0.35\text{PbTiO}_3)$ from nanocrystalline powders obtained by mechanochemical activation", *J. Eur. Ceram. Soc.*, vol. 28, no. 14, pp. 2755-2763, 2008.
2. Harvey Amorín, Jesús Ricote, R. Jiménez, Janez Holc, Marija Kosec, Miguel Algueró, "Submicron and nanostructured $0.8\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3}\text{O}_3 - 0.2\text{PbTiO}_3)$ ceramics by hot pressing of nanocrystalline powders", *Scr. mater.*, vol. 58, no. 9, pp. 755-758, 2008.
3. Darko Belavič, Marko Hrovat, Janez Holc, Marina Santo-Zarnik, Marija Kosec, Marko Pavlin, "The application of thick-film technology in C-MEMS", *J. Electroceram.*, vol. 19, no. 4, pp. 363-368, 2008.
4. Janez Bernard, Andreja Benčan, Tadej Rojac, Janez Holc, Barbara Malič, Marija Kosec, "Low-temperature sintering of $\text{K}_{0.5}\text{Na}_{0.5}\text{NbO}_3$ ceramics", *J. Am. Ceram. Soc.*, vol. 91, no. 7, pp. 2409-2411, 2008.
5. Vid Bobnar, Marko Hrovat, Janez Holc, Marija Kosec, "Giant dielectric response in $\text{Pb}(\text{Zr}, \text{Ti})\text{O}_3 - \text{Pb}_2\text{Ru}_2\text{O}_{6.5}$ all-ceramic percolative composite", *Appl. phys. lett.*, vol. 92, no. 18, pp. 182911-1-182911-3, 2008.
6. E. Buixaredas, I. Gregora, Stanislav Kamba, Jan Petzelt, Marija Kosec, "Raman spectroscopy and effective dielectric function in PLZT $x/40/60$ ", *J. phys., Condens. matter*, vol. 20, no. 34, pp. 345229-1-345229-10, 2008.
7. Laila Čakare-Samardžija, Barbara Malič, Marija Kosec, " $\text{K}_{0.5}\text{Na}_{0.5}\text{NbO}_3$ thin films prepared by chemical solution deposition", In: *EMF-2007 - 11th European Meeting on Ferroelectricity, September 3-7 2007, Bled, Slovenia*, (Ferroelectrics, vol. 367/370, no. 1/4, 2008), EMF-2007 - 11th European Meeting on Ferroelectricity, September 3-7 2007, Bled, Slovenia, Boštjan Zalar, ed., Ljubljana, J. Stefan Institute, 2008, vol. 369, part 3, pp. 149-156, 2008.
8. John Gerard Fisher, Andreja Benčan, Jerneja Godnjavec, Marija Kosec, "Growth behaviour of potassium sodium niobate single crystals grown by solid-state crystal growth using $\text{K}_2\text{CuNb}_8\text{O}_{23}$ as a sintering aid", *J. Eur. Ceram. Soc.*, vol. 28, no. 8, pp. 1657-1663, 2008.
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Regular papers

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THESES

M. Sc. Theses

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B. Sc. Theses

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PATENT APPLICATIONS

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ENGINEERING CERAMICS DEPARTMENT

K-6

The Engineering Ceramics Department is the leading group in the field of structural ceramics and ceramic technologies in Slovenia. The research programme comprises phenomena relevant to materials synthesis and component fabrication as well as mechanisms leading to the degradation of engineering ceramic structures under operating conditions. The applied research work is focused on new applications of engineering ceramics, the development of novel, high-strength, wear-, corrosion- and/or heat-resistant materials and the development of alternative, cost-effective and environmentally friendly ceramic technologies.



Head:

Prof. Tomaž Kosmač

We continued the application of the reactivity of aluminium nitride (AlN) powder with water at elevated temperatures in the synthesis of thin coatings of aluminium hydroxide with large specific areas on ceramic substrates. We studied the kinetics of the hydrolysis and determined the aluminium species in aqueous suspensions of AlN powder, which are responsible for the formation of the hard crystalline phase. We investigated the influence of the temperature and the reaction time on the nucleation and growth of crystalline products, with the focus on the growth of nanostructured boehmite (AlOOH). By using stereometric analyses we characterized quantitatively the morphology of the boehmite nanocoatings and the geometry of individual boehmite particles on the substrate. We also determined the crystal structure and the morphology of the oxide coating after thermal treatment.

In the frame of bioceramics research, tetragonal ZrO_2 , partially stabilized with Y_2O_3 (Y-TZP), was used as the basic material that possesses the best mechanical properties from among all bio-compatible ceramic materials. However, it is bio-inert because of its chemical stability. Bio-inertness is desirable for the friction surfaces of artificial joints, but it imposes great problems for the fixation of an implant since the tissue does not grow on the implant's inert surface. The bio-inertness problem was first tackled by inserting bioactive particles of $Ca_3(PO_4)_2$ and $CaTi_4(PO_4)_6$ into the Y-TZP matrix. However, since these composites could not be sintered to a high density and with the desirable strength by the usual procedures because of the reactivity of the secondary-phase particles with the matrix at elevated temperatures, we paid, in the following, greater attention to the synthesis of bioactive coatings on an Y-TZP substrate. We used the biomimetic method of precipitation of hydroxi-apatite (HA) from a super-saturated solution of calcium and phosphate ions. Polycrystalline particles of octacalcium phosphate (OCP) in the form of large, semicircular agglomerates or thin homogeneous coatings were formed on the substrate, depending on the concentration of calcium, phosphate and hydroxide ions. The formation of OCP was proved by electron diffraction (SAED), energy-dispersive spectroscopy (EDS) and electron energy-loss spectroscopy (EELS). The different morphologies of the coatings were explained by the influence of the supersaturation degree of the solution on the critical size and the corresponding number of nuclei, together with the influence of temperature on the saturation speed and the final coating thickness. With these results, we set up a model to describe the mechanism and the kinetics of the saturation of calcium phosphate from the Ca/P solution on the surface of sintered Y-TZP ceramics.

In the frame of the R&D of dental ceramics based on tetragonal (Y-TZP) ZrO_2 we also studied the influence of mechanical surface treatments, e.g., grinding and sand-blasting, on the kinetics of the accelerated ageing of this material in artificial saliva, as well as fatigue under simulated clinical conditions. We showed that untreated specimens are subjected to the most accelerated ageing, while the sand-blasted and ground surfaces are more resistant. The better stability of mechanically surface treated Y-TZP ceramics is attributed to twinning and the partial deformation of the crystal lattice of re-transformed tetragonal grains, although it is also influenced by surface compressive stresses. The survival level after mechanical fatigue in artificial saliva is significantly lowered in comparison with the fatigue in air, which indicates a strong influence of stress corrosion that is additionally influenced by the mechanical damage due to grinding. We continued the clinical study of restoring teeth with ceramic posts, which were developed in cooperation with stomatologists from the Medical Faculty, University of Ljubljana. The results so far indicate a high percentage of success in restoring endodontically cured teeth with zirconia ceramic posts, and they confirm the hypothesis that this material is appropriate for the fabrication of dental posts in the intercanine region of dental arcs. Since the Young's modulus of Y-TZP ceramics is significantly higher than the modulus of dentine the large elastic stresses appear at the connection of the dental restoration framework with tooth preparation, which in turn increases the

In 2008, three researchers – two of them from the Medical Faculty of the University of Ljubljana – received their PhD degrees in the area of bioceramics under the supervision of researchers from our department.

probability of the malfunction of the marginal seal and consequently the secondary caries and periodontal disease. In the frame of a young-researcher fellowship we started the development of porous ceramics with a lower elastic modulus, while retaining a satisfactory bending strength. We tried to achieve this by coating ZrO_2 microparticles with nanoparticles of the same material. This combination should ensure intermediate porosity (80%) with pore sizes in the nanometre range. We made use of the help of the homo-aggregation of nano- and microparticles. SEM/FEG analyses revealed pores of nanometre dimensions and their uniform distribution across the fracture surface. In addition, we worked a lot on the adhesion of dental cements to the surface of sintered Y-TZP ceramics as a structural material for full-ceramic dental restorations. We found that coating the structural ceramic surface with a thin adhesion layer made of alumina may lead to values of the contact shear strength that are even five times higher. The fact that the contact strength with the use of adhesion coating does not decrease even after long-term thermocycling is even more important for clinical practice.

We began research on the rheological properties of paraffin suspensions with a high solids loading. We found that the yield stress of these suspensions after cooling below the melting temperature of the dispersion medium (paraffin) and heating again above this temperature increases by at least an order of magnitude. The magnitude of this change increases with the volume fraction of powder in the suspension and decreases with the size of the powder particles used. The reason for this is attributed to the strengthening of attractive inter-particle forces, because the distances between the suspension particles are decreased due to the significant contraction of the medium (approximately 20 vol.%) in the liquid-solid phase transition.

We have run preliminary Monte Carlo simulations of critical-crack propagation in uniaxial tests of the bending strength of flat ceramic monoliths or multilayered composites. In the first step of the simulation development we focused on narrow edge cracks with commonly known weight functions for the calculation of the intensity factor of the mechanical stress. We searched for parameters in the Weibull distribution of the breaking forces or the corresponding tensile stresses. We also simulated Gaussian measurement uncertainty and the possible arrestment of the crack in the layers with compressive stresses and studied this influence on the Weibull distribution. The measurement uncertainty apparently decreases the Weibull modulus due to a widening of the standard deviation of the measurements. An analytical approach cannot deal with all these complications. Further developments of this method including other types of faults in the material will enable the forecast and crude recognition of fault types just on the basis of a sufficient number of strength measurements, rather than the time-consuming fractographic analysis method that is used at present.

We investigated theoretically the effective uniaxial bending strength of full or hollow cylindrical multilayered composites. We also considered the residual stresses that can arise in individual layers for different reasons, such as the different temperature expansion coefficient in different layers. The findings will be applied to 4-point measurements of the uniaxial bending strength of sintered cylindrical Al_2O_3 composites and hollow monolithic cylindrical green bodies, from which all the binder or just a part of it was expelled during different drying times.

In 2008 our cooperation with other research organizations and industrial partners continued to be very extensive.

Work continued in the field of new composites on the basis of the compound B_4C infiltrated with Al, in cooperation with the K-9 department and the private researcher V. Kevorkijan. The possibilities of the fabrication of these materials without increased pressure, with the use of reaction infiltration of melted metal into the ceramic preform were investigated. Our results revealed the possibility of the preparation of such composites and also their good mechanical properties, which indicates their potential use in anti-ballistic protection.

We continued our work on the preparation of ceramic composites with a double matrix and carbon fibres. Composites of this kind are used in the production of brake pads in the company MS Production from Bled, Slovenia. We investigated predominantly the influence of the preparation process and the conditions of thermal treatment on the microstructure, mechanical and friction properties. We studied the wear mechanisms of sintered metal brake pads, which are used in combination with composite ceramic brake discs. We found that a thin friction layer made of a mixture of metal oxides is formed on the surface of brake pads during braking, which in turn influences the coefficient of friction as well as the wear of the pad. We made tests on some other commercial products of the companies MS Production and Sinter with the aim of improving and optimizing the serial production. The investigations included the phase analysis of materials, microstructure analyses and measurements of the mechanical properties.

In the frame of the project "Ageing of dental zirconia (Y-TZP) ceramics under simulated clinical conditions" we cooperate with the company Interdent d.o.o. from Celje. In choosing materials we consider two criteria: sensibility to mechanical damage in standard machining procedures of fixed-prosthetic constructions, i.e., grinding with diamond drills and sand-blasting, and the durability of sintered Y-TZP ceramics in an aqueous environment. We used two commercial powders of ZrO_2 with equal compositions, but different specific areas, to make green bodies, followed by pre-sintering at various temperatures. In this way, we influenced the strength and machining ability of semi-products.

In the frame of the applicative project "The influence of fillers on the mechanical properties of fibre-cement composites", we continued to study the possibility of substituting amorphous silica by meta-kaoline. We applied

various methods for the preparation of fibre-cement (FC) composites as well as various conditions. We confirmed our finding from previous research year that the substitution described does not degrade the mechanical properties. Next, we investigated the influence of different additives, such as polyacrylates, polyacrylates modified with silanes, colloidal SiO_2 , boron silicate and PRIMAL E-330 EF, between the layers in the fabrication of FC composites, on their mechanical properties, in particular the bending strength. We found that the additives do not influence significantly the mechanical properties. This is an important conclusion since we subsequently began with a study of the rheological properties of cement pastes, in order to determine the conditions that make possible the evaluation of the rheological properties of the composite that still allow plastic shaping of the flat FC sheet into a corrugated one. In 2008 an industrial test was performed in Esal where polyacrylate additives were injected between the layers of the FC composite during fabrication, with the aim of improving the mechanical and other properties. We found that the additives did not improve significantly the mechanical properties; however, they strongly decrease the leakage of water, and this is an important parameter for composites used for roofing sheets.

In the frame of the development of a ceramic glow plug for diesel engines, in cooperation with the company Hidria AET d.o.o. from Tolmin, Slovenia, in 2008 we studied the preparation and properties of ceramic composites on the basis of silicon nitride with dispersed particles of the conducting phase. Conducting TiN or ZrN particles were synthesized by the gel-precipitation of hydroxides and a subsequent thermal treatment. After calcination at 600°C in air TiO_2 and ZrO_2 are formed, which react with Si_3N_4 at elevated temperatures in nitrogen to form TiN (at 1250°C) and ZrN (at 1600°C). In the fabrication process of electrically conducting $\text{Si}_3\text{N}_4/\text{TiN}$ and $\text{Si}_3\text{N}_4/\text{ZrN}$ composites we added an appropriate amount of oxide additives (Y_2O_3 , Al_2O_3) to coated Si_3N_4 powder and then we sintered such mixtures at 1850°C , 2h in N_2 . In both cases we achieved a high density and a high strength of the composites. However, we could not obtain the appropriate electrical conductivity, because of the intense growth of TiN and ZrN particles during sintering.

In cooperation with the same partner, within the project "Two-component low pressure injection moulding (LPIM) of ceramic heaters" we focused on the development of the two-component injection of paraffin suspensions prepared from mixtures of silicon nitride (Si_3N_4) and molybdenum disilicide (MoSi_2). For this purpose we optimized the rheological properties of paraffin suspensions, with the aim of preparing suspensions with the highest possible fraction of ceramic powders, while keeping the appropriate viscosity. We studied the influence of the suspension's composition on the contraction of the bodies after the thermal removal of the binder, as well as the conditions which still allow for the successful preparation of two-component green bodies. We found that both suspensions must have a similar contraction, which depends on the solids loading and the size of the particles used for the preparation of the suspension. The appropriate rheological properties were achieved by optimising the quantity of the surface agent octadecyl amine. We chose appropriate conditions for shaping the green bodies, which were subsequently thermally treated to remove the binder and finally sintered to a high density. The final result was the fabrication of a working heater for the glow plug by LPIM method.

In the frame of our cooperation with the University of Maribor in the project "Patterns, structural self-organization and magnetoelectrics in mixtures of nano-particles and liquid crystals" we performed preliminary theoretical investigations of the interaction between nematic molecules and ferromagnetic particles in a mixture of liquid crystal and ferromagnetic powder. To help in the understanding of this complex system we first studied in detail the three-dimensional Heisenberg spin model as the basis for investigating the behaviour of a nematic liquid crystal with impurities in a flat cell. We were interested mostly in the influence of impurity concentration, ordering of the external field and the preparation history (i.e., the memory effect) on system ordering, e.g., whether there is long-range order or not. This question is still unresolved in basic science. After the successful testing of the Heisenberg model on the liquid crystal it was generalized to the system of liquid crystal and magnetic particles.

Within our bilateral cooperation with the University Chubu, near Nagoya in Japan, we investigated the possibility of improving the wear resistance of titanium alloys for bone implants by the method of direct nitriding in ammonium. Preliminary results indicate that it is possible to increase the surface hardness significantly in this way, while the adhesion of the layer with the substrate still has to be improved.

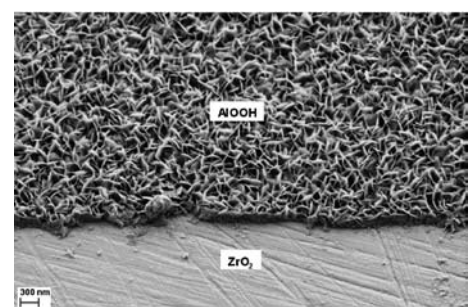
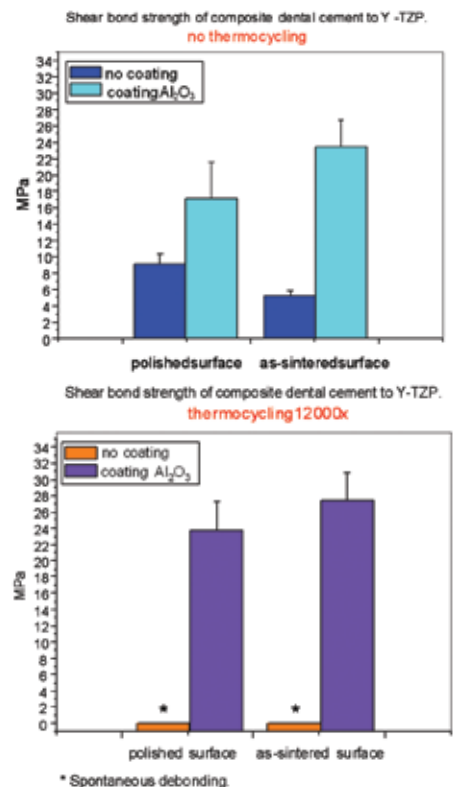


Figure 1: SEM photograph of boehmite coating on a ZrO_2 substrate and its adhesion with dental cement.

Some outstanding publications in the past three years

1. Zmago Stadler, Tomaž Kosmač, Kristoffer Krnel. Friction and wear of sintered metallic brake linings on C/C-SiC composite brake disc. *Wear*, 2008, vol. 265, p. 278-285.
2. Kristoffer Krnel, Aljoša Maglica, Tomaž Kosmač. β -SiAlON/TiN nanocomposites prepared from TiO₂-coated Si₃N₄ powder. *Engineering ceramics '07: from engineering to functionality: the Advanced Research Workshop*, 06-10 May 2007, Smolenice, Slovakia, J. Eur. Ceram. Soc., 2008, vol. 28, p. 953-957.
3. Milan Ambrožič, Tomaž Kosmač. Applied and residual stresses in brittle cylindrical multilayered composites. *J. Appl. Phys.*, 2008, vol. 103, p. 073515-1-073515-5.
4. Andraž Kocjan, Kristoffer Krnel, Tomaž Kosmač. The influence of temperature and time on the AlN powder hydrolysis reaction products. *J. Eur. Ceram. Soc.*, 2008, vol. 28, p. 1003-1008.
5. Tomaž Kosmač, Aleš Dakskobler, Čedomir Oblak, Peter Jevnikar. The strength and hydrothermal stability of Y-TZP ceramics for dental applications. *International journal of applied ceramic technology*, 2007, vol. 4, p. 164-174.
6. Kristoffer Krnel, Zmago Stadler, Tomaž Kosmač. Preparation and properties of C/C-SiC nano-composites. *J. Eur. Ceram. Soc.*, 2007, vol. 27, p. 1211-1216.
7. Milan Ambrožič, Tomaž Kosmač. Optimization of the bend strength of flat-layered alumina-zirconia composites. *J. Am. Ceram. Soc.*, 2007, vol. 90, p. 1545-1550.
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10. Matjaž Valant, Aleš Dakskobler, Milan Ambrožič, Tomaž Kosmač. Giant permittivity phenomena in layered BaTiO₃-Ni composites. *J. Eur. Ceram. Soc.*, 2006, vol. 26, p. 891-896.

Patents granted

1. Process for Applying Adhesion Coating to a Substrate
Tomaž Kosmač, Kristoffer Krnel, Andraž Kocjan, Peter Jevnikar
SI Patent No. 22527

Awards and appointments

1. Aljoša Maglica: Award for the best lecture presentation among fellow researchers in the group for inorganic materials, 1st International Conference on Materials and Technology, sponsored by IUVSTA and FEMS, Portorož, Slovenia, 13-15 Oct. 2008

INTERNATIONAL PROJECTS

1. Novel Technology for High-PERformance pieoelectric Actuators
HIPER-Act
CP-IP 212394, FP7-NMP-2007-LARGE-1
7. FP
EC; Anders Bjerrum, Claus Bo Andersen, Noliac A/S, Kvistgaard, Denmark
Prof. Tomaž Kosmač, Prof. Marija Kosec
2. Monolithic above IC Ultra High Value Capacitors for Mobile and Wireless Communication Systems
CAMELIA
6. FP, NMP3-CT-2006-033103
EC; Cliodhna Horan, Tyndall National Institute, Lee Maltings, Cork; University College Cork, National University of Ireland, College Road, Cork, Ireland
Prof. Tomaž Kosmač, Asst. Prof. Barbara Malič
3. Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
appliCMA
7. FP, 214407
EC; Susanne Fuchs, Austrian Research Centers GmbH - ARC, Functional Materials, Seibersdorf, Austria
Dr. Kristoffer Krnel, Dr. Miha Čekada, Prof. Janez Dolinšek, Dr. Srečo D. Škapin
4. Formation of Modified Oxide Layers to Improve the Wear Resistance of Titanimu-based Alloys for Artificial Joint Prostheses
BI-JP/08-10-003
Prof. Tadashi Kokubo, Chubu University, Department of Biomedical Sciences, College of Life and Health Sciences, Aichi, Japan
Prof. Tomaž Kosmač

R & D GRANTS AND CONTRACTS

1. Patterns, structural self-assembling and magnetoelectrics in mixtures of nano-particles and liquid crystals
Prof. Samo Kralj, Asist. Prof. Milan Ambrožič
2. Ageing of dental zirconia (Y-TZP) ceramics under simulated clinical conditions
Prof. Tomaž Kosmač
3. Development of multifunctional B₄C-Al and B₄C-Mg composite materials for new products
Prof. Tomaž Kosmač
4. Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
Prof. Darko Makovec
5. Influence of the fillers on mechanical properties of fibre-cement composites
Dr. Kristoffer Krnel

RESEARCH PROGRAMS

1. Engineering and bio-ceramics
Prof. Tomaž Kosmač
2. Advanced inorganic magnetic and semiconducting materials
Prof. Mihael Drogenik, Natalija Petkovič Habe

NEW CONTRACTS

1. Ageing of dental zirconia (Y-TZP) ceramics under simulated clinical conditions
INTERDENT, d. o. o., Celje
Prof. Tomaž Kosmač
2. Research & development work in the frame of the project "CarCIM"
HIDRIA AET, d.o.o., Tolmin
Prof. Tomaž Kosmač
3. Co-financing of the project "Influence of the fillers on mechanical properties of fibre-cement composites"
ESAL, d.o.o., Anhovo
Dr. Kristoffer Krnel

VISITORS FROM ABROAD

1. Dr. Shen Zhijian, Stockholm University, Stockholm, Sweden, 19 Mar. 2008
2. Dr. Ferhat Kara, Anadolu University, Faculty of Engineering and Architecture, Department of Materials Science and Engineering, Eskişehir, Turkey, 28 Apr. 2008
3. Prof. Tomihara Matsushita, Prof. Hiroaki Takatama, Dr. Takashi Kizuki, Chubu University, College of Life and Health Sciences, Department of Biomedical Sciences, Kasugai, Japan, 20–25 Aug. 2008
4. Dr. Robert Danzer, Dr. Peter Supančič, Dr. Raul Bermejo, Dr. Tanja Lube, Leoben University, Leoben, Austria, 18–19 Sept. 2008

STAFF

Researchers

1. **Prof. Tomaž Kosmač, Head**
2. Dr. Kristoffer Krnel

Postdoctoral associates

3. Asst. Prof. Milan Ambrožič
4. Dr. Aleš Dakskobler
5. Dr. Irena Pribošič
6. Dr. Jaroslav Slunečko*
7. Dr. Krunoslav Vidović*

Postgraduates

8. Dr. Sabina Beranič Klopčič, left 1 Oct. 2008
9. Andraž Kocjan, B. Sc.

10. Aljoša Maglica, B. Sc.
11. Sebastjan Perko, DMD

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12. Natalija Petković Habe, B. Sc.

Technical and administrative staff

13. Darko Eterović
14. Mojca Hren
15. Tomislav Pustotnik

Note:

* part-time JSI member

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2. Milan Ambrožič, "Porazdelitev trdnosti keramičnih materialov", *Vakuumist*, vol. 28, no. 1/2, pp. 25-29, 2008.
3. Milan Ambrožič, Fulvio Bisi, Epifanio G. Virga, "Director reorientation and order reconstruction: competing mechanisms nematic cell", *Contin. mech. thermodyn.*, vol. 20, no. 4, pp. 193-218, 2008.
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5. Milan Ambrožič, Stojana Veskovič Bukudur, Tomaž Kosmač, Kristoffer Krnel, Darko Eterović, Natalija Petkovič, Irena Pribošič, "Merjenje obrabne obstojnosti strukturne keramike Al_2O_3 ", *Mater. tehnol.*, vol. 42, no. 5, pp. 221-225, 2008.
6. Sabina Beranič, Irena Pribošič, Tomaž Kosmač, U. Ploska, G. Berger, "The reactivity of $CaTi_4(PO_4)_6$ with alumina and Y-TZP ceramics", In: *Proceedings of the 20th International Symposium on Ceramics in Medicine, The Annual Meeting of the International Society for Ceramics in Medicine (ISCM), Nantes, France, 24-26 October 2007*, (Bioceramics, vol. 20, part 2), (Key engineering, vol. 361-363, 2008), Zuerich, Trans Tech Publications, 2008, vol. 361-363, pp. 787-790, 2008.
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9. Tomaž Kosmač, Čedomir Oblak, Ljubo Marion, "The effects of dental grinding and sandblasting on ageing and fatigue behavior of dental zirconia (Y-TZP) ceramics", In: *Engineering ceramics '07: from engineering to functionality: the Advanced Research Workshop, 06-10 May 2007, Smolenice, Slovakia*, (Journal of the european ceramic society, vol. 28, no. 5, 2008), Pavol Šajgalík, ed., Michael J. Hoffmann, ed., Ralf Riedel, ed., Barking, Elsevier, 2008, vol. 28, no. 5, pp. 1085-1090, 2008.
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11. Kristoffer Krnel, Zmago Stadler, Tomaž Kosmač, "Carbon/carbon-silicon-carbide dual-matrix composites for brake discs", In: *YUCOMAT 2007: Conference of the Yugoslav Materials Research Society, Herceg Novi, Montenegro, September, 10-14, 2007*, (Materials and manufacturing processes, Vol. 23, Issue 6, 2008), Dragan Uskoković, ed., New York, Marcel Dekker, 2008, issue 6, vol. 23, pp. 587-590, 2008.
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14. Zmago Stadler, Tomaž Kosmač, Kristoffer Krnel, "Friction and wear of sintered metallic brake linings on C/C-SiC composite brake disc", *Wear*, vol. 265, no. 3/4, pp. 278-285, 2008.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Tomaž Kosmač, Aleš Dakskobler, "Tetragonal zirconia (Y-TZP) ceramics for dental applications: criteria for materials selection", In:

Global roadmap for ceramics: ICC2 proceedings, 2nd International Congress on Ceramics, [Verona, Italy, June 29 - July 4, 2008], Alida Bellosi, ed., Gian Nicola Babini, ed., [S. l.], Institute of Science and Technology for Ceramics, National Research Council, 2008, pp. 97-106.

Regular papers

1. Milan Ambrožič, Raúl Bermejo, Peter Supancic, Tomaž Kosmač, "Monte Carlo simulation of Weibull distribution of ceramic strength values", In: *Proceedings of the 2008, SEM XI International Congress and Exposition on Experimental and Applied Mechanics*, June 2-5, 2008, Orlando, Florida, USA, [S. l.], Society for Experimental Mechanics, 2008, 8 pp.
2. Milan Ambrožič, Matej Cvetko, Samo Kralj, "Memory effects in randomly perturbed nematic liquid phase", In: *Proceedings of the 2008, SEM XI International Congress and Exposition on Experimental and Applied Mechanics*, June 2-5, 2008, Orlando, Florida, USA, [S. l.], Society for Experimental Mechanics, 2008, pp. [1-6].
3. Kristoffer Krnel, Aljoša Maglica, Tomaž Kosmač, "Development of new electro-conductive ceramic composites for ceramic glow plugs", In: *Global roadmap for ceramics: ICC2 proceedings*, 2nd International Congress on Ceramics, [Verona, Italy, June 29 - July 4, 2008], Alida Bellosi, ed., Gian Nicola Babini, ed., [S. l.], Institute of Science and Technology for Ceramics, National Research Council, 2008, 6 pp.
4. Kristoffer Krnel, Aljoša Maglica, Tomaž Kosmač, "Development of new electro-conductive ceramic composites for ceramic glow plugs", In: *Greener, safer and smarter road transport for Europe, Proceedings*, TRA,

Transport Research Arena Europe 2008, Ljubljana, Slovenia, 21-24 April 2008, Aleš Žnidarič, ed., Ljubljana, DDC svetovanje inženiring, ZAG, Zavod za gradbeništvo Slovenije, DRC, Družba v cestni in prometni stroki Slovenije, 2008, 6 pp.

5. Kristoffer Krnel, Aljoša Maglica, Tomaž Kosmač, "Reaction sintered Si_3N_4 based electroconductive ceramics composites", In: *Global roadmap for ceramics: ICC2 proceedings*, 2nd International Congress on Ceramics, [Verona, Italy, June 29 - July 4, 2008], Alida Bellosi, ed., Gian Nicola Babini, ed., [S. l.], Institute of Science and Technology for Ceramics, National Research Council, 2008, 6 pp.

TEXTBOOKS AND LECTURE NOTES

1. 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.

THESES

Ph. D. Theses

1. Sabina Beranič, *Bioaktivni keramični materiali na osnovi cirkonijevega oksida za uporabo v medicini: Ph. D. thesis*, Ljubljana, [S. Beranič Klopčič], 2008.

DEPARTMENT FOR NANOSTRUCTURED MATERIALS K-7

The basic and applied research in the Department for Nanostructured Materials includes ceramic materials, metals, intermetallic alloys and minerals. Our research encompasses conventional processing as well as the development of new technologies and methods for preparing new materials with novel properties. It includes the experimental and theoretical investigations of structures, the 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

One-dimensional **Co-Pt-based nanostructures** were prepared via template-assisted electro-deposition into high-aspect-ratio track-etched polycarbonate membranes. Tubular nanostructures with a diameter of 200 nm and lengths of 1000–8000 nm were obtained directly, without any pore-wall functionalization, as was previously reported to be necessary in the literature. The mechanism of direct tube formation was attributed to the appropriate relative rates of the deposition and the diffusion of the Co^{2+} and Pt^{2+} ions into partially Au-covered pores. We found that diffusion is the rate-determining step of the electro-deposition process; therefore, the stoichiometry and the related properties can be controlled via the electrolyte composition. The highest obtained coercivity was $H_c=670$ kA/m, which makes these materials interesting for **advanced electronic and magnetic devices**, as media for **high-density magnetic recording** or as a potential **drug-delivery agent**. Furthermore, their large surface-to-volume ratio and Pt content would make them interesting for catalytically driven processes. Another ferromagnetic system, **Fe-Pd**, was successfully synthesized via the electro-deposition method and thin films as well as one-dimensional nanostructures were obtained. The reaction regime was found to be kinetically controlled; therefore, the stoichiometry and the related properties can be influenced via the applied voltage. This knowledge is extremely important since the $\text{Fe}_{50}\text{Pd}_{50}$ composition gives high coercivities, while the $\text{Fe}_{70}\text{Pd}_{30}$ composition is a **magnetic shape-memory alloy** capable of producing strains of 6-10 % in moderate magnetic fields.

The combination of scanning electron microscopy (SEM, FEGSEM) and atomic force microscopy (AFM) was used to analyze the grain size, the distribution and the morphology of the nanoparticles in submicrometre thin films that were obtained by the electro-deposition and laser-ablation methods. An improved method of quantitative electron-probe microanalysis with wavelength-dispersive x-ray spectroscopy (WDXS) was applied for the analysis of the chemical composition of thin nanostructured ferromagnetic Co-Pt films. The results of the microanalysis allowed us to study and define the influence of the process parameters of electro-deposition on the thickness and the composition of Co-Pt films as well as to correlate the composition with the magnetic properties of the material.

One-dimensional Co-Pt-based fibril or tubular nanostructures were prepared via template-assisted electro-deposition with the highest coercivity $H_c=670$ kA/m. These materials can be used in advanced electronic and magnetic devices, and as media for high-density magnetic recording.

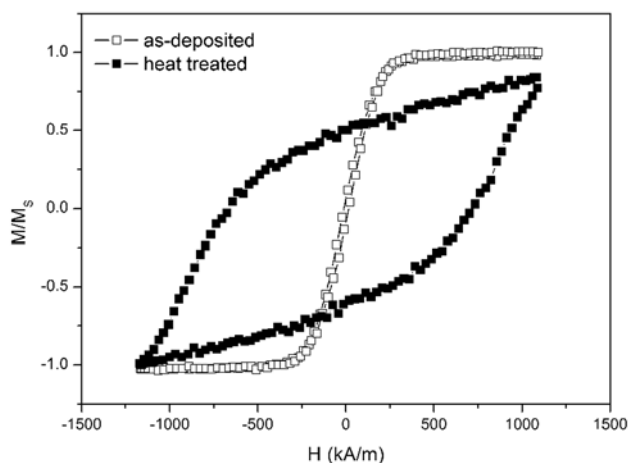


Figure 1: Co-Pt-based tubular structures synthesised with direct electroplating (left). Magnetic properties of the as-deposited Co-Pt-based nanotubes and the heat treated Co-Pt-based nanotubes (right).

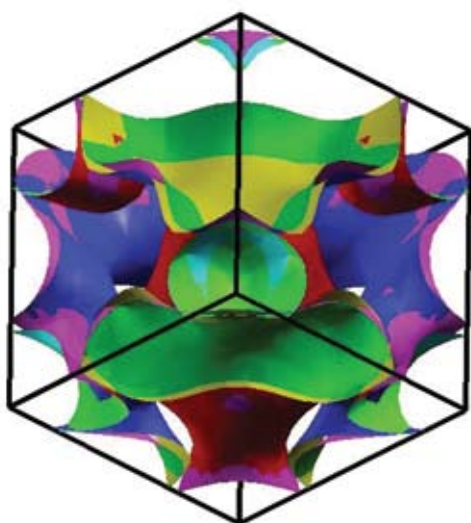


Figure 2: Picture of the Fermi surface (visualized with the program Xcrysden) for the majority spin states in the magnetocaloric alloy LaFe₁₃

We found a new composition of quasicrystal phase (i-phase), Ti₅₈Zr₂₄Ni₁₈, which has not been reported previously. This material absorbed the largest amount of hydrogen of all our samples, up to 2.4 mass percent.

We continued our work on **quasicrystals** as a promising material for **hydrogen storage** by performing melt-spinning experiments on Ti-Zr-Ni-Cu alloys with various compositions: Ti₄₀Zr₄₀Ni₂₀, Ti₄₅Zr_{38-x}Ni₁₇Cu_x (x=3.5), Ti₅₃Zr_{27-x}Ni₂₀Cu_x (x=3.5) and Ti₅₈Zr_{24-x}Ni₁₈Cu_x (x=3.5). We were mainly interested in the formation of the icosahedral quasicrystalline phase (the i-phase). From previous studies we know that the optimal cooling rate for i-phase formation is at a wheel speed of 22 m/s. Using this technique we prepared a series of samples under identical conditions, varying only the composition. XRD results showed that the i-phase is formed across a relatively wide range of compositions. Also, with increasing content of titanium from the ideal value (40 at.%) the content of crystalline phases increases (the hexagonal C14 Laves phase and the FCC cubic (Ti, Zr) solid solution). Doping with copper, in general, does not contribute to a higher i-phase content. With a higher titanium-to-zirconium ratio the quasicrystalline lattice constant a_i is linearly decreasing. A **new composition of i-phase** was found, i.e., **Ti₅₈Zr₂₄Ni₁₈**, which to the best of our knowledge has not been reported previously. This material absorbed the largest amount of hydrogen of all our samples, up to **2.4 mass percent**. Using XPS analysis we determined that the thickness of the oxide layer containing TiO₂ and ZrO₂ in the surface of melt-spun ribbons was 5 nm. Using mass spectrometry we analysed the desorbed hydrogen and discovered that the **bonding energy of the hydrogen** depends only on the structure of the material, and not on the composition, nor on the content of bonded hydrogen.

In the frame of the EU MNT-ERA.Net project “Hydrogen-impermeable nano-material coatings for steels” (Hy-nano-IM) we investigated the possibility of producing **hydrogen-impermeable coatings** for steels for

the long-term storage and transport of gaseous and liquid hydrogen. Initial efforts have been focused on depositing diamond-like carbon (DLC) layers, either directly onto a steel substrate, or in combination with a chromium layer, to improve the adhesive properties. High-resolution transmission electron microscopy has been employed to investigate the layer thickness and the state of the boundaries between the steel, chromium and DLC.

The technologically interesting properties of materials were studied within the framework of the density-functional theory. We focused on **calculations of the transport properties** in the approximants of quasicrystals and the alloys which exhibit magnetocaloric effect by applying the semi-classical Boltzman theory and the relaxation-time approximation.

In the field of intermetallic alloys with **magnetocaloric properties** we continued our research by studying iron substitutions in the matrix phase. We observed very significant differences in terms of the macrostructures, microstructures and magnetic properties. The matrix phase with the **Gd₅(Si,Ge)₄** composition and no iron addition is gradually replaced by the new matrix phase Gd₅(Si,Ge)₃, when substituted with iron. The iron contributes mainly to the grain-boundary phases that are formed and to a change in the relative amounts of Si and Ge in the matrix phases. The final properties are strongly dependent on the element that is substituted. This also affects the transition temperature of the alloy. The low losses and the broad **ΔS peak** suggest that the first-order transition is suppressed when substituting germanium. However, this is not the case when substituting silicon. Here, a sharp peak and large hysteresis losses are present. The TEM study confirmed the presence of twins in the Gd₅Si₂Ge₂ sample and revealed the presence of features not seen previously in the iron-containing sample, such as amorphous regions, dislocations, planar faults and crystallographically related grains.

Nanostructured magnetic-based materials, such as in-situ-nitrogenated Sm-Fe-based **magnetic nanospheres** prepared by pulsed-laser deposition (PLD), were investigated by employing state-of-the-art techniques of TEM. The magnetic response of individual nanospheres was detected and quantified for the first time in this system by applying **electron holography**. The development and implementation of electron holography is part of the **EU project ESTEEM**. The electron energy-loss spectroscopy (EELS) technique was implemented to study multilayer coatings based on the Ti/Al/Cr/V-N system. By using **spatially resolved EELS** we were able to simultaneously detect and quantify the amount of N and the related electronic structure in the investigated phases, enabling us to trace the compositional and structural differences across the interfaces localized over only a few nanometres. In the Zn-Mn-O system the thermal evolution of spinel phases was found to be induced by the Mn(IV) to Mn(III) reduction

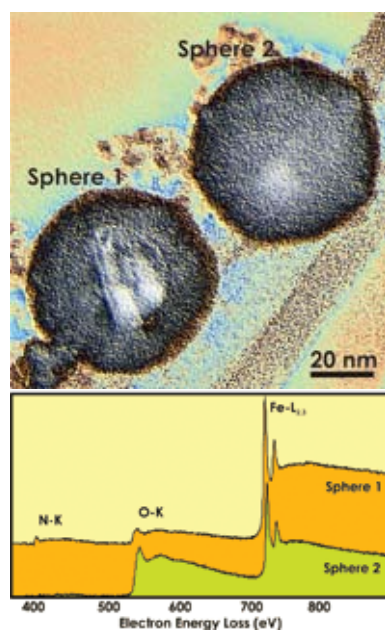


Figure 3: Above: TEM image of two representative in-situ nitrogenated Sm-Fe-based nanospheres prepared by PLD: one amorphous and the other with a core-shell structure, where the amorphous rim and the crystalline core can be differentiated. Below: EEL spectra confirming that the nitrogen is associated only with the core-shell-type of nanospheres.

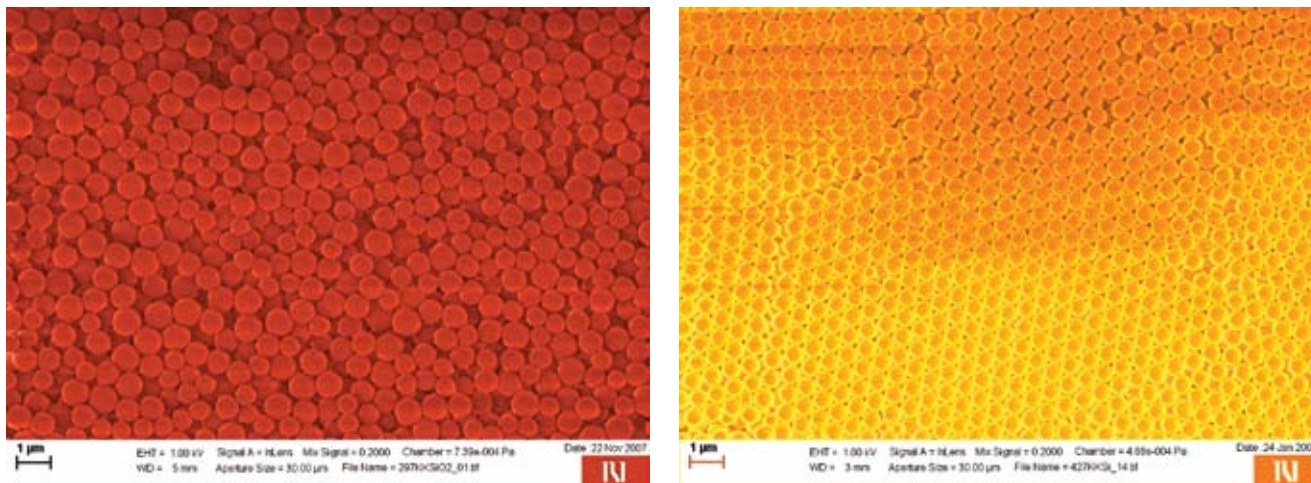


Figure 4. Random structure (left) and well-ordered structure (right) of nanosized SiO_2 in a deposit processed by electrodeposition. The ordering was achieved by adjusting the surface charge of the particles (Collaboration with NIGS).

process. This phenomenon was successfully experimentally verified by tracing the $\text{Mn}^{4+}/\text{Mn}^{3+}$ ratio of the spinel phases sintered at different temperatures by a detailed fine-structure analysis of the EELS Mn-L_{2,3} ionization edges. We also studied doped anatase nanowires using HRTEM and EDXS. By combining electrical measurements with TEM studies a potential use of nanostructured anatase for Li-based batteries was successfully demonstrated.

Our research work also involves **colloidal processing**, which enables us to prepare composite materials with improved properties as well as to develop new forming techniques. Based on a comprehensive study of the electrokinetic behaviour of the fine particles and fibres we developed an efficient electric-field-assisted technique for the infiltration of thick ceramic fibre-fabrics with ceramic particles and hence to prepare **composites SiC_f/SiC and C_f/SiC** , which are being developed as part of a collaboration within the European Fusion Research Programme and with the French Atomic Energy Agency, CEA. The electrophoretic deposition technique has also been employed for the deposition of a **thin bioglass coatings** on metallic body implants and, in collaboration with National Institute of Chemistry, Ljubljana, for the assembly of monodispersed SiO_2 nanospheres as well as for the separation of the inclusion bodies used as therapeutic agents from the bacteria matrix.

A part of the research within the EU 6FP project **MEDDELCOAT** has been focused on the synthesis and study of **bioactive titania coatings** on Ti6Al4V body implants that should, in particular, prevent the diffusion of toxic elements (Al, V) from the alloy into the body. A layer of anatase, up to 1 µm thick, has been successfully synthesized by hydrothermal treatment and proved to beneficially affect the wetting behaviour as well as a the cells' response.

We continued the research and development of new fusion-relevant materials within the **European fusion programme** Euratom. The first batch of fibre-reinforced composite samples for neutron irradiation has been prepared and in collaboration with the Department for Reactor Physics irradiated in the TRIGA reactor and analyzed for their activation. It has been proved that the activations were lower than those for the other available fusion-relevant materials. Lately, the most attention has been paid to the required increase in thermal conductivity, which we have tried to increase by the incorporation of tungsten or carbon nanotubes.

The nucleation and crystallization of various nanomaterials were investigated using analytical electron microscopy. In collaboration with different research groups from Slovenia, Croatia, Greece and Portugal we studied the evolution of particles in NiO, SiO_2 , InN, CeO_2 and TiO_2 . Using high-resolution electron microscopy and Z-contrast imaging we determined the quantity, morphology and the position of the nanoparticles of Pt and Au on matrix CeO_2 - TiO_2 used as a material for catalysis. We also studied the development and the structure of ZnO nanoparticles and the formation of mesoporosity in SiO_2 gels. Together with our industrial partner Cinkarna Celje we investigated the chemical composition and the structure of nanometre-sized Al_2O_3 - SiO_2 coatings on the top of **TiO_2 rutile particles**, which improve the optical and chemical properties of the pigment. We found that at the coating–rutile particle interface there is a very thin layer (a few atomic layers thick) of alumina. Based on these results the technological procedure during the fabrication of the rutile pigment was optimized.

In the field of the **nanosstructural engineering** of semiconducting materials we have shown in several polycrystalline materials that special boundaries are responsible for anisotropic and exaggerated grain growth. The most common types of special boundaries in semiconducting materials are the so-called inversion boundaries (IBs), which form with the addition

The magnetic response of individual nanospheres of Sm-Fe-Ta-N was detected and quantified for the first time by applying electron holography. The development and implementation of electron holography is part of the EU project ESTEEM.

Composite materials with improved properties were prepared by using colloidal processing. In the frame of the European fusion research programme we developed an efficient electric-field-assisted technique for the infiltration of thick ceramic fibre-fabrics with ceramic particles and hence to prepare composites of SiC_f/SiC and C_f/SiC.

parameters for the reproducible synthesis of either ZnO tetrapodes or arrays of ZnO nanorods were determined. Also, the synthesis of ZnO nanopowder from water solutions with different concentrations of Zn-acetate using a combination of spray-drying and the decomposition of Zn-acetate powder to ZnO, either by conventional or microwave calcinations, was studied. The advantages of microwave calcinations resulted in the preparation of uniform ZnO powder with the size of the spherical particles being about 80 nm and the crystallite size being about 20 nm. Based on studies of **ZnO ceramics** doped with only up to several 1000 ppm of Bi₂O₃ and Sb₂O₃ we determined the conditions for tailoring the microstructure using the IB-induced grain-growth mechanism. We prepared a fine-grained and, like the first one, also a coarse-grained ZnO ceramic doped with Bi₂O₃ and Sb₂O₃, with an average grain size much larger than in pure ZnO, sintered under the same conditions. Consequently, we were able to prepare low-doped varistor ceramics with the addition of only about 3 wt.% of varistor dopants (typical

additions are about 10 wt.%) with the grain size in the range from 22 μm to 7 μm, the breakdown voltage from 100 V/mm to 330 V/mm and the nonlinearity between 30 and 50. The synthesis of conductive **polymer composites** was also studied. Using thermal curing of the mixtures from a polyethylene powder (matrix) and varistor powder (filler), varistor-type polymer composites with current-voltage nonlinearity expressed in the nonlinear coefficient ranging from 9 to 17, depending on the amount of filler and the curing temperature, were prepared. Also, **hollow varistors** with lengths from 30 to 60 mm, outer diameter 10 to 25 mm and wall thickness from 2 to 4 mm, were successfully prepared using slip-casting technology of a varistor water suspension into a gypsum mould.

Perovskite BaTiO₃ nanorods and **SrTiO₃ nanotubes** were synthesized by sol-gel electrophoretic deposition into track-etched hydrophilic polycarbonate (PC) membranes and/or anodic aluminium oxide (AAO) membranes. The stability of the sols and the optimization of the parameters for the electro-deposition was a prerequisite for successful synthesis. The obtained nanorods and nanotubes were polycrystalline in nature with diameters ranging from 100 to 250 nm and grain sizes from 25 to 50 nm. Electron diffraction studies and high-resolution TEM revealed that the BaTiO₃ nanorods consist of all three polymorph structures (cubic, tetragonal and hexagonal), while the SrTiO₃ nanotubes possess a cubic structure. Hydrothermal synthesis was used to synthesize BiFeO₃, goethite and hematite in various nanosized morphologies. **Multiferroic BiFeO₃** and hematite were obtained in the shape of isotropic nanocubic crystals, while goethite was prepared as nanorods. The aspect ratio of the goethite nanorods was controlled by varying the concentration of Bi³⁺ ions in the reaction. The observed stacking faults in the hematite may indicate potential sites for additional Bi³⁺ incorporation, suggesting a possible mechanism for the synthesis of **nanosized BiFeO₃ in anisotropic morphologies**.

One of the important research areas of the group is the **implementation and development** of various **electron microscopy analytical techniques** within the existing EU project ESTEEM, such as electron energy-loss spectroscopy (EELS), high-resolution scanning transmission electron microscopy (STEM, HAADF-STEM), electron holography and the mechanical preparation of TEM samples. In atomically resolved HAADF-STEM we were among the first to show, on the model ceramic materials CaTiO₃, SrTiO₃ and BaTiO₃, that the local lattice distortions, apart from chemical composition,

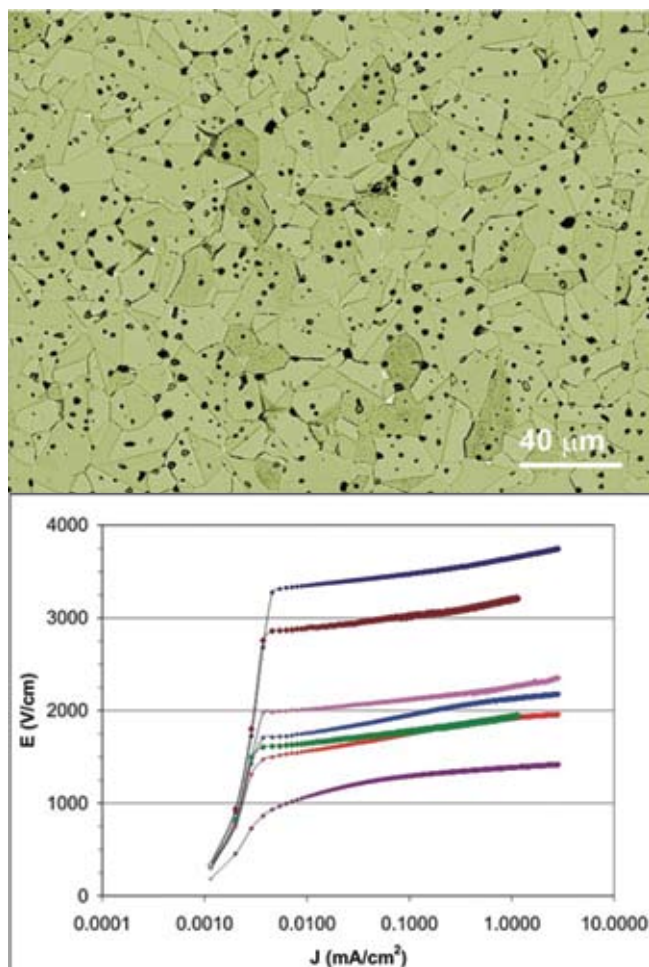


Figure 5: Tailoring the microstructure using an inversion-boundary-induced grain-growth mechanism enabled us to prepare ZnO varistor ceramics with the desired grain size. These ceramics have excellent varistor characteristics expressed by the current-voltage coefficient of nonlinearity in the range from 30 to 50, and the breakdown voltage in the range from 100 V/mm to more than 300 V/mm, depending on the ZnO grain size, which is in the range from 7 μm to 22 μm.

significantly influence experimentally determined intensities of single-atom columns. Furthermore, we showed that realistic values of the Debye-Waller factor for atoms comprising the investigated structure (interface, planar fault, etc.) are needed for an exact quantitative interpretation of the experimental HAADF-STEM intensities. Only then can the intensities of atom columns in the simulated images correspond to true values and can they be successfully compared with the intensities in simulated images. The research group is additionally heavily involved in managing the **Center for Electron Microscopy** within the frame of the national infrastructure Center for Microstructural and Surface Analysis.

The implementation of various electron microscopy analytical techniques and the possibility for researchers to access a research infrastructure for electron microscopy is of utmost importance for numerous research institutions, industrial partners, as well as for graduate and post-graduate education.

Hydrothermal synthesis was used to synthesize BiFeO_3 , goethite and hematite in various nanosized morphologies. Multiferroic BiFeO_3 and hematite were obtained in the shape of isotropic nanocubic crystals, while goethite was prepared as nanorods.

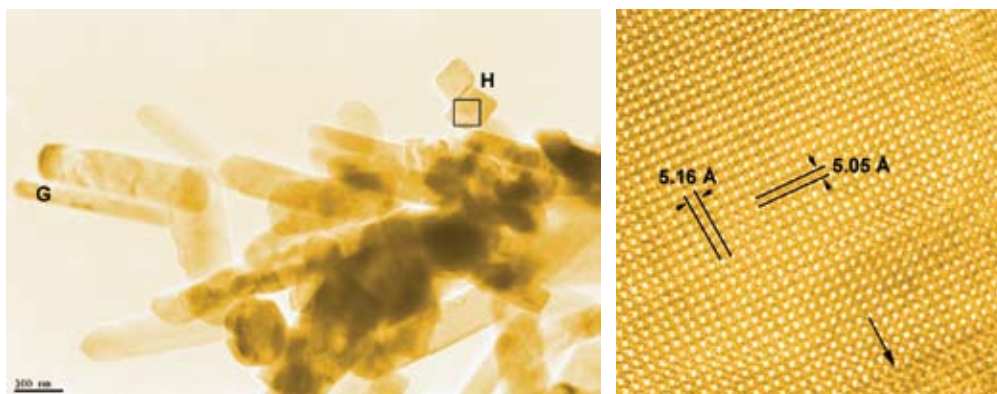


Figure 6: (left) Goethite (G) nanorods and hematite (H) nanocubes after 1 week of hydrothermal reaction. (right) HRTEM of hematite with stacking faults (denoted by arrow).

The most important technological achievements in the past year

1. Novak, Saša, Rade, Katja, Koenig, Katja, Boccaccini, Aldo R. Electrophoretic deposition in the production of SiC composites for fusion reactor applications, J. Eur. Ceram. Soc., 28 (2008)14, 2801-2807.
2. Cefalas, Alciviadis-Constantinos, Kobe, Spomenka, Dražić, Goran, Sarantopoulou, Evangelia, Kollia, Zoe, Stražičar, Janez, Meden, Anton. Nanocrystalization of CaCO_3 at solid/liquid interfaces, Appl. surf. sci., 254 (2008)21, 6715-6724.
3. Kocjan, Andraž, McGuinness, Paul J., Rajič Linarič, Maša, Kobe, Spomenka. Amorphous-to-quasicrystalline transformations in the Ti-Zr-Ni and Ti-Hf-Ni systems, J. alloys compd., 457 (2008)1/2, 144-149.
4. Srecković, Tatjana, Bernik, Slavko, Čeh, Miran, Vojisavljević, Katarina. Microstructural characterization of mechanically activated ZnO powders, J. Microsc. (Oxf.), 232 (2008)3, 639-642.
5. Lazar, Petr, Šturm, Sašo, N-K electron energy-loss near-edge structures for TiN/VN layers : an ab initio and experimental study, Anal. bioanal. chem., 390 (2008)6, 1447-1453.

Patent granted

1. Tool for measuring magnetic properties at high temperatures
Paul J. McGuinness, Gregor Geršak, Spomenka Kobe
patent US7368906 B2

Awards and Appointments

1. Katja Koenig: "Influence of the suspension stability on the electrophoretic deposition of nanosized alumina and silica"; 3rd Best Poster Award, HOT NANO TOPICS 2008, Workshop "Functional nanostructures and particles", Portorož, 26-30 May 2008.
2. Katarina Rade: "Hungry Bacteria Was Here". 3rd Best nanoArt Contribution at the HOT NANO TOPICS 2008, Portorož, 23-30 May 2008, for the nanoArt photo of the Hydroxyapatite precipitated from simulated body fluid on bio-glass substrate.

Organization of conferences, congresses and meetings

1. WomenInNano Winter School, Kranjska Gora, Slovenia, 5–8 Feb. 2008
2. Hot Nano Topics 2008 incorporating SLONANO2007; 3 overlapping workshops on current hot subjects in nanoscience, Portorož, Slovenia, 23–30 May 2008 (co-organisation)
3. 1st International Conference on Materials and Technology sponsored by FEMS and IUUVSTA, Portorož, Slovenia, 13–15 Oct. 2008 (co-organisation)
4. European School in Materials Science: Properties and Application of Complex Metallic Alloys, Ljubljana, Slovenia, 26–31 May 2007 (co-organisation)
5. 20th Workshop on rare Earth Permanent Magnets and Applications, REPM '08, Heraklion, Crete, Greece, 8–10 Sept. 2008 (member of International Scientific Board)

INTERNATIONAL PROJECTS

1. Development of Composites with Advanced/Alternative Manufacturing Concepts: Vacuum slip infiltration of SiC/SiC - 4.1.2. FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Goran Dražič, Asst. Prof. Saša Novak Krmpotič
2. Development of functional material for insulating flow channel inserts: Ceramic Processing of SiC Composites for Functional Application - 4.1.1. FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Saša Novak Krmpotič, Asst. Prof. Goran Dražič
3. Research Unit - Administration and Services - RU-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Saša Novak Krmpotič, Prof. Milan Čerček
4. FUSEX: Fusion Expo Support Action
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education, Science and Technology, Ljubljana, Slovenia
Asst. Prof. Saša Novak Krmpotič, Melita Lenošek
5. SiC/SiC composite for structural application in fusion reactor, WPO08-09-MAT-SiSiC, EUROATOM-MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA, FU07-CT-2007-00065
Asst. Prof. Goran Dražič
6. Multifunctional Bioresorbable Biocompatible Coatings with Biofilm Inhibition and Optimal Implant Fixation
MEDDELCOAT
6. FP, NMP3-CT-2006-026501
EC; Prof. Jozef Vleugels, Katholieke Universiteit Leuven, Research & Development, Leuven, Belgium
Asst. Prof. Saša Novak Krmpotič
7. Enabling Science and Technology through European Electron Microscopy
ESTEEM
6. FP, 026019
EC; Prof. Gustaaf Van Tendeloo, Universiteit Antwerpen, Antwerpen, Belgium
Asst. Prof. Miran Čeh, Dr. Sašo Šturm
8. Complex Metallic Alloys
CMA
6. FP, NMP3-CT-2005-500140
EC; Centre National de la Recherche Scientifique, Paris, France
Prof. Spomenka Kobe, Prof. Janez Dolinšek, Dr. Peter Panjan
9. Strengthening the Role of Women Scientists in Nano-Science
WOMENINANO
6. FP, SAS6, 016754
EC; Dr. Annett Gebert, IFW Dresden, Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden E.V., Dresden, Germany
Prof. Spomenka Kobe
10. Hydrogen Impermeable Nano-material Coatings for Steels
Hy - Nano - IM
MNT ERA NET
Dr. Paul McGuinness
11. Development of Ceramic Matrix Composite for Advanced Nuclear Applications, with an SiC Continuous Fiber Reinforcement and a Nanostructured Carbide Matrix, Processes by the Electrophoretic Infiltration
1000-07-380046
Dr. Jérôme Canel, Commissariat à l'énergie atomique - CEA Saclay, Gif-sur-Yvette, France
Asst. Prof. Saša Novak Krmpotič
12. Influence of Quantum Effects on Vibrational Properties of Nano-crystalline Silicon
BI-HR/07-08-028
Dr. Davor Gracin, Rudjer Boškovic Institute, Zagreb, Croatia
Asst. Prof. Miran Čeh
13. Environmental Hydrogen-based Recycling of Nd-Fe-B magnets
BI-CN/05-07/008
dr. Gaolin Yan, Harbin Institute of Technology, ShenZhen Graduate School, HIT Campus of ShenZhen University Town, ShenZhen, China
dr. Paul McGuinness
14. Structural and Chemical Characterization of Titanate-based Nanorods and Nanotubes
BI-CN/07-09-006
Prof. Hui Gu, Shanghai Institute of Ceramics, Shanghai, China
Asst. Prof. Miran Čeh
15. Synthesis and Characterization of Nanostructured Catalytic Materials
BI-PT/08-09-003
Dr. Adrian M.T. Silva, Associated Laboratory LSRE/LCM, FEUP-University of Porto, Porto, Portugal
Asst. Prof. Goran Dražič
16. Development of Single Crystalline and Electroceramic Materials by Sintering Process
BI-TR/05-08-002
Prof. Mehmet Ali Gülgün, Sabanci University, Orhanli Tuzla, Istanbul, Turkey
Asst. Prof. Miran Čeh
17. Texturing and Characterisation of ZnO-based Ceramics
BI-TR/05-08-003
Prof. Ender Suvaci, Anadolu University, Department of Materials Science and Engineering, Eskisehir, Turkey
Dr. Slavko Bernik
18. ZnO-Nanostructures for Novel Applications
BI-RS/08-09-015
Dr. Zorica Branković, Center for multidisciplinary studies, Belgrade, Serbia
Dr. Slavko Bernik
19. Development of fusion relevant ceramic matrix composites, BI-GB/08-007
prof. dr. Aldo Boccaccini, Imperial College London, Department of Materials, London, UK
doc. dr. Saša Novak Krmpotič

R & D GRANTS AND CONTRACTS

1. Fabrication of novel thin films by pulsed-laser ablation with in situ ICP-MS analysis of target plumes for deposition control
Prof. Spomenka Kobe
2. Nanostructural engineering of semiconducting materials
Dr. Aleksander Rečnik
3. A development of low-activation material for the first wall in fusion reactor
Asst. Prof. Saša Novak Krmpotič
4. The influence of magnetic structure of the materials on the magnetocaloric effect
Dr. Matej Andrej Komelj
5. Ecotechnological 1D nanomaterials: Synthesis and characterisation of 1D titanate nanomaterials doped with transition metal ions
Dr. Polona Umek, Dr. Sašo Šturm
6. Physics and chemistry of interfaces of nanostructured metallic materials
Asst. Prof. Miran Čeh
7. Low-doped ZnO-based ceramics for energy varistors
Dr. Slavko Bernik

8. Hard magnetic Co-Pt thin films produced with electrodeposition
Prof. Spomenka Kobe, Dr. Kristina Žužek Rožman
9. Development of ceramic matrix composite for advanced nuclear applications, with an
sic continuous fiber reinforcement and a nanostructured carbide matrix, processes by
the electrophoretic infiltration
Dr. Saša Novak Krmpotić

RESEARCH PROGRAM

1. Nanostructured materials
Prof. Spomenka Kobe

VISITORS FROM ABROAD

1. Aidan Taylor, Erich Smid Institut für Materialwissenschaft und Montanuniversität
Leoben, Leoben, Austria, 28 Jan. to 1 Feb. 2008
2. Dr Davor Gracin, Institut Rudjer Bošković, Zagreb, Croatia, 30 Jan. 2008
3. Prof. Marie-Geneviève Barthes-Labrousse, CNRS, Centre d'Etudes de Chimie
Metallurgique, Vitry Cedex, France, 5-6 Feb. 2008
4. Karl Höhner, Temas AG, Arbon, Switzerland, 5-6 Feb. 2008
5. Prof. Aldo Boccaccini, Imperial College London, London, United Kingdom, 24 May 2008
6. Dr Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 25-30 May 2008
7. Prof. Mihály Posfai, Ilona Kósa and Dorottya Sára Csákbérenyi Nagy, University of
Pannonia, Veszprém, Hungary, 24-25 May 2008
8. Prof. Michael Coey, Trinity College, Dublin, Ireland, 30-31 May 2008
9. Dr Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 10 Jun. 2008
10. Dr Mehmet Ali Gülgün, Sabanci University, Istanbul, Turkey, 18-20 Jun. 2008
11. Prof. J.-M. Dubois, CNRS, Ecole de Mines, Nancy, France, 9 Feb. 2008
12. Prof. A. C. Cefalas, National Hellenic Research Foundation, Athens, Greece, 9 Feb. 2008
13. Dr Mehmet Ali Gülgün, Sabanci University, Istanbul, Turkey, 1 Oct. 2008 to 28 Feb. 2009
14. Prof. Jing Shi, Dr Gaolin Yan, Lifeng Fu, Harbin Institute of Technology, Harbin, China,
13-20 Sept. 2008
15. Dr Adrian Silva, Faculdade de Engenharia da Universidade do Porto, Departamento de
Engenharia Quimica, Porto, Portugal, 12-19 Oct. 2008
16. Prof. J.-M. Dubois, CNRS, Ecole de Mines, Nancy, France, 30 Sept. to 1 Oct. 2008
17. Dr Dan Gazit, Negev Nuclear Research Center, Haifa, Israel, 10 Oct. 2008
18. Dr Davor Gracin, Dr Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 20. Oct. 2008
19. Dr Helder Gomes, Faculdade de Engenharia da Universidade do Porto, Departamento de
Engenharia Quimica, Porto, Portugal, 9-14 Nov. 2008
20. Decheng Meng, Imperial College London, United Kingdom, 5-14 Dec. 2008
21. Dr Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 1-3 Dec. 2008
22. İsmail Özgür Özer, Anadolu University, Department for Materials Science and
Engineering, Eskişehir, Turkey, 27 Nov. to 16 Dec. 2008
23. Dr Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 19-24 Dec. 2008

STAFF

Researchers

1. Dr. Slavko Bernik
2. Asst. Prof. Miran Čeh
3. Dr. Nina Daneu
4. Asst. Prof. Goran Dražić
5. **Prof. Spomenka Kobe, Head**
6. Dr. Matej Andrej Komelj
7. Asst. Prof. Paul John McGuinness
8. Asst. Prof. Saša Novak Krmpotić
9. Dr. Aleksander Rečnik
10. Dr. Sašo Šturm

Postdoctoral associates

11. Dr. Kristina Žužek Rožman

Postgraduates

12. Nataša Drnovšek, B. Sc.

13. Barbara Horvat, B. Sc.
14. Aljaž Iveković, B. Sc.
15. Andraž Kocjan, B. Sc.
16. Katja König, B. Sc.
17. Alenka Lenart, B. Sc.
18. *Blaž Miklavič, B. Sc., left 1 Oct. 2008*
19. Katarina Rade, B. Sc.
20. Dr. Zoran Samardžija
21. Tea Toplišek, B. Sc.
22. Kristina Žagar, B. Sc.

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23. Sanja Fidler, B. Sc.
24. Medeja Gec, B. Sc.
25. Matejka Podlogar, B. Sc.
26. Benjamin Podmiljšak, B. Sc.

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Slavko Bernik, Goran Branković, Saša Rustja, Milan Žunić, Matejka Podlogar, Zorica Branković, "Microstructural and compositional aspects of ZnO-doped varistor ceramics prepared by direct mixing of the constituent phases and high-energy milling", *Ceram. int.*, vol. 34, no. 6, pp. 1495-1502, 2008.
2. Slavko Bernik, Matejka Podlogar, Nina Daneu, Aleksander Rečnik, "Tailoring the microstructure of ZnO-based ceramics", *Mater. tehnol.*, vol. 42, no. 2, pp. 69-77, 2008.
3. Jana Bezjak, Boštjan Jančar, Aleksander Rečnik, Danilo Suvorov, "The synthesis and polymorphic phase transitions of $Ba_xNb_2O_9$ ceramics", *J. Eur. Ceram. Soc.*, issue 14, vol. 28, pp. 2771-2776, 2008.
4. Aldo R. Boccaccini, Florencia Chicatun, Johann Cho, Oana Bretcanu, Judith A. Roether, Saša Novak, Qizhi Chen, "Carbon nanotube coatings on bioglass-based tissue engineering scaffolds", *Adv. funct. mater. (Print)*, vol. 17, no. 15, pp. 2815-2822, 2008.
5. Maja Buljan, Uroš Desnica, Mile Ivanda, Nikola Radić, Pavo Dubček, Goran Dražić, K. Salamon, Sigrid Bernstorff, Václav Holý, "Formation of three-dimensional quantum-dot superlattices in amorphous systems: experiments and Monte Carlo simulations", *Phys. rev. B, Condens. matter mater. phys.*, vol. 79, no. 3, pp. 035310-1-035310-11, 2008.
6. Alciviadis-Constantinos Cefalas, Spomenka Kobe, Goran Dražić, Evangelia Sarantopoulou, Zoe Kollia, Janez Stražišar, Anton Meden, "Nanocrystallization of $CaCO_3$ at solid/liquid interfaces", *Appl. surf. sci.*, vol. 254, no. 21, pp. 6715-6724, 2008.
7. Alciviadis-Constantinos Cefalas, Spomenka Kobe, Evangelia Sarantopoulou, Zoran Samardžija, Mersida Janeva, Goran Dražić, Zoe Kollia, "Growth, clustering and morphology of intermetallic alloy core-shell nanodroplets", *Phys. status solidi, A, Appl. res.*, vol. 206, no. 6, pp. 1465-1471, 2008.
8. Alciviadis-Constantinos Cefalas, Janez Kovač, Evangelia Sarantopoulou, Goran Dražić, Zoe Kollia, Spomenka Kobe, "Growth and adhesion of biphasic crystalline-amorphous Sm/Fe-Ta-N magnetic nanospheroids on a Ta surface", In: *The 12th European conference on applications of surface and interface analysis: Brussels, Belgium, 9-14 September 2007: ECASIA'07*, (Surface and interface analysis, Vol. 40, Issues 3-4), Wiley, 2008, Heyden & Son, vol. 40, no. 3/4, pp. 364-367, 2008.
9. Romana Cerc Korošec, Jerneja Šauta, Petra Draškovič, Goran Dražić, Peter Bukovec, "Electrochromic nickel oxide/hydroxide thin films prepared by alternately dipping deposition", *Thin solid films*, vol. 516, no. 23, pp. 8264-8271, 2008.
10. Goran Dražić, Spomenka Kobe, Alciviadis-Constantinos Cefalas, Evangelia Sarantopoulou, Zoe Kollia, "Observation of nanostructured cluster formation of Tm ions in CaF_2 crystals", In: *Proceedings of 4th International Workshop on Nanosciences & Nanotechnologies, (NN07) 16-18 July 2007, Thessaloniki, Greece*, (Materials science & engineering, B, Solid-state materials for advanced technology, vol. 152, no. 1/3, 2008), Lausanne, Elsevier Sequoia, 2008, vol. 152, no. 1/3, pp. 119-124, 2008.

11. Boštjan Erjavec, Robert Dominko, Polona Umek, Sašo Šturm, Stane Pejovnik, Miran Gaberšček, Janko Jamnik, "RuO₂ – wired high-rate nanoparticulate TiO₂ (anatase)", *Electrochem. commun.*, vol. 10, no. 6, pp. 926-929, 2008.
12. Davor Gracin, Andreja Gajović, Krunoslav Juraić, Miran Čeh, Z. Remeš, A. Poruba, Mirko Vančček, "Spectral response of amorphous-nano-crystalline silicon thin films", In: *Proceedings of 22nd International Conference on Amorphous and Nanocrystalline Semiconductors - Science and Technology Breckenridge, CO, USA 19-24 August 2007*, (Journal of non-crystalline solids, vol. 354, no. 19/25, 2008), Amsterdam, North-Holland, 2008, vol. 354, no. 19/25, pp. 2286-2290, 2008.
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THESIS

B. Sc. Thesis

1. Vesna Papež, *Electrochemical deposition of hard magnetic Co-Pt-based thin films* (Prof. Boris Pihlar, Dr. Kristina Žužek Rožman)

DEPARTMENT FOR MATERIALS SYNTHESIS

K-8

The research of the Department for Materials Synthesis is mainly related to the synthesis of different advanced materials, especially magnetic and semiconducting oxides. Special attention is given to nanostructured materials, such as ferrofluids, functionalized nanoparticles for use in biomedicine, multifunctional nanocomposites, and magnetic coatings for use in the microwave-frequency range.

In 2008 our investigations were directed to three important materials, i.e., materials containing magnetic nanoparticles, microwave magnetic ceramics and ceramic coatings for use in the area of telecommunications, and ferroelectric materials with a high Curie temperature for the preparation of high-temperature thermistors.

The research on magnetic nanoparticles mainly focused on their functionalization. For biomedical applications, the magnetic nanoparticles should be functionalized with a surface layer of organic molecules, which enables the selective bonding of different bioactive molecules to their surfaces. At the same time, the functionalization layer allows the nanoparticles to be compatible with physiological fluids and prevents their agglomeration. The bonding of different organosilane molecules directly onto the nanoparticles' surfaces or through a surface layer of silica was systematically studied. The functionalization layer was then used to further bind different molecules that are needed in biomedical applications. In cooperation with the National Institute of Chemistry, University of Ljubljana, we have studied the coordination binding of histidine-rich protein and its controlled release from nanoparticles. In cooperation with the Faculty of Pharmacy, University of Ljubljana, we studied the targeting of nanoparticles into cancer cells using the bonding of monoclonal antibodies.

A significant part of our research has been devoted to the synthesis of nanoparticles. In cooperation with the Faculty of Chemistry and Chemical Engineering, University of Maribor and with the support of the co-founder Nanotesla Institute we were the first in the world to synthesize superparamagnetic nanoparticles of Ba-hexaferrite ($\text{BaFe}_{12}\text{O}_{19}$) using the hydrothermal method. Normally, high temperatures are needed to form hexaferrite, resulting in relatively large particles. By understanding the involved mechanisms, especially the formation of iron hydroxo complexes at increased pH, we managed to decrease the temperature of hexaferrite formation during hydrothermal synthesis, and consequently to decrease the nanoparticle size to the superparamagnetic range. The structural and magnetic properties of Ba-hexaferrite nanoparticles have been extensively studied. We also prepared stable colloidal suspensions – ferrofluids, based on Ba-hexaferrite.

In cooperation with the Faculty of Electrical Engineering and Computer Science, University of Maribor, we developed a system for measurements of ferrofluid energy dissipation under high-frequency magnetic fields. The apparatus will be used in the testing of the ferrofluids for magnetic hyperthermia.

A new method for the synthesis of particles of cubic magnetite spinel with an anisotropic plate-like shape and of spinel-hexaferrite intergrowth nanocomposite particles has been developed. The method is based on the hydrothermal decomposition of pre-synthesized Ba-hexaferrite ($\text{BaFe}_{12}\text{O}_{19}$) particles in the presence of NaHCO_3 and a hydrazine reducing agent. By the preferential reaction of Ba from the layered, hexagonal structure of $\text{BaFe}_{12}\text{O}_{19}$ with CO_3^{2-} , the hexaferrite crystals disintegrate to thin platelets containing only the cubic spinel magnetite. When the disintegration is only partial, nanocomposite particles containing an intergrowth of spinel and hexaferrite are obtained.

Synthesized superparamagnetic nanoparticles were dispersed in different matrixes and thus superparamagnetic nanocomposites were prepared. Here, it is of crucial importance to disperse a high content of nanoparticles to ensure high magnetizations, without their agglomeration, which would influence their superparamagnetic properties. The



Head:
Prof. Darko Makovec

Hard-magnetic particles were successfully stabilized in polar media and hard-magnetic ceramic films were prepared by electrophoretic deposition.

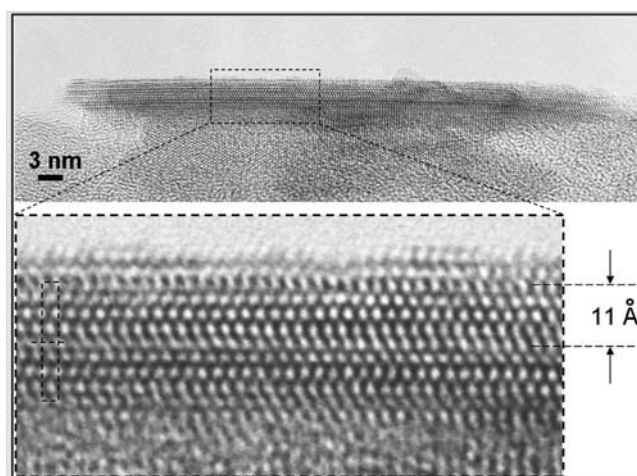


Figure 1: High-resolution electron micrograph of a superparamagnetic Ba-hexaferrite nanoparticle synthesized using the hydrothermal method.

The functionalization of magnetic nanoparticles by binding different silane molecules to their surfaces, directly or through a thin silica layer, was studied.

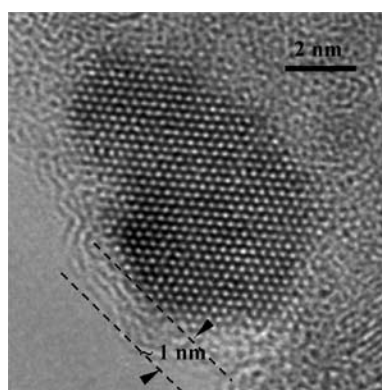


Figure 2: High-resolution electron micrograph of a magnetic nanoparticle coated with a thin layer of silica.

A method for the synthesis of superparamagnetic photocatalytic nanocomposite nanoparticles for the decomposition of organic pollutants in water was developed.

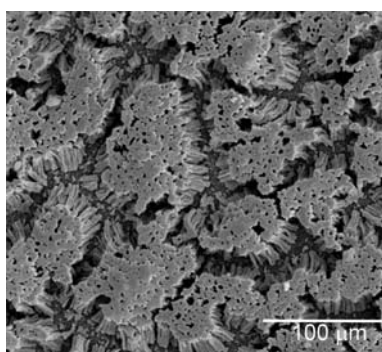


Figure 3: Top view of an artificially structured magnetic layer prepared by the magnetophoretic deposition of $BaFe_{12}O_{19}$ particles.

We were the first to successfully stabilize hard-magnetic particles in polar media and we prepared hard-magnetic ceramic films by electrophoretic deposition.

nanocomposites containing large amounts of the magnetic nanoparticles were prepared with the polymerization of their suspensions in a methyl methacrylate monomer. Using polymerization in a mini-emulsion system, round nanocomposite particles were prepared, which can be used as magnetic beads for magnetic separation.

We also studied the synthesis of nanocomposite particles used for the decomposition of organic pollutants in water. The nanocomposite particles are composed of photocatalytic anatase (TiO_2) nanoparticles coated on the superparamagnetic maghemite (Fe_2O_3) nanoparticles. For the photocatalytic purification, the particles are dispersed in polluted water. The surface layer provides high photocatalytic activity, while the superparamagnetic cores enable the separation of the particles from the suspension after the purification and their re-dispersion. In cooperation with the co-founder Cinkarna and researchers from the Public Health Institute, Maribor, appropriate anatase nanoparticles were synthesized. The nanoparticles were then coated onto the pre-synthesized magnetic nanoparticles with adapted surface properties using a control of the electrostatic interactions.

The research related to magnetic materials for telecommunications was directed towards the development of ceramic films for high-frequency applications of micro- and mm-waves. In the frame of an EU project we studied the possibility of the application of thermal spraying technologies for the preparation of absorbing coatings. The contribution of our department was related to the studies on crystallization of the coatings with different compositions. Namely, when using standard thermal spraying conditions, the feedstock powder is partly or completely melted. Due to the extremely high cooling rate in the process of the deposition on the substrate the degree of crystallization is very small.

An additional thermal treatment at $1000^\circ C$ was necessary to improve the crystallinity of these coatings. Such coatings with the composition $BaFe_{12}O_{19}$ showed suitable properties for broad-band absorbers in the frequency range around 50 GHz, whereas coatings with the composition $BaCoTiFe_{10}O_{19}$ showed an increased absorption of electromagnetic waves at around 10 GHz. In parallel, we also conducted a study of the thermally sprayed coatings with the composition $NiFe_2O_4$. Due to a higher crystallization rate the degree of crystallinity in the as-sprayed coatings was higher than in the Ba-hexaferrite-based coatings. These coatings showed suitable absorption at around 1 GHz.

The other research study was related to the electrophoretic deposition of $BaFe_{12}O_{19}$ particles. The aim was to develop a chemical method for the preparation of magnetically oriented low-loss thick films for mm-wave nonreciprocal devices. At the beginning we studied the stabilization of the appropriate suspensions in various solvents, which proved to be a great challenge. Namely, the magnetic attractions between the particles, which are much stronger than Van der Waals attractions, have to be prevented. We calculated that in water-based systems it would be possible to stabilize only suspensions of particles with a volume smaller than approximately 4200 nm^3 . Experimentally, the method for preparation of the appropriate suspensions in 1-butanol was developed. These suspensions were used for electrophoretic deposition onto various substrates. The degree of magnetic orientation was substantially increased by an external magnetic field. Such films showed anisotropic magnetic behaviour.

In the field of high-temperature thermistors the processes of reduction and reoxidation related to the formation of temperature-dependent potential barriers at the grain boundaries of ferroelectric ceramics in the $BaTiO_3$ - $BaNb_2O_6$ system were studied.

The most important technological achievements in the past year

1. Darko Makovec, Mihael Drofenik. Synthesis of plate-like spinel particles and spinel-hexaferrite intergrowth nanocomposite particles using the hydrothermal decomposition of Ba-hexaferrite. *Cryst. growth des.*, 2008, vol. 8, no. 7, 2182-2186.
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4. Darja Lisjak, Andrej Žnidaršič, Anna Sztanislaw, Mihael Drofenik. A two-step synthesis of W-hexaferrites. *J. Eur. Ceram. Soc.*, 2008, vol. 28, no. 10, 2057-2062.
5. M. Peiteado, Sašo Šturm, Amador C. Caballero, Darko Makovec. $Mn_{(3-x)}Zn_xO_4$ spinel phase in the Zn-Mn-O system. *Acta mater.* [Print ed.], 2008, vol. 56, no. 15, 4028-4035

Patent granted

1. Procedure of preparation of magnetic nanocomposites with high content of nanoparticles dispersed in polymer matrix
Darko Makovec, Sašo Gyergyek, Miroslav Huskić, Miha Drogenik
SI Patent No. 22539.

INTERNATIONAL PROJECTS

1. New Generation Microwave Ferrite Thick Films for Absorbers
ABSOFILM
MATERA ERA-NET, 3211-07-000176
Technical Research Centre of Finland, Finland
Asst. Prof. Darja Lisjak
2. Integrated Miniature Circulators for Microwave Modules
IMICIMO
EUREKA
Chelton Telecom & Microwave FRANCE, France
Asst. Prof. Darja Lisjak
3. Non Conductive Magnetic Materials for Microwave Absorbers
BI-IT/05-08-007
Dr. Enzo Ferrara, Istituto Elettrotecnico Nazionale Galileo Ferraris Torino, Torino, Italy
Asst. Prof. Darja Lisjak
4. Co-fired Ferrite-ceramic Systems for Integrated Miniature Circulators applied in Microwave Modules
Együttégetett ferit-kerámia rendszerek mikrohullámu modulokban használt korszerű, integrált miniatűr cirkulátorokhoz
BI-HU/08-09-008
Prof. Anna Sztaniszlav, TKI-Ferrit Development and Manufacturing Ltd., Budapest, Hungary
Asst. Prof. Darja Lisjak

2. Development of photocatalytic superparamagnetic nanocomposites for application in diminishing emissions of harmful pollutants into an environment
Prof. Darko Makovec
3. Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
Prof. Darko Makovec

RESEARCH PROGRAM

1. Advanced inorganic magnetic and semiconducting materials
Prof. Mihael Drogenik

NEW CONTRACTS

1. Synthesis of magnetic nanoparticles
Nanotesla Institute Ljubljana, Ljubljana
Prof. Darko Makovec
2. Development of photocatalytic superparamagnetic nanocomposites for application in diminishing emissions
Cinkarna Celje d. d., Celje
Prof. Darko Makovec

R & D GRANTS AND CONTRACTS

1. Patterns, structural self-organization and magneto-electrics in mixtures of nanoparticles and liquid crystals
Prof. Samo Kralj, Prof. Mihael Drogenik

VISITORS FROM ABROAD

1. Pertti Lintunen, VTT Chemical Research Centre of Finland Tampere, Finland, 26–27 Jun. 2008
2. Arto Hujanen, VTT Chemical Research Centre of Finland Espoo, Finland, 26–27 Jun. 2008
3. Marion Begard, RWTH, Aachen University, Aachen, Germany, 26–27 Jun. 2008
4. Luca Lusvardi and Giovanni Bolleli, Università di Modena e Reggio Emilia, Modena, Italy, 26–27 Jun. 2008.

STAFF

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2. Asst. Prof. Darja Lisjak
3. **Prof. Darko Makovec, Head**
4. Dr. Igor Zajc

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9. Slavko Kralj, B. Sc.
10. Simona Ovtar, B. Sc.
11. Darinka Primc, B. Sc.

Note:

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ORIGINAL ARTICLES

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Invited Papers

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1. Anita Danč, Valerija Danč, Irena Ban, Matjaž Kristl, Mihael Drofenik, "Sinteza in karakterizacija nanodelcev CdS in CdSe z ultrazvočnim obsevanjem", In: *Slovenski kemijski dnevi 2008, Maribor, 25. in 26. september 2008: [zbornik referatov]*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, Univerza v Mariboru, Fakulteta za kemijo in kemijsko tehnologijo, 2008, [7] pp.
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DEPARTMENT FOR ADVANCED MATERIALS

K-9

Research in the Department for Advanced Materials is focused mainly on synthesizing and characterizing new inorganic materials. The emphasis is on investigations of high-temperature phase equilibria, the identification of new compounds, and determining their crystal structures and properties. Investigations relating to ceramics with special electrical and magnetic properties and super-hard materials and glasses are of primary importance. In recent years, nanomaterials and nanotechnologies have become an important part of the department's activities.



Head:
Prof. Danilo Suvorov

In 2008 the investigations of the Department for Advanced Materials were directed to two main important fields, i.e., the research and investigation of materials exhibiting special electrical properties and the research of nanostructured materials and the processes for their preparation.

In the scope of the investigations of materials exhibiting special electrical properties we investigated tunable materials, microwave dielectrics and materials compatible with low-temperature co-fired ceramic (LTCC) technology.

The investigations of voltage-tunable materials by the scientific community have focused mainly on paraelectric modifications near ferroelectric transitions of the displacive type, in particular on $(\text{Ba}_{1-x}\text{Sr}_x)\text{TiO}_3$ -based compounds. However, their high losses, dielectric constant and the temperature dependence of the dielectric constant limit their widespread use, leading us to search for novel materials. We focused our investigations of tunable materials on ferroelectrics of the relaxor type, in particular on $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$. The temperatures of the $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ phase transitions and thus the intensities of the dielectric relaxations were modified by the addition of various incipient ferroelectrics, such as SrTiO_3 , KTaO_3 and NaTaO_3 . We observed that samples with the highest tunability also exhibit the highest dielectric relaxations as well as having a morphotropic phase composition. However, these samples also show increased dielectric losses. Improved figures of merit were obtained for samples with increased additive concentrations and paraelectric polar order. We determined that this improvement relates to the low-temperature dielectric relaxations and to the dynamics of nanosized polar regions. In addition, it might be expressed by the exceptionally high nonlinear coefficients β .

In the scope of tunable materials we investigated the mechanical-stress tunability of $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-KTaO}_3$ and $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-K}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ solid solutions. These solid solutions have potential applications in pressure sensing, due to their stress-dependent dielectric properties. Therefore, the effect of axial pressure on the permittivity of these materials was investigated. The responses of the different compositions were very different, which is connected with the materials' structural and electrical properties. According to the obtained results, the most interesting materials

- Investigations of voltage-tunable and mechanical-stress-tunable materials based on $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ and $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-KTaO}_3$, $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-K}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$, respectively.
- Investigations of microwave dielectrics based on complex perovskites ($\text{Ba}_3\text{CoNb}_2\text{O}_9$), hexagonal perovskites ($\text{Ba}_4\text{Nb}_2\text{O}_9$), $\text{CaLa}_4\text{Ti}_5\text{O}_{17}$, $\text{SrLa}_4\text{Ti}_5\text{O}_{17}$, $\text{Mg}_3\text{B}_2\text{O}_6$, scheelites (BaWO_4 , CaWO_4 , NaLaW_2O_8) and feldspars ($\text{KxBa}_{1-x}\text{Ga}_{2-x}\text{Ge}_{2+x}\text{O}_8$).
- Synthesis and characterization of CaTiO_3 and $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ low-dimensional nanostructures.
- In-situ synthesis of ZnS and Mn^{2+} -doped ZnS nanocrystallites in a polymer matrix.
- Investigations of hard materials based on Ti_3Al , TiAl and TiAl_3 with additions of TiB_2 , TiC and B_4C .

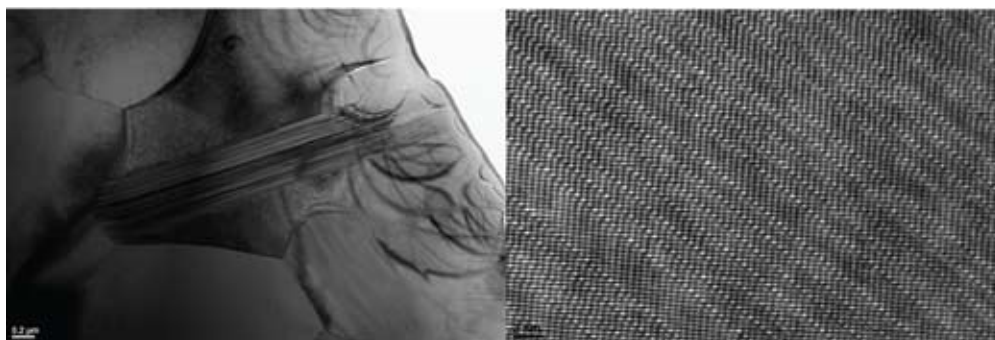


Figure 1: The coherent intergrowth of hexagonal-perovskite polytypes and the cubic perovskite $\text{Ba}_3\text{CoNb}_2\text{O}_9$, triggered by Co-deficiency.

are those which exhibit relaxor properties. In these materials, a high stress dependence of the permittivity and reversibility with changing stress were observed.

Special emphasis was also given to the solid-state synthesis of the $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-KTaO}_3$ and $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-K}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ solid solutions. Our investigations showed that during the synthesis of $\text{K}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ ceramics the potassium and bismuth components volatilize, resulting in the formation of secondary phases, which were identified using X-ray powder diffraction. The sinterability of the material is low and at elevated temperatures a thermal decomposition of the matrix phase occurs. Scanning electron microscopy with wavelength-dispersive spectroscopy revealed that the matrix phase is non-stoichiometric; it is potassium deficient and contains an excess of bismuth. The secondary phase, i.e., potassium polytitanate, also forms during the synthesis of other compounds that contain potassium and bismuth oxides, e.g., the $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-KTaO}_3$ and $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-K}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ solid solutions. Therefore, the choice of the firing temperatures is important if we wish to obtain dense ceramics with a low fraction of secondary phases.

We investigated the piezoelectric properties of $(\text{Na}_{1-x}\text{K}_x)_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ solid solutions. These materials are good candidates to replace lead-based piezoelectric materials, which are toxic for humans and the environment. As we know from previous studies, some solid solutions with the complex perovskite structure reach a morphotropic phase boundary (MPB) at a certain ratio of different A-site cations. This boundary region is important because of the higher remanent polarization, and therefore enhanced electromechanical properties for a material are possible

at room temperature. As an example of such a ceramic material with more than one phase we chose the $(\text{Na}_{1-x}\text{K}_x)_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ solid solution. It is known that pure $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ is rhombohedral, whereas pure $\text{K}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ is tetragonal. We found that there is a morphotropic phase, with the coexistence of the rhombohedral and tetragonal structures, in the region between 17 and 25 mol percent of potassium. The dielectric, ferroelectric and piezoelectric properties were measured for different compositions at and near the MPB. The investigated piezoceramic material has a high dielectric constant and a high transition temperature (near 300°C), a relatively high remanent polarization and a relatively high piezoelectric constant (up to 134pC/N).

In the field of microwave dielectrics we investigated several materials, such as complex perovskites ($\text{Ba}_3\text{CoNb}_2\text{O}_9$), hexagonal perovskites ($\text{Ba}_4\text{Nb}_2\text{O}_9$), $\text{CaLa}_4\text{Ti}_5\text{O}_{17}$ and $\text{SrLa}_4\text{Ti}_5\text{O}_{17}$. Within the scope of the research of microwave dielectrics we found that Co-deficiency leads to an increase in the Q-value of $\text{Ba}_3\text{CoNb}_2\text{O}_9$ complex perovskite ceramics. Apart from exhibiting faster B-site cation ordering kinetics the Co off-stoichiometry causes the formation of hexagonal-perovskite polytypes that are coherently intergrown with a 1:2 ordered cubic-perovskite matrix. Such coherent intergrowth can also be understood as a sequence of two succeeding BaO layers arranged in the ABA hexagonal close-packing arrangement in a matrix of an ABC cubic close-packed crystal structure, where the B-site vacancies are ordered between the hexagonally packed layers. The experimental results indicate that an increase in Qxf can be mainly attributed to such a superstructure of ordered cation vacancies. The highest Q-value, $\text{Qxf} > 100000 \text{ GHz}$, was measured in the case of ceramics with the nominal composition $\text{Ba}_8\text{CoNb}_6\text{O}_{24}$, which was found to consist mainly of the intergrown cubic $\text{Ba}_3\text{CoNb}_2\text{O}_9$ and hexagonal $\text{Ba}_5\text{Nb}_4\text{O}_{15}$ perovskites.

The investigations of $\text{Ba}_4\text{Nb}_2\text{O}_9$ were focused on the study of high-temperature polymorphic phase transitions in $\text{Ba}_4\text{Nb}_2\text{O}_9$ and on the crystal-structure determination of individual polymorphs with the help of transmission electron microscopy (TEM) and a tilting experiment. We have isolated two stable polymorphs – the low-temperature α -modification and the high-temperature γ -modification – with a phase-transition temperature at 1160°C. The rate of cooling applied to the γ - $\text{Ba}_4\text{Nb}_2\text{O}_9$ sample strongly affects the nature of the phase transitions. The rapid cooling (quenching) of the γ -phase sample down to room temperature results in the γ -modification, while slow cooling (1-2°C/min) leads to the formation of a pure α -modification. Cooling the γ -phase at a rate of ~3°C/min results in the formation of the β -modification, which was also observed between 360-585°C after reheating the γ -modification and on the surface of the quenched γ - $\text{Ba}_4\text{Nb}_2\text{O}_9$ sample. Using HT-TEM experiments the orthorhombic β - $\text{Ba}_4\text{Nb}_2\text{O}_9$ has been proved to be a distorted γ -modification (γ'). All the polymorphs of $\text{Ba}_4\text{Nb}_2\text{O}_9$ are structurally closely related, implying that only minor structural perturbations are involved in the polymorphic phase-transformation processes in this system. Collected high-resolution electron images and electron-diffraction patterns along different low-index zone axes allowed us to propose the crystal-structural model of the α -modification. Regarding the stoichiometry of the $\text{Ba}_4\text{Nb}_2\text{O}_9$ compound and the discrepancy in the distance between the Ba-O layers along the hexagonal c-axis with respect to this distance in the conventional perovskite structures, we proposed a crystal-structural model that is closely related to the 2H-type perovskite structure. The proposed structure comprises alternating Ba_3O_9 and oxygen-deficient Ba_3O_6 close-packed layers along the c-axis. Such a stacking of the close-packed layers creates the infinite chains of octahedrally and trigonal-prismatically coordinated B-sites cations. Based on the data collected by SAED and HRTEM we confirmed the validity of the chosen structural model. In addition, based on the tilting experiment we reconstructed the orthorhombic unit

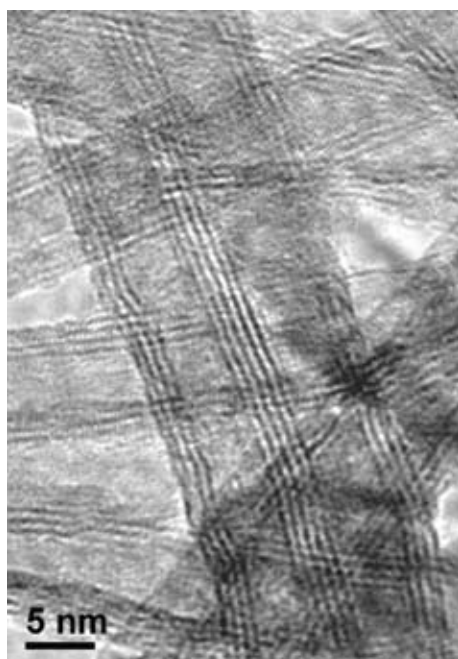


Figure 2: Hydrothermally synthesized titanate precursor in the form of nanotubes.

cell for α -Ba₄Nb₂O₉ and measured the unit-cell parameters ($a = 17.81 \text{ \AA}$, $b = 10.25 \text{ \AA}$ in $c = 8.5 \text{ \AA}$). We observed that the γ -Ba₄Nb₂O₉ in air partially decomposes to Ba₅Nb₄O₁₅ and BaO, which instantly reacts with CO₂ to form BaCO₃, whereas heating the Ba₄Nb₂O₉ sample in vacuum results the formation of Ba₃Nb₂O₈, due to the increased loss of BaO from the system.

A major part of our investigations of microwave dielectrics was focused on low-permittivity materials ($\epsilon < 10$), which, in comparison to high-permittivity materials, are more appropriate for high-frequency applications ($> 10 \text{ GHz}$). During a study of magnesium borates (Mg₃B₂O₆ and Mg₂B₂O₅) we focused on the synthesis conditions and correlations between the microstructural characteristics and the dielectric properties. We found that the synthesis of single-phase Mg₃B₂O₆ and Mg₂B₂O₅ required 11 and 14 wt.% excess of B₂O₃. The highest Qxf values of over 200,000 GHz were measured for Mg₃B₂O₆ ceramics with a grain size of around 1000 microns. In the scope of our study of low-temperature-sinterable, low-permittivity and low-loss materials we investigated materials based on K_xBa_{1-x}Ga_{2-2x}Ge_{2+x}O₈ solid solutions with the paracelsian crystal structure and materials with the scheelite structure. In our study of K_xBa_{1-x}Ga_{2-2x}Ge_{2+x}O₈ the focus was on determining the crystal structure with a Rietveld structural refinement and on determining the structural changes that occurred during the P2₁/a → C2/m phase transition. On the basis of the difference in the fundamental features of the topology between the P2₁/a and C2/m phase, we found that the tetrahedral T-O bonds in the crystal structure have to be partially disassociated and reconnected to form the new phase, which led to an intensive thermal effect during the phase transition.

A comparative microstructural and dielectric study of BaWO₄, SrWO₄ and CaWO₄ scheelite ceramics revealed some important differences between these materials in terms of the grain size, their growth and their sensitivity to humid air. Compared to BaWO₄ and CaWO₄, SrWO₄ ceramics were found to be hygroscopic and more incongruently soluble in water. These properties mean SrWO₄ ceramics are inappropriate as materials for electronic components. In contrast to SrWO₄, BaWO₄ and CaWO₄ ceramics were found to be resistant to water and humidity. Scheelite LiLaW₂O₈, NaLaW₂O₈ and KLaW₂O₈ ceramics could be densely sintered at temperatures as low as 700–800°C. Only NaLaW₂O₈ exhibits promising microwave dielectric properties, i.e., $\epsilon = 11.7$, $Qxf = 27900 \text{ GHz}$ and $\tau_f = -20 \text{ ppm/}^\circ\text{C}$.

In the scope of low-permittivity LTCC materials we investigated materials from the MgO-B₂O₃-SiO₂ system, which were in contrast to K_xBa_{1-x}Ga_{2-2x}Ge_{2+x}O₈ and scheelites, prepared by recrystallization.

In the field of investigating LTCC ceramics with higher permittivity ($\epsilon = 80$) we studied the influence of Nb substitution in the compound Bi₃NbO₇ by Ta and the sintering conditions on the microwave dielectric properties of the resulting ceramics. We confirmed that the properties of the formed solid solution Bi₃Nb_{1-x}Ta_xO₇ depended on the Ta content: the permittivity of the ceramics decreased with Ta content, while the quality factor (Qxf) increased; however, the temperature coefficient of resonant frequency decreased and reached the value $\tau_f = 12 \text{ ppm/K}$ at $x = 0.6$. Based on these properties our ceramics can be classified as commercially interesting materials.

The research on nanostructured materials was mainly focused on the synthesis of low-dimensional nanostructures, inorganic-organic composites and the preparation of thin films. The synthesis of low-dimensional nanostructures of CaTiO₃ and Na_{0.5}Bi_{0.5}TiO₃ was carried out under hydrothermal conditions. The synthesis of CaTiO₃ started from nanostructured, layered alkali metal titanates with tubular morphology. The layered structure of the titanate

- In the scope of our investigations with TRIMO Trebnje we developed a new product - termoinsulation plate - which is made entirely from recycled waste mineral fibres.
- In a cooperation with researchers from Gorenje Velenje we investigated the possibilities of the application of recycled polymers in the production of household appliances and developed the method and technology for the production of refrigerators from recycled materials.
- In the scope of industrial research projects we developed several middle-permittivity LTCC materials, which are compatible with other already-commercialized LTCC materials. The compatibility includes, in addition to chemical compatibility, the matching of the thermal expansion coefficient and the kinetics of sintering.

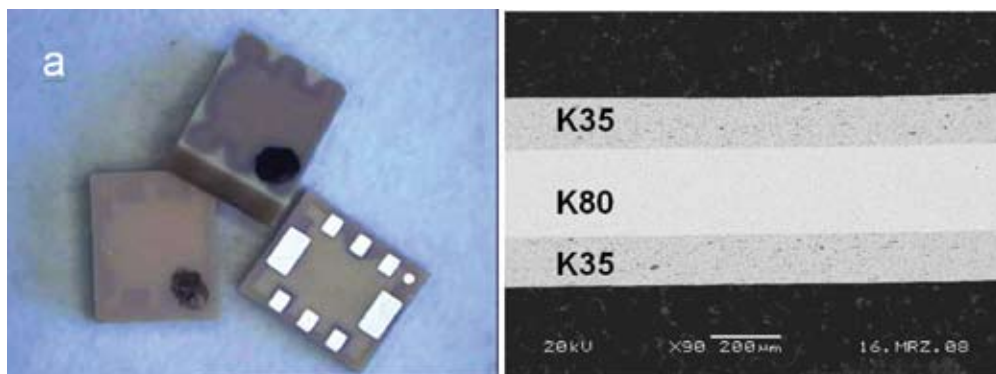


Figure 3: The application of K80 in a balun (a) and the perfect co-sintering of K35 and K80, without any reaction zone or cracks (b).



Figure 4: New Laboratories at the Department for Advanced Materials

In 2008 the Department for Advanced Materials was renovated and the building was completed with additional laboratories for the synthesis and characterisation of thin layers and nanoparticles.

precursor enables the ion exchange of an alkali metal cation with calcium under hydrothermal conditions. Hydrothermal treatment (100-150°C) of the tubular precursor with $\text{Ca}(\text{OH})_2$ leads to the ion-exchange reaction of interlayer Na^+ cations with Ca^{2+} cations. The morphology is preserved but the chemical composition is changed. According to the EDS analysis, nanotubes prepared under these conditions contained about 10 at. % of calcium after the hydrothermal ion-exchange reaction. Increasing the temperature to 200°C led to the formation of well crystallised, anisotropic single crystals of CaTiO_3 with a length of 800 nm and a width of 100–200 nm. The hydrothermal synthesis of $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ was optimized by changing the concentrations of the reactants, the temperature and the duration of the synthesis. $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$ with a crystallite size of 20–75 nm was successfully synthesized.

Nanocomposite inorganic/organic thin films were fabricated by the in-situ synthesis of ZnS and Mn^{2+} -doped ZnS nano-crystallites in a polymer matrix. The polymer network acts as a nanoreactor, where the morphology, size and volume density of the synthesized crystallites are controlled by the pH value of the polymer solution and the number of reaction cycles. By controlling the size of the semiconducting nanocrystallites a control over the optical properties is obtained, resulting in an efficient fluorescence of the composite films.

Thin $\text{Bi}_{12}\text{SiO}_{20}$ films were prepared by the Pechini and sol-gel methods. In the Pechini route the metallic precursors were prepared and then esterified with the addition of ethylene glycol. The prepared precursor solution was deposited on $\text{Si}/\text{SiO}_2/\text{TiO}_2/\text{Pt}$ substrates. We studied the influence of the precursor

concentration, the number of deposited layers and the thermal treatment on the microstructure and thickness of BSO thin films. The thin films were thermally treated in three stages: drying, pyrolyzing and annealing. The results showed that for both precursor concentrations, 0.3 M and 0.2M, we obtained dense, homogenous BSO thin films. The difference between the precursor solutions was shown in the thickness and the grain size. Therefore, we obtained, in the case of a 0.3-M solution, a thickness of 200 nm and an average grain size of 450 nm, and for a 0.2-M solution, a thickness of 100 nm and average grain size of 300 nm.

For the preparation of thin $\text{Bi}_{12}\text{SiO}_{20}$ films by the sol-gel route two synthesis procedures using different solvents, 2-ethoxyethanol and acetic acid, were compared. The solvents actually behave as true chemical reagents; they are able to react with the precursors and change them at the molecular level, therefore changing the whole process, i.e., the stability and ageing time of the sols, the morphology and the thickness of thin films. We found that in sols prepared with the help of acetic acid, acetate groups bidentately bonded to bismuth ions. This shortened the gelation time (t_g) ($c = 0.78 \text{ M}$, $t_g = 24 \text{ h}$) compared to sols prepared with 2-ethoxyethanol ($c = 0.78 \text{ M}$, $t_g = 192 \text{ h}$). The microstructure development of $\text{Bi}_{12}\text{SiO}_{20}$ thin films, prepared from sols using 2-ethoxyethanol, showed homogeneous and dense thin films. A porous microstructure was observed for $\text{Bi}_{12}\text{SiO}_{20}$ thin films deposited from a sol using acetic acid as the co-solvent.

In the field of hard materials we studied the influence of the additives TiB_2 , TiC and B_4C on the compounds Ti_3Al , TiAl and TiAl_3 . We determined the phase composition and the mechanical properties of samples fired at 800 to 1300°C.

In the research area of glass and mineral fibres our investigations were made for the industrial partners Gamma Meccanica, Knauf Insulation and Paroc. The investigations included the analysis of mineral rocks, glassy materials and fibres. The basic aim of the investigations was to determine the correlations between the composition and the glass-forming conditions in order to obtain the optimal melt properties of the glass for the production of fibres. We performed numerous melting tests on the samples to analyse the melting behaviour of various basalts and their compositions with dolomites. In the scope of the investigations with TRIMO Trebnje we developed new product, termoinsulation plate, which is made entirely from recycled waste mineral fibres.

In the scope of industrial research projects we developed several middle-permittivity LTCC materials that are compatible with other already-commercialized LTCC materials. The compatibility includes, in addition to chemical compatibility, a matching of the thermal expansion coefficient and the kinetics of sintering.

Some outstanding publications in 2008

1. Jana Bezjak, Boštjan Jančar, Aleksander Rečnik, Danilo Suvorov. The synthesis and polymorphic phase transitions of $\text{Ba}_4\text{Nb}_2\text{O}_9$ ceramics. *J. Eur. Ceram. Soc.*, 28 (2008) 14, 2771-2776
2. Špela Kunej, Danilo Suvorov. Subsolidus phase equilibria in the pyrochlore-rich part of the $\text{Bi}_2\text{O}_3\text{-TiO}_2\text{-Y}_2\text{O}_3$ system. *J. Am. Ceram. Soc.*, 91 (2008) 10, 3472-3475

3. Marjeta Maček Kržmanc, Boštjan Jančar, Danilo Suvorov. The influence of tetrahedral ordering on the microwave dielectric properties of $\text{Sr}_{0.05}\text{Ba}_{0.95}\text{Al}_2\text{Si}_2\text{O}_8$ and $\text{BaM}_2\text{M}'_2\text{O}_8$ ($\text{M} = \text{Al}, \text{Ga}, \text{M} = \text{Si}, \text{Ge}$) ceramics. *J. Eur. Ceram. Soc.*, 28 (2008) 16, 3141-3148
4. Qin Ni, Marjeta Maček Kržmanc, Danilo Suvorov. Glass-free $\text{K}_x\text{Ba}_{1-x}\text{Ga}_{2-2x}\text{Ge}_{2+x}\text{O}_8$ ceramics for low-temperature cofired ceramics technology: Synthesis, phase transitions, sintering and microwave dielectric properties. *J. Am. Ceram. Soc.*, 91 (2008) 8, 2593-2600.
5. Srečo D. Škapin, Špela Kunej, Danilo Suvorov. Phase relations and electrical properties in the pseudo-ternary $\text{La}_2\text{O}_3\text{-TiO}_2\text{-Mn}_2\text{O}_3$ system in air. *J. Eur. Ceram. Soc.*, 28 (2008) 16, 3119-3124

Awards and Appointments

1. Danilo Suvorov: Inauguration: Academician of the World Academy of Ceramics, The Council of the World Academy of Ceramics, Chianciano, Italy, 6 Aug. 2008
2. Danilo Suvorov: Inauguration: Fellow of the American Ceramic Society, Board of Directors of the American Ceramic Society, Pittsburgh, USA, 6 Oct. 2008.
3. Asja Veber: Award for the best poster on conference YUCOMAT 2008, Herceg Novi, Montenegro, Awarding Committee of the YUCOMAT 2008 Conference, poster entitled The Thickness, Morphology and Structure of Sol-Gel $\text{Bi}_{12}\text{SiO}_{20}$ thin films.
4. Mojca Žnidaršič: Award for the best contribution of young researchers, 1. International Conference on Materials and Technologies, Portorož, Awarding Committee of the Conference, contribution entitled The structural and electrical properties of a solid solution based on $\text{Na}_{0.5}\text{Bi}_{0.5}\text{TiO}_3\text{-K}_{0.5}\text{Bi}_{0.5}\text{TiO}_3$.
5. Srečo D. Škapin: Award for the poster presentation, Hot Nano Topics 08, 23-30 May, 2008, Portorož Slovenia, "Photocatalytic undoped and doped nanotitania for building applications"

Organization of conferences, congresses and meetings

1. Meeting of the EU 6FP project: Safe, integrated and controlled production of high tech multifunctional products and their recycling (SAPHIR), Ljubljana, 17-19 Mar. 2008
2. 2nd International Congress on Ceramics, Verona, Italy, 29 Jun. to 4 Jul. 2008 (co-organizers).
3. International Workshop on Contemporary Ceramics for Electronics, Verona, Italy, 30 Jun. 2008
4. International Symposium on Advanced Dielectric Materials at Materials Science and Technologies Conference and Exhibition, Pittsburgh, USA, 5-9 Oct. 2008
5. 1st International Conference on Materials and Technologies, Portorož, 13-15 Oct. 2008 (co-organizers)
6. 5th International Conference on Microwave Materials and Their Applications (MMA-2008), Hangzhou, China, 1-4 Nov. 2008 (co-organizers)

INTERNATIONAL PROJECTS

- | | |
|---|---|
| <ol style="list-style-type: none"> 1. Controlled Production of High Tech Multifunctional Products and their Recycling
SAPHIR
6. FP, NMP2-CT-2006-026666
EC; Laurence Demoor, Christophe Goepfert, Compagne Industrielle des Lasers Cilas SA, Orleans, France
Prof. Danilo Suvorov 2. Tantalum-Free Microwave Dielectric Resonators with Enhanced Quality Factor
NATO SFP 980881
NATO Public Diplomacy Division, North Atlantic Treaty Organisation, Brussels, Belgium; Prof. Peter Mascher, McMaster University, Department of Engineering Physics, Faculty of Engineering, Hamilton, Ontario, Canada
Dr. Boštjan Jančar 3. Relaxor-based Tunable Materials
T080038
Dr. Christian Hoffmann, Dr. Andrea Testino, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
Prof. Danilo Suvorov, Dr. Boštjan Jančar 4. LTCC Materials for High Frequency Applications
T080033
Pavol Dudesek, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
Prof. Danilo Suvorov, Dr. Marjeta Maček Kržmanc 5. Characterisation of Bio Soluble Mineral Fibres
T070032
Markus Mente, B. Sc., Heraklith GmbH, Furnitz, Austria
Prof. Danilo Suvorov 6. LTCC Materials for High Frequency Applications
T070033 | <ol style="list-style-type: none"> 7. Characterization of Bio Soluble Mineral Fibres
T070031
Niklas Bergman, B. Sc., Paroc Group OY AB/R&D, Pargas; Vantaa, Finland
Prof. Danilo Suvorov 8. Characterization of the Materials for Mineral Fibres Production
T070001
Giovanni Burini, B. Sc., Gamma Meccanica, Bibbiano, Reggio Emilia, Italy
Prof. Danilo Suvorov 9. Designing of Functional Materials on Molecular and Nano Level
BI-RS/08-09-027
Prof. Dragan Uskoković, Institut tehničkih nauka Srpske akademije nauka i umetnosti, Belgrade, Serbia
Prof. Danilo Suvorov 10. Materials World Network: Improved Lanthanide-based Filters for Mobile Telecommunications
BI-US/08-10-005
Prof. Rick Ubic, Boise State University, Boise, Idaho, USA
Prof. Danilo Suvorov 11. Development of Wear Resistant Coatings based on Complex Metallic Alloys for Functional Applications
applicMA
7. FP, 214407
EC; Susanne Fuchs, Austrian Research Centers GmbH - ARC, Functional Materials, Seibersdorf, Austria
Dr. Srečo D. Škapin, Dr. Miha Čekada, Prof. Janez Dolinšek, Dr. Kristoffer Krnel |
|---|---|

R & D GRANTS AND CONTRACTS

1. Development of multi-functional B₄C-Al and B₄C-Mg composites for emerging applications
Prof. Tomaž Kosmač, Dr. Srečo Davor Škapin
2. Multifunctional composites based on Al-Mg-ti intermetallic compounds reinforced with ceramic particles
Dr. Srečo Davor Škapin
3. Self-cleaning photocatalytic coatings
Asst. Prof. Miran Mozetič, Dr. Srečo Davor Škapin
4. Smart functional coatings for increasing sustainability of structures and components for defense purposes
Dr. Peter Panjan, Dr. Srečo Davor Škapin

RESEARCH PROGRAM

1. Contemporary inorganic materials and nanotechnologies
Prof. Danilo Suvorov

NEW CONTRACT

1. Development of procedures for economically efficient use of waste mineral wool from Trimmo production
Trimmo, Trebnje
Prof. Danilo Suvorov

VISITORS FROM ABROAD

1. Dr Christian Hoffmann, Pavol Dudesek, B. Sc., EPCOS OHG, Deutschlandsberg, Austria, 1 Apr. 2008
2. Prof. Velimir Radmilović, National Center for Electron Microscopy, University of California, Berkeley, USA, 13-15 Jun. 2008
3. Julie Cornette, B. Sc., University of Limoges, France, 26-29 Jun. 2008
4. Dr Philippe Thomas, University of Limoges, France, 26-29 Jun. 2008
5. Dr Jeon Jae-Ho, Korea Institute of Materials Science, Changwong, Korea, 4-6 Sept. 2008
6. Dr Ivan Sondi, Institut Rudjer Bošković, Zagreb, Croatia, 25 Sept. 2008
7. Christopher John Hull, M. Sc., European Association of Research and Technology Organisations, Brussels, Belgium, 23 Oct. 2008.
8. Prof. Erkki Leppävuori, VTT Technical Research Centre of Finland, Espoo, Finland, 23 Oct. 2008

9. Dr Michael Maurer, German Federation of Industrial Research Associations, Köln, Germany, 23 Oct. 2008
10. Dr Eugenio Otal, Universidad de Buenos Aires, Buenos Aires, Argentina 30 Oct. 2008
11. Manuela Leticia Kim, M. Sc., Universidad de Buenos Aires, Buenos Aires, Argentina 30 Oct. 2008
12. Dr Andrea Testino, EPCOS OHG, Deutschlandsberg, Austria, 19 Nov. 2008
13. Mathieu Antoni, B. Sc., EPCOS OHG, Deutschlandsberg, Austria, 19 Nov. 2008
14. Dr Kim Byoung-Kee, Korea Institute of Materials Science, Changwong, Korea, 20 Nov. 2008
15. Dr Jeon Jae-Ho, Korea Institute of Materials Science, Changwong, Korea, 20 Nov. 2008

Visiting Researchers:

1. Dr Qin Ni, Zhejiang University, Hangzhou, China, 1 Dec. 2006 to 30 Oct. 2008
2. Dr Olivier Noguera, Faculte des Sciences et Techniques, UMR-CNRS, Limoges, France, 1 Nov. 2007 to 31 Oct. 2008
3. Dr Jyoti Prosad Guha, University of Rolla, Rolla, USA, 3 Jun. to 31 Aug. 2008

STAFF

Researchers

1. Dr. Boštjan Jančar
2. Dr. Marjeta Maček Kržmanč
3. **Prof. Danilo Suvorov, Head**
4. Dr. Srečo Davor Škapin

Postdoctoral associates

5. Dr. Uroš Kunaver*
6. Dr. Špela Kunej
7. Dr. Matjaž Spreitzer
8. Dr. Marko Udovič*

Postgraduates

9. Ines Bračko, B. Sc.
10. Urban Došler, B. Sc.

11. Jakob König, B. Sc.
12. Manca Logar, B. Sc.
13. Tina Šetinc, B. Sc.
14. Asja Veber, B. Sc.
15. Mojca Žnidaršič, B. Sc.
16. Vojka Žunič, B. Sc.

Technical officers

17. Maja Šimaga Saje, M. Sc.

Technical and administrative staff

18. Silvo Zupančič

Note:

* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Jana Bezjak, Boštjan Jančar, Aleksander Rečnik, Danilo Suvorov, "The synthesis and polymorphic phase transitions of Ba₄Nb₂O₉ ceramics", *J. Eur. Ceram. Soc.*, issue 14, vol. 28, pp. 2771-2776, 2008.
2. Katarina Demšar, Srečo D. Škapin, Anton Meden, Danilo Suvorov, "Ritveld refinement and dielectric properties of CaLa₄Ti₅O₁₇ and SrLa₄Ti₅O₁₇ ceramics", *Acta chim. slov.*, vol. 55, no. 4, pp. 966-972, 2008.
3. Teresa Jardiel, Marina Villegas, Angel Caballero, Danilo Suvorov, Amador C. Caballero, "Solid-state compatibility in the system Bi₂O₃ - TiO₂ - Bi₂WO₆", *J. Am. Ceram. Soc.*, vol. 91, no. 1, pp. 278-282, 2008.
4. Marija Jevtić, Miodrag Mitrić, Srečo D. Škapin, N. Ignjatović, Dragan Uskoković, "Crystal structure of hydroxyapatite nanorods synthesized by sonochemical homogeneous precipitation", *Cryst. growth des.*, vol. 8, no. 7, pp. 2217-2222, 2008.
5. Dragana Jugović, Miodrag Mitrić, Nikola Cvjetičanin, Boštjan Jančar, Slavko Mentus, Dragan Uskoković, "Synthesis and characterization of LiFePO₄/C composite obtained by sonochemical method", *Solid state ion.*, vol. 179, no. 11-12, pp. 415-419, 2008.
6. Varužan Kevorkijan, Srečo D. Škapin, "Boron carbide-aluminum and boron carbide-titanium boride-aluminum composites reactively bonded with aluminum magnesium boride", *Am. Ceram. Soc. bull.*, vol. 86, no. 5, pp. 9301-9308, 2008.
7. Špela Kunej, Danilo Suvorov, "Subsolidus phase equilibria in the pyrochlore-rich part of the Bi₂O₃ - TiO₂ - Y₂O₃ system", *J. Am. Ceram. Soc.*, vol. 91, no. 10, pp. 3472-3475, 2008.
8. Marjeta Maček, Boštjan Jančar, Danilo Suvorov, "The influence of tetrahedral ordering on the microwave dielectric properties of Sr_{0.05}Ba_{0.95}A₁₂Si₂O₈ and BaM₂M'₂O₈ (M = Al, Ga, M' = Si, Ge) ceramics", *J. Eur. Ceram. Soc.*, vol. 28, no. 16, pp. 3141-3148, 2008.
9. Roberto L. Moreira, Franklin M. Matinaga, Urša Pirnat, Danilo Suvorov, Anderson Dias, "Optical phonon characteristics of incommensurate and commensurate modulated phases of Bi₃NbO₇ ceramics", *J. appl. phys.*, vol. 103, no. 9, pp. 094108-1-094108-7, 2008.
10. Ni Qin, Marjeta Maček, Danilo Suvorov, "Glass-free K_xBa_{1-x}Ga_{2-x}Ge_{2+x}O₈ ceramics for low-temperature cofired ceramic technology: synthesis, phase transitions, sintering, and microwave dielectric properties", *J. Am. Ceram. Soc.*, vol. 91, no. 8, pp. 2593-2600, 2008.
11. Ivan Sondi, Srečo D. Škapin, Branka Salopek-Sondi, "Biomimetic precipitation of nanostructured colloidal calcite particles by enzyme-

- catalyzed reaction in the presence of magnesium ions", *Cryst. growth des.*, vol. 8, no. 2, pp. 435-441, 2008.
12. M. Soulis, A. Mirgorodsky, T. Merle-Méjean, O. Masson, P. Thomas, Marko Udovič, "The role of modifier's cation valence in structural properties of TeO_2 -based glasses", In: *11th international conference on the physics of non-crystalline solids: physics of non-crystalline solids 11*, (Journal of non-crystalline solids, Vol. 354, Issues 2-9, 2008), George Kordas, ed., Amsterdam, North-Holland, 2008, vol. 354, no. 2/9k, pp. 143-149, 2008.
 13. Srečo D. Škapin, Špela Kunej, Danilo Suvorov, "Phase relations and electrical properties in the pseudo-ternary $La_2O_3 - TiO_2 - Mn_2O_3$ system in air", *J. Eur. Ceram. Soc.*, vol. 28, no. 16, pp. 3119-3124, 2008.
 14. Srečo D. Škapin, Andrijana Sever Škapin, Danilo Suvorov, Miran Gaberšček, "A stabilization mechanism for the perovskite $La_{2/3}TiO_3$ compound with Fe_2O_3 : a structural and electrical investigation", *J. Eur. Ceram. Soc.*, vol. 28, no. 10, pp. 2025-2032, 2008.
 15. Matjaž Valant, Boštjan Podobnik, Drago Kovačič, Manca Logar, "Direct-laser writing of striplines on AgCl single crystals", *Mater. chem. phys.*, vol. 110, no. 2/3, pp. 280-284, 2008.

PUBLISHED CONFERENCE PAPERS

Regular papers

1. Andreja Gajovič, Sašo Šturm, Boštjan Jančar, Miran Čeh, "Phase relations in the Fe-Bi-O system under hydrothermal conditions", In: *EMC 2008*, 14th European Microscopy Congress, 1-5 September 2008, Aachen, Germany, Silvia Richter, ed., Alexander Schwedt, ed., Berlin, Heidelberg, Springer, 2008, zv. 2, pp. 129-130.

THESIS

Ph. D. Theses

1. Matjaž Spreitzer, *Influence of synthesis and structural characteristics in electrical properties of $Na_{0.5}Bi_{0.5}TiO_3$* , Ljubljana, (Prof. Danilo Suvorov), 2008.

B. Sc. Theses

1. Tina Šetinc, *Electrical conductivity of porous LSM ceramic*, Ljubljana, [T. Šetinc], 2008. (Asst. Prof. Marjan Marinšek)
2. Vojka Žunič, *Mineralogy and usability of clay from deposit Boreci at Križevcih*, Ljubljana, (Asst. Prof. Meta Dobnikar), 2008.

DEPARTMENT OF BIOCHEMISTRY, MOLECULAR AND STRUCTURAL BIOLOGY

B-1

The research activities of the members of the Department of Biochemistry, Molecular and Structural Biology 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.

Proteases, which were long considered as primarily protein-degrading enzymes, are extremely important signalling molecules involved in numerous vital processes, such as cell-cycle regulation, proliferation, cell death and immune response. Their catalytic activities are precisely regulated, the most important ways being zymogen activation and inhibition by their endogenous protein inhibitors. Any imbalance of this regulation can lead to pathologies such as autoimmune, neurological and cardiovascular disorders, cancer and osteoporosis.

Monitoring protease activities *in vivo* is one of the major challenges of the postgenomic era in biomedical research. In collaboration with partners from Sanofi-Aventis we developed selective cell-permeable activity-based probes for the detection of cysteine cathepsins in cellular systems. The probes were developed by so-called reverse-design from existing optimized compounds in preclinical development, rather than starting from the substrates. This offers an enormous advantage over existing probes, as such compounds have been already optimized for *in vivo* use. It also provides an excellent basis for future work in drug discovery, focusing on the *in vivo* imaging of proteases in various diseases, such as cancer, osteoporosis and inflammatory diseases, with a further goal to identify new targets and/or to monitor disease treatment.

Proteases, in particular caspases and recently also cysteine cathepsins, have a major role in various cell-death processes. We have characterized the action of the lysosomotropic agent LeuLeuOMe using distinct cellular models as a model for defining the role of lysosomal cathepsins in apoptosis. LeuLeuOMe was found to induce lysosomal membrane permeabilization, resulting in the release of lysosomal cathepsins that cleave the proapoptotic Bcl-2 family member Bid and degrade the antiapoptotic member Bcl-2, Bcl-xL, or Mcl-1. On the basis of inhibitor studies, we demonstrated that lysosomal disruption triggered by LeuLeuOMe occurred before mitochondrial damage. The degradation of anti-apoptotic Bcl-2 family members by lysosomal cathepsins was found to synergize with the cathepsin-mediated activation of Bid to trigger a mitochondrial pathway to apoptosis. Moreover, XIAP (X-chromosome-linked inhibitor of apoptosis) was also found to be a target of cysteine cathepsins, suggesting that cathepsins can also mediate caspase-dependent apoptosis downstream of the mitochondria. Since the antiapoptotic Bcl-2 family members and IAPs are often upregulated in cancer, it is possible that lysosomal destabilization has a major potential in cancer treatment.

On the other hand, the expression levels of various cysteine cathepsins, including cathepsin B, have been positively correlated with mammary-tumour progression and metastasis, although their roles in the hallmark processes of malignant growth remain poorly defined. In collaboration with a group from Freiburg we investigated tumour-cell differentiation, proliferation and apoptosis in the Tg(MMTV-PyMT) mouse mammary cancer model using cathepsin B-deficient mice. The absence of cathepsin B significantly impaired the development of high-grade invasive ductal carcinomas and reduced the metastatic burden in the lungs. Mice lacking cathepsin B exhibited reduced cell proliferation in mammary carcinomas and their lung metastases. However, no cathepsin-B-dependent difference in tumour-cell death was observed *in vivo* or by the treatment of isolated PyMT cancer cells with tumour necrosis factor-alpha. However, cancer cells lacking cathepsin B exhibited a significantly higher resistance to apoptosis induction by the lysosomotropic agent Leu-Leu-OMe.

We have also investigated the role of proteases in autophagy, which is the major mechanism used by eukaryotic cells to degrade and recycle proteins and organelles. Using a bioinformatics analysis of the genome of the protozoan parasite *Trypanosoma cruzi* we identified the presence of all the components of the Atg8 conjugation system, whereas several components of the Atg12 pathway could not be identified. The two TcATG4 (cysteine protease autophagin) homologs present in the genome were



Head:
Prof. Boris Turk



Figure 1: 2-D LC/MS system represents the core of the new proteomics laboratory

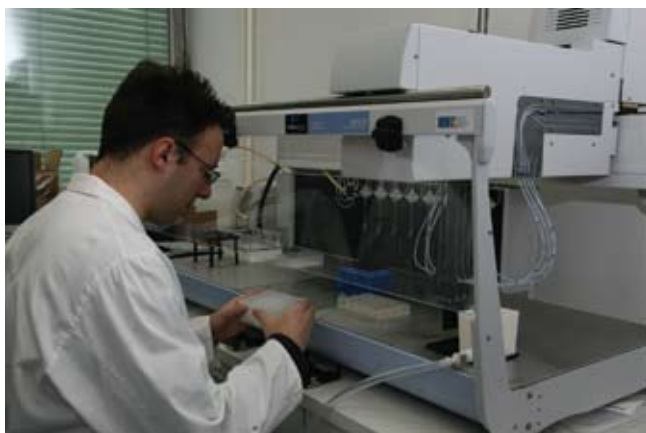


Figure 2: New JANUS system enables automatic high-throughput liquid handling, including trypsin digestion as part of the sample preparation for MS analysis.

found to correctly process the two ATG8 homologs after the conserved Gly residue. During starvation of the parasite, TcAtg8.1 was found to be located in autophagosome-like vesicles, which confirms its function as an Atg8/LC3 homolog and its potential to be used as an autophagosomal marker. Most importantly, autophagy was found to be involved in the differentiation between the developmental stages of *T. cruzi*, a process that is essential for parasite maintenance and survival. These findings suggest that the autophagy pathway could represent a target for a novel chemotherapeutic strategy against Chagas disease. The paper was also highlighted in the Faculty of 1000 Biology.

Cysteine cathepsins also play an indispensable role in the proteolytic processing of the major histocompatibility complex class-II-associated invariant chain (Ii) and the foreign antigens in a number of antigen-presenting cells. A comparison of 3D structures indicated that the selectivity of the interactions between cysteine cathepsins and the p41 fragment is far from being understood. The p41 fragment was thus shown to inhibit the human cathepsins V, K, and F and the mouse cathepsin L with K_i values in the low nanomolar range. These values are sufficiently low to ensure the

complex formation at physiological concentrations. In addition, the p41 fragment was found to inhibit both mouse and human cathepsin S. These findings suggest that the regulation of the proteolytic activity of most of the cysteine cathepsins by the p41 fragment is an important and widespread control mechanism of antigen presentation.

We have also continued our work on other inhibitors and successfully expressed and characterized several of the thyroproins. Similarly, our studies on the steffin formation of amyloid fibers extended our knowledge on their structure and cellular toxicity.

In the Group of Structural Biology they have, in addition solved, the structures of several new proteins and/or protein complexes and developed the PURY database of geometric parameters of chemical compounds, together with a server that accesses it. The PURY database is suitable for use in macromolecular crystal-structure refinement and should be of value to the crystallographic community. The database can be accessed through the web server <http://pury.ijs.si/>, which creates topology and parameter files from deposited coordinates in suitable forms for the refinement programs MAIN, CNS and REFMAC.

Most recently, we entered into the field of proteomics, with the ultimate goal of analyzing the functional regulation of investigated proteins with a major focus on potential physiological protease substrates. We established a complete Proteomics Laboratory and the first experiments were performed.

We participate in two projects within the EU FP6 and one FP7 project. We also participate in the prestigious project within the Human Science Frontiers Program (HSFP) jointly with the groups from the University of Tokyo, Stanford University and the Burnham Institute for Medical Research, San Diego. In addition, there are many other international collaborations with many high-quality research teams from different countries, including Germany, USA, Australia and Japan, which resulted in joint publications. Several members of the group were invited to give lectures at international symposia and foreign universities.

Some outstanding publications in 2008

1. Alvarez, V.E., Kosec, G., Sant'Anna, C., Turk, V., Cazzulo, J.J., Turk, B. (2008) Autophagy is involved in nutritional stress response and differentiation in *Trypanosoma cruzi*. *J. Biol. Chem.* 283, 3454-3464.
2. Watzke, A., Kosec, G., Kindermann, M., Nestler H.P., Jeske, V., Turk, V., Turk, B., *Wendt, K.U.* (2008) Selective activity-based probes for cysteine cathepsins. *Angewandte Chemie Intl. Edition* 47, 406-409 (*shared last authorship).
3. Droga-Mazovec, G., Bojič, L., Petelin, A., Ivanova, S., Romih, R., Repnik, U., Salvesen, G.S., Stoka, V., Turk, V., Turk, B. (2008) Cysteine cathepsins trigger caspase-dependent cell death through cleavage of Bid and antiapoptotic Bcl-2 homologues. *J. Biol. Chem.* 283, 19140-19150.
4. Mihelič, M., Doberšek, A., Gunčar, G., Turk, D. (2008) Inhibitory fragment from the p41 form of invariant chain can regulate activity of cysteine cathepsins in antigen presentation. *J. Biol. Chem.* 283, 14453-14460.

Organization of conferences, congresses and meetings

1. 25th Winter School on Proteinases and their Inhibitors, Recent Developments, Tiers, Italy, 27 Feb. to 2 Mar. 2008 (coorganisers)
2. 11th International Symposium on Proteinase inhibitors and Biological control, Portorož, Slovenia, 30 Aug. to 3 Sept. 2008

INTERNATIONAL PROJECTS

1. Understanding and Fighting Metastasis by Modulating the Tumour Microenvironment through Interference with the Protease Network
MICROENVIRONMENT
7. FP, 201279
EC; Universite de Liege, Liege, Belgium
Dr. Olga Vasiljeva
2. Chemical Genomics by Activity Monitoring of Proteases
6. FP, CAMP
LSHG-CT-2006-018830
EC; Dr. Manuel Morillas, Universitat Autònoma de Barcelona, Institut de Biotecnologia i de Biomedicina (IBB), Bellaterra (Cerdanyola del Vallès), Spain
Prof. Boris Turk
3. High Throughput Development of Drugs for Immunotherapy of (Auto)immune Diseases Drugs for Therapy
6. FP
MRTW-CT-2004-512385
EC; Prof. Frits Koning, Leiden University Medical Center, Leiden, The Netherlands
Prof. Dušan Turk
4. Safe Production and Use of Nanomaterials
NANOSAFE2
6. FP
NMP2-CT-2005-515843
EC; Commissariat à l'Énergie Atomique, Grenoble, France
Prof. Boris Turk, Asst. Prof. Maja Remškar, Marko Žumer, B. Sc., Andrej Detela, B. Sc.
5. Intracellular Protease Signaling induced by Homopolymeric Amino Acid (HPAA) Tracts
RG105, 0024/2006-C
HFSPO - International Human Frontier Science Program Organisation, Strasbourg, France
Prof. Boris Turk
6. FEBS Fellowship for Dr. Zorana Štefanić
FEBS Fellowship for 13
FEBS - Federation of European Biochemical Societies, Prof. Maciej Nalecz, UNESCO, SB/BES, Paris, France
Prof. Dušan Turk
7. Proteolytic Activities in Trypanosoma Cruzi: Cruzipain, Metacaspase, Serine Carboxypeptidase
BI-AR/06-08-03
Prof. Juan Jose Cazzulo, Instituto de Investigaciones Biotecnológicas, Instituto Tecnológico de Chascomus, Universidad Nacional de General San Martín- CONICET, San Martín, Provincia de Buenos Aires, Argentina
Prof. Vito Turk
8. Chosen Site-mutations of Aromatic Amino Acids in Human Stefins A and B. Influence on Dimerization, Folding and Aggregation
Izabrane tačkaste mutacije aromata u čovječijim stefinima A i B. Uticaj na stabilnost, dimerizaciju i svijanje protein
BI-BIH/05-06-001
Prof. Selma Berbić, Farmaceutska fakulteta, Univerza v Tuzli, Tuzla, Bosnia and Herzegovina
Asst. Prof. Eva Žerovnik

9. Izabrane tačkaste mutacije aromata u čovječijim stefinima A i B. Uticaj na stabilnost, dimerizaciju i svijanje protein
BI-BIH/06-08/001
prof. dr. Selma Berbić, Medicinski fakultet, Univerza v Tuzli, Tuzla, Bosnia and Herzegovina
Asst. Prof. Eva Žerovnik
10. Bayesian Decision Making to support Change Detection in Complex Manufacturing Systems
BI-CZ/07-08-020
Prof. Libor Grubbhofer, Faculty of Biological Sciences, University of South Bohemia, České Budejovice, Czech Republic
Dr. Tina Zavašnik Bergant
11. Interactions between Tuberculosis causing Mycobacteria and Dendritic Cells
Interacciones entre a bacteria causal de tuberculose com celulas dendriticas
BI-PT/08-09-002
Prof. Elsa Anes, University of Lisbon, Faculty of Pharmacy, CPM-URIA, Lisbon, Portugal
Dr. Tina Zavašnik Bergant
12. Export of the Cathepsin B
Csaba C Pazmany, Dyax Corp., Cambridge, MA, USA
Prof. Boris Turk

R & D GRANTS AND CONTRACTS

1. Proteomic identification of extracellular substrates of cysteine proteases
Dr. Marko Fonović
2. Role of cysteine cathepsins in regulation of proliferation and cell death
Prof. Boris Turk
3. Differences Between Mouse And Human Endosomal Immune Response Pathway: Crystal Structures of Protein Complexes and their Analysis
Prof. Dušan Turk
4. The effect of citrullination of extracellular matrix proteins to degradation by cysteine and metalloproteases in arthritic joints
Prof. Boris Turk
5. Cathepsin F, new cysteine proteinase involved in neuronal ceroid lipofuscinosis
Asst. Prof. Veronika Stoka
6. The role of nuclear cystatins in the regulation of interleukin-10 synthesis during endotoxin tolerance
Asst. Prof. Nataša Kopitar Jerala
7. The role of cysteine proteinases and their inhibitors in endotoxin tolerance
Asst. Prof. Nataša Kopitar Jerala
8. Using phage display for new medicinal substances of biotechnological source
Prof. Borut Štrukelj, Polonca Pirš Kovačić

RESEARCH PROGRAMS

1. Structural biology
Prof. Dušan Turk
2. Proteolysis and its regulation
Prof. Vito Turk

VISITORS FROM ABROAD

1. Dušana Majera, Bački Petrovac, Serbia, 1 Jan. to 31 Dec. 2008, (Scholarship Marie Curie Actions: Research Training Network)
2. Zoran Štefanić, Ruder Bošković Institute, Physical Chemistry - Laboratory for Chemical and Biological Crystallization, Zagreb, Croatia, 1 Jan. to 31 Dec. 2008, (scholarship Ruder Bošković Institute, Zagreb)
3. Georgy Mikhaylov, Siberian State Medical University, Tomsk, Siberia, Russia, 1 Jan to 31 Dec. 2008
4. dr. Maria Luisa Jordao, Centro de Patogenese Molecular-URIA, faculty of Pharmacy, University of Lisbon, Lisbon, Portugal, 2-31 May 2008
5. prof. Bai He, prof. Liu Yongyu, prof. Sun Tao, prof. Sun Ping, prof. Piao Haozhe, prof. Li Sen, asst. prof. Sun Lihua in Wang Lijun, Liaoning Cancer Hospital, Shenyang, China, 12 May 2008
6. prof. Boštjan Kobe, ARC Federation, Fellow Professor of Structural Biology School of Molecular and Microbial Sciences and Institute for Molecular Bioscience, University of Queensland, Brisbane, Australia, 24 Jun. 2008
7. dr. Jernej Ule, Cambridge University, Cambridge, England, 2 Jul. 2008
8. prof. dr. Francesc Xavier Aules, Universitat Autònoma de Barcelona, Institut de Biotecnologia i de Biomedicina Campus UAB, Barcelona, Spain, 27 Aug. to 3 Sept. 2008
9. prof. dr. Kazuo Umezawa, Keio University, Yokohama, Japanska in Nami Miyaniishi, Keio University, Yokohama, Japan, 12-15 Oct. 2008
10. dr. Salvador Ventura, Department of Biochemistry and Molecular Biology and the Institute of Biotechnology and Medicine of the Autonomous University of Barcelona (UAB), Spain, 11 Nov. 2008

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8. Prof. Dušan Turk

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 11. Asst. Prof. Eva Žerovnik
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 13. Dr. Dejan Caglić
 14. Dr. Marko Fonović
 15. Dr. Saška Ivanova
 16. Dr. Saša Jenko Kokalj, left 1 Jun. 2008

17. Dr. Gregor Kosec, *left 1 Jul. 2008*
18. Dr. Marko Mihelič
19. Dr. Kristina Orešič
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BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Vanina Alvarez, Gregor Kosec, Celso Sant'Anna, Vito Turk, Juan José Cazzulo, Boris Turk, "Autophagy is involved in nutritional stress and differentiation in *Trypanosoma cruzi*", *J Biol Chem*, vol. 283, no. 6, pp. 3454-3464, 2008.
2. Vanina Alvarez, Gregor Kosec, Celso Sant'Anna, Vito Turk, Juan José Cazzulo, Boris Turk, "Blocking autophagy to prevent parasite differentiation: a possible new strategy for fighting parasitic infections?", *Autophagy*, vol. 4, no. 3, pp. 361-363, 2008.
3. Miha Andrejašič, Jure Praznikar, Dušan Turk, "PURY: a database of geometric restraints of hetero compounds for refinement in complexes with macromolecular structures", *Acta crystallogr., D, Biol. crystallogr.*, vol. 64, no. 11, pp. 1093-1109, 2008.
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7. Slavko Čeru, Saša Jenko, Sabina Rabzelj, Miha Škarabot, Ion Gutierrez-Aguirre, Nataša Kopitar-Jerala, Gregor Anderluh, Dušan Turk, Vito Turk, Eva Žerovnik, "Size and morphology of toxic oligomers of amyloidogenic proteins: a case study of human stefin B", *Amyloid (Carnforth)*, vol. 15, no. 3, pp. 147-159, 2008.
8. Slavko Čeru, Eva Žerovnik, "Similar toxicity of the oligomeric molten globule state and the prefibrillar oligomers", *FEBS lett.*, vol. 582, no. 2, pp. 203-209, 2008.
9. Gabriela Droga-Mazovec, Lea Bojič, Ana Petelin, Saška Ivanova, Rok Romih, Urška Repnik, Guy S. Salvesen, Veronika Stoka, Vito Turk, Boris Turk, "Cysteine cathepsins trigger caspase-dependent cell death through cleavage of Bid and antiapoptotic Bcl-2 homologues", *J Biol Chem*, issue 27, vol. 283, pp. 19140-19150, 2008.
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12. Saška Ivanova, Urška Repnik, Lea Bojič, Ana Petelin, Vito Turk, Boris Turk, "Chapter nine Lysosomes in apoptosis", *Methods enzymol.*, vol. 442, pp. 183-199, 2008.
13. Boštjan Kobe, Gregor Gunčar, (9 authors), "Crystallography and protein-protein interactions: biological interfaces and crystal contacts", In: *2nd international conference on molecular perspectives on protein-protein interactions: 27 June - 1 July 2008, Dubrovnik, Croatia*, (Biochemical Society transactions, Vol. 36, Issue 6, 2008), London, Biochemical Society, 2008, vol. 36, no. 6, pp. 1438-1441, 2008.
14. Marko Mihelič, Andreja Doberšek, Gregor Gunčar, Dušan Turk, "Inhibitory fragment from the p41 form of invariant chain can regulate activity of cysteine cathepsins in antigen presentation", *J Biol Chem*, vol. 283, no. 21, pp. 14453-14460, 2008.
15. Georgy Andreevič Mikhaylov, Olga Vasiljeva, "Tehnologija budućega: ispolzovanje magnetnih nanočastic v onkologiji", *Bull. Sib. otd. Ross. akad. med. nauk (Print)*, vol. 131, no. 3, pp. 17-22, 2008.
16. Gareth J. Morgan, Silva Giannini, A. Hounslow, Jeremy Craven, Eva Žerovnik, Vito Turk, Jonathan P. Waltho, Rosemary A. Staniforth, "Exclusive of the native α -helix from the amyloid fibrils of a mixed α/β protein", *J. mol. biol.*, vol. 375, pp. 487-498, 2008.
17. Marko Novinec, Lidija Kovačič, Nives Škrlj, Vito Turk, Brigita Lenarčič, "Recombinant human SMOCs produced by in vitro refolding: calcium-binding properties and interactions with serum proteins", *Protein expr. purif.*, issue 1, vol. 62, pp. 75-82, 2008.
18. Nataša Obermajer, Urška Repnik, Zala Jevnikar, Boris Turk, Marko Kreft, Janko Kos, "Cysteine protease cathepsin X modulates immune response via activation of β_2 integrins", *Immunology (Oxf.)*, vol. 124, no. 1, pp. 76-88, 2008.
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21. Alejandro Rabossi, Veronika Stoka, Vida Puizdar, Vito Turk, Luis A. Quesada-Allué, "Purification and characterization of two cysteine peptidases of the Mediterranean fruit fly *Ceratitis capitata* during metamorphosis", *Arch. insect biochem. physiol.*, vol. 68, no. 1, pp. 1-13, 2008.
22. Sabina Rabzelj, Gabriella Viero, Ion Gutierrez-Aguirre, Vito Turk, Mauro Dalla Serra, Gregor Anderluh, Eva Žerovnik, "Interaction with model membranes and pore formation by human stefin B - studying the native prefibrillar states", *FEBS journal*, issue 10, vol. 275, pp. 2442-2454, 2008.
23. Urška Repnik, (7 authors), "Comparison of macrophage phenotype between *Decidua basalis* and *Decidua parietalis* by flow cytometry", *Placenta (Eastbourne)*, issue 5, vol. 29, pp. 405-412, 2008.

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26. Olga Vasiljeva, Matvey Korovin, Mieczyslaw Gajda, Harald Brodoefel, Lea Bojič, Achim Krüger, Uta Schurigt, Lisa Sevenich, Boris Turk, Christoph Peters, Thomas Reinheckel, "Reduced tumour cell proliferation and delayed development of high-grade mammary carcinomas in cathepsin B-deficient mice", *Oncogene (Basingstoke)*, vol. 27, no. 30, pp. 4191-4199, 2008.
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29. Tina Zavašnik-Bergant, "Cystatin protease inhibitors and immune functions", *Front. biosci. (Print)*, vol. 13, no. 13, pp. 4625-4637, 2008.

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1. Nathan P. Cowieson, Elisabeth Wensley, Gautier Robin, Gregor Gunčar, Jade K. Forwood, David A. Hume, Boštjan Kobe, Jennifer L. Martin, "A medium or high-throughput protein refolding assay", In: *Structural proteomics: high-throughput methods*, (Methods in molecular biology, vol. 426), Boštjan Kobe, ed., Mitchel Guss, ed., Thomas Huber, ed., Totowa [New Jersey, USA], Humana, London, Springer [distributor], 2008, pp. 269-275.
2. Weining Meng, Jade K. Forwood, Gregor Gunčar, Gautier Robin, Nathan P. Cowieson, Pawel Listwan, Dmitri Mouradov, Gordon King, Ian Ross, Jodie Robinson, Munish Puri, Justine M. Hill, Stuart Kellie, Thomas Huber, David A. Hume, Jennifer L. Martin, Boštjan Kobe, "Overview of the pipeline for structural and functional characterization of macrophage proteins at the University of Queensland", In: *Structural proteomics: high-throughput methods*, (Methods in molecular biology, vol. 426), Boštjan Kobe, ed., Mitchel Guss, ed., Thomas Huber, ed., Totowa [New Jersey, USA], Humana, London, Springer [distributor], 2008, pp. 577-587.
3. Gautier Robin, Nathan P. Cowieson, Gregor Gunčar, Jade K. Forwood, Pawel Listwan, David A. Hume, Boštjan Kobe, Jennifer L. Martin, Thomas Huber, "A general target selection method for crystallographic

proteomics", In: *Structural proteomics: high-throughput methods*, (Methods in molecular biology, vol. 426), Boštjan Kobe, ed., Mitchel Guss, ed., Thomas Huber, ed., Totowa [New Jersey, USA], Humana, London, Springer [distributor], 2008, pp. 27-35.

4. Vito Turk, Boris Turk, "Lysosomal cysteine proteases and their protein inhibitors: recent developments", *Acta chim. slov.*, vol. 55, no. 4, pp. 727-738, 2008.
5. Eva Žerovnik, "Using stefin B as a model amyloidogenic protein: overview: pregled", *Zdrav Vestn (Tisk. izd.)*, vol. 77, suppl. II, pp. II-21-II-26, 2008.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Marko Fonovič, "Proteomika - veda ali tehnologija", In: *Proteomika*, (Pomen biotehnologije in mikrobiologije za prihodnost, 05), Posvetovanje Pomen biotehnologije in mikrobiologije za prihodnost, 31. januar in 1. februar 2008, Ljubljana, Peter Raspor, ed., Polona Jamnik, ed., Ljubljana, Biotehniška fakulteta, Oddelek za živilstvo, 2008, pp. 1-9.

THESES

Ph. D. Theses

1. Slavko Čeru, *Mehanizem citoksičnosti prefibrilarnih agregatov stefina B in izbranih mutantov v razmerah in vitro/ex vivo: doktorska disertacija*, Ljubljana, [S. Čeru], 2008.
2. Gabriela Droga-Mazovec, *Role of cysteine cathepsins in the regulation of activities of the oncogene Bcl-2 and its homologues in apoptosis: doctoral thesis*, [Ljubljana, C. G. Pinto Droga Mazovec], 2008.
3. Marko Novinec, *Evolucija in biokemijske lastnosti tiroglobulinskih domen tipa 1: modular architecture as the basis for functional diversity of multidomain proteins: phd thesis*, Ljubljana, [M. Novinec], 2008.

PATENT APPLICATION

1. Matthew Bogyo, Steven H. L. Verhelst, Marko Fonovič, *A mild chemically cleavable linker system: patent application no. 3815.33-1 PCT*, Stanford, National Technology Center for Networks and Pathways, 2008.

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 to acquire a new understanding of mammalian pathophysiology, with the aim of improving human and animal health.

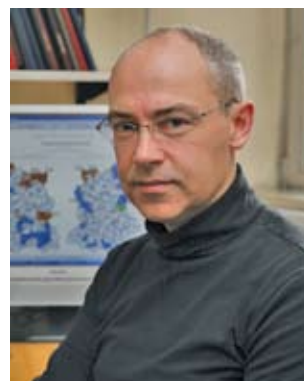
Secreted phospholipases A₂ (sPLA₂)

The major research topic of the department is secreted phospholipases A₂ (sPLA₂s) originating from animal toxins as well as those found in humans. We are studying the molecular mechanisms of the action of the toxic sPLA₂s, particularly those endowed with presynaptic neurotoxicity, and the role of endogenous sPLA₂s in pathological and physiological processes in mammals.

In 2008 we studied the molecular mechanism of the action of ammodytoxin (Atx), a presynaptically neurotoxic sPLA₂ from the long-nosed viper's (*Vipera a. ammodytes*) venom, on murine cell lines and on murine and rat neuromuscular (NM) preparations. Our results, obtained by fluorescent and electron microscopy (EM) analysis of the cell culture, have demonstrated the uptake of Atx into motoneuron-like cells, as well as its translocation into the cytosol (Figure 1). The results from the microscopy studies were confirmed by the detection of the formation of the complex between the toxin and cytosolic proteins, calmodulin (CaM) and 14-3-3, in living cells, Z. Jenko Pražnikar et al., *Biochim. Biophys. Acta - Mol. Cell Res.* 1783 (2008) 1129–1139. In this way we also confirmed *in vivo* the results obtained *in vitro*, that the cytosolic concentrations of Ca²⁺ allow the interaction between Atx and CaM U. Logonder et al., *Acta Chimica Slovenica* 55 (2008) 541-546. We were the first to demonstrate that an sPLA₂ can translocate into the cytosol of a nerve cell from the extracellular space. The exposure of the cells in a culture to the toxic sPLA₂ *in vitro* resulted in the apoptotic death of cells, Z. Jenko Pražnikar et al., in International Meeting Mechanism(s) of Exocytosis and 15th Young Neuroscientists Meeting, Ljubljana, Slovenia, Book of Abstracts, 2008, p. 65. As the recent results show, one of the main factors of apoptotic cell death is a particular product of the enzymatic degradation of cellular membranes by the toxic sPLA₂. The photoreactive derivative of AtxC, sulfo-SBED-AtxC, was used to develop a new method for the targeted therapy of cancer. We synthesized the conjugate of sulfo-SBED-AtxC and "targeting" antibodies, which specifically recognized the CaCo-2 cancer cells. Following the specific binding on the cancer cells, the conjugate was internalized into the cells. In the reducing conditions of the cytosol the toxin molecule was released, A. Premzl et al., *Toxicon* 51 (2008), 754–764.

Mitochondria are one of the main targets of Atx following its internalization into nerve cells. The consequence of the enzymatic action of Atx on mitochondria in the nerve ending is also the reduced production of ATP, which is likely to be one of the main reasons for the interruption of the cycling of synaptic vesicles filled with neurotransmitter. The data gathered on the NM preparations were published in the distinguished medical pathophysiology journal, U. Logonder et al., *Journal of Neuropathology and Experimental Neurology* 67 (2008), 1011-1019. The high relevance of our report is reflected in its announcement on the cover page of the journal, presenting a collage of figures from the paper (Figure 2). Atx was labelled with a nanogold particle and used to block *in vivo* mouse NM junctions. Labelled junctions were isolated and in collaboration with colleagues from Newcastle University, UK, analysed by EM. We demonstrated the localization of the nanogold toxin derivative inside the nerve ending, which was done for the first time in the case of the nerve ending of a motoneuron, not only for a neurotoxic but for any sPLA₂. These results are in preparation for publication.

The study of the topology of the interaction of Atx with CaM, which is ready for submission, revealed two very interesting facts: the stability and the phospholipase activity of Atx increased substantially in the complex with CaM, both in reducing (cytosol-like) and non-reducing conditions. We performed a detailed kinetic study of the activation of the enzymatic activity of Atx and some other sPLA₂ with CaM. The most accurate description of the activation is by the non-essential activation model and the Atx-CaM system



Head:
Prof. Igor Krizaj

New substances and molecular tools to improve human and animal health.

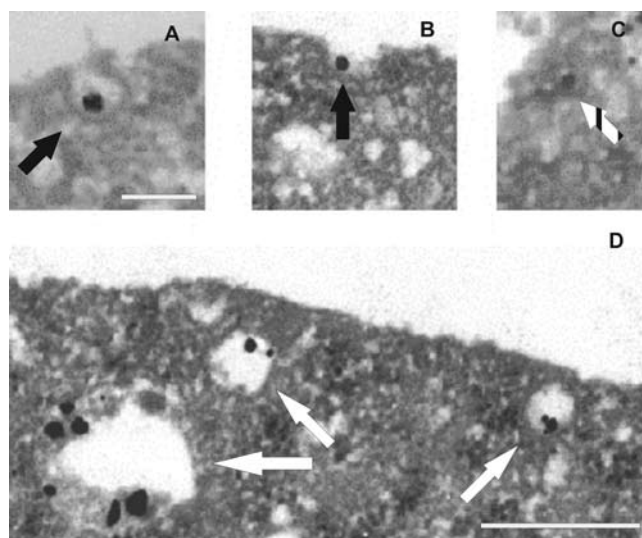


Figure 1. Localization of AtxA(N79C)-nanogold in motoneuron-like cells.

is the first practical example discovered. The results are in preparation for publication. Following the demonstration of the interaction of Atx with CaM in the cytosol of motoneuron-like cells, Z. Jenko Pražnikar et al., *Biochim. Biophys. Acta - Mol. Cell Res.* 1783 (2008) 1129–1139, and the internalization of the toxin into the nerve ending of a motoneuron, this finding indicates the enzymatic activity of sPLA₂ also in the cytosol and nucleus of mammalian cells, its role in the process of β -neurotoxicity and in some other processes connected to endogenous sPLA₂s (e.g., during nuclear signalling, mRNA transport and apoptosis). With the obtained results we further strengthened our hypothesis about the molecular mechanism of action of presynaptically neurotoxic sPLA₂s, which claims that for the full expression of the toxic action of these sPLA₂s their internalization into the nerve cell is crucial. In order to exactly describe what happens at the nerve ending on the molecular level, e.g., molecular details of the internalization of the Atx into the cytosol of the nerve cell and its translocation into the mitochondria, we continued this year with efforts to identify some known Atx-receptors: R25, R45 and R47. However, we have not made any final conclusions yet. We were also looking for novel Atx-binding molecules (proteins, lipids and glycolipids).

In the past year we published an extensive study on the structural features of presynaptically neurotoxic snake sPLA₂s that are responsible for their potent and specific action, P. Prijatelj et al., *Toxicon* 51 (2008) 1520-1529. To identify the residues that distinguish a highly neurotoxic ammodytoxin A from a structurally similar but more than two-orders-of-magnitude less toxic Russell's viper (*Daboia r. russelli*) sPLA₂, VIIIa, we prepared a range of mutants and compared their properties. The results showed that the structural features that confer high neurotoxicity to AtxA extend from its C-terminal part, with a central role of the residues Y115, I116, R118, N119 (the YIRN cluster) and F124, across the interfacial binding surface (IBS) in the vicinity of F24, to the N-terminal helix, whose residues M7 and G11 are located on the edges of the IBS. Binding studies indicated that the surface of interaction with the neuronal M-type sPLA₂ receptor extends over a similar region of the molecule. In addition, the YIRN cluster of AtxA is crucial for the high-affinity interaction with two intracellular binding proteins, cytosolic CaM and mitochondrial R25. The concept of a single "presynaptic neurotoxic site" on the surface of snake venom sPLA₂s is not consistent with these results, which suggest that different parts of the toxin molecule are involved in distinct steps of the presynaptic neurotoxicity (Figure 3).

We participated in the development of the chromatographic method for the rapid and accurate determination of Atx content in venoms of *Vipera a. ammodytes* specimens, B. Halassy et al., *Journal of Liquid Chromatography & Related Technologies*, 31 (2008), 38-53. Namely, we found a high correlation between the content of Atx in the venom and the suitability of the venom for the preparation of high-quality antiserum by animal immunization, B. Halassy et al., *Comparative Biochemistry and Physiology*, 148 (2008), 178-183. These findings will substantially lower the price of high-quality antiserum production and reduce the work on animals in the process of its preparation.

At the beginning of this year we published a review article on the pathophysiological role of sPLA₂s where, among others, their involvement in various cancer and neurodegenerative disorders was presented, B. Jerman et al., *Farmaceutski vestnik*, 59 (2008), 9-15. In 2008 we started a new project aimed at exploring the role of sPLA₂s in the development and progression of breast cancer (Research project: The role of secretory phospholipases A₂ in breast cancer). Currently, ten structurally distinct sPLA₂ enzymes are known in humans, which differ in enzymatic activity, membrane-binding and receptor-binding affinities. These enzymes show diverse tissue expression patterns, suggesting tissue-specific pathophysiological roles and mechanisms of action. Our hypothesis is that certain sPLA₂ enzymes are involved in cellular processes that have an impact on breast-cancer development and progression. In the first year of the project we focused our attention on identifying members of the sPLA₂ family that display differential levels of expression in the cell models of breast cancer. We used several human breast-cancer cell lines, which differ in their invasiveness *in vitro*, tumourigenicity *in vivo* and steroid hormone receptor status, as well as two nontumourigenic cell lines, which retain the characteristics of normal breast epithelial cells. We determined the differences in mRNA expression levels of the whole set of human sPLA₂s in the selected cell models using real-time quantitative PCR (qPCR). Our results indicate that breast-cancer cell lines with different tumourigenic characteristics, reflecting the progression of the disease from less aggressive and hormone-dependent to the more invasive and hormone-independent forms, display different levels of expression of particular sPLA₂s.

An investigation has also been focused on the presence and role of endogenous sPLA₂s in the (peripheral) nervous system, which is also an important target site of action for snake venom neurotoxic sPLA₂s. In collaboration with the Institute of Pathophysiology, Medical Faculty, University of Ljubljana, we analyzed a co-culture of rat embryonal spinal cord explants and human skeletal muscle cells (Figure 4) by immunocytochemistry for the presence of five groups of endogenous sPLA₂s, IB, IIA, IIE, V and X. This heterologous co-culture could also serve as a model for the study of the action of endogenous and snake sPLA₂s in the region of neuromuscular junction. Preliminary results showed the



Figure 2. Cover page of the *Journal of Neuropathology and Experimental Neurology* with a collection of images from our paper.

presence of group IIA, V and X sPLA₂s in different cell types in the co-culture (neurons, their support cells, muscle cells). The demonstration of different sPLA₂s in the co-culture, able to form functional neuromuscular junctions, has provided a good basis for the investigation of sPLA₂s in less-complex systems of neuronal cells. We confirmed the presence of group X sPLA₂ in a mouse motoneuronal cell line, and groups V and X in a rat neuron-like cell line. Aiming to investigate the specificity of immunodetection of different groups of sPLA₂s, we are currently occupied with the production of certain recombinant mammalian sPLA₂s. The latter will be used to test the potential cross-reactivity of particular antibodies and to observe the effect of different sPLA₂s on the neuronal cells and functional heterologous co-culture.

Other pharmacologically active components from natural toxins

We studied *Vipera a. ammodytes* venom components that affect haemostasis, particularly different proteases, and published the work describing the isolation and characterization of two novel coagulation factor X activators with the potential to treat patients with dysfunctional factors IXa or VIIa, A. Leonardi et al., *Toxicon*, 52 (2008), 628-637. In this year we also started with a new project dedicated to the development of the potential of fibrinolytic and non-haemorrhagic ammodytase to serve in the therapy of thrombosis (Research project: Proteins of the long-nosed viper venom acting on haemostasis – development of innovative biomedical antitrombotic).

In 2008 we continued work on the EU 6FP Integrated Project Conco. As one of the 20 partners we have been involved in the analysis of the genome, transcriptome and venom proteome of the marine snail *Conus consors*. We investigated the toxicity of the Cc001 conopeptide from the venom of this snail possessing a potent inhibitory activity on Na⁺ voltage-gated channels. No cytotoxicity on neuroblastoma cells was observed, even at a 100 μM concentration, whereas a transient cytotoxicity was detected in myoblasts and motoneuron-like cells. Currently, we are analyzing different HPLC fractions of the *C. consors* venom for the presence of phospholipase activity. Venoms of two species of cone snails, piscivorous *C. consors* (whose prey is mainly fish) and vermivorous *C. quercinus* (whose prey are marine worms), have been successfully separated by 2D electrophoresis into individual protein components.

The methodology of the preparation of the photoreactive derivative of AtxC was successfully used to prepare photoreactive derivatives of human SMOC (“secreted modular Ca²⁺ binding”) proteins to study interactions with proteins in human serum, M. Novinec et al., *Protein Expression and Purification*, 62 (2008), 75-82. In collaboration with a group from the New York University Langone School of Medicine from New York we investigated the perturbation of transforming growth factor (TGF)-ss1 association with latent TGF-β binding protein and found positive effects on inflammation and tumorigenesis, K. Yoshinaga et al., *Proceedings of the National Academy of Sciences of the United States of America*, 48 (2008), 18758-18763.

High-throughput genetics and functional genomics in yeast *Saccharomyces cerevisiae*

In 2008 we have made some important steps toward measuring yeast-colony volumes on agar plates, which is an important advancement in high-throughput genetics (Figure 5). We have demonstrated that by the application of this development into our experimental platform, the quality of the generated data is significantly improved.

Based on the interpretation of our high-throughput genetics data, we have elucidated the first contours of the core genetic network of membrane biology: we discovered a functional interaction between peroxisome proliferation and endocytosis and some of the genes/proteins involved in this pathway.

In close collaboration with the Faculty of Computer and Information Sciences of the University of Ljubljana we have started to analyze the not-yet-published 3rd generation data on the genetic interactome of yeast *Saccharomyces cerevisiae*, generated at the University of Toronto. This project is making a huge contribution towards the understanding and treatment of polygenetic diseases.

In collaboration with the University of Nova Gorica we have identified some novel targets of the action of pesticides, which could explain some of their side effects and enable the development of safer new compounds.

In the past year we have also initiated work on a new applicative project. With our partners, the Lek-Novartis pharmaceutical company and the Faculty of Computer and Information Sciences of the University of Ljubljana, we have started to develop novel knowledge-technology

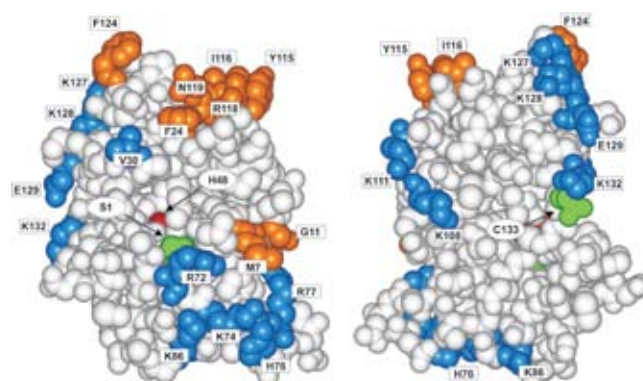


Figure 3. Structural model of AtxA showing the residues involved in β-neurotoxicity. It appears that different parts of the toxin molecule are involved in different stages of the complex process of β-neurotoxicity. Consequently, it is not appropriate to use the term “a distinct presynaptic neurotoxic site” on the toxin molecule.

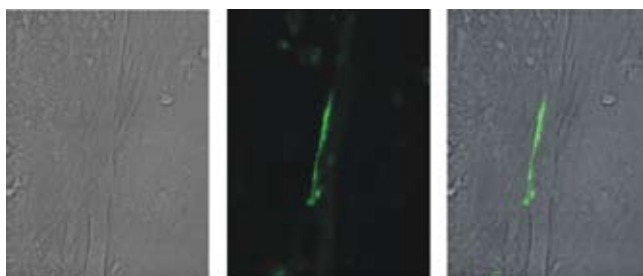


Figure 4. Heterologous co-culture of the explant from rat embryo spinal cord and human skeletal muscles as a model for the study of the activity of endogenous and snake venom sPLA₂s at the neuromuscular junction. The heterologous junction (synapse) is stained green. Accomplished in a collaboration with the Institute of Pathophysiology, Medical Faculty, University of Ljubljana.

approaches in drug discovery that are based on analyses and experiment planning in high-throughput genetics (Research project: Knowledge technology approaches in drug discovery: analysis and experiment planning in high-throughput genetic)

Evolutionary genomics of transposable elements and functional studies of retrotransposons

The origin of the novel mammalian genes (neogenes) from retro-element remains (e.g., gag and integrase) and their evolution has until now been only partially elucidated, due to the absence of the genome data or the limited analysis of a single family of neogenes. By using phylogenomic analysis (combining phylogenetic tree construction, integration of the experimental data and differentiation of orthologs and paralogs) we obtained and characterized retro-element-derived neogenes from all the currently available mammalian genomes (more than 50 different species available at NCBI and ENSEMBL) and their progenitors from the genomes of the key tetrapod genomes (amphibians and reptiles). Phylogenomic analysis provided a very large amount of information for each novel neogene, such as the genome sequence, the gene structure, the genome locus, the chromosomal location, the protein sequence, the coding and the non-coding regions as well as the regulatory regions. With the analysis of numerous mammalian genomes (from monotremes, marsupials and four placental superorders) and by the analysis

of novel neogene families, an in-depth insight into the origins, evolution, regulatory and functional diversification of diverse retro-element-derived neogenes in mammals has been obtained. We explained where and when the domestication of retro-elements occurred and how similar to the modern neogenes the first mammalian retro-element-derived neogenes were. Until now the evolutionary relationships of currently known retro-element-derived neogenes were not well resolved due to the poor taxonomic sampling. Novel data that we obtained from the genomes of monotremes, marsupials and basal placental superorders has greatly improved and finally resolved the evolutionary relationships of diverse neogenes. The well resolved evolutionary relationships of mammalian retro-element-derived neogenes are crucial for the elucidation of their unusual dynamics of chromosomal mobility as well as for the timing of domestication.

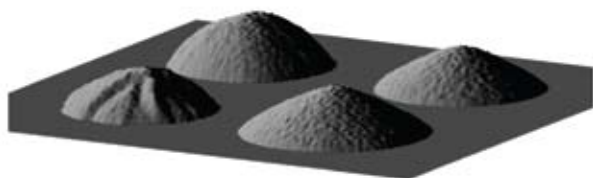


Figure 5. Reconstruction of yeast colonies' shapes on an agar plate, which allows an accurate determination of their volume.

Several APOBEC3 proteins (A3F and A3G), a group of cytidine deaminases, restrict the human immunodeficiency virus (HIV) replication in the absence of the viral infectivity factor (Vif) protein. However, Vif leads to their degradation and counteracts their effects. Another member, A3A, restricts some retrotransposons and another virus, but not HIV. We reasoned that this failure was due to the lack of appropriate targeting. Thus, we fused A3A to another viral protein, Vpr, which binds p6 in Gag and is incorporated into viral cores. Indeed, the Vpr.A3A chimera but not A3A was found abundantly in the viral core. It also potently restricted the replication of HIV and the simian immunodeficiency virus (SIV) in the presence and absence of Vif. Since a high frequency of G to A mutations in viral cDNAs was identified, we assumed this antiviral activity was mediated by DNA editing. Interestingly, our fusion protein did not restrict the murine leukemia virus, which does not incorporate Vpr. Thus, by appropriately targeting a potent single-domain cytidine deaminase, we rendered HIV and SIV restriction resistant to Vif. Because the Vpr.A3A chimera inhibited SIV, such therapeutic strategies could be tried first in the monkey model of AIDS in rhesus macaques, R. S. Aguiar et al., *The Journal of Biological Chemistry*, 283 (2008), 2518-2525.

Outstanding publications in 2008

1. Z. Jenko Pražnikar, L. Kovačič, E. G. Rowan, R. Romih, P. Rusmini, A. Poletti, I. Križaj and J. Pungerčar. (2008) A presynaptically toxic secreted phospholipase A_2 is internalized into motoneuron-like cells where it is rapidly translocated into the cytosol. *Biochim. Biophys. Acta - Mol. Cell Res.* 1783, 1129-1139.
2. U. Logonder, I. Križaj, E. G. Rowan and J. B. Harris. (2008) Neurotoxicity of ammodytoxin A in envenoming bites of *Vipera ammodytes ammodytes*. *J. Neuropathol. Exp. Neurol.* 67, 1011-1019.
3. A. Premzl, L. Kovačič, B. Halassy and I. Križaj. (2008) Generation of ammodytoxin-anti-cathepsin B immun-conjugate as a model for delivery of secretory phospholipase A_2 into cancer cells. *Toxicon* 51, 754-764.
4. A. Leonardi, J. W. Fox, A. Trampuš-Bakija and I. Križaj. (2008) Two coagulation factor X activators from *Vipera a. ammodytes* venom with potential to treat patients with dysfunctional factors IXa or VIIa. *Toxicon* 52, 628-637.
5. S. Kohlwein, H. Wolinski, U. Petrovič, M. Mattiazzi, J. Petschnigg, K. Natter and B. Heise (2008) Imaging-based live cell yeast screen identifies novel factors involved in peroxisome assembly. *J. Proteome Res.*

Awards and appointments

1. Uroš Petrovič: Lapanje prize of the Slovenian Biochemical Society for outstanding achievements in biochemical sciences
2. Igor Križaj: Elected to the post of Secretary of the European Section of the International Society on Toxinology (EIST) and a member of the Council of the IST
3. Franc Gubenšek (retired member of the department): Slovenian Biochemical Society Honorary membership

INTERNATIONAL PROJECTS

1. Applied venomomics of the cone snail species *Conus consors* for the accelerated, cheaper, safer and more ethical production of innovative biomedical drugs
CONCO
6. FP, IP
037592, LSHB-CT-2007-03792
EC; Dr. Reto Stöcklin, Atheris Laboratories, Plan-les-Quates - Geneve, Switzerland
Prof. Igor Križaj
2. Phospholipases A₂ and PEX11 in fatty acid signalling in yeast
BI-AT/07-08-014
Prof. Sepp D. Kohlwein, University of Graz, Institute of Molecular Biosciences, Graz, Austria
Asst. Prof. Uroš Petrovič
3. Biochemical and structural characterization of phospholipases A₂ from viperids in complexes with their binding proteins
Etudes biochimiques et structurales des Phospholipases A₂ des venins de Viperidae en complexes avec leurs cibles protéiques
PROTEUS 2008 - 2009
BI-FR/08-09-PROTEUS-007
Dr. Grazyna Faure, Institut Pasteur, Unite d'Immunologie Structurale, Paris, France
Prof. Igor Križaj
4. The role of secreted phospholipases A₂ in mitochondrial function and dysfunction
BI-IT/05-08-021
Prof. Gianfrancesco Goracci, Department of Internal Medicine, Division of Biochemistry, University of Perugia, Perugia, Italy
Prof. Igor Križaj

R & D GRANTS AND CONTRACTS

1. Use of yeast for determination of toxicity of selected neonicotinoids on the genome level
Asst. Prof. Uroš Petrovič
2. Computational phenomics
Asst. Prof. Uroš Petrovič
3. The role of secretory phospholipases A₂ in breast cancer
Prof. Jože Pungercar
4. Proteins of the long-nosed viper venom acting on haemostasis - development of innovative biomedical antitrombotics
Prof. Igor Križaj
5. Knowledge technology approaches in drug discovery: analysis and experiment planning in high-throughput genetic
Asst. Prof. Uroš Petrovič

RESEARCH PROGRAM

1. Toxins and biomembranes
Prof. Igor Križaj

NEW CONTRACT

1. Knowledge technology approaches in drug discovery: analysis and experiment planning in high-throughput genetics
Lek d. d., Ljubljana
Asst. Prof. Uroš Petrovič

VISITORS FROM ABROAD

1. Kristina Radošević, dipl. ing., Faculty of Food Technology and Biotechnology, Laboratory for Cell Technology, Application and Biotransformations, Zagreb, Croatia, 6 Feb. to 28 May, and 11 Nov. 2008
2. Dr. Matej Orešič, Quantitative Biology and Bioinformatics Group, VTT, Espoo, Finland, 30 Sept. 2008
3. Dr. Grazyna Faure Kuzminska, Mr. Frederick Saul, Institut Pasteur, Paris, France, 7-10 Dec. 2008
4. Dr. Klaus Natter, Dr. Jürgen Zanghellini, University of Graz, Austria, 9-10 Dec. 2008
5. Dr. Antonio Baici, Department of Biochemistry, University of Zürich, Switzerland, 10. Dec. 2008

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2. **Prof. Igor Križaj, Head**
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4. Prof. Jože Pungercar

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6. Dr. Jernej Šribar

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10. Lidija Kovačič, B. Sc.
11. Adrijana Leonardi, M. Sc.
12. Dr. Uroš Logonder
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14. Anja Pucer, B. Sc.
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16. Petra Kaferle, B. Sc.

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17. Igor Koprivec
18. Darja Žunič Kotar

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Renato S. Aguiar, Nika Lovšin, Amilcar Tanuri, Boris Matija Peterlin, "VPR.A3A chimera inhibits HIV replication", *J Biol Chem*, vol. 283, no. 5, pp. 2518-2525, 2008.
2. Beata Halassy, Marija Brgles, Lidija Habjanec, Maja Lang Balija, Jelka Tomašič, Igor Križaj, Aleš Štrancar, Miloš Barut, "Use of convective interaction media for analysis of long-nosed viper venom", *J. liq. chromatogr. relat. technol.*, vol. 31, no. 1, pp. 38-53, 2008.
3. Beata Halassy, Lidija Habjanec, Marija Brgles, Maja Lang Balija, Adrijana Leonardi, Lidija Kovačič, Petra Prijatelj, Jelka Tomašič, Igor Križaj, "The role of antibodies specific for toxic sPLA₂s and haemorrhagins in neutralizing potential of antisera raised against *Vipera ammodytes ammodytes* venom", *Comp. biochem. physiol., Toxicol. pharmacol.*, vol. 148, no. 2, pp. 178-183, 2008.
4. Zala Jenko Pražnikar, Lidija Kovačič, Edward G. Rowan, Rok Romih, Paola Rusmini, Angelo Poletti, Igor Križaj, Jože Pungertar, "A presynaptically toxic secreted phospholipase A₂ is internalized into motoneuron-like cells where it is rapidly translocated into the cytosol", *Biochim. biophys. acta, Mol. cell res.*, vol. 1783, no. 6, pp. 1129-1139, 2008.
5. Adrijana Leonardi, Jay W. Fox, Alenka Trampuš-Bakija, Igor Križaj, "Two coagulation factor X activators from *Vipera a. ammodytes* venom with potential to treat patients with dysfunctional factors IXa or VIIa", *Toxicon (Oxford)*, vol. 52, no. 5, pp. 628-637, 2008.
6. Antonija Lesar, Tamara Sajevec, "Structures, vibrational spectra, and relative energetics of FC(O)ONO and FC(O)NO₂ isomers at DFT and ab initio levels", *Mol. Phys.*, vol. 106, no. 19, pp. 2301-2308, 2008.
7. Uroš Logonder, Jernej Jorgačevski, Gregor Anderluh, Uroš Petrovič, Igor Poberaj, Igor Križaj, "A secreted phospholipase A₂ binds to calmodulin at sub-micromolar concentrations of calcium", *Acta chim. slov.*, vol. 55, pp. 541-546, 2008.
8. Uroš Logonder, Igor Križaj, Edward G. Rowan, J. B. Harris, "Neurotoxicity of ammodytoxin A in the envenoming bites of *Vipera ammodytes ammodytes*", *J. neuropathol. exp. neurol.*, issue 10, vol. 67, pp. 1011-1019, 2008.
9. Marko Novinec, Lidija Kovačič, Nives Škrlj, Vito Turk, Brigita Lenarčič, "Recombinant human SMOCs produced by in vitro refolding: calcium-binding properties and interactions with serum proteins", *Protein expr. purif.*, issue 1, vol. 62, pp. 75-82, 2008.
10. Aleš Premzl, Lidija Kovačič, Beata Halassy, Igor Križaj, "Generation of ammodytoxin-anti-cathepsin B immuno-conjugate as a model for delivery of secretory phospholipase A₂ into cancer cells", *Toxicon (Oxford)*, vol. 51, no. 5, pp. 754-764, 2008.
11. Petra Prijatelj, Zala Jenko Pražnikar, Toni Petan, Igor Križaj, Jože Pungertar, "Mapping the structural determinants of presynaptic neurotoxicity of snake venom phospholipases A₂", *Toxicon (Oxford)*, vol. 51, no. 8, pp. 1520-1529, 2008.
12. Tomaž Vaupotič, Peter Veranič, Uroš Petrovič, Nina Gunde-Cimerman, Ana Plemenitaš, "HMG-CoA reductase is regulated by environmental salinity and its activity is essential for halotolerance in halophilic fungi", *Stud. Mycol.*, vol. 61, pp. 61-66, 2008.
13. Keiji Yoshinaga, Petra Prijatelj, Vesna Todorović, (12 authors), "Perturbation of transforming growth factor (TGF)- β 1 association with latent TGF- β binding protein yields inflammation and tumors", *Proc. Natl. Acad. Sci. U. S. A.*, vol. 105, no. 48, pp. 18758-18763, 2008.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Borut Jerman, Jože Pungertar, "Sekretorne fosfolipaze A₂ in njihova (patofiziološka vloga", *Farm. vestn.*, vol. 59, no. 1, pp. 9-15, 2008.

PUBLISHED CONFERENCE PAPER

Invited Paper

1. Igor Križaj, "Metode za analizo proteoma", In: *Proteomika*, (Pomen biotehnologije in mikrobiologije za prihodnost, 05), Posvetovanje Pomen biotehnologije in mikrobiologije za prihodnost, 31. januar in 1. februar 2008, Ljubljana, Peter Raspor, ed., Polona Jamnik, ed., Ljubljana, Biotehniška fakulteta, Oddelek za živilstvo, 2008, pp. 19-31.

THESES

Ph. D. Thesis

1. Uroš Logonder, *Interakcija nevrotoksične fosfolipaze A₂ s presinaptično membrano: doktorska disertacija*, Ljubljana, [U. Logonder], 2008.

B. Sc. Theses

1. Petra Kaferle, *Razvoj bioinformatične podpore za visoko-zmogljivostne genetske eksperimente: uporaba na primeru valprojske kisline: diplomsko delo*, Ljubljana, [P. Kaferle], 2008.
2. Janez Kokošar, *Določanje genetskega interaktoma glavnega regulatorja proliferacije peroksisomov pri kvasovki *Saccharomyces cerevisiae**, diplomsko delo, Ljubljana, [J. Kokošar], 2008.
3. Anja Pucer, *Vpliv amoditoksina, fosfolipaze A₂ iz strupa modrasa, na mitohondrije modelne celične linije PC12*, diplomsko delo, Ljubljana, [A. Pucer], 2008.

DEPARTMENT OF BIOTECHNOLOGY

B-3

At the Department of Biotechnology we generate new knowledge and participate in education in the fields of biochemistry, pharmacy, molecular and cell biology, immunology for health prevention, and the protection of the environment. The main interests of our research are biological molecules that can be used for diagnostic and therapeutic applications in human and veterinary medicine, for the protection of plants and for the production of safe food.

In 2008 we continued with the characterization of mycospins, cysteine protease inhibitors from mushrooms. We focused our research on the new representative of mycospins, i.e., macrocypin from the parasol mushroom (*Macrolepiota procera*). Macrocypin is encoded by a family of genes that we put into five groups based on the sequence identity. From among the five macrocypin groups it is 75–86%, while sequences within the groups share more than 90% of the identity. Three macrocypin clones, belonging to three different groups, were heterologously expressed in the bacterial expression system and homogenous material for biochemical characterization was obtained. These proteins are exceptionally stable at high temperatures and extreme pH. The sequence variability is reflected in the pattern and the strength of the inhibition of selected cysteine proteases. In collaboration with the Department of Biochemistry and Molecular and Structural Biology (B1) three-dimensional structures of the clitocypin and macrocypin were determined. The three-dimensional structure of clitocypin in a complex with cathepsin V was also determined, which revealed the active site of the mycospins responsible for the inhibition of cysteine proteases belonging to the papain family. On the basis of the determined N-terminal amino acid sequence and some internal sequences of the native protein we expressed in *E. coli* also the recombinant inhibitor of serine proteases CnSPI (Cnispin). This mushroom inhibitor was studied with regard to the physiological role, its anti-tumour activity and potential impact on the growth of bacteria, fungi and plant pathogens.

From the mushroom *Clitocybe nebularis* we investigated lactozil-specific lectin (CNL), which exhibited an anti-proliferative effect on leukemic T lymphocytes. We identified the complete genome with the promoter region (available GenBank code EU682006) and cDNA. The deduced amino acid sequence was analyzed, providing a ricin-like β -trefoil tertiary structure. Recombinant CNL, expressed in *E. coli* was also prepared. Hemagglutination tests showed that CNL specifically agglutinates the group A erythrocytes, whereas hemagglutination tests provided specific binding to asialofetuin, lactose and galactose. The specific binding of biotinylated lectin to sugars was assessed by using glycan microarrays. The CNL was determined to be specific for carbohydrate chains with determinants for the blood group A ($\text{GalNAc}\alpha 1-3(\text{Fuc}\alpha 1-2)\text{Gal}\beta$), as already determined by the hemagglutination test. Additionally, the glycan microarray test showed the specificity of the CNL to also bind *N,N'*-diacetyllactosidamine ($\text{GalNAc}\beta 1-4\text{GlcNAc}$). This glycan is present predominantly in tumour cells and tissues, suggesting that it might be a target for CNL in leukemic T lymphocytes, providing an anti-proliferative effect.



Head:
Prof. Janko Kos

- **Determination of the 3D structure of clitocypin and macrocypin**
- **Determination of the glycan structure of lectin CNL**
- **Prediction of the effectiveness of antibiotic therapy in patients infected with *Helicobacter pylori***
- **Preparation of mutants affecting the sweet taste and profile of brazzein**
- **Publication of 34 scientific papers in journals with an impact factor**

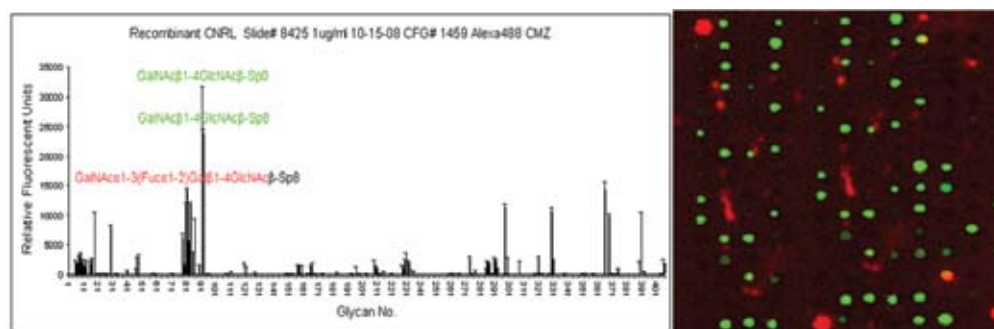


Figure1: Determination of glycans bound to lectin using a glycan micro-array

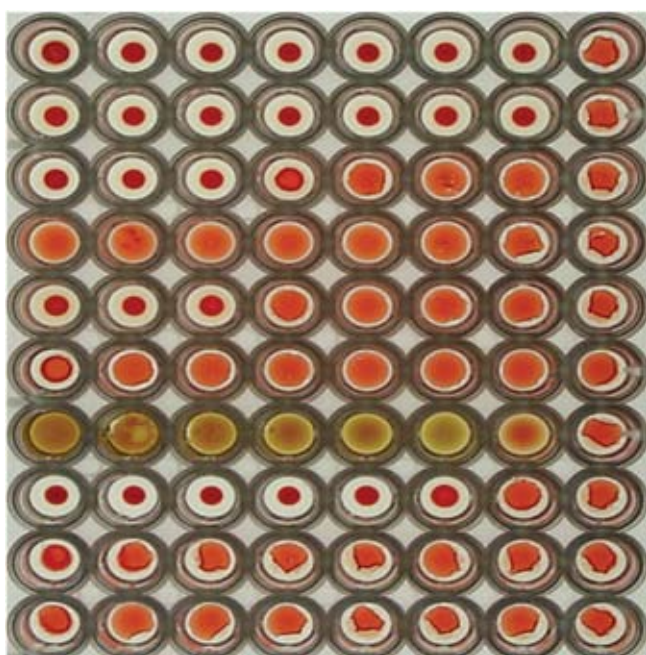


Figure 2: Hemagglutination with lectin CNL.

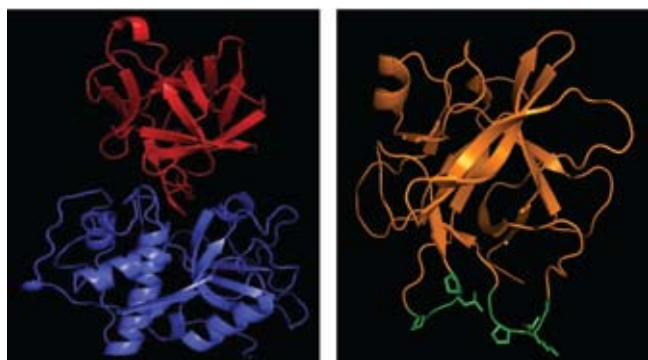


Figure 3. 3D structure of the inhibitors cliticypin and macrocypin

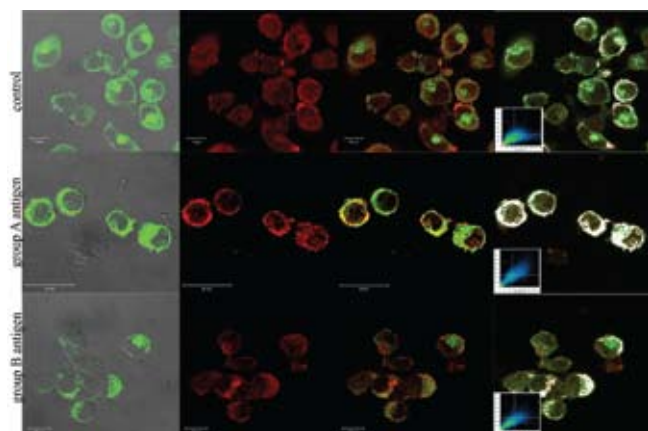


Figure 4: Determination of *Helicobacter pylori* stains using cathepsin X labelling and confocal microscopy

Within the study of the response of plants to drought we developed and optimised the quantitative zymography using fluorogenic substrates, enabling the detection of substrate specificity, pH optimum and the quantity of active enzymes. An important advantage of the method is the simultaneous detection of the protease activity in leaves of stress and control plants. In this way we determined in the plants *Phaseolus vulgaris* and *Ramonda serbica* various aminopeptidases, which are involved in the response to drought. The response of a bean (*Phaseolus spp.*) to drought was also followed at the gene level, and for three genes the changes in expression were confirmed.

In 2008 we continued our studies of the role of cysteine proteases and their endogenous inhibitors in cell signalling and the regulation of the immune response. For cystatin F, which is predominantly present in immune cells, we determined the mechanism of transition of the inactive dimeric form to an active monomer. In dendritic cells we investigated its changes in sub-cellular localisation during the cell maturation and found that it is significantly different compared to the related cystatin C. In collaboration with the Faculty of Pharmacy of the University of Ljubljana we studied the role of cathepsin X in cell signalling, adhesion and migration. We found that the expression and localisation of this enzyme in macrophages correlates with the step of eradication of the disease with antibiotic therapy after infection with the bacteria *Helicobacter pylori*. The method could serve for the prediction of the aggressiveness of *Helicobacter pylori* strains and the selection of the most appropriate therapy for an individual patient.

We optimized the expression of the sweet protein brazzein in *Lactococcus lactis* and *Escherichia coli*. In *Lactococcus lactis* we detected an 800-times-higher expression of brazzein if the combination of the NZ9000 strain and the plasmid pNZ8148 was used instead of the IL1403 strain and the plasmid pMSP3545. With the RT-qPCR method we determined that the larger number of pNZ8148 plasmid copies was the reason for the higher expression. In *Escherichia coli* we prepared gene constructs for nine point mutations, resulting in changes to the encoded amino acids, which should affect the sweet taste and profile. Wild-type brazzein was fused with the protein SUMO, which was cleaved after expression with the SUMO protease enabling the easier purification and characterisation of brazzein. The expression of brazzein as a fusion protein with SUMO will be subsequently used for the preparation of its mutants.

We also started the preparation of a system that will enable the expression of heterologous proteins on the surface of *Lactococcus lactis*. We intend to use these bacteria as a vector for the delivery of heterologous proteins with various biological functions to the gut. For now we have a gene construct that enables the expression of the binding domain of streptococcus protein A in *Lactococcus lactis*, its secretion to the medium and the binding to peptidoglycan on the cell membrane via autolysin AcmA, as was also determined by the antibody to protein A.

The results of the research work at the Department of Biotechnology in 2008 were published in 34 scientific papers in journals with an impact factor, in three chapters in books and presented at scientific conferences as lectures and posters. Two national and one international patent applications have been filed. The members of the department were also very active in pedagogical work as lecturers and mentors to students preparing diploma, master's and doctoral theses at the University of Ljubljana, University of Maribor and the Jožef Stefan Postgraduate School. A member of the department was awarded the Krka prize for research work.

The most important publications in the past three years:

1. T. Langerholc, V. Zavašnik Bergant, V. Turk, B. Turk, M. Abrahamson, J. Kos, Inhibitory properties of cystatin F and its localisation in U937 promonocyte cells. *Eur. J. Biochem.* 2005, 272, 1535-1545.
2. J. Sabotič, T. Trček, T. Popovič, J. Brzin. Basidiomycetes harbour a hidden treasure of proteolytic diversity. *J. Biotechnol.* 2007, 128, 297-307
3. A. Berlec, Z. Jevnikar, I. Čanžek Majhenič, I. Rogelj, B. Štrukelj. Expression of the sweet-tasting plant protein brazzein in *Escherichia coli* and *Lactococcus lactis*: a path toward sweet lactic acid bacteria. *Appl. Microbiol. Biotechnol.* 73(2006) 158-165.
4. D. Morisset, D. Dobnik, S. Hamels, J. Žel, K. Gruden. NAIMA: target amplification strategy allowing quantitative on-chip detection of GMOs. *Nucleic acids res.*, 2008, 36, 11.
5. Z. Jevnikar, N. Obermajer, M. Bogyo, J. Kos. The role of cathepsin X in the migration and invasiveness of T lymphocytes. *J Cell Sci*, 2008, 121, 2652-2661

Awards and appointments

1. Jerica Sabotič, Krka Award for Ph. D. thesis:
Characterisation of mycocybins from selected basidiomycete species using genetic and protein engineering (Borut Štrukelj, Jože Brzin)
2. Zupančič Janja: Student Prešeren Award for B. Sc. Thesis:
Development and usage of gene construct for expression of heterologous proteins by using lactic bacteria (Borut Štrukelj)

Organization of conferences, congresses and meetings

1. 5th Conference on Experimental and Translational Oncology, Kranjska gora, 26–30 Mar. 2008.

R & D GRANTS AND CONTRACTS

1. Lectins as modulators of anti-tumor immune response
Prof. Janko Kos
2. Evaluation of genotypes of bean (*Phaseolus vulgaris* L.) with the help of candidate genes for drought resistance
Prof. Janko Kos
3. Food supplements for optimal diet in extreme conditions
Prof. Borut Štrukelj

RESEARCH PROGRAM

1. Pharmaceutical biotechnology: Man and environment
Prof. Janko Kos

VISITOR FROM ABROAD

1. Goran Hellekant, Medical School Duluth, Department of Physiology and Pharmacology, Duluth, Great Britain, 7–9 Sept. 2008

STAFF

Researchers

1. *Dr. Jože Brzin, retired 7 Dec. 2008*
2. Asst. Prof. Kristina Gruden*
3. **Prof. Janko Kos*, Head**
4. *Dr. Tatjana Popovič, retired 1 Dec. 2008*
5. Dr. Boris Rogelj
6. Prof. Borut Štrukelj*

Postdoctoral associates

7. Dr. Aleš Berlec
8. *Dr. Tomaž Langerholc, left 1 Jul. 2008*
9. Dr. Jerica Sabotič

Postgraduates

10. Petra Avanzo, B. Sc.
11. Špela Magister, B. Sc.

Technical and administrative staff

12. Darja Žunič Kotar

Note:

* part-time JSI member

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- Aleš Berlec, Gorazd Tompa, Nina Slapar, Urša Pečar Fonovič, Irena Rogelj, Borut Štrukelj, "Optimization of fermentation conditions for the expression of sweet-tasting protein brazzein in *Lactococcus lactis*", *Let. appl. microbiol.*, vol. 46, no. 2, pp. 227-231, 2008.
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PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Katja Barle, Kristina Gruden, "Proučevanje interakcije rastlina-patogen-škodljivca z metodami proteomike", In: *Proteomika*, (Pomen biotehnologije in mikrobiologije za prihodnost, 05), Posvetovanje Pomen biotehnologije in mikrobiologije za prihodnost, 31. januar in 1. februar 2008, Ljubljana, Peter Raspor, ed., Polona Jamnik, ed., Ljubljana, Biotehniška fakulteta, Oddelek za živilstvo, 2008, pp. 53-59.
2. Bojan Doljak, Nataša Obermajer, Janko Kos, "Določitev epitopa monoklonskega protitelesa proti citokeratinom", In: *Proteomika*, (Pomen biotehnologije in mikrobiologije za prihodnost, 05), Posvetovanje Pomen biotehnologije in mikrobiologije za prihodnost, 31. januar in 1. februar 2008, Ljubljana, Peter Raspor, ed., Polona Jamnik, ed., Ljubljana, Biotehniška fakulteta, Oddelek za živilstvo, 2008, pp. 77-84.
3. Roman Paškulin, Polona Jamnik, Janko Kos, Peter Raspor, Borut Štrukelj, "Ibogain in metabolizem energije", In: *Proteomika*, (Pomen

- biotehnologije in mikrobiologije za prihodnost, 05), Posvetovanje Pomen biotehnologije in mikrobiologije za prihodnost, 31. januar in 1. februar 2008, Ljubljana, Peter Raspor, ed., Polona Jamnik, ed., Ljubljana, Biotehniška fakulteta, Oddelek za živilstvo, 2008, pp. 71-76.
4. Borut Štrukelj, "Biochemistry, cell biology and molecular biology", In: *Postgraduate European Radiopharmacy Course: block 1: pharmacy: course notes: september 8. - 19. 2008, Ljubljana, Slovenia*, Ljubljana, University of Ljubljana, Faculty of Pharmacy, 2008, [15] pp.
5. Borut Štrukelj, "Interferoni beta", In: *Multipla skleroza: zdravstveni tim 2008*, Ljubljana, [s.n.], 2008, pp. 13-16.
6. Borut Štrukelj, "Kako varni so heparini? Nova dognanja in dejstva", In: *[Zbornik prispevkov]*, Mirjam Jezeršek, ed., Ljubljana, Javna agencija RS za zdravila in medicinske pripomočke, 2008, pp. 35-39.

Regular papers

1. Polona Jamnik, Roman Paškulin, Kristina Gruden, Hrvoje Petković, Aleš Podgornik, Peter Raspor, Borut Štrukelj, Janko Kos, "Proteomika kot orodje za spremljanje biosinteznih procesov", In: *Proteomika*, (Pomen biotehnologije in mikrobiologije za prihodnost, 05), Posvetovanje Pomen biotehnologije in mikrobiologije za prihodnost, 31. januar in 1. februar 2008, Ljubljana, Peter Raspor, ed., Polona Jamnik, ed., Ljubljana, Biotehniška fakulteta, Oddelek za živilstvo, 2008, pp. 145-156.
2. Rade Injac, Katarina Karljickovic-Rajic, Borut Štrukelj, "Upotreba micelarne elektrokinetičke kapilarne hromatografije u rutinskoj analizi različnih uzoraka", In: *Šesta konferencija mladih istraživača nauka i inženjerstvo novih materijala: u ukviru obeležavanja 60 godina rada Instituta tehničkih nauka SANU: program & zbornik apstrakata: Beograd, 24.-26. decembar 2007 godine*, Beograd, [s.n.], 2007, vol. 62, no. 3, pp. 181-190, 2008.
3. Primož Strojjan, Aleksandar Aničin, Branka Svetic, Maja Pohar Perme, Alojz Šmid, Janko Kos, "Katepsini in stefini pri raku glave in vratu", In: *Zbornik predavanj*, (Medicinski razgledi, vol. 47), 5. kongres otorinolaringologov Slovenije, Radenci, 25.-27.9.2008, Miha Žargi, ed., Ljubljana, Medicinski razgledi, 2008, vol. 47, suppl. 2, pp. 215-219, 2008.

THESES

Ph. D. Thesis

1. Aleš Berlec, *Izražanje brazeina, proteina sladkega okusa, v mlečnokislinskih bakterijah: doktorska disertacija*, Ljubljana, [A. Berlec], 2008.

PATENT APPLICATIONS

1. Mojca Lunder, Tomaž Bratkovič, Petra Ekar, Samo Kreft, Uroš Urleb, Borut Štrukelj, *Improved affinity selection of legends from phage-displayed libraries: European patent no. EP7112356.6, publication date: 12.7.2007*, Munich, European Patent Organisation, 2008.
2. Nataša Obermajer, Bojan Doljak, Janko Kos, *Peptid uroaktivin, kot aktivator encima urokinaze: patentna prijava no.: P-200800224*, Ljubljana, Urad RS za intelektualno lastnino, 25.09.2008.
3. Nataša Obermajer, Zala Jevnikar, Urša Pečar Fonovič, Bojan Doljak, Janko Kos, *Inhibicija aktivnosti katepsina X za zdravljenje boleznih povezanih z nevrodegenerativnimi procesi: patentna prijava no.: P-200800237*, Ljubljana, Urad RS za intelektualno lastnino, 13.10.2008.

DEPARTMENT OF ENVIRONMENTAL SCIENCES

O-2

The basic characteristic of the Department of Environmental Sciences is multidisciplinary: our research covers a variety of fields in natural and sociological sciences, especially physical, chemical, geological and biological processes that create our environment, society and human activity. Above all, we wish to explain the connections between natural processes and human activity, and the influences of those activities on human and environmental health. We are combining the scientific excellence of our research work with solving concrete technological problems in industry, education and development that are interplayed with research in the fields of analytical chemistry, radiochemistry and radioecology, biological and the geochemical cycles of elements, nutrition and health of humans, animals and plants, waste management, mathematical and GIS modelling of environmental processes and risk and environmental impact assessment.

Environmental analytical chemistry

In 2008, new analytical procedures for the determination of separate species, complexes and the isotopic composition of elements in the environment were developed, as state-of-the-art analytics is the basic prerequisite for researching the pathways and mechanisms of the transport and transformations of different natural and anthropogenic compounds in the environment. Some new analytical procedures were developed and applied on different sample matrices to study the speciation of elements (Al, As, Cr, Hg, Sn) and processes governing their distribution. A new analytical procedure using anion-exchange separation support based on convective-interaction media (CIM) was developed for the speciation of Al in unspiked human serum. The Al species in the serum were separated on a weak anion-exchange CIM diethylamine (DEAE) fast-monolithic column and detected online using ICP-MS. The results confirmed that $90 \pm 5\%$ of the Al in human serum is eluted under the transferring peak. The main advantage of the developed procedure is in its ability to quantitatively determine the Al species in human serum at very low concentration levels (around 1 ng mL^{-1}). We continued our collaboration with the University of Padova, Italy, in investigations of the potential pathogenic role of the β -amyloid₍₁₋₄₂₎-aluminium complex in Alzheimer's disease. The parameters influencing the detection of organotin compounds by a pulsed-flame photometric detector were investigated in collaboration with the University of Pau, France, in order to develop a reliable analytical procedure for the determination of these toxic compounds in sewage sludge. To estimate the pollution with organotin compounds in the Slovenian marine environment, a survey based on measurements of butyl-, phenyl- and octyltin species by gas-chromatography–mass-spectrometry was performed in the period from 2000 to 2006 in water, sediment and mussel samples from the Northern Adriatic Sea. The results indicated a decrease in the organotin pollution in the investigated period. The extraction of chromium species from yeast biomass (*Candida intermedia*) was optimized to determine the proportion of biologically active chromium bound to organic molecules. An amount of 0.05 mol L^{-1} EDTA was found to be the optimal extracting agent.

For the determination of arsenic compounds, a method of arsenic speciation is used that allows the separation and quantitative determination of the twelve ecologically and/or toxicologically most important arsenic compounds by chromatographic separation in combination with atomic fluorescence spectrometry (AFS). In 2008, an alternative method with the coprecipitation of dibenzil dithiocarbamate and AFS or ICP-MS detection was developed. The method is used to determine ultra-low arsenite and arsenate concentrations in water samples. A method to determine the hexafluoroarsenate in waste water from the glass production industry was also developed. The method uses ICP-MS detection.

The development and validation of the method for determining methylation and the reduction potentials of mercury using the radioisotope Hg-197 in environmental samples was continued. The method was validated on sediment samples from the Idrijca River. The sensitivity of the method was improved, so it is possible to perform experiments with additions of very small amounts of tracer. It was pointed out that when reporting the results of methylation of inorganic mercury, it is important to present the results, not only as the percentage of methylation (as in most publications up to now), but also in absolute amounts of produced methylmercury.



Head:

Prof. Milena Horvat

- **The concentration and size distribution of nano-aerosols in different environments have been measured for the first time**
- **A new, analytical procedure for Al speciation in human serum at very low concentration levels was developed and applied in clinical studies**
- **Large-scale human biomonitoring in Slovenia was launched for the first time as part of the Environment and Health strategy.**
- **Waste materials from steel production were investigated for their effective re-use in construction.**

This year we studied the extraction of Se compounds with enzymes from biological samples. In the literature, the most frequently used enzymes for Se speciation are proteases. The aim of our work was to check if commercially available enzymes are pure enough to be used for selenium speciation analysis and the contribution of impurities on Se determination on a real-sample basis. For this purpose, twelve commercially available enzymes of different origin and classification – protease, amylase, cellulase, lipase – were analysed. After the dissolution of the enzyme in water, the separation of the Se species was made by ion-exchange chromatography, with inductively coupled plasma mass spectrometry used as the detection system. The results showed that the Se content was found to be relevant in several cases. The highest value was obtained for β -amylase from barley, 3100 ng Se per g of enzyme. Speciation analysis showed that Se-methionine, selenite, selenate and some unknown compounds were present in several enzymes. In general, the identified Se species represented a low fraction of the total Se. For instance, only 17% of the total Se was determined for β -amylase from barley. On the other hand, about 100% of the total Se was identified in protease from *Streptomyces griseus*. The results from different lots of the same enzyme were not all comparable. Therefore, the presence of selenium species in commercially available enzymes could be due to the preparation procedure used for the enzyme, or as a degradation product. Therefore, attention should be paid to enzyme purity regarding selenium compounds when an enzyme is used for hydrolysis in determining the selenium species in samples with a low Se content. This work is very important on the field of Se speciation.

In the field of organic analytical chemistry our main achievement was the identification of numerous degradation products of selected pharmaceutical residues that persist in the environment. We also evaluated their toxicity and highlighted the importance of studying the fate of emerging contaminants, since many of the transformation products that we identified were found to be more toxic than the parent compounds.

In 2008 we continued with the development of methods based on instrumental neutron activation analysis (INAA) for the determination of macro, micro and trace elements in environmental samples. Among the INAA methods, the greatest attention is paid to the development of the k₀-method, for which two programs are available: Kayzero for Windows and k₀_IAEA. The former is validated at our department and has been used routinely for many years. We participated in the validation of the k₀_IAEA software in the framework of the IAEA SLO-13279/RB project "Measurements and calculations of the neutron spectrum in different irradiation channels of the TRIGA Mark II reactor, Slovenia" and in cooperation with the Centre of Nuclear Technology from Belo Horizonte, Brazil (CDTN/CNEN). In addition, the k₀-method has been optimized to work with samples that have Fe as a matrix element. The accuracy and reliability of the method we checked by analysing reference materials from Japan (JSS). Together with colleagues from SS. Cyril and Methodius University from Skopje, Macedonia, we analyzed iron minerals from Macedonia and discovered that the introduced technique k₀-RNAA is also an appropriate tool for such very complicated matrices. We participated in the certification processes of three new reference materials – Polymers EC590 and EC591 and Rye Grass ERM-CD281 – organized by the Institute for Reference Materials and Measurements (IRMM, Geel, Belgium). We also collaborated with Slovenian industry, especially with thermal power plants and pharmaceutical factories.

The cooperation with EC-JRC-IRMM was in the field of impurities in Pu-240 solutions and gamma spectrometry as well as the organisation of a laboratory intercomparison within the framework of preparing a new EU directive for drinking water.

In the field of RNAA, a method for the simultaneous determination of vanadium, uranium and manganese in biological samples through their short-lived radionuclides was developed as well as a method for cobalt determination through its short-lived nuclide Co-60m.

The Centre for Mass Spectrometry (CMS) services researchers from various scientific areas, such as chemistry, biochemistry, pharmacy, medicinal chemistry and biology. Currently, the CMS supports the research of about 30 national and international research programs, projects and some technological applications of the pharmaceutical industry and produces about 4500 analyses a year.

Recently, a new, hybrid orthogonal acceleration time-of-flight mass spectrometer (oa-ToF) Q-ToF Premier™ equipped with an atmospheric pressure ionization (ESI) source and coupled with an ultra-performance liquid chromatograph (Aquity UpLC, Waters) has been applied in the following projects: a) identification of drug biodegraded products, and b) analyses of target endogenous opiopeptides in urine samples as potential biomarkers of autistic disorders, and c) ESI studies of proteins and the inclusion of complexes of cyclodextrins and isomeric coumaric acids.

We collaborated with the Metrology Institute of the Republic of Slovenia in ensuring measurement traceability at the international level as a carrier of reference etalon for soil. For the purpose of ensuring traceability we bought the certified reference material BCR-320R (Channel Sediment). We cooperated during the certification of new reference materials, and we were included into various interlaboratory comparison tests.

Our task within the EU project PHIME is to supervise all aspects of quality control and quality assurance. Therefore, four interlaboratory comparisons were organised to assess laboratory performance in determining trace elements and their species in blood. Special attention was paid to three elements, mercury, lead and cadmium, which are crucial for the realisation of the project.

Biological and geochemical cycles

We introduced the measurement of forest-soil respiration and flux measurements of CO₂ between vegetation and the atmosphere with the Eddy Covariance technique at different selected forest platforms. In addition, these conventional measurements were combined with measurements of the carbon isotopic composition. The obtained data were used as the input data for the model GOTILWA+ and Castanea, with which we have accurately studied the structure of the transport processes of carbon (plants-soil-water; layout design) in selected beech stands. Using ¹⁵N-labelled fertilizer, nitrogen cycling in the system soil-plant-soil water was studied on an experimental field near Ljubljana. Different agricultural practices for the production of white cabbage and endive were studied and optimized with respect to the biomass growth and the nitrate leaching from the soil.

The first results of the measurements of the carbon isotopic composition in tree rings in Slovenia show the possibility of using stable isotopes in the determination of anthropogenic emissions of CO₂ to the atmosphere. The potential of riverine tufas as palaeoclimate archives on the Dinaric carbonate platform was studied. Standard uncertainties attached to the input parameters used in isotope (δ¹⁸O) and geochemical (Mg/Ca) thermometers were estimated; it was shown that the complicated hydrological situation and uncertain trends in the temporal variation of input parameters increase the uncertainties to a level that makes tufas unsuitable for palaeotemperature estimation.

The importance of iodine for humans, especially in the early stages of life, is well recognized. The chemical forms of iodine in food supplements, infant formulae and iodated salt are either iodide (KI) or iodate (KIO₃). Because there are no or only few data on iodine uptake by yeasts, we investigated the influence of different sources of iodine, i.e., KI, KIO₃ and periodate (KIO₄), on its uptake in, and growth of, the model yeast *Saccharomyces cerevisiae*. KIO₃ inhibited the growth of the yeast the most. Even at a 400-μM initial concentration in the growth medium, the optical density was reduced by 23% in comparison to the control, where no KIO₃ was added. The uptake of different iodine sources by the yeast *S. cerevisiae* was minimal: in total less than 1%. We investigated the specificity of iodine uptake added as KIO₃ in the presence of Na₂SeO₄ or ZnCl₂ or K₂CrO₄ in the growth medium; the chromate had the most influence on the reduction of KIO₃ uptake.

A detailed investigation of the biogeochemical cycling of members of the uranium-radium decay series was carried out under the specific conditions within the area of the former uranium mine at Žirovski vrh. Special emphasis was given to the speciation of the particular radionuclides in the soil-water system, and their transfer and mobility within the studied area.

Our investigations in the Radon Centre have mainly been devoted to radon's short-lived decay products (RnDP). Initially, they appear in the air as positively charged metal ions, which after recombination form clusters of nano RnDP aerosols of 10 nm size; a great part of them are then attached to particulates in air and are eventually present as radioactive RnDP aerosols in the size range 200–600 nm. The dependence of the fraction of the nanosize RnDP on the ventilation rate and the indoor air movement was studied under controlled conditions, both in a radon chamber and in the living environment. This research was recently extended to non-radioactive nano-aerosols. Thus, the concentration of the aerosols and their size distribution in the range from 10 to 1100 nm were carried out at some selected places, such as in a clean room, an office, a laboratory, a mechanical workshop and at a parking lot close to a street with heavy traffic. In addition, our study of the dependence of radon transport on the seismic and tectonic activity was continued by continuous radon recording in thermal springs at Bled and Hotavlje, in soil gas in Friuli and Sicily in Italy, and in Sapporo in Japan, as well as in air at a fault zone in the Postojna Cave. Machine-learning programs (decision trees and neuron networks) were used successfully to identify the anomalies in the time series of the radon activity concentration, possibly caused by seismic activity, and not ascribed solely to environmental parameters. The influence of tectonic activity on the soil-gas radon concentration was also studied at the Ravne fault (north-western Slovenia), where in several profiles, both perpendicular and parallel to the fault, the radon concentration, the radon exhalation rate, the soil permeability and the gamma dose rate were measured (Slovenia-Poland bilateral collaboration). In addition, on the slopes of Mt. Etna in Sicily, the radon concentration in the outdoor air was measured (Slovenia-Italy bilateral collaboration) and the relationship with the tectonic and volcanic activity sought.

On the River Idrijca, research was focused on the periphyton community, both on natural substrates and using glass plates as artificial substrates. Samplings of the periphyton community and in-situ measurements of the relevant abiotic parameters (physical and chemical) were performed seasonally. The diatom composition is analysed in the periphyton from

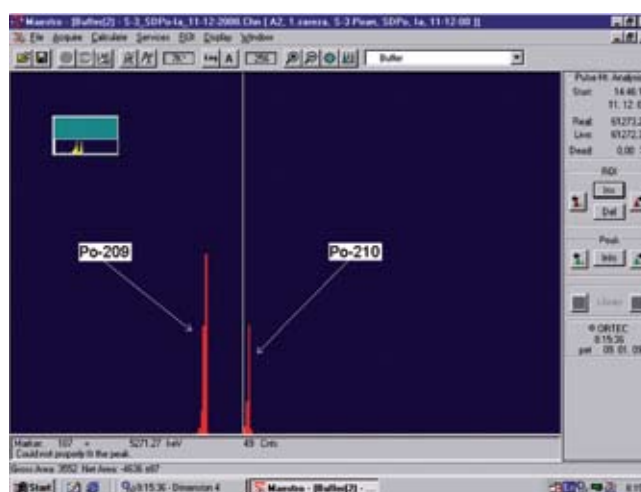


Figure 1. In 2008, a method for the determination of Po-210 was developed. Po-210 is one of the most radiotoxic elements. The figure shows Po-210 spectra in fish samples measured with an alpha spectrometer.

natural and artificial substrates in order to establish whether there are significant differences in the abundance and diversity between the two communities and to see the differences in these communities at sites with different mercury levels. Using the radioisotope ^{197}Hg , we traced the processes of mercury methylation ($\text{Hg}^{2+} \rightarrow \text{CH}_3\text{Hg}$) and reduction ($\text{Hg}^{2+} \rightarrow \text{Hg}^0$).

In the area of the former mercury mine at Idrija, work from previous years was continued and focused mainly on the development of erosion models for the simulation of mercury transport into the basin of the River Idrijca.

Besides the anthropogenic sources of mercury, natural sources that are very poorly understood are also of great importance. Tectonic activity with the accompanying phenomena, such as volcanoes, earthquakes, tectonic movements of the earth's crust and others are the main natural mercury sources in the environment. At Europe's most active volcano, Mt. Etna, on the island of Sicily, Hg concentrations were measured in the air, the soil gases and evaporation in connection with other gases such as CO_2 , SO_2 , Rn and others. The influence of the tectonics on Hg evaporation was also studied at some other tectonically active areas, such as Postojna Cave and thermal springs in Hotavlje and Bled.

Environment, nutrition, health

Recently, much attention has been given to the research of chemical forms in which Se appears in functional foods and dietary supplements, as information only about Se concentration is not enough to estimate its bioavailability, mobility and eventual toxicity. The ability of several plants to accumulate and transform inorganic forms of selenium into bioactive organic compounds has important implications for human and animal nutrition and health. We studied the selenium (Se) distribution in the potato (*Solanum tuberosum* L.) cultivar Desiree, enriched in Se by foliar spraying with

a water solution containing 10 mg Se per L in the form of sodium selenate. Four combinations of treatments were utilised: well-watered plants with and without Se foliar spraying, and drought-exposed plants with and without Se foliar spraying. We optimized a method for the isolation and determination of selenium species. Water-soluble Se compounds were extracted from potato tubers by water or by enzymatic hydrolysis with the enzyme protease XIV or amylase or a combination of protease XIV and amylase. The extraction was performed using incubation at constant temperature and stirring (37°C, 24h) and by ultrasound-assisted extraction (300 W), using different extraction times. The results showed that the concentration of selenate extracted was found to be independent of the technique, whereas the concentration of SeMet changed with the enzymatic extraction technique. Selenate and SeMet were the main soluble Se species (representing 51–68% of the total Se) in the potato tubers, regardless of the growth conditions.

Stable isotopes were also used as tracers of the sources, origin and authenticity of various natural and processed foodstuffs, such as honey, oil, wine, fruit juices and milk.

An assessment of the Po-210 ingestion dose due to marine-food consumption was carried out. Fish and squid samples from the Slovenian market were collected in accordance with the statistical data on their consumption. The assessed yearly effective ingestion dose is 34 $\mu\text{Sv}/\text{year}$ for fish and 5.0 $\mu\text{Sv}/\text{year}$ for mussels.

Cadmium and arsenic metabolism was investigated in terms of its influence on the cellular protective mechanisms in human glia: in normal human astrocytes (NHA cells) and in human tumor cells (U87 astrocytoma). So far, we confirmed the interplay between metallothioneins and cadmium or arsenic, but also the influence of this interaction on copper metabolism. The metallothioneins identification and their interactions with various metals (Hg, Se, As, Cd, Sb, Cu, and Au) was also followed in tetrahymena, a unicellular organism used as environmental pollution marker. In a clinical study of cancer patients treated with arsenic trioxide we proceeded with the investigation of individual differences in the formation of arsenic metabolites. The metabolites were followed in blood and urine samples. In all cases, we also followed the metabolism of selenium regarding its involvement in cellular antioxidative mechanisms and its interactions with arsenic.

In cooperation with University Medical Centre in Ljubljana, many investigations on the influence of mercury on the health on Idrija's inhabitants



Figure 2. Measurements of the concentrations and evaporation of natural gases, such as mercury, CO_2 , SO_2 , Rn and others, in the air and soil gases at (above) the Eastern slope of the Mt. Etna volcano and (below) Postojna Cave. These gases are important for understanding the tectonic processes in the Earth's crust, estimating the natural contribution to the atmosphere and eventually for predicting earthquakes and volcanic eruptions.

and the wider Slovenian population, especially women in childbearing age and pregnancy, were continued within the project PHIME.

Within the PHIME framework, research was conducted on exposure to cadmium, lead and mercury in different areas of Slovenia on the population of children aged between 6 and 11 years. Children living in rural (Žužemberk), urban (Ljubljana) and industrial (Idrija) areas of Slovenia were sampled for blood, urine and hair. The analytical work was done at the Jožef Stefan Institute and the University Medical Centre Ljubljana. This research provided preliminary information on general exposure to cadmium, lead and mercury of the selected Slovenian population of children and therefore preliminary reference values for Slovenia, which have not been identified so far.

Another study was conducted within the PHIME framework, in which we assessed the suitability of different validated as well as potential biomarkers (indicators) of prenatal methyl mercury exposure in humans, as this is of crucial importance when conducting large-scale epidemiological studies. We have evaluated and compared the total and methyl mercury values measured in maternal and umbilical cord blood, umbilical cord tissue, maternal scalp and pubic hair, placenta, foetal membranes and meconium, collected in connection with randomly selected parturitions in the Maternity Hospital in Ljubljana.

A human biomonitoring programme was implemented in Slovenia in 2008, which involves our department as well as the National Chemical Bureau of the Republic of Slovenia, the University Medical Centre Ljubljana and the Institutes of Public Health in Slovenia. Within this research, concentrations of toxic metals (cadmium, lead, mercury) and persistent organic pollutants (dioxins, furans, pesticides, polychlorinated biphenyls, polybrominated flame retardants) in body fluids (blood, breast milk, urine) and hair are followed. The obtained results will be the basis for a determination of the reference values and an estimation of human exposure to selected environmental pollutants.

Environmental Monitoring

To estimate the pollution with organotin compounds in the Slovenian marine environment, a survey based on measurements of butyl-, phenyl- and octyltin species by gas chromatography, mass spectrometry was performed in the period from 2000 to 2006 in water, sediment and mussel samples from the Northern Adriatic Sea. The results indicated a decrease of organotin pollution in the period investigated.

In cooperation with the Environmental Agency of the Republic of Slovenia, the monitoring of metals and organotin compounds in marine and riverine waters was continued

Upgrade and maintenance of the database on the isotopic composition of the rivers Sava and Danube, as well as the GNIP database of the isotopic composition of the precipitation in Slovenia and Croatia, were performed.

Researchers participated in two regional projects of the International Atomic Energy Agency (IAEA) concerned with collecting internationally comparable data on air and marine pollution within the Mediterranean area as well as in radiological monitoring surveys of the Krško nuclear power plant and the Žirovski vrh uranium mine.

Concentrations of mercury in the air at the location Iskrba (southern Slovenia) were measured for the Environmental Agency of the Republic of Slovenia. At the same location, measurements of mercury concentration in precipitations and deposition were also conducted. Monthly control measurements of the Hg concentrations in the River Sava were performed.

We collaborated in radioactivity monitoring of the environment in the area of the Nuclear Power Plant Krško (contractor Nuclear Power Plant Krško) and in the monitoring of food and drinking-water radioactivity (contractor URSJV). The specific activity of the radionuclides strontium and tritium in environmental samples, food and water were measured, as well as the presence of tritium and C-14 in gas effluents from the Nuclear Power Plant Krško. In the Idrija area, the long-term monitoring of mercury in precipitations, surface waters, air, garden vegetables, game, mushrooms and wild berries, were started.

Within the framework of postgraduate studies of a student from Serbia at the Biotechnical Faculty, the biomonitoring method using epiphytic lichens has been applied to assess the air quality in South Serbia. In-situ and transplanted lichens were used to obtain insight not only into the degree of heavy-metal air pollution but also to assess and control secondary contamination with depleted uranium at selected sites (Borovac I and Borovac II) around the city of Vranje, where an extensive decontamination took place in 2005. These two sites were the most bombarded sites by NATO in the south of Serbia with depleted uranium ammunition during the Balkan conflicts.

In the framework of an international project using mosses as biomonitors, a cross-border quality of mapping metal loads in mosses in 8 European countries in three sampling campaigns (1990, 1995 and 2000) was checked



Figure 3. Concentrations and size distribution of nano-aerosols at a parking place near heavy traffic.

using geostatistical methods and the confounding factors affecting the local variation in metal concentrations (metal accumulation) in mosses were investigated. It was found that after using harmonised procedures for the preparation and chemical analysis, the main factors that influence the bioaccumulation of metals in mosses could be ranked as follows: moss species, potential emission sources around the monitoring site, canopy drip and precipitation.

Clean technologies and waste management

Among the research for industry, the most important investigations were performed on the cycling of mercury and its compounds, and some other toxic and non-toxic elements in the combustion cycle of clinker production in the cement plant Anhovo and electricity production in the Thermal Power Plant Šoštanj.

For the industrial partners EkoplanA, d.o.o. and Štore Steel, d.o.o., the potential for using electric arc furnace (EAF) dust was investigated. From the point of view of their physical and mechanical properties, as well as from the environmental point of view, it was experimentally established that EAF dust up to 2% per mass may be used in asphalt composites. It was also demonstrated that cement composites to which a maximum of 1.5% by mass of EAF dust has been added can be used in civil engineering for all purposes, including applications in the external environment. Cement composites with the addition of EAF dust can also be used as balances in washing machines which, at the end of their service life, are disposed of in landfills. The re-use of waste materials from steel production represents an opportunity to save natural resources.

The Hot Cell Facility was fully licensed as a nuclear facility. This enabled our participation in the project entitled "Improvement of the management of institutional radioactive waste" in Slovenia that was carried out for the Agency for Radwaste Management.

Risk and environmental impact assessment

Projects in 2008 were primarily associated with strategic (spatial) environmental evaluation. The project "A case study integration of risk assessment into spatial development planning of the Municipality of Koper" dealt with making a risk analysis of a part of the overall spatial planning process. A schematic representation of this integration is presented in Figures 1 and 2.

The targeted research project on sustainability of the Port of Koper is aimed at clarifying the role and contribution of the Port of Koper on the development of the coastal region. The results show that the port contributes significantly to environmental qualities' improvement at the local level; however, more should be done at regional level and in terms of public health investments.

A targeted research project on TIA (Territorial Impact Assessment) explores the impacts of the energy policy of Slovenia on the goals of spatial cohesion. Preliminary results provide an insight into the whole heterogeneity of the issue and the difficulty of specifying the impacts on individual territorial cohesion components: spatial efficiency, identity, and quality.

The EU projects CIVITAS II – MOBILIS and CIVITAS – ELAN confirmed the expected environmental benefits of different measures in public transportation in Ljubljana.

Expert basis for the preparation of an argumentation document on the reduction of mercury's negative impacts on humans and the environment on a global level were contributed within the framework of the Slovenian Presidency of the EU. The document should present the EU's official statements due to the demands of the United Nations Environmental Programme (UNEP).

The negative consequences of mercury mobilisation in the Gulf of Trieste due to the building of gas terminals were re-estimated.

Some outstanding publications in 2008

1. P. Cuderman, I. Kreft, M. Germ, M. Kovačevič, V. Stibilj Selenium species in selenium-enriched and drought-exposed potatoes. *J. agric. food chem.*, 2008, 19, 59, 9114-9120.
2. Davor Kontić, Branko Kontić. Introduction of threat analysis into the land-use planning process. *J. hazard. mater.* 2008, 18 pp.
3. Tina Kosjek, Ester Heath. Applications of mass spectrometry to identifying pharmaceutical-transformation products in water treatment. *TrAC, Trends anal. chem. (Regul. ed.)*, 2008, issue 10, vol. 27, pp. 807-820.
4. Nives Ogrinc, Tjaša Kanduč, Wilibald Stichler, Polona Vreča. Spatial and seasonal variations in $\delta^{18}\text{O}$ and δD values in the river Sava in Slovenia. *J. Hydrol. (Amst.)*, 2008, vol. 359, no. 3/4, 303-312.
5. Zdenka Šlejkovec, Ingrid Falnoga, Walter Goessler, Johannes Teun Van Elteren, Reingard Raml, Helena Podgornik, Peter Černelč. Analytical artefacts in the speciation of arsenic in clinical samples. *Anal. chim. acta.* 2008, vol. 607, no. 1, pp. 83-91.
6. J. Vaupotič, 2008. Nanosize radon short-lived decay products in the air of the Postojna Cave. *Sci. Total Environ.* 393, 27-38.

7. Tea Zuliani, Gaëtane Lespes, Radmila Milačič, Janez Ščančar, Martine Potin-Gautier. Comprehensive study of the parameters influencing the detection of organotin compounds by a pulsed flame photometric detector in sewage sludge. *J. chromatogr.*, 2008, vol. 1188, no. 2, pp. 281-285.
8. Suzana Žižek, Sergio Ribeiro Guevara, Milena Horvat. Validation of methodology for determination of the mercury methylation potential in sediments using radiotracers. *Anal. bioanal. chem.*, 2008, vol. 390, pp. 2115-2122.
9. G. Sibbens, T. Altizoglou, Ljudmila Benedik, S. Pomme, R. Van Ammel. α -particle and γ -ray spectrometry of a plutonium solution for impurity determination. *Appl. radiat. isotopes.*, 2008, issues 6-7, vol. 66, pp. 813-818.

Organization of conferences, congresses and meetings

1. Ester Heath: "Basics of Toxicology with Introduction to Risk Assessment", Bled, 22–26 Sep.; 20–24 Oct.; 17–21 Nov. 2008.

INTERNATIONAL PROJECTS

1. Floating Sensorised Networked Robots for Water Monitoring
HYDRONET
7. FP, 212790, FP7-ENV-2007-1
EC; Dr. Monica Vignoni, Scuola Superiore di Studi Universitari e di Perfezionamento Sant'Anna, Pisa, Italy
Prof. Milena Horvat
2. Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related Risks
iNTeg-Risk
7. FP, 213345, NMP2-LA-2008-213345
EC; European Virtual Institute for Integrated Risk Management, Stuttgart, Germany
Asst. Prof. Branko Kontić, Asst. Prof. Marko Gerbec
3. Evaluation of Methyl-mercury Production and Decomposition by Using Hg-197 Radiotracer Produced Out of Mercury Enriched in Hg-196 Isotope
Hg-197 MeHg Assess
7. FP, 221724
EC
Prof. Milena Horvat
4. CIVITAS-ELAN "Mobilising Citizens for Vital Cities Ljubljana-Gent-Zagreb-Brno-Porto"
ELAN
7. FP, 218954, TREN/FP7TR/218954
EC; Zdenka Šimonovič, City of Ljubljana, Ljubljana, Slovenia
Asst. Prof. Branko Kontić
5. A Future for Radioecology in Europe
FUTURAE
6. FP, 036453
EC; Dr. Jean-Christophe Gariel, Institut de Radioprotection et de Sureté Nucléaire, Clamart, France
Prof. Borut Smodiš, Asst. Prof. Branko Kontić
6. Public Health Impact of Long-term, Low-level Mixed Element Exposure in Susceptible Population Strata
PHIME
6. FP, 016253
EC; Ingela Byström, Prof. Staffan Skerfving, Lund University Hospital, Department of Occupational and Environmental Health, Lund, Sweden
Prof. Milena Horvat
7. Network of Reference Laboratories and Related Organizations for Monitoring and Bio Monitoring of Emerging Environmental Pollutants
NORMAN
6. FP, 018486
EC; Dr. Valeria Dulio, INERIS - Direction Scientifique, Verneuil-en-Halatte, France
Asst. Prof. Ester Heath
8. Access to Technology and Know-how in Cleaner Production in Central Europe
ACT CLEAN
Central Europe Programme
EC; Jakob Gross, Horst Pohle, Federal Environment Agency, Dessau-Roßlau, Germany
Dr. Andrej Stergaršek, Andrej Gyergyek, B. Sc., Dr. Sonja Lojen
9. Xenobiotics in the Urban Water Cycle
COST 636
EC
Asst. Prof. Ester Heath
10. Global Study on Contaminated Sites
UNEP
Per Bakken, UNEP Chemicals Branch, Châtelaine, Geneve, Switzerland
Prof. Milena Horvat
11. Conditioning of Drinking Water with Constructed Wetlands
WETPUR
EUREKA
Limnos Company for Applied Ecology Ltd., Great Britain
Asst. Prof. Janez Ščančar
12. Isotope Investigation of the River Sava in Slovenia: Long-term Isotopic Monitoring of Surface Water and Precipitation at Selected Sites
14343/R0, R1
IAEA, Vienna, Austria
Asst. Prof. Nives Ogrinc
13. Measurements and Calculations of the Neutron Spectrum in Different Irradiation Channels of the TRIGA Mark II Reactor, Slovenia
13279/R1
IAEA, Vienna, Austria
Dr. Radojko Jačimović
14. Nutritional Status and Exposure to Mercury and its Compounds in Pregnant Women and Women of Childbearing Age in Former Mercury Mining Site using Nuclear and other Techniques; Exposure to Toxic and Potentially Toxic Elements in Women of Childbearing Age in Developing Countries
13250/R1, R2
IAEA, Vienna, Austria
Prof. Milena Horvat, Dr. Jože Kotnik
15. Fellowship for Mr Dennis Kpakpo Adotey
IAEA Fellow, GHA/07017
IAEA, Vienna, Austria
Prof. Vekoslava Stibilj
16. Fellowship for Ms Tatsiana Lazarevich
IAEA Fellow, BYE/08004
IAEA, Vienna, Austria
Prof. Borut Smodiš
17. Fellowship for Mr Belgar Kakushadze
IAEA Fellow, GEO/07015
IAEA, Vienna, Austria
Asst. Prof. Janja Vaupotič
18. Fellowship for Ms Maxim Ignatyev
IAEA Fellow, KIG/07016
IAEA, Vienna, Austria
Prof. Borut Smodiš
19. Fellowship for Ms Mounir El Hassani
IAEA Fellow, MOR/08005
IAEA, Vienna, Austria
Dr. Radojko Jačimović
20. Fellowship for Ms Gulnura Beishenkulova
IAEA Fellow, KIG/07028
IAEA, Vienna, Austria
Asst. Prof. Janja Vaupotič
21. Fellowship for Ms Mirjana Čolović
IAEA Fellow, SRB/08001
IAEA, Vienna, Austria
Asst. Prof. Nives Ogrinc
22. Fellowship for Mr Dennis Kpakpo Adotey
IAEA Fellow, GHA/07017
IAEA, Vienna, Austria
Prof. Vekoslava Stibilj
23. Sources and Sinks of Mercury in Freshwater Ecosystems
BI-AR/06-08/01
Prof. Ribeiro Guevara Sergio, Centro Atómico Bariloche, Comisión Nacional de Energía Atómica, Bariloche, Argentine
Prof. Milena Horvat
24. Supporting Activities in Upgrading the Homepage of Climate Change in SEEC by Creating a List of Researchers and Providing Relevant Publications to publish
RTG.2007.GF.027-01
Cornelia Sterner, M. Sc., Dr. F. Pretenthaler, Prof. Bernhard Pelzl, Edmund Müller, M. Sc., Joanneum Research Forschungsgesellschaft mbH, Institut of Technology and Regional Policy, Graz, Austria
Asst. Prof. Sonja Lojen

25. Determination of Aqua Regia Soluble Content and Total Content of As, Cd, Co, Cr, Hg, Fe, Mn, Ni, Pb and Zn in Sewage Sludge
IRMM.B050919
European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Prof. Milena Horvat
26. Characterisation of ERM-CD281 Rye Grass: Cr, Cu, Mn, Sb, Pb, Zn, by ICP-MS, Cd, Cr, Cu, Ni, Pb by ETAAS, Mn, Zn, by FAAS, As, Cd, Cr, Cu, Hg, Mn, Mo, Sb, Se, Sn, Zn by KO-INAA, Hg by CVAAS, Hg by DMA, As by RNAA, Se by RNAA
IRMM.B048637
European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Prof. Milena Horvat, Prof. Vekoslava Stibilj, Asst. Prof. Janez Ščančar
27. Characterisation Study for Total Br in Polymers (EC590 and EC591)
P048609
Katharina Teipel, Connie Biesmans, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Dr. Radojko Jačimović
28. LOT 7: Measurements of Cd in Polyethylene
IRMM.B051353
Monique Arnould, European Commission, Joint Research Centre (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Dr. Radojko Jačimović
29. Improvement of the Management of Institutional Radioactive Waste in Slovenia
11145406-06-01-0001
Agency for Radwaste Management, Ljubljana, Slovenia; Leniko bvba, Antwerp, Belgium
Prof. Borut Smodiš, Dr. Gašper Tavčar, Bogdan Pucelj, M. Sc., Bojan Huzjan, M. Sc.
30. Radioecological Investigations in the Territory of Bosnia and Herzegovina
Radioekološka istraživanja na području Bosne i Hercegovine
BI-BIH/05-06-009
Dragana Stojisavljević, M. Sc., Bojan Štrbac, B. Sc., Institut za zaštitu zdravlja Republike Srpske (Public Health Institute of Republic of Srpska), Banja Luka, Bosnia and Herzegovina
Prof. Borut Smodiš
31. Određivanje uranovih radioizotopa u uzorcima okoline
BI-BIH/06-08/007
Dr. Stjepan Marić, Zavod za javno zdravstvo FBiH, Sarajevo, Bosnia and Herzegovina
Dr. Ljudmila Benedik
32. Radioekološka istraživanja na području Bosne i Hercegovine
BI-BIH/06-08/009
Dr. Marko Lalić, Institut za zaštitu zdravlja Republike Srpske, Banja Luka, Bosnia and Herzegovina
Prof. Borut Smodiš
33. The Creation of Cypriot and Slovenian Analytical Databases for Authentic Fruit Juices
Dr. Rebecca Kokkinofa, Ministry of Health, State General Laboratory, Acropolis, Nikosia, Cyprus; Dr. Iztok Jože Košir, Slovenian Institute for Hop Research and Brewing, Žalec, Slovenia
Asst. Prof. Nives Ogrinc
34. Development of Innovative Technologies for Determination and Treatment of Xenobiotic Organic Compounds in Eastewater
Udvikling af innovative teknologier for kvantificering og fjernelse af miljøfremmede stoffer fra spildevand
BI-DK/07-09-003
Prof. Anna Ledin, Institute of Environment & Resources, Technical University of Denmark, Kgs. Lyngby, Denmark
Asst. Prof. Ester Heath
35. Organotin Compounds and Selected Metals in Freshwater and Terrestrial Environment: Mobility and Transfer between Solid and Aqueous Phases
BI-FR07-PROTEUS-006
PROTEUS
Prof. Gaetane Lespes, Laboratoire de Chimie Analytique, Bio-Inorganique et Environnement, UMR CNRS 5034, Université de Pau et des Pays de l'Adour, Pau, France
Asst. Prof. Janez Ščančar
36. Study of Defects in Si and Ge Irradiated by Fast Neutrons
BI-HR/07-08-030
Dr. Branko Pivac, Rudjer Boškovic Institute, Zagreb, Croatia
Dr. Radojko Jačimović
37. Mercury Interdisciplinary Research for Appropriate Clam farming in Lagoon Environment
MIRACLE
Agreement-Disgam-JSI
Università Degli Studi Di Trieste, Dipartimento Di Scienze Geologiche, Ambientali E Marine, Comprensorio di S. Giovanni, Trieste, Italy
Prof. Milena Horvat
38. Characterization of Food Products in Apulia and Slovenia by Spectroscopic and Chemometric Methods: Similarities and Differences
BI-IT/05-08-013
Prof. Antonio Sacco, Università di Bari, Dipartimento di Chimica, Bari, Italy
Asst. Prof. Nives Ogrinc
39. Mercury Emission, its Influence and its Correlation to Radon in Mount Etna Area
BI-IT/05-08-026
Dr. Salvatore Giammanco, Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Palermo, Palermo, Italy
Dr. Jože Kotnik
40. Monitoring of Chemical and Physical Parameters at the Seismic Active Zone at the Slovenian Italian Border at the Etna Volcanic Area
BI-IT/05-08-027
Dr. Anna Riggio, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Sgonico (Trieste), Italy
Asst. Prof. Janja Vaupotič
41. The Estimation of the Impact of Mercury Released in Environmental by a Human Activity The Behavior of Mercury Released from the Mining Area
JSPS - Grant No. 15404003
Prof. Takashi Tomiyasu, Kagoshima University, Department of Earth and Environmental Science, Faculty of Science, Kagoshima, Japan
Prof. Milena Horvat
42. Cycling of Mercury in Contaminated Environments
BI-JP/08-10/005
Prof. Takashi Tomiyasu, Kagoshima University, Department of Earth and Environmental Science, Faculty of Science, Kagoshima, Japan
Prof. Milena Horvat
43. Modelling of Mercury and its Compounds in Polluted Freshwater Systems: Comparison between Reservoirs in the Guizhou Province and the Idrjica River System
BI-CN/07-09-009
Prof. Xinbin Feng, State Key of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, China
Dr. Jože Kotnik
44. Harmonization of Determining the Radiation Dose of the Population Originating from Radon, in Slovenia and in Hungary
A lakosság radontól származó sugárterhelés meghatározásának harmonizációja Szlovéniában és Magyarországon
BI-HU/08-09-016
Prof. Tibor Kovács, University of Pannonia, Veszprém, Hungary
Asst. Prof. Janja Vaupotič
45. Elemental Composition of Minerals from The Republic of Macedonia
BI-MK/07-08-023
Dr. Trajče Stafilov, Faculty of Natural Sciences and Mathematics, Skopje, The Republic of Macedonia
Dr. Radojko Jačimović
46. WG 25 Validation Measurements
CEN/TC 264/WG 25/338, M/360, SA/CEN/ENV/000/2005-37
Ir. Jan A. Wesseldijk, Nederlands Normalisatie-instituut, Delft, The Netherlands
Prof. Milena Horvat, Dr. Jože Kotnik
47. Radon Potential on Different Geologic Basis-Continuation
BI-PL/08-09-017
Dr. Zozak Krzysztof, The Henryk Niewodniczanski, Institute of Nuclear Physics of the Polish Academy of Sciences, Laboratory of Radiometric Expertise, Kraków, Poland
Asst. Prof. Janja Vaupotič
48. Stable Isotope Applications in Hydrologic Studies of Slovenian and Serbian River Systems
Upotreba stabilnih izotopa u hidrološkim ispitivanjima rečnih sistema u Sloveniji i Srbiji
BI-RS/08-09-016
Dr. Nada Miljević, Institute of Nuclear Sciences "Vinca", Belgrade, Serbia
Asst. Prof. Nives Ogrinc
49. Accumulation of Mercury and Methylmercury in Natural Forest Sites in Switzerland
U3-12/06
Dr. Beat Frey, Swiss Federal Research Institute WSL, Soil Sciences, Birmensdorf, Switzerland
Prof. Milena Horvat
50. Exchange of Toxic Metals between Eater and Sediment in Polluted Freshwater Systems. The Idrjica River System (Slovenia) and Lake Coeur d'Alene (USA)
BI-US/08-10-015
Prof. Timothy Ginn, Department of Civil & Environmental Engineering, University of California, Davis, CA, USA
Prof. Milena Horvat

R & D GRANTS AND CONTRACTS

1. Chemical and biological cycling of compounds with endocrine disrupting function in wastewater treatment
Asst. Prof. Janez Ščančar
2. Assessment of the risk from metal contaminated soils and aerosols to human health through advanced in vitro gastrointestinal and respiratory bioaccessibility tests
Dr. Zdenka Šlejkevč
3. Assessment of the risk from metal contaminated soils and aerosols to human health through advanced in vitro gastrointestinal and respiratory bioaccessibility tests
Asst. Prof. Janja Vaupotič
4. The impact of microbial processes on Hg biomagnification in food webs of the Gulf of Trieste (N Adriatic Sea)
Prof. Milena Horvat
5. Development and evaluation of a toxicity test for engineered nanoparticles with terrestrial isopods
Dr. Ingrid Falnoga

6. CO₂ fixation in river carbonates: mass balance, hydrological, geochemical and biochemical controls
Asst. Prof. Sonja Lojen
7. Influence of arsenic trioxide metabolites on treatment of various cancer types
Dr. Zdenka Šlejkovec
8. Biochemical correlates of autism spectrum disorders
Dr. Bogdan Kralj
9. Deforested karst grasslands and their changes in sink activities for carbon
Asst. Prof. Nives Ogrinc
10. The response of soil organic matter and natural ecosystems (primarily forests) to climate change
Asst. Prof. Nataša Jaecks Vidic
11. Functional foods with polyphenol's antioxidants, plant proteins and trace elements.
Asst. Prof. Vekoslava Stibilj
12. Carbon transport processes and mechanisms in forest ecosystems
Asst. Prof. Nives Ogrinc
13. The influence of UV-B radiation to antioxidant content and distribution in cultivated plants
Asst. Prof. Vekoslava Stibilj
14. Integrated methodology for remediation of Hg contaminated site
Prof. Milena Horvat
15. Natural hydrochemical backgrounds of groundwaters in Slovenia
Asst. Prof. Sonja Lojen
16. Nitrate migration in the plant-soil-water system
Asst. Prof. Sonja Lojen
17. Biological methods for Hg monitoring
Prof. Milena Horvat
18. Modeling, hydrodynamics, transport of suspended matter and pollutants using SPH
Prof. Milena Horvat
19. The use of new materials from the recycled industrial products and building rubbles in civil engineering
Asst. Prof. Radmila Milačić
20. Emission control of mercury and other toxic elements from termopowerplants, cement kilns and other highly temperature industrial processes
Prof. Milena Horvat
21. Radiotherapy and evaluation of their therapeutic potential
Asst. Prof. Nives Ogrinc
22. Establishment of ratio between 129-I and 127-I in marine and terrestrial environment in Slovenia
Asst. Prof. Vekoslava Stibilj
23. The comparison and development of new methods for determining the authenticity of oil in foodstuff
Asst. Prof. Nives Ogrinc
24. Determination of geographical and botanical origin of honey
Asst. Prof. Nives Ogrinc
25. Fate and speciation of pollutants during production of synthetic fuel and pure hydrogen from polluted biomass
Dr. Jože Kotnik
26. Port of Koper in the framework of sustainable development of the coastal region
Asst. Prof. Branko Koutić
27. Territorial impact assessment of sectoral policies"
Asst. Prof. Branko Koutić
28. Development and preparation of new radiotherapeutic agents for targeted
Dr. Urška Repinc
2. Cycling of nutrients and contaminants in the environment, mass balances and modeling of environmental processes and risk analysis
Dr. Bogdan Kralj
3. Modeling and environmental impact assessment of processes and energy technologies
Asst. Prof. Borut Smodiš

NEW CONTRACTS

1. Radioactivity monitoring in RS 2008-2010
Krško NPP
Prof. Vekoslava Stibilj
2. Monitoring of radioactivity in drinking water for 2008
Ministry of Health, Slovenian Radiation Protection Administration, Ljubljana
Prof. Vekoslava Stibilj
3. Co-funding of measurement traceability of reference etalons and reference measurements to international level in year 2008
Ministry of Higher Education, Science and Technology, Metrology Institute of the Republic of Slovenia, Ljubljana
Dr. Polona Vreča
4. Control of mercury emission and other elements in termopower plants, cement production and other high temperature industrial processes
Esotech, d. d., Velenje
Prof. Milena Horvat
5. Ljubljana measures evaluation in CIVITAS-Mobilis
Municipality of Ljubljana
Prof. Branko Koutić
6. Integrated methodology for remediation of contaminated sites
Mercury Mine, Idrija
Prof. Milena Horvat
7. Iotope analyses for water tracing
Ministry of the Environment and Spatial Planning, Environmental Agency of the Republic of Slovenia, Ljubljana
Asst. Prof. Sonja Lojen
8. Support during the Slovenia presidency EU
Ministry of Health, Slovenian Radiation Protection Administration, Ljubljana
Prof. Milena Horvat
9. Emission evidences of POPs and HM with implementing the UNECE questionnaires
Ministry of the Environment and Spatial Planning, Environmental Agency of the Republic of Slovenia, Ljubljana
Dr. Tjaša Kanduč
10. Analyses of selected metals, mercury and organotin compounds in water and cadmium and mercury in sediment and mussels.
Ministry of the Environment and Spatial Planning, Environmental Agency of the Republic of Slovenia, Ljubljana
Asst. Prof. Janez Ščančar
11. Monitoring of mercury in precipitation
Ministry of the Environment and Spatial Planning, Environmental Agency of the Republic of Slovenia, Ljubljana
Prof. Milena Horvat
12. Technical basis for the spatial development plan of the Ljubljana urban region
Urban Planning Institute of the Republic of Slovenia
Prof. Branko Koutić
13. Radioactivity monitoring RŽV 2008
Žirovski vrh Mine
Asst. Prof. Borut Smodiš
14. Measurements of C14 and H3 in gas effluents
Krško NPP
Prof. Vekoslava Stibilj

RESEARCH PROGRAMS

1. Modelling of structure-property relationships - QSAR-QSPR
Dr. Bogdan Kralj

VISITORS FROM ABROAD

1. Dennis Kpakpo Adotei, Ghana Atomic Energy Commission, Accra, Ghana, 1 Jan. to 1 May 2008; 13 Oct. to 31 Dec. 2008
2. Ingvar Bergdahl, Staffan Skarving, University of Gotheburg, Gotheburg, Sweden, 14–18 Jan. 2008
3. Snežana Milošević, Skupština opštine Bujanovac, Vranje, Vinča, Serbia, 15 Nov. 2007 to 15 Mar. 2008
4. Mirjana Čolović, Institut of Nuclear Sciences, Physical Chemistry Department, Vinča, Belgrade, Serbia, 2 Mar. to 3 Apr. 2008
5. Prof. Dr. Hiroki Tamura, Graduate School of Engineering, Hokkaido University, Sapporo, Japan, 13–16 Mar. 2008
6. dr. Adriana D. Hulsmann, KIWA Water Research, Nieuwegein, Netherlands, 27–28 Mar. 2008
7. Dr. Sergio Ribeiro Guevarra, Laboratorio de Analisis por Activacion Neutronica, Centro Atomico Bariloche, Argentina, 10 May to 1 Jun. 2008 and 31 Oct. to 31 Dec. 2008
8. Nada Miljević, Institut of Nuclear Sciences, Physical Chemistry Department, Vinča, Belgrade, Serbia, 28 Mar. to 4 Apr. 2008
9. Dr. Martin Murin, Ecotoxicological Institute, Brno, Slovaška, 17–18 Mar. 2008
10. Maxym Ignatyev, Gulnura Beishenkulova, IAEA Fellowship No. KIG/07/7028, Bishkek, Kyrgyz Republic, Bolat Uralbekov, Kazakhstan, 1–31 May 2008
11. Dr. Salvatore Giammanco, Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Catania, Catania, Italy, 20–29 May 2008
12. Dr. Xinbin Feng, Guizhou Provincial Center for Environmental Education and Communications, Peng Bin, Meng Bo, Yao Heng, State Key Laboratory of Environmental Geochemistry, Chinese Academy of Science, Guiyang, China, 5–10 May 2008
13. Dr. Branko Pivac, Rudjer Bošković Institut, Zagreb, Croatia, 10 Jun. 2008
14. Prof. Dr. Lynn Walters, Lisa M. Nelson Wakefield, Dr. Kathryn Szramek, University of Michigan, USA, 31 May to 18 Jun. 2008
15. Prof. Dr. Gaetane Lespes, University of Pau, Pau, France, 24 Apr. to 3 May 2008
16. Prof. Dr. Werner Hoffmann, Division of Physics and Biophysics, Department of Materials Engineering & Physics, University of Salzburg, Austria, 5–6 Jun. 2008
17. Mounir el Hasani, Centre Nationale de l'Energie des Sciences et des Techniques Nucleaire CNESTEN, Rabat, Morocco, 1–21 Aug. 2008
18. Dr. Dušan Golobočanin, Vinča Institut, Belgrade, Serbia, 16 Jul. to 16 Aug. 2008
19. Dr. Ryoko Fujiyoshi, Division of Quantum Science and Engineering, Graduate School of Engineering, Hokkaido University, Sapporo, Japan, 6–11 Aug. 2008
20. Prof. dr. Takashi Tomiyasu, Dr. Akito Matsuyama, National Minamata Institute Dr. Ryusuke Imura, Dr. Hitoshi Kodamatani, Kagoshima University, 18–23 Aug. 2008

21. Dr. Elzbieta Kochowska, Dr. Jadwiga Mazur, mag. Henryk Grzadziel in Dr. Krzysztof Kozak, Laboratory of Radiometric Expertise at the Henryk Niewodniczanski Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland, 25 Aug. to 7 Sept. 2008
22. Prof. Brent Peyton, Prof. Timothy R. Ginn, Prof. Peter Green, University of Montana, USA, 25 Aug. to 2 Sept. 2008
23. Belgar Kakushadze, IAEA Fellowship št. GEO/07015, National Forensics Bureau, Radiation expertise laboratory, Tbilisi, Georgia, 1 Sept. to 31 Oct. 2008
24. Tatsiana Lazarevich, IAEA Fellowship št. BYE/08004, Mogilev Branch of Research Institute of Radiology, Mogilev, Minsk, Belarus, 16 Sept. to 15 Nov. 2008
25. Dr. Anna Riggio, Dr. Marco Santulin, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, (OGS), Trieste, Italy, 20–29 Oct. 2008
26. Ranko Zekić, Benard Berišaj, Center za ekotoksikološke raziskave Črne gore, Podgorica, Montenegro, 20–24 Oct. 2008
27. Katia Sofianov, Institute of Child Health, Athens, Greece, 30 Aug. to 1 Sept. 2008
28. Dr. Franco Baldi, University of Venezia, Italy, 19 Nov. 2008
29. dr. Maria Angela de Barros Correira Menezes, CDTN/CNEN, Belo Horizonte, Brazil, 20 Nov. to 1 Dec. 2008
30. Dr. Franco Baldi, University of Venezia, Venezia, Italy, 16–18 Dec. 2008

STAFF

Researchers

1. Asst. Prof. Ljudmila Benedik
 2. Dr. Ingrid Falnoga
 3. Asst. Prof. Ester Heath
 4. **Prof. Milena Horvat, Head**
 5. Dr. Radojko Jačimović
 6. Dr. Zvonka Jeran
 7. Prof. Branko Kontić
 8. Dr. Jože Kotnik
 9. Dr. Bogdan Kralj
 10. Asst. Prof. Sonja Lojen
 11. Asst. Prof. Radmila Milačič
 12. Asst. Prof. Nives Ogrinc
 13. *Dr. Arkadije Popović, retired 16 Jul. 2008*
 14. Dr. Sergio Ribeiro Guevara
 15. Asst. Prof. Borut Smodiš
 16. Prof. Vekoslava Stibilj
 17. Asst. Prof. Janez Ščančar
 18. Dr. Zdenka Šlejkovec
 19. Asst. Prof. Janja Vaupotič
 20. Dr. Polona Vreča
 21. Dr. Dušan Žigon
- Postdoctoral associates**
22. Dr. Tjaša Kanduč
 23. Dr. David Kocman
 24. Dr. Darja Mazej
 25. Dr. Andrej Osterc
 26. Dr. Urška Repinc
- Postgraduates**
27. Miha Avberšek, B. Sc.
 28. Petra Cuderman, B. Sc.

29. Marko Černe, B. Sc.
 30. Marinka Gams Petrišič, B. Sc.
 31. *Dr. Darja Gibičar, left 1 Mar. 2008*
 32. Asta Gregorič, B. Sc.
 33. *Dr. Rožle Jakopič, left 1 Apr. 2008*
 34. Dr. Davor Kontić
 35. Ana Miklavčič, B. Sc.
 36. *Dr. Tadeja Milivojevič Nemanič, left 1 Feb. 2008*
 37. *Dr. Tanja Mrak, left 1 May 2008*
 38. Simona Murko, B. Sc.
 39. Marko Štrok, B. Sc.
 40. Martina Šturm, B. Sc.
 41. Tina Šturm, B. Sc.
 42. Janja Tratnik, B. Sc.
 43. Mitja Vahčič, B. Sc.
 44. Saša Zavavlav, B. Sc.
 45. Andreja Zelenik, B. Sc.
 46. Dr. Tea Zuliani
 47. Suzana Žižek, B. Sc.
- Technical officers**
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- Technical and administrative staff**
49. Vesna Fajon
 50. Barbara Korc
 51. Damjana Nikovski, B. Sc.
 52. Silva Perko, B. Sc.
 53. Janja Smrke
 54. Barbara Svetek, B. Sc.
 55. Zdenka Trkov, B. Sc.
 56. Stojan Žigon

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Maja Andrič, Bojana Kroflič, Mihael Jožef Toman, Nives Ogrinc, Tadej Dolenc, Meta Dobnikar, Branko Čermelj, "Late Quaternary vegetation and hydrological change at Ljubljansko barje (Slovenia)", *Palaeogeogr. palaeoclimatol. palaeoecol.*, vol. 150-165, no. 1/2, pp. 150-165, 2008.
2. Meleq Bahtijari, Janja Vaupotič, Asta Gregorič, Peter Stegnar, Ivan Kobal, "Exposure to radon in dwellings in the Sharri community, Kosovo", *Radiat. prot. dosim.*, vol. 130, no. 2, pp. 244-248, 2008.
3. Meleq Bahtijari, Janja Vaupotič, Asta Gregorič, Peter Stegnar, Ivan Kobal, "Exposure to radon in the Gadime cave, Kosovo", *J. environ. radioact.*, vol. 99, no. 2, pp. 343-348, 2008.
4. Michael Philip Beeston, Johannes Teun van Elteren, Zdenka Šlejkovec, Hylke J. Glass, "Migration of arsenic from old tailings ponds - a case study on the King Edward Mine, Cornwall, UK", *Environ. res. (N.Y. N.Y.)*, vol. 108, no. 1, pp. 28-34, 2008.
5. Tinkara Bučar, Borut Smodiš, "Computer-assisted uncertainty assessment of k[sub]0-NAA measurement results", *Nucl. instrum. methods phys. res., Sect. A, Accel.*, vol. 595, pp. 647-652, 2008.
6. Tinkara Bučar, Borut Smodiš, Radojko Jačimović, Zvonka Jeran, "Quality assessment of k[sub]0-NAA by statistical evaluation of CRM results", *Acta chim. slov.*, vol. 55, pp. 166-171, 2008.
7. Tinkara Bučar, Borut Smodiš, Primož Pelicon, Jurij Simčič, Radojko Jačimović, "Micro-PIXE characterisation of reference samples intended for QA/QC of k[sub]0NAA", *J. radioanal. nucl. chem.*, vol. 278, pp. 789-794, 2008.
8. Stefano Covelli, Jadran Faganeli, Cinzia De Vittor, Sergio Predonzani, Alessandro Acquavita, Milena Horvat, "Benthic fluxes of mercury species in a lagoon environment (Grado Lagoon, northern Adriatic Sea, Italy)", *Applied geochemistry*, Vol. 23, Issue 3, 2008, Mae Sexauer Gustin, ed., Oxford, Pergamon, 2008, vol. 23, no. 3, pp. 529-546, 2008.
9. Petra Cuderman, Ivan Kreft, Mateja Germ, Miroslav Kovačević, Vekoslava Stibilj, "Selenium species in selenium-enriched and drought-exposed potatoes", *J. agric. food chem.*, issue 19, vol. 59, pp. 9114-9120, 2008.
10. Petra Cuderman, Vekoslava Stibilj, "Investigation of selenium in infant starting, special and follow-on formulae", *Nutr. food sci.*, issue 4, vol. 38, pp. 361-372, 2008.
11. Paolo De Zorzi, S. Barbizzi, Maria Belli, Maria Barbini, Aleš Fajgelj, Radojko Jačimović, Zvonka Jeran, Sandro Menegon, A. Patti, G. Petruzzelli, U. Sansone, Marcel Van der Perk, "Estimation of uncertainty arising from different soil sampling devices: The use of variogram parameters", *Chemosphere (Oxford)*, vol. 70, pp. 745-752, 2008.
12. Paolo De Zorzi, S. Barbizzi, Maria Belli, Aleš Fajgelj, Radojko Jačimović, Zvonka Jeran, U. Sansone, Marcel Van der Perk, "A soil sampling reference site: the challenge in defining reference material for sampling", *Applied radiation and isotopes*, Vol. 66, Issue 11, 2008, Oxford, Pergamon, 2008, issue 11, vol. 66, pp. 1588-1591, 2008.
13. Denise Drago, Mikol Bettella, Silvia Bolognin, Laura Cendron, Janez Ščančar, Radmila Milačič, Fernanda Ricchelli, Angela Casini, Luigi Messori, Giuseppe Tognon, Paolo Zatta, "Potential pathogenic role of β - amyloid₁₋₄₂-aluminum complex in Alzheimer's disease", *Int J Biochem Cell Biol*, vol. 40, no. 4, pp. 731-746, 2008.

14. Johannes Teun van Elteren, Koos J. Kroon, Zdenka Šlejkevec, T. Verburg, Zvonko I. Kolar, "Topical isotopic exchange and compartmental analysis approach for probing solute behaviour at the soil/arsenate solution interface", *Talanta (Oxford)*, vol. 75, no. 1, pp. 253-257, 2008.
15. M. Farré, Tina Kosjek, Ester Heath, (23 authors), "First interlaboratory exercise on non-steroidal-inflammatory drugs analysis in environmental samples", *Talanta (Oxford)*, vol. 76, no. 3, pp. 580-590, 2008.
16. Asta Gregorič, Boris Zmazek, Janja Vaupotič, "Radon concentration in thermal water as an indicator of seismic activity", *Coll. antropol.*, vol. 32, suppl. 2, pp. 95-98, 2008.
17. Ester Heath, Tina Kosjek, Boris Kompare, "Zdravilne učinkovine pod lupo", *Embalaža, okolje, logistika*, no. 39, pp. 40-41, jun./jul. 2008.
18. Julien Heroult, Tea Zuliani, Maïté Bueno, Laurence Denaix, Gaëtane Lespes, "Analytical advances in butyl-, phenyl- and octyltin speciation analysis in soil by GC-PFPD", *Talanta (Oxford)*, issue 2, vol. 75, pp. 486-493, 2008.
19. Nada Horvatinčič, Jadranka Barešič, Slavica Babinka, Bogomil Obelič, Ines Krajcar Bronić, Polona Vreča, Axel Suckow, "Towards a deeper understanding of how carbonate isotopic (^{14}C / ^{13}C / ^{18}O) reflect environmental changes: a study with recent ^{210}Pb -dated sediments of the Plitvice lakes", *Radiocarbon*, vol. 50, no. 2, pp. 233-253, 2008.
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TEXTBOOKS AND LECTURE NOTES

1. Janez Ščančar, Radmila Milačič, *Element speciation: part of "Ecotechnology" programme: fall semester 2008/09*, (Postgraduate courses in ecotechnology), Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2008.
2. Janez Ščančar, Radmila Milačič, *Trace elements in the environment: part of "Ecotechnology" programme: fall semester 2008/09*, (Postgraduate courses in ecotechnology), Ljubljana, Mednarodna podiplomska šola Jožefa Stefana, 2008.

THESES

Ph. D. Theses

1. Darija Gibičar, *Ocena bioloških kazalcev ledvičnih poškodb in oksidativnega stresa pri poklicni in splošni izpostavljenosti živemu srebru: doktorska disertacija*, Ljubljana, [D. Gibičar], 2008.
2. Rožle Jakopič, *Analizne metode za določanje izotopskih razmerij uranovih in plutonijevih radioizotopov: doktorska disertacija*, Ljubljana, [R. Jakopič], 2008.
3. David Kocman, *Mass balance of mercury in the Idrija river catchment: doctoral dissertation: doktorska disertacija*, Ljubljana, [D. Kocman], 2008.
4. Davor Kontić, *Introduction of threat analysis for hazardous industrial installations into the land-use planning process: doctoral dissertation*, Ljubljana, [D. Kontić], 2008.
5. Tanja Mrak, *Sledenje elementov in njihovih interakcij v lišajskih steljkah s poudarkom na arzenu: doktorska disertacija: doctoral dissertation*, Ljubljana, [T. Mrak], 2008.
6. Tea Zuliani, *Kritično ovrednotenje analizičnih postopkov za speciacijo organokositrovih spojin v vzorcih kopenskega okolja: doctoral dissertation*, Ljubljana, [T. Zuliani], 2008.

DEPARTMENT OF AUTOMATION, BIOCYBERNETICS AND ROBOTICS E-1

Our research brings together the different fields of automatics, robotics, biocybernetics, kinesiology and environmental medicine. Most of the research topics are connected to the so-called “movement of man and machine” and its connection and interaction with the environment. The purpose of our activities is to bridge the gap between the advanced knowledge from research and systems development, in order to provide our customers in industry, medicine and sports with sophisticated applied technology.



Head:
Asst. Prof. Leon Žlajpah

The main directions of research in the past year focused on: a) humanoid robotics, b) learning strategies and the control of robot systems, c) studies of human physiology in extreme environments, d) the evaluation of protective equipment, e) the development of biomedical devices and methods, and f) the robotics and automation of industrial manufacturing.

In the area of humanoid robotics we continued with our research on the realization of cognition in humanoid robots. This work was initiated by our participation in the FP6 Integrated Project “Perception, Action, and Cognition through Learning of Object-Action Complexes” (PACO+). PACO+ aims at the design of a cognitive robot that is able to develop perceptual, behavioural and cognitive categories in a measurable way and to communicate and share these with humans, as well as with other artificial agents. In the past year we focused on robot action learning, without assuming the availability of models describing the physics of the task. Our basic strategies were twofold: learning by exploration, and imitation learning. Learning by exploration was used to provide basic sensorimotor knowledge, whereas imitation learning was applied to overcome problems arising from high dimensional and continuous perception-action spaces. We tested various approaches to learning, including neural networks, reinforcement learning, dynamic systems, and locally weighted regression. As particular examples we studied the learning of tasks that involve the manipulation of objects, including pushing, pouring, and reaching. Another important issue was to what extent we can use 3D vision on a humanoid robot with an active vision system. This is much more difficult than on a static vision system because various transformations need to be updated online to enable 3D computations. We showed that such systems can nevertheless be used to acquire 3D information with sufficient accuracy to implement tasks such as grasping.

We continued to collaborate with ATR Computational Neuroscience Laboratories, Kyoto, Japan. Together we completed the project “Sensorimotor primitives for nonverbal humanoid communication”. The aim of this research was to implement methods that can be used to transfer human gestures to humanoid robots. This comprised the transformation of motion-capture data acquired from people demonstrating a gesture, movement interpolation between the key postures of the observed gestures, and a suitable trajectory controller that enables the robot to follow the newly learned gestures. In this way we provided techniques that can be used by a humanoid robot to acquire a rich repertoire of gestures. Special attention was paid to the hand gestures (involving one or two hands), which are the most numerous category of gestures.

We continued with studies of the methods for controlling periodic robotic tasks. The emphasis was on a system for imitating periodic motion without specifying the input frequency and the waveform of the signal. The important improvement is that all an operator needs to do is to demonstrate a few periods of the signal and the system will extract the frequency and learn a single period. Two methods were used, i.e., the adaptive frequency oscillators for extracting the frequency and a statistical learning method for learning the waveform. The work was implemented and demonstrated on a HOAP-2 robot at EPFL in Lausanne, Switzerland.

In the field of robot control we developed an original strategy for treating the kinematic redundancy that originates from the shape of the tool or the active object. The idea is to describe the tool as a serial link mechanism and then to include this mechanism as a virtual mechanism in the control and

Learning by exploration was used to provide basic sensorimotor knowledge, whereas imitation learning was applied to overcome the problems arising from high-dimensional and continuous perception-action spaces.



Figure 1: Humanoid robot HOAP using humanoid vision for autonomous learning of object pushing

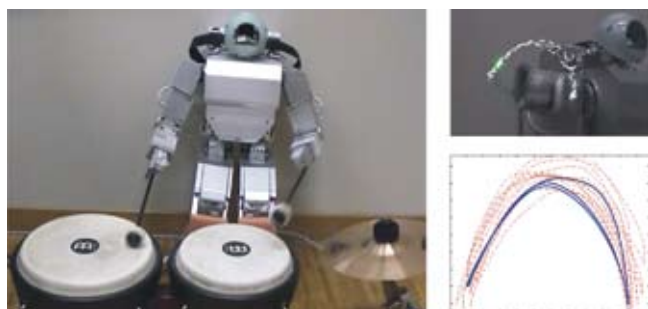


Figure 2: Application of the imitation system for drumming with the humanoid robot HOAP. Right bottom: Motion learning by demonstration. Right top: Actual robot motion

optimization algorithms for redundancy resolution. Using this approach we developed a shoe-grinding workcell. The same approach, in combination with branching-mechanism methods, was used for tracking an object with a humanoid robot head and a stereo vision system. Here, the position of the object in 3D space was estimated using stereo vision and wide-angle cameras, while the object was tracked using narrow-angle cameras.

The contemporary trends in robotics are also oriented towards new types of biologically inspired actuators. It is a common belief that in the future these actuators should have certain cognitive capabilities. In order to develop cognitive machines we are developing new types of algorithms and control methods for controlling artificial, vertebral-like motor-sensory systems. These actuators will be composed of an array of binary-actuated electrical sensitive elastomers. Different artificial neural network topologies and structures are being used in order to find an optimal control approach. Additionally, the actuator's mechanical design and the materials used are also a big issue and need to be addressed thoroughly.

The detection and recognition of abnormal events (such as falls) or unexpected behaviour that may be related to a health problem in elderly people has been studied in the framework of the European project "Ubiquitous Care System to Support Independent Living" (CONFIDENCE). Using a motion-capture system we measured the motion of people for different everyday situations and for abnormal behaviour, like characteristic falls or motion influenced by the typical pathologies associated with elderly people. After the motion capture and the tracking of 12 markers, the trajectories of the characteristic points of the human body were used as the input for analysis, modelling and recognition.

To achieve a flexible production facility for the concurrent production of different tea products, functional improvements to the supervisory and control systems were needed, together with the tight integration of the manufacturing execution and enterprise resource planning levels.

In the context of our past research on kinematics and dynamics we continued our research of the energy-efficient motion of human and robot mechanisms. Due to the low gear-ratio between the motors and the joints of the robotic jumper that we developed in previous years we extended all the actuators with speed-measurement devices that enable us to measure joint speeds without any calculations. This means that the robot control at

high speeds is significantly improved. To classify the state of the foot on the ground, we installed foot switches on the robot's foot. Using the information from the switch states we can easily detect the transitions between the push-off and flight phases of the jump. We developed a modern control scheme which, on the basis of the sensor inputs and past experiences, generates joint trajectories of the robot and therefore enables the jumping to be learned.

We investigated the closed-loop transfer of human motion to a humanoid robot where a human subject actively controls the humanoid robot motion through an adaptive controller. Instead of the visual feedback information that we used in the past, we designed and manufactured a Stewart parallel platform that enables the information transfer from the humanoid robot to the subject, which controls the robot through the closed loop. We enhanced the adaptive controller with the Supported Vector Machines method. The research was carried out in the collaboration with the Japanese institute ATR.

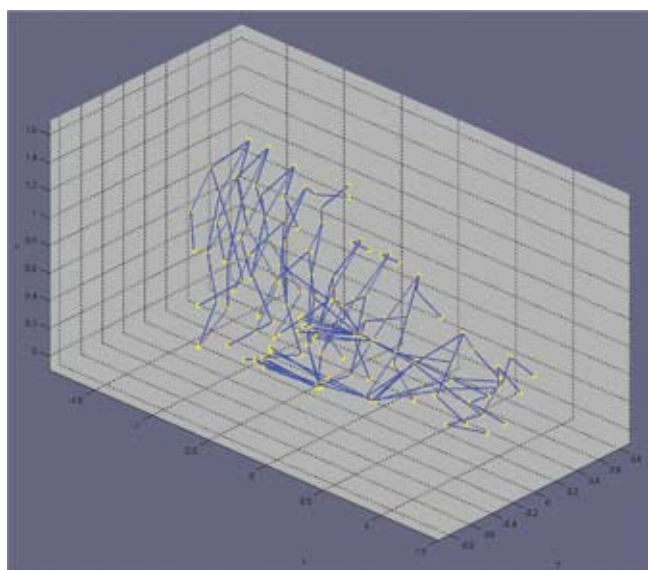


Figure 3: Human-motion analysis during a fall: Twelve markers are attached to the hands and legs and then the motion is captured with an optoelectronic measuring system

During the past year we continued our research on human-body movement during sports activities. We developed and built a robot-skier mechanism, capable of autonomous navigation of the ski slope. The robot uses a complex sensory system for control and navigation, which consists of robot vision, GPS, force sensors and an electronic gyroscope. We applied hierarchical control structures and developed a new decision-making stabilization control algorithm, which simultaneously tracks the desired path of a non-holonomic system and ensures the stability in the presence of external disturbances on the ski slope. We also developed a new navigation algorithm based on a human-like navigation strategy. One of the most challenging problems was the race-gate detection using a vision sensor in the presence of changeable lighting conditions in an unstructured environment. We solved the problem using the extended Kalman filter for the path prediction and reconstruction. We also accomplished a number of experiments on the ski slope and proved that our robot is capable of autonomous skiing between the gates on the ski slope.

We continued the applied research work for a large regional food production company Droga-Kolinska. Specifically, we were working on a three-year R&D project to make a major rearrangement and upgrade of a tea-production plant. The company has taken over complete tea production

for a foreign company. In order to integrate the production of existing and new items at the same plant, major changes and updates to the present facility are required. To achieve a flexible production facility and the concurrent production of a large number of different tea products, we carried out the functional improvements of the supervisory and control-system components. Following the introduction of the company's new manufacturing execution and enterprise resource planning levels we also designed and developed components for the integration of these with the plant's supervisory and control system.

In the past year we started to cooperate with a large glass production company Steklarna Hrastnik. We started a feasibility study for the automation of a production cell where the operations are now predominantly manual. We are defining the specifications of the requirements and the solutions, identifying the processes that are critical for the automation and proposing the appropriate solutions. Following this phase, the intention of both partners is to carry on with the design and implementation of an automated production cell.

In cooperation with the Slovenian Olympic Committee we continued to conduct research in the area of hypoxic training, particularly in the use of a "sleep high and train low" regimen. The experiments were performed at the Olympic Nordic Centre Planica, where the subjects slept at simulated altitudes of 2800 to 3200 metres above sea level and trained at ambient conditions during the day. In addition to other aspects affecting performance, we investigated the effect of prolonged hypoxic training on the oxygenation of the brain and skeletal muscle. Additionally, within the framework of a project funded by the Ministry of Defence we studied the effect of prolonged hypoxic training on the cold-induced vasodilatation (CIVD) response in hands and feet. We showed that the response is substantially improved in the feet, suggesting that hypoxic exercise may act as a protective mechanism against cold injury. Our current research is focussed on determining the mechanism of this hypoxia-induced improvement of CIVD.

Within the framework of the "Knowledge for Security and Peace" funding initiative of the Ministry of Defence, we demonstrated the contribution of individual components of the protective clothing ensemble worn by members of the Slovenian Armed Forces in desert conditions to the overall heat stress under simulated desert conditions while wearing full battle gear. Experiments with human subjects evaluated the physiological responses during work in hot and dry conditions, whereas studies with a manikin determined the thermal and evaporative resistances of different combinations of garment ensembles for work in desert conditions. With colleagues from the Centre d'Etudes de Physiologie Appliquee at CNRS, France, we evaluated the psychomotor ability of subjects during prolonged work in a hot and dry environments simulated in the climatic chamber. Studies completed with colleagues from the University of Wollongong, Australia, revealed the regional pattern of sweating for the foot, hand, torso, and head. These regional patterns of sweating were incorporated into the control of sweating in the sweating thermal manikins. This innovation allows a more physiological evaluation of the thermal characteristics of the clothing and clothing systems. The development and manufacturing of manikins has now been transferred to a UCS d.o.o., a small-medium enterprise.

An older version of the electromechanical Gait simulator was modified to obtain a more reliable device and it is now used as a reference and testing simulator. A built-in micro PLC is used for the control and communication with other devices. The new Gait simulator enables the thorough testing and evaluation of footwear under different conditions, for different gait paces and loads.

In collaboration with the Swedish Defence Research Agency we investigated the efficacy of different pharmacological agents on motion sickness. The focus of our research was also to determine which pharmacological agents also exert an influence on temperature regulation in cold environments. This study revealed which agents would be preferred in extreme environments.

Cooperation with the Swedish Defence Research Agency also continued in the fields of space and diving medicine. During investigations of the effects of simulated weightlessness on physiological systems conducted at the Orthopaedic Hospital Valdoltra, Ankaran, Slovenia, we investigated the effect of the regular local distension of vessels of one leg on the vascular distensibility, and compared the results with the untreated leg. We also investigated the effect of 5 weeks of bed rest on the risk of decompression



Figure 4: Evaluation of military equipment for desert conditions in a climatic chamber

We have investigated the effect of prolonged hypoxic training on the cold-induced vasodilatation (CIVD) response in hands and feet.



Figure 5: Robot skier mechanism on a ski slope skiing between gates

sickness. Astronauts and cosmonauts need to conduct a decompression procedure in preparation for extravehicular activities (EVAs). Namely, the atmosphere in the international space station is normobaric, whereas the pressure in the space suit is substantially lower. Thus, donning the space suit requires a carefully controlled decompression procedure to avoid the aetiology of venous gas emboli (VGE), which would enhance the risk of decompression sickness. In our study we investigated the risk of decompression sickness during EVAs in collaboration with the Eye Clinic at the Clinical Centre of Ljubljana. In this collaboration we also compared the incidence of VGE with ocular tear film bubble formation, both precursors of decompression sickness.

The most important technological achievements in the past three years

1. Aleš Ude, Damir Omrčen, Gordon Cheng. Making object learning and recognition an active process. *International Journal of Humanoid Robotics* 5(2):267-286, 2008.
2. Ola Eiken, Roger Kölegård, Igor B. Mekjavič. Pressure-distension relationship in arteries and arterioles in response to five weeks of horizontal bedrest. *Am J Physiol Heart Circ Physiol*, 2008, 295: H1296-H1302
3. Andrej Gams, Leon Žlajpah, Jadran Lenarčič. Imitating human acceleration of a gyroscopic device. *Robotica*, 2007, vol. 25, 501-509.
4. Bojan Nemeč, Leon Žlajpah. Shoe grinding cell using virtual mechanism approach. V: Fifth International Conference on Informatics in Control, Automation and Robotics, 11-15 May, 2008, Funchal, Madeira, Portugal. ICINCO 2008: proceedings. Setúbal: Insticc Press, 2008, 159-164.
5. Leon Lahajnar, Andrej Kos, Bojan Nemeč. Skiing robot-design, control, and navigation in unstructured environment. *Robotica*, 2008, 11.

Awards and appointments

1. Igor Mekjavič: BORELLI medal for his Original Cotribution to Space Medicine, granted by 2nd University of Napoli, Italy.

INTERNATIONAL PROJECTS

1. Ubiquitous Care System to Support Independent Living
CONFIDENCE
7. FP, 214986
EC; Centro de Estudios e Investigaciones Tecnicas de Guipuzcoa, San Sebastian, Spain
Prof. Leon Žlajpah, Prof. Matjaž Gams
2. Innovation Relay Centre of Slovenia
Si-IRC-04-08
6. FP, 510419 (IRC 6)
Alice Wu, European Commission, DG Enterprises and Industry Innovation Policy D/2,
Support for Innovation, Brussels, Belgium
Prof. Leon Žlajpah, Prof. Peter Stegnar
3. Perception, Action & Cognition through Learning of Object-Action Complex
PACO-PLUS
6. FP, 027657
EC; Universität Karlsruhe (TH), Karlsruhe, Germany
Dr. Aleš Ude
4. European Robotics Network
EURON
6. FP, 507728
EC; Kungliga Tekniska Högskolan, Stockholm, Sweden
Prof. Jadran Lenarčič
5. Sensorimotor Primitives for Nonverbal Humanoid Communication
027657
Advanced Telecommunications Research Institute International, Computational
Neuroscience Laboratories, Department of Humanoid Robotics and Computational
Neuroscience, Kyoto, Japan
Dr. Aleš Ude

6. Human to Humanoid Robot Full Body Motion Transfer
BIJP/08-10/009
Dr. Erhan Oztop, JST, ICORP Computational Brain Project/Advanced
Telecommunications Research Institute International (ATR), Computational
Neuroscience Laboratories, Kyoto, Japan
Dr. Jan Babič

R & D GRANTS AND CONTRACTS

1. Controlled internal combustion engine
Dr. Jan Babič
2. System for automatic supervision and control of a production line for simultaneous
production of different products
Asst. Prof. Leon Žlajpah
3. Protective systems for warrior
Prof. Igor Mekjavič

RESEARCH PROGRAM

1. Automation, robotics and biocybernetics
Prof. Jadran Lenarčič

NEW CONTRACT

1. Production analysis and automation assessment for a class of glass components
Steklarna Hrastnik - Opal LLC, Hrastnik
Dr. Anton Ružič

VISITORS FROM ABROAD

1. Dr. Tamim Asfour, University of Karlsruhe, Germany, 30 Sept. to 7 Oct. 2008
2. Dr. Leslie Blogg, Karolinska Insitut, Stockholm, Sweden, 8-23 Aug. and 23-30 Oct. 2008
3. Prof. Ola Eiken, Karolinska Insitut, Stockholm, Sweden, 8-23 Aug. and 23-30 Oct. 2008

4. Doc. Mikael Gennser, Karolinska Insitut, Stockholm, Sweden, 8-23 Aug. and 23-30 Oct. 2008
5. Denis Herzog, University of Aalborg, Denmark, 3 Jan. to 31 Mar. 2008
6. Frederik Karelstad, Thelma, Bergen, Norway, 21-25 Jan. 2008
7. Dr. Minija Tamošiunaite, Vytautas Magnus University, Kaunas, Lithuania, 11-22 Nov. 2008
8. prof. Florentin Wörgöter, Bernstein Center for Computational Neuroscience BCCN
Göttingen, Germany, 15-21 Oct. 2008

STAFF

Researchers

1. Dr. Jan Babič
2. Dr. Ladislav Lenart
3. Prof. Igor Mekjavič
4. Dr. Bojan Nemeč
5. Dr. Anton Ružič
6. Dr. Aleš Ude
7. **Asst. Prof. Leon Žlajpah, Head**

Postdoctoral associates

8. Dr. Stylianos Kounalakis
9. Dr. Damir Omrčen
10. Dr. Martin Tomšič

Postgraduates

11. Mitja Babič, B. Sc.
12. Tadej Debevec, B. Sc.
13. Andrej Gams, B. Sc.

14. Blaž Hajdinjak, B. Sc.
15. Michail Keramidas
16. Leon Lahajnar, B. Sc., left 1 Oct. 2008
17. Tadej Petrič, B. Sc.
18. Eva Stergaršek Kuzmič, B. Sc.
19. Daniel Wolowske, M. Sc., left 1 Apr. 2008

Technical officers

20. Andrej Kos, B. Sc.
21. Borut Lenart, B. Sc.
22. Marija Trampuž, B. Sc.
23. Bogomir Vrhovc, B. Sc.

Technical and administrative staff

24. Dušan Filipič
25. Jožef Opeka
26. Janez Zalar

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2. Mitja Babič, Jadran Lenarčič, Leon Žlajpah, Nigel A. S. Taylor, Igor B. Mekjavič, "A device for simulating the thermoregulatory responses of the foot: estimation of footwear insulation and evaporative resistance", *Stroj. vestn.*, vol. 54, no. 9, pp. 628-638, 2008.
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9. Alan Kacin, Petra Golja, Michael J. Tipton, Igor B. Mekjavič, "The influence of fatigue-induced increase in relative work rate on temperature regulation during exercise", *Eur. j. appl. physiol. (Print)*, vol. 103, no. 1, pp. 71-77, 2008.
10. Stylianos N. Kounalakis, Ioannis A. Bayios, Maria D. Koskolou, Nickos D. Geladas, "Anaerobic capacity of the upper arms in top-level team handball players", *International journal of sports physiology and performance*, vol. 3, no. 3, pp. 251-261, 2008.
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16. Igor B. Mekjavič, Uroš Dobnikar, Stylianos N. Kounalakis, Bojan Musizza, Stephen S. Cheung, "The trainability and contralateral response of cold-induced vasodilatation in the fingers following repeated cold exposure", *Eur. j. appl. physiol. occup. physiol.*, vol. 104, no. 2, pp. 193-199, 2008.
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1. Tamim Asfour, Kai Welke, Aleš Ude, Pedram Azad, Ruediger Dillmann, "Perceiving objects and movements to generate actions on a humanoid robot", In: *Unifying perspectives in computational and robot vision*, (Lecture notes in electrical engineering, vol. 8), Danica Kragič, ed., Ville Kyrki, ed., New York, Springer, 2008, pp. 41-55.
2. José González-Alonso, Ola Eiken, Igor B. Mekjavič, "A critical core temperature and the significance of absolute work rate", In: *Physiological bases of human performance during work and exercise*,

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PUBLISHED CONFERENCE PAPERS

Invited Papers

- Matej Supej, Bojan Nemeč, "Uporaba digitalne obdelave slik v športu", In: *Računalniška obdelava slik in njena uporaba v Sloveniji 2008: zbornik 3. strokovne konference*, Božidar Potočnik, ed., Maribor, Fakulteta za elektrotehniko, računalništvo in informatiko, Inštitut za računalništvo, 2008, pp. 22-32.

Regular papers

- Tamim Asfour, Kai Welke, Pedram Azad, Aleš Ude, Ruediger Dillmann, "The Karlsruhe humanoid head", In: *Humanoids 08*, 8th IEEE-RAS International Conference on Humanoid Robots, December 1-3, 2008, Daejeon, Korea, [S. l.], IEEE, 2008, pp. 447-453.
- Mitja Babič, Rocco Verterchy, Giovanni Berselli, Jadran Lenarčič, Vincenzo Parenti-Castelli, "Elektroelastični polimerski aktuatorji", In: *Zbornik sedemnajste mednarodne Elektrotehniške in računalniške konference ERK 2008, 29. september - 1. oktober 2008, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2008, zv. B, pp. 199-202.
- Andrej Gams, Sarah Degallier, Auke Jan Ijspeert, Jadran Lenarčič, "Dynamical system for learning the waveform and frequency of periodic signals - application to drumming", In: *RAAD 2008: CD of proceedings*, 17th International Workshop on Robotics in Alpe-Adria-Danube Region, RAAD 2008, 15-17 September 2008, Ancona, Italy, Ancona, Università Politecnica delle Marche, 2008, 7 pp.
- Andrej Gams, Pierre-André Mudry, "Gaming controllers for research robots: controlling a humanoid robot using a WIIIMOTE", In: *Zbornik sedemnajste mednarodne Elektrotehniške in računalniške konference ERK 2008, 29. september - 1. oktober 2008, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2008, zv. B, pp. 191-194.
- Andrej Gams, Ludovic Righetti, Auke Jan Ijspeert, Jadran Lenarčič, "A dynamical system for online learning of periodic movements of unknown waveform and frequency", In: *BioRob 2008*, The Second IEEE/RAS-EMBS International Conference on Biomedical Robotics and Biomechatronics, Scottsdale, Arizona, USA, October 19-22, 2008, [Piscataway], IEEE, 2008, pp. 85-90.
- Dennis Herzog, Aleš Ude, Volker Krüger, "Motion imitation and recognition using parametric hidden Markov models", In: *Humanoids 08*, 8th IEEE-RAS International Conference on Humanoid Robots, December 1-3, 2008, Daejeon, Korea, [S. l.], IEEE, 2008, pp. 339-346.
- Đani Juričič, Bojan Musizza, Matej Gašperin, Bogomir Vrhovec, Gregor Dolanc, Igor B. Mekjavič, Daniela Zavec Pavlinič, "System for evaluation of fire protective garments", In: *Magic world of textiles: book of proceedings*, 4th International Textile, Clothing & Design Conference [also] ITC&DC, October 5th to October 8th, 2008, Dubrovnik, Croatia, Zvonko Dragčević, ed., Zagreb, Faculty of Textile Technology, University of Zagreb, 2008, pp. 787-792.
- Andrej Kos, Aleš Ude, "Učenje ciljno-usmerjenih gibov z uporabo knjižnice podobnih gibov", In: *Zbornik sedemnajste mednarodne Elektrotehniške in računalniške konference ERK 2008, 29. september - 1. oktober 2008, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in

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- Ladislav Lenart, Jan Babič, "Direktni in indirektni algoritmi optimalnega upravljanja", In: *Dnevi slovenske informatike 2008 in interoperabilnost*, Karl Petrič, ed., V Ljubljani, Ministrstvo za notranje zadeve RS, 2008, 10 pp.
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 - Bojan Nemeč, Leon Žlajpah, "Shoe grinding cell using virtual mechanism approach", In: *ICINCO 2008: proceedings*, Fifth International Conference on Informatics in Control, Automation and Robotics, 11-15 May, 2008, Funchal, Madeira - Portugal, [Setúbal], Insticc Press, 2008, pp. 159-164.
 - Bojan Nemeč, Leon Žlajpah, "Task redundancy resolution using virtual mechanism approach", In: *RAAD 2008: CD of proceedings*, 17th International Workshop on Robotics in Alpe-Adria-Danube Region, RAAD 2008, 15-17 September 2008, Ancona, Italy, Ancona, Università Politecnica delle Marche, 2008, 7 pp.
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 - Erhan Oztop, Jan Babič, Joshua G. Hale, Gordon Cheng, Mitsuo Kawato, "From biologically realistic imitation to robot teaching via human motor learning", In: *Neural information processing. part 2: revised selected papers*, (Lecture notes in computer science, vol. 4985), Masumi Ishikawa, ed., Berlin, Heidelberg, New York, Springer, vol. 4985, pp. 214-221, 2008.
 - Matej Supej, Otmar Kugovnik, Bojan Nemeč, "DGPS measurement system in alpine skiing track and center of mass estimation", In: *Proceedings of First Joint International Pre-Olympic Conference of Sports Sciences and Sports Engineering: Nanjing, China, August 4-7, 2008. Vol. 1, Computer Science in Sports*, (2008 Pre-Olympic Congress on Science and Engineering), Yong Jiang, ed., Arnold Baca, ed., Hui Zhang, ed., Liverpool, World Academic Union (World Academic Press, cop. 2008, pp. 120-125.
 - Boštjan Šimunič, Rado Pišot, Joern Rittweger, Igor B. Mekjavič, "Regular sport activity does not prevent skeletal muscle contraction time loss in master athletes", In: *Sport a kvaliteta života 2008: zbornik prispěvků*, Marie Blahutková, ed., Brno, Masarykova univerzita, Fakulta sportovních studií, 2008, 10 pp., 2008.
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TEXTBOOKS AND LECTURE NOTES

- Drago Matko, Peter Omersel, Anton Ružič, Marjan Mihelin, Vinko Kunc, *Računalniško podprto načrtovanje*, Ljubljana, Fakulteta za elektrotehniko in računalništvo, 1988.

PATENT APPLICATIONS

- Aleš Jurca, Damir Omrčen, *Postopek za merjenje notranjih dimenzij obuvala: patentna prijava no. P-200800195*, Ljubljana, Urad RS za intelektualno lastnino, 2008.

DEPARTMENT OF SYSTEMS AND CONTROL

E-2

The Department of Systems and Control is engaged in research, development, applications and education across a variety of areas of control technology. Its mission is “to bridge the gap between theory and practice”. Hence, the research activities are relatively application oriented, and the content of the work is closely related to the needs of production companies. 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 and construction 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.

Basic and applied research

The basic and applied research during 2008 was devoted to four sub-areas: the analysis and control of complex systems and processes, fault detection and isolation, computer-integrated production control, and advanced implementation technology.

In the sub-area **analysis and control of complex systems and processes** our work was devoted to the development of some general purpose methods. The research in dynamic systems modelling of Gaussian process models was directed towards various computer-simulation methods and the propagation of prediction uncertainties. Application case studies of conventional and explicit predictive control based on Gaussian process models were also pursued. In the field of advanced control algorithms we continued R&D on parametric predictive controllers based on linear and hybrid models. In the final phase of the EU 6FP project CONNECT we have successfully completed two pilot case studies using such controllers in industrial environments: pressure control in a vacuum chamber and cooling-water temperature control in a CHP unit. The tuning of PID controllers is a traditional research area at our department. In 2008 a new, efficient tuning algorithm was developed, which does not require any additional input from the operator, except an open-loop or a closed-loop experiment.

New control methods and algorithms were developed in various specific problem domains. Within the EU 6FP project PEGASE a system for landing aircraft and helicopters automatically is being developed, which is completely autonomous and does not depend on any kind of infrastructure or equipment, located outside the aircraft. The idea is to guide the aircraft using images, acquired by a camera installed on the aircraft. In 2008 a position-based predictive control scheme that uses a set of local linear models was developed (Fig 1). Within the EU 6FP project PRISM the control algorithms for the online dosing of process ingredients was proposed and tested on the developed mathematical model of the polymerization process. The control algorithms keep the reactor temperature in a narrower region and shorten the batch cycle by around 10%. For wastewater-treatment processes, research on the automatic generation of conceptual descriptions of classifications was performed in cooperation with foreign partners.

In the sub-area of **fault detection and isolation** work has been conducted along two main lines. In the area of rotational machinery the focus was on gearbox drives. In cooperation with the Faculty of Mechanical Engineering, University of Ljubljana, a laboratory test-bed has been functionally completed along with a new prototype for online oil analysis (Fig. 2). The software for the administration of the experimental runs is realized in the Labview environment. It takes care of the acquisition and archiving of 21 measurement channels, so that the content is accessible over the web. Thus, a valuable benchmark is believed to become available to the researchers and potential users. Research has been concentrated on feature extraction for several of the most common faults in mechanical drives, such as pitting, scarfing, unbalance and various misalignment faults. New algorithms have been designed by employing the vibration measurements, the noise and the current of an electrical motor. An extensive laboratory study has been performed, showing that features based on electrical current reflect the nature of mechanical faults in mechanical drives reliably enough. This result paves the way for the development of an efficient, low-cost monitoring and fault-diagnosis device, which would be widely applicable in industry.



Head:
Prof. Stanislav Strmčnik

Within the highest state awards for scientific and research achievements, issued by the Slovenian Ministry of Higher Education, Science and Technology, the “Puh” award for development achievements was this year bestowed on our colleague Dr Gregor Dolanc, for a system for the automatic control of a steel-strip slitting line.

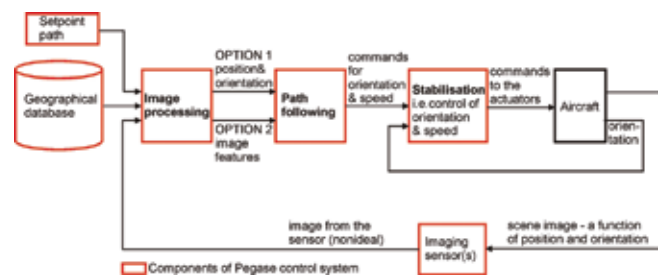


Figure 1: A simplified scheme of the image-based aircraft-landing control system

An international workshop called “PhD Workshop on Systems and Control - a young generation viewpoint” was this year organised by PhD students from our department and sponsored by the IEEE Slovenian section.

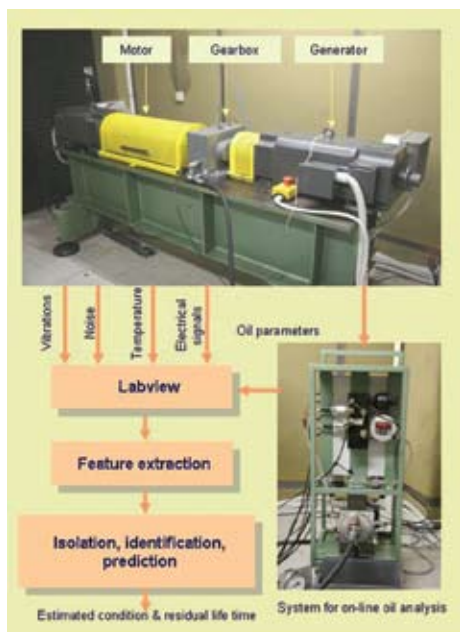


Figure 2: A monitoring system for rotational machinery and drives



Figure 3: A 7-kilowatt fuel-cell-based auxiliary electrical power unit installed in a special purpose military vehicle

Among their new products, Mitsubishi Electric announces PLC Batch – a tool designed at our department and implemented in cooperation with the company INEA

Another area refers to the robust model-based fault diagnosis of non-linear dynamic systems. Almost all of the available techniques assume prior knowledge of the system model, which is not easy to obtain. Therefore, the emphasis in the initial phase of the research was on the identification of continuous nonlinear models from discrete process data. This includes parameter estimation, the estimation of noise statistics and, potential miss-modelling effects.

A part of the work related to this sub-area was devoted to the EU 6FP project BRACCIA, which deals with the problem of monitoring the depth of anaesthesia. A special device, Cardio&BrainSignals, which was developed at our department, was used to perform experiments on laboratory animals during anaesthesia. The gathered data was then analysed using state-of-the-art methods for causality inference. The preliminary results of the study indicate that interactions between several biological oscillations could be used to monitor the depth of anaesthesia.

Our research in the sub-area of **computer-integrated production control** was concentrated on the design and verification of a hierarchical production control system. In 2008 a concept for production control, based on an expert system for a case-study chemical batch production, was developed. The activities towards the development of a suitable methodology for the identification of key production indicators have also been performed using the well-known Tennessee-Eastman benchmark process.

In the area of **advanced implementation technologies** a part of the activities was devoted to the development of a rapid-prototyping tool for the design and implementation of control algorithms. A feed-forward compensator, multivariable controller and PFC (Predictive Functional Controller), with appropriate tuners, have been implemented in 2008. The second part was related to methods and tools for the development of control SW. Guidelines for the systematic procurement of software tools, used for the realization of the model-driven engineering paradigm in software development, have been developed. These guidelines minimize the cost and risk during the adoption of model-driven engineering. Based on the guidelines a suitable tool was selected. To fulfil the needs for the development of new electronic devices further work on the environment, which will enable the design of embedded control and digital signal processing systems, was carried out. The ARM-microcontroller-based evaluation boards were successfully connected into the Ethernet communication network and the distant code downloading and execution supervision were prepared. With the connection to the LabView software tools a very convenient design environment was established and successfully used during the design of the ARM-based embedded control devices for various industrial customers. Also, the Cortex-M3-based ARM microprocessor was evaluated for diverse applications.

R&D projects for industry and other users

In cooperation with the **Slovenian Ministry of Defence** four projects in the area of fuel-cell-based system applications and the development of subsystems for fuel-cell power units are being performed. In November 2008 the project to install a 7-kilowatt fuel-cell-based auxiliary electrical power unit into a special purpose military vehicle was completed. A still ongoing project is the design of a mobile cogeneration fuel-cell-based system for military use, where during this year the complete project documentation has been elaborated. In the frame of the project with the goal to develop a reliable ceramic fuel reformer for small-power fuel cells we have developed a miniature reactor for steam reforming. The last ongoing project is the development of the experimental laboratory set-up for the testing and validation of various subsystems for PEM fuel cells, where in 2008 all the necessary subsystems were defined and the majority of the installation equipment was purchased.

We were also very active in R&D projects for industry. Based on a contract with the company **DOMEL** an Air Delivery Control System was developed. It is intended for the control of air flow in the fuel-cell and natural-gas reformer based a co-generation heating/power supply system. The control system consists of the SmartModule control board

and the control algorithm. The SmartModule is an ARM-based embedded control board, while the algorithm is based on the cross-coupled control automaton and PID control loops. Besides the functional requirements a low cost was also taken into consideration during the design as the final product is also intended for domestic applications. A small series of 25 SmartModules was produced and sold to the PlugPower company (Fig. 4). For the company **GOAP** a new version of an algorithm for calculating the optimal room-temperature set-points in buildings was developed and tested on a simulation model of a hotel building.

In cooperation with the company **INEA** a control system for the resin-synthesis process at the **COLOR** chemical works was developed. In the frame of the project the batch control tool PLCbatch was used. Based on the feedback information from the project, the tool was further improved in terms of the phase behaviour and synchronization model and the recipe system efficiency in terms of reducing the repetition of information and increasing the degree of reuse. For the company **Danfoss-Trata** a new, patented, innovative system for reducing the oscillations in the control loop has been developed and tested within the project "Intelligent Actuators". For the same company a new series of electronic drives for valves, based on BLDC motors, has also been developed.

Education and training activities

Some members of the department are giving lectures and practical courses at 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 M.Sc. and Ph.D. students. Special care was given to post-qualification training for engineers from industry. In 2007, four one-week courses were organized. These courses were organized in close cooperation with the Information Technologies Knowledge Transfer Centre at the Jozef Stefan Institute.

Some outstanding publications in the past three years

1. Aljaž Stare, Darko Vrečko, Nadja Hvala, Stanko Strmčnik. Comparison of control strategies for nitrogen removal in an activated sludge process in terms of operating costs : a simulation study. *Water res.* (Oxford). [Print ed.], 2007, vol. 41, no. 9, 2004-2014.
2. Alexandra Grancharova, Juš Kocijan, Tor Arne Johansen. Explicit stochastic predictive control of combustion plants based on Gaussian process models. *Automatica* (Oxf.). [Print ed.], 2008, vol. 44, no. 6, 1621-1631.
3. Gregor Dolanc, Stanko Strmčnik. Design of a nonlinear controller based on a piecewise-linear Hammerstein model. *Syst. control. lett.*. [Print ed.], 2008, vol. 57, no. 4, 332-339.

The most important technological achievements in the past three years

1. A series of electronic drives for valves, based on BLDC motors, 2008, (Janko Petrovčič, Damir Vrančič, Aleš Svetek, Stane Černe, Miroslav Štrubelj)
2. PLCbatch - a tool for the control of batch processes with PLC's, based on the S88.01 standard, 2007, (Giovanni Godena)

Awards and appointments

1. Dr Gregor Dolanc: within the "Zois" awards, the highest state awards for scientific and research achievements, issued by the Slovenian Ministry of Higher Education, Science and Technology, the "Puh" award for development achievements was this year bestowed for a system for the automatic control of a steel-strip slitting line

Members of our department played an important role in the establishment of the Hydrogen Technology Development Centre, of which Jozef Stefan Institute is a founding member.



Figure 4: SmartModule - an Air Delivery Control System intended for the control of air flow in the fuel-cell and natural-gas reformer based on a co-generation heating/power supply system



Figure 5: Resin-synthesis batch-process control system based on the PLCbatch tool

A substantial part of our work was devoted to final activities within projects of the Centre of Excellence for Advanced Control Technologies (it includes 15 industrial and four academic partners), which is coordinated by our department.

INTERNATIONAL PROJECTS

- Design of Advanced Controllers for Economic, Robust and Safe Manufacturing Performance
CONNECT
6. FP, COOP-CT-2006, 031638
EC; Dr. Constantinos Pantelides, Process Systems Enterprise Limited, London, Great Britain
Dr. Samo Gerškšič, Dr. Vladimir Jovan
- Helicopter and aEronef naviGation Airborne System Experimentations
PEGASE
6. FP, AST5-CT-2006-030839
EC; Bruno Pattin, Claire Lallemant, Dassault Aviation, Paris, France
Prof. Stanko Strmčnik, Dr. Gregor Dolanc
- Towards Knowledge - Based Processing Systems
PRISM
6. FP, MRTN-CT-2004-512233
EC; Imperial College of Science Technology and Medicine, London, Great Britain
Dr. Gregor Kandare
- Explicit Nonlinear Model Predictive Control based on Gaussian Process Models
Prof. Alexandra Grancharova, Institute of Control and System Research, Bulgarian Academy of Sciences, Sofia, Bulgaria
Prof. Juš Kocijan
- Bayesian Decision Making to support Change Detection in Complex Manufacturing Systems
BI-CZ/07-08-011
Dr. Tatiana Valentine, Department of Adaptive Control, Institute of Information Theory and Automation, Prague, Czech Republic
Prof. Đani Juričić
- On-line Monitoring and Fault Diagnosis of Industrial Systems
BI-MK/07-08-018
Prof. Mile Stankovski, Faculty of Electrical Engineering, Skopje, The Republic of Macedonia
Prof. Đani Juričić

- Design of PID Controllers: Interchange of Technology and Experience - Second Part
BI-PT/06-07-005
Prof. José Paulo de Maura Oliveira, Engineering Department, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal
Asst. Prof. Damir Vrančić
- Building Virtual Communities for Research and Education in Automation and Control
BI-SK/05-07-009
Prof. Mikuláš Huba, Slovak University of Technology in Bratislava, Bratislava, Slovakia
Asst. Prof. Damir Vrančić

R & D GRANTS AND CONTRACTS

- An intelligent system for condition monitoring of rotating machinery
Prof. Đani Juričić
- Optimization of HVAC systems using dynamic models
Prof. Đani Juričić
- Rapid prototyping of advanced control algorithms in industrial environment
Asst. Prof. Damir Vrančić
- Early detection of lung cancer in workers with asbestos disease
Prof. Đani Juričić
- Fuel cell based auxiliary power system for autonomous operation of military vehicles
Dr. Janko Petrovčič

RESEARCH PROGRAM

- Systems and control
Prof. Stanislav Strmčnik

VISITORS FROM ABROAD

- Pavle Boškosi, Faculty of Electrical Engineering, Ss. Cyril and Methodius University, Skopje, R. Macedonia, 1 Jan. to 31 Dec. 2008
- Dr Kosta Boshnakov, University of Chemical Technology and Metallurgy, Sofia, Bulgaria, 16-17 Apr. 2008

- Dr Jan Prikryl, Institute of Information theory and automation, Academy of sciences in the Czech republic, Prague, Czech Republic, 2-15 Jun. 2008
- Dr Pavel Ettler, Compureg Plzen, Plzen, Czech Republic, 11-14 Nov. 2008
- Teodora Miteva, work in the frame of the project PRISM, Sofia, Bulgaria, 1 Jan. to 23 Dec. 2008

STAFF

Researchers

- Dr. Gregor Dolanc
- Dr. Samo Gerškšič
- Dr. Nadja Hvala
- Dr. Vladimir Jovan
- Asst. Prof. Đani Juričić
- Prof. Juš Kocijan
- Dr. Janko Petrovčič
- 8. Prof. Stanislav Strmčnik, Head**
- Asst. Prof. Damir Vrančić
- Dr. Darko Vrečko

Postdoctoral associates

- Dr. Dejan Gradišar
- Dr. Gregor Kandare
- Dr. Alenka Žnidaršič*

Postgraduates

- Matej Gašperin, B. Sc.

- Giovanni Godena, B. Sc.
- Tomaž Lukman, B. Sc.
- Satja Lumar, B. Sc.
- Jernej Mrovlje, B. Sc.
- Dr. Bojan Musizza
- Boštjan Pregelj, B. Sc.
- Aleš Svetek, B. Sc.
- Technical officers**
- Stanislav Černe, B. Sc.
- Primož Fajdiga, B. Sc.
- Maja Janežič, B. Sc.
- Dr. Zoran Marinšek*

Technical and administrative staff

- Miroslav Štrubelj

Note:

* part-time JSI member

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ORIGINAL ARTICLES

- Kristijan Ažman, Juš Kocijan, "Non-linear model predictive control for models with local information and uncertainties", *Trans. Inst. Meas. Control*, vol. 30, no. 5, pp. 371-396, 2008.
- Uroš Benko, Đani Juričić, "Frequency analysis of noisy short-time stationary signals using filter-diagonalization", *Signal process.*, vol. 88, no. 7, pp. 1733-1746, 2008.

- Gregor Dolanc, Stanko Strmčnik, "Design of a nonlinear controller based on a piecewise-linear Hammerstein model", *Syst. control. lett.*, vol. 57, no. 4, pp. 332-339, 2008.
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- Marko Gerbec, Vladimir Jovan, Janko Petrovčič, "Operational and safety analyses of a commercial PEMFC system", *Int. j. hydrogen energy*, vol. 33, no. 15, pp. 4147-4160, 2008.

6. Samo Gerškšič, Stanko Strmčnik, Ton van den Boom, "Feedback action in predictive control: an experimental case study", *Control eng. pract.*, vol. 16, no. 3, pp. 321-332, 2008.
7. Dejan Gradišar, Sebastjan Zorzut, Vladimir Jovan, "Model-based production control", *Automatika (Zagreb)*, vol. 49, no. 3/4, pp. 151-158, 2008.
8. Dejan Gradišar, Sebastjan Zorzut, Vladimir Jovan, "Production control of a polymerization plant based on production performance indicators", *Organizacija (Kranj)*, vOL. 41, nO. 6, sTR. 207-217, 2008.
9. Alexandra Grancharova, Juš Kocijan, Tor Arne Johansen, "Explicit stochastic predictive control of combustion plants based on Gaussian process models", *Automatica (Oxf.)*, vol. 44, no. 6, pp. 1621-1631, 2008.
10. Nadja Hvala, Mario Zec, Stanko Strmčnik, "Non-linear model parameter estimation-estimating a feasible parameter set with respect to model use", *Math. comput. model. dyn. syst.*, vol. 14, no. 6, pp. 587-605, 2008.
11. Juš Kocijan, "Survey of the methods used in patent on auto-tuning controllers", *Recent patents on electrical engineering*, vol. 1, no. 3, pp. 201-208, 2008.
12. Juš Kocijan, Bojan Likar, "Gas-liquid separator modelling and simulation with Gaussian process models", *Simulation modelling practice and theory*, vol. 16, no. 18, pp. 910-922, 2008.
13. Satja Lumbar, Damir Vrančič, Stanko Strmčnik, "Comparative study of decay rations of disturbance-rejection magnitude optimum method for PI controllers", *ISA trans.*, vol. 47, no. 1, pp. 94-100, 2007.
14. Igor B. Mekjavič, Uroš Dobnikar, Stylianos N. Kounalakis, Bojan Musizza, Stephen S. Cheung, "The trainability and contralateral response of cold-induced vasodilatation in the fingers following repeated cold exposure", *Eur. j. appl. physiol. occup. physiol.*, vol. 104, no. 2, pp. 193-199, 2008.
15. Aljaž Stare, Nadja Hvala, Darko Vrečko, Stanko Strmčnik, "Primerjava strategij vodenja odstranjevanja dušikovih komponent na študijskem modelu čistilne naprave odpadnih voda", *Elektroteh. vestn.*, vol. 75, no. 4, pp. 183-188, 2008.
- Control (ISIC): parts of the IEEE Multi-conference on Systems and Control, San Antonio, Texas, 3-5 September 2008, [S. l.], Institute of Electrical and Electronics Engineers, 2008, pp. 1007-1012.
4. Matej Gašperin, Vladimir Jovan, Dejan Gradišar, "Decision support system for polymerization production plant using pPIs", In: *MED'08: proceedings of the 16th Mediterranean Conference on Control and Automation, June 25-27, 2008, Ajaccio, Corsica, France*, [S. l.], The IEEE Control Systems Society, 2008, pp. 547-551.
5. Marko Gerbec, Vladimir Jovan, Janko Petrovčič, "Operational reliability and safety risk assessment of fuel cell proton exchange membrane system", In: *34th ESReDA, 2nd ESReDa/ESRA Seminar on Supporting technologies for advanced maintenance information management: 13-14th May, 2008, San Sebastian, Spain*, [S. l., s. n.], 2008, 15 pp.
6. Giovanni Godena, Janez Tancek, Igor Steiner, Marko Svetina, "Design of a batch process control tool on the PLC platform", In: *Shaping the future of manufacturing, sharing and learning with the leaders in automation and manufacturing: WBF 2008 North American Conference, March 24-26, Dolce Valley, Philadelphia, Pennsylvania*, [S. l.], WBF-Forum for Automation and Manufacturing Professionals, 2008, 13 pp.
7. Dejan Gradišar, Vladimir Jovan, "Control system design for polymerization production plant", In: *Proceedings of the Control 2008 conference*, 8th Portuguese Conference on Automatic Control, 21-23 July 2008, Vila Real, Portugal, José Boaventura Cunha, ed., Vila Real, Universidade de Trás-os-Montes e Alto Douro, 2008, 6 pp.
8. Dejan Gradišar, Vladimir Jovan, Sebastjan Zorzut, "Simulation model of a polymerization plant", In: *EMSS 2008, The 20th European Modeling & Simulation Symposium*, September 17-19 2008, Campora S. Giovanni (Amantea, CS), Italy, Agostino G. Bruzzone, ed., Genova, DIPTEM University, 2008, pp. 374-379.
9. Vladimir Jovan, Dejan Gradišar, Sebastjan Zorzut, "Production control of a polymerization plant using a reduced set of control variables", In: *2008 International Conference on Cybernetics and Intelligent Systems: September 21-24, 2008, Chengdu, China*, Singapore, Institute of Electrical and Electronics Engineers, 2008, 6 pp.
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13. Jani Kleindienst, Đani Juričič, "Optimal selection of information terminals for data acquisition in manufacturing processes", In: *EUROSIM 2007: proceedings of the 6th EUROSIM Congress on Modelling and Simulation, 9-13 September 2007, Ljubljana, Slovenia. Vol. 2, Full papers*, 6th EUROSIM Congress on Modelling and Simulation, Ljubljana, Slovenia, 9-13 September, 2007, Borut Zupančič, ed., Rihard Karba, ed., Sašo Blažič, ed., Vienna, ARGESIM, cop. 2007, 6 pp.
14. Tomaž Lukman, Marjan Mernik, "Model-driven engineering and its introduction with metamodeling tools", In: *Proceedings of the 9th International PhD Workshop on Systems and Control, October 1-3, 2008, Izola, Simonov zaliv, Slovenia: young generation viewpoint*, Matej Gašperin, ed., Boštjan Pregelj, ed., Ljubljana, Institut Jožef Stefan, 2008, 6 pp.
15. Teodora Miteva, Rodrigo Alvarez, Nadja Hvala, Dolores Kukanja, "Modeling of polyvinyl acetate polymerization processes for control purposes", In: *18th European Symposium on Computer Aided Process Engineering, June 1-4, 2008, Lyon, France: selected papers*, (Computer-aided chemical engineering, 25), Bertrand Braunschweig, ed., Xavier Joula, ed., Amsterdam [etc.], Elsevier Science, 2008, 6 pp.
16. Teodora Miteva, Nadja Hvala, "Optimization and control of a semi-batch polymerization reactor", In: *Proceedings of the 9th International PhD Workshop on Systems and Control, October 1-3, 2008, Izola, Simonov*

REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Andrew Crossan, Roderick Murray-Smith, Stephen Brewster, Bojan Musizza, "Instrumented usability analysis for mobile devices", In: *Handbook of research on user interface design and evaluation for mobile technology*, Joanna Lumsden, ed., Hershey, New York, Information Science Reference, cop. 2008, pp. 927-944.
2. Jani Kleindienst, Đani Juričič, "Optimum selection of information terminals for production monitoring in manufacturing industries", *Stroj. vestn.*, vol. 54, no. 1, pp. 49-55, 2008.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Juš Kocijan, "Gaussian process models for systems identification", In: *Proceedings of the 9th International PhD Workshop on Systems and Control, October 1-3, 2008, Izola, Simonov zaliv, Slovenia: young generation viewpoint*, Matej Gašperin, ed., Boštjan Pregelj, ed., Ljubljana, Institut Jožef Stefan, 2008, 8 pp.

Regular papers

1. Uroš Benko, Janko Petrovčič, Bojan Musizza, Đani Juričič, "A system for automated final quality assessment in the manufacturing of vacuum cleaner motors", In: *Preprints of the 17th IFAC World Congress: Seoul, Korea, July 6-11, 2008*, 17th IFAC World Congress, Seoul, Korea, July 6-11, 2008, Myung Jin Chung, ed., Pradeep Misra, ed., Hyungbo Shim, ed., [Seoul], International Federation of Automatic Control, cop. 2008, pp. 7399.
2. Pavle Boškoski, Đani Juričič, Anton Urevc, Jože Vižintin, "Early gear pitting detection using multiple signal sources", In: *SLOTTRIB '08: zbornik predavanj Posvetovanja o tehnični diagnostiki, mazivih in alternativnih gorivih, Ljubljana, Slovenija, 18. november 2008*, Jože Vižintin, ed., Boris Kržan, ed., Bojan Podgornik, ed., Ljubljana, Slovensko društvo za tribologijo, = Slovenian Society of Tribology, 2008, pp. 67-78.
3. Gregor Dolanc, Stanko Strmčnik, "Design of a nonlinear controller based on a piecewise-linear Hammestein model", In: *Proceedings of 9th IEEE International Symposium on Computer-Aided Control System Design (CACSD), 17th IEEE International Conference on Control Applications (CCS), 23rd IEEE International Symposium on Intelligent*

- zaliv, Slovenia: young generation viewpoint, Matej Gašperin, ed., Boštjan Pregelj, ed., Ljubljana, Institut Jožef Stefan, 2008, 6 pp.
17. Teodora Miteva, Nadja Hvala, Rodrigo Alvarez, Dolores Kukanja, "Model-based optimization of a semi-batch industrial polymerization process", In: *Proceedings of the 10th International chemical and biological engineering conference: Braga, Portugal, 4-6 September 2008: ChemPor 2008*, Eugenio C. Ferreiro, ed., Manuel M. Mota, ed., [S.l., s.n.], 2008, 6 pp.
 18. P.B. de Moura Oliveira, José Boaventura Cunha, E. J. Solteiro Pires, Damir Vrančič, "Maximin multi-objective particle swarm optimization design of PID controllers", In: *Proceedings of the 9th International PhD Workshop on Systems and Control, October 1-3, 2008, Izola, Simonov zaliv, Slovenia: young generation viewpoint*, Matej Gašperin, ed., Boštjan Pregelj, ed., Ljubljana, Institut Jožef Stefan, 2008, 6 pp.
 19. Jernej Mrovlje, Damir Vrančič, "Distance measuring based on stereoscopic pictures", In: *Proceedings of the 9th International PhD Workshop on Systems and Control, October 1-3, 2008, Izola, Simonov zaliv, Slovenia: young generation viewpoint*, Matej Gašperin, ed., Boštjan Pregelj, ed., Ljubljana, Institut Jožef Stefan, 2008, 6 pp.
 20. Peter Nemček, Mitja Bizjak, Zoran Marinšek, Bogdan Filipič, Matjaž Gams, Tomaž Šef, Igor Podbelšek, Matjaž Glavič, Igor Volf, Rado Kunavar, Jože Kopač, Štefan Sabol, "Razvoj e-storitev za optimiranje pretokov električne energije v distribucijskem omrežju s prilaganjem odjema in razpršene proizvodnje", In: *Zbornik sedemnajste mednarodne Elektrotehniške in računalniške konference ERK 2008, 29. september - 1. oktober 2008, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ...), Bldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2008, zv. A, pp. 287-290.
 21. Alejandra Perez-Bonilla, Karina Gibert, Darko Vrečko, "Automatic generation of conceptual descriptions of classifications in environmental domains", In: *Integrating sciences and information technology for environmental assessment and decision making: proceedings of the iEMs 2008: international Congress on Environmental Modelling and Software, incorporating the 4th Biennial Meeting of IEMs, July 7-10, 2008, Barcelona, Catalonia*, Miquel Sánchez-Marré, ed., [S. l.], International Environmental Modelling and Software Society, 2008, pp. 1791-1798.
 22. Boštjan Pregelj, Samo Gerškšič, "Implementation of tracking multiparametric predictive controller", In: *Proceedings of the 9th International PhD Workshop on Systems and Control, October 1-3, 2008, Izola, Simonov zaliv, Slovenia: young generation viewpoint*, Matej Gašperin, ed., Boštjan Pregelj, ed., Ljubljana, Institut Jožef Stefan, 2008, 6 pp.
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 24. Aljaž Stare, Nadja Hvala, Darko Vrečko, Stanko Strmčnik, "Evaluation of different nitrogen control strategies for a combined pre- and post-denitrification plant", In: *Preprints of the 17th IFAC World Congress: Seoul, Korea, July 6-11, 2008*, 17th IFAC World Congress, Seoul, Korea, July 6-11, 2008, Myung Jin Chung, ed., Pradeep Misra, ed., Hyungbo Shim, ed., [Seoul], International Federation of Automatic Control, cop. 2008, pp. 13599-13604.
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 29. Damir Vrančič, Raymond Gorez, Stanko Strmčnik, "Equalisation tuning method", In: *Proceedings, UKACC 2008, International Conference on Control, September 2-4, 2008, Manchester, UK, Manchester, The University of Manchester, 2008*, 6 pp.
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TEXTBOOKS AND LECTURE NOTES

1. Borut Zupančič, Vladimir Jovan, Tomaž Dogša, Denis Trček, Andrej Rakar, Mitja Bizjak, Boštjan Hauptman, Saša Sokolič, Matjaž Ostroveršnik, Igor Steiner, Gašper Mušič, Gregor Dolanc, Jure Lukač, Giovanni Godena, *Programska oprema za vodenje procesov: študijsko gradivo za tečaj dopolnilnega izobraževanja in specializacije "Tehnologija vodenja industrijskih procesov": Ljubljana, 20. do 24. oktober 2008*, Ljubljana, Institut "Jožef Stefan", Fakulteta za elektrotehniko, 2008.

THESES

Ph. D. Thesis

1. Bojan Musizza, *Metode za analizo faznih interakcij in študij vzročnih povezav med možganskimi in kardio-respiratornimi oscilacijami : Ph. D. Thesis*, Ljubljana, [B. Musizza], 2008. [COBISS.SI-ID 6878292]

B. Sc. Thesis

1. Jernej Mrovlje, *Izvedba merilnika položaja na osnovi stereoskopskih posnetkov : B. Sc. Thesis*, Ljubljana, [J. Mrovlje], 2008. [COBISS.SI-ID 6690900]

LABORATORY FOR OPEN SYSTEMS AND NETWORKS

E-5

The main activities of the Laboratory for Open Systems and Networks are the R&D of next-generation networks, telecommunications technologies, components and integrated systems and information-society services and applications, especially those which ensure an efficient and pervasive life-long learning concept.

In 2008 the research group implemented the research program “Technology, services and business in next generation networks”. Research was also carried out in the EU 7FP projects P2P-Next, Eiffel and GLOBAL, the EU 6FP projects iCamp and SERENITY, the eContentPlus iCoper project, the Merlab and e⁴VET projects from the Leonardo da Vinci programme, the MAUSE project from the COST programme, and in a few national projects. The main fields of work were technology-enhanced learning, security and privacy in information systems, and technologies and services in advanced next-generation networks. Members of the laboratory are also teaching at the undergraduate and graduate levels at the University of Ljubljana, the University of Maribor, and the Jožef Stefan International Postgraduate School.

Concepts, architectures, technologies and services in the future internet

The group is a partner in the EU 7FP project “Evolving Future Internet for European Leadership” (**EIFFEL**) that aims at identifying and developing the major concepts and design architecture of the future internet. This area of research is being carried out within the “think tank” group of European and world-wide scientists and experts. In the frame of this project, in 2008 we organized a very successful conference called The Future of the Internet, which gathered everyone in Europe working in this field. At the conference The Bled Declaration on European research strategy and an approach to the Future Internet was adopted, which is vital for the future European economy. The Future Internet Forum was also formed.

R&D of an open-source, efficient, trusted, personalized, user-centric and participatory television and media delivery system with social and collaborative connotations using the emerging peer-to-peer (P2P) paradigm is part of the “Next Generation Peer-to-Peer Content Delivery Platform” (**P2P-Next**) project. The research takes into account the existing EU legal framework and is oriented towards the development of a next-generation P2P content-delivery platform by taking into account the heterogeneous and demanding environments and the demands for the low-cost delivery of professional and user-created content.

An important project in the field of research e-infrastructures is the “Global Linkage Over Broadband Links” (**GLOBAL**) project. This project will provide a virtual conference centre using advanced communication technologies and concepts to support the promotion of e-infrastructure topics in Europe and around the world. With the ISABEL videoconference tool we connected the infrastructures in South America, India and Africa and transferred knowledge and the research results of European researchers and projects.

Technology-enhanced learning

In the EU 6FP project “Innovative, inclusive, interactive & intercultural learning campus” (**iCamp**) we have created an infrastructure – the iCamp Space – for collaboration and social networking across systems, countries and disciplines. The iCamp Space builds on existing interfaces and integrates shared community features. The large number of repositories raises the problem of finding and selecting the right learning resources for particular learning goals and required competencies. As a solution to this problem we have created a framework for personalized access to educational networks that enables a learner to find the optimal resources on the basis of his or her learner personal profile and resources metadata. The results were presented in a special issue of the ACM Transactions on Internet Technology. Competencies are also the main research theme of the “Interoperable Content for Performance in a Competency-driven Society” (**iCoper**) project. In this project we evaluate technology-enhanced learning standards and describe good practices in learning needs and learning opportunities identification and description, instructional modeling, content development, content



Head:

Prof. Borka Jerman Blažič



Figure 1: Organization of the conference The Future of the Internet

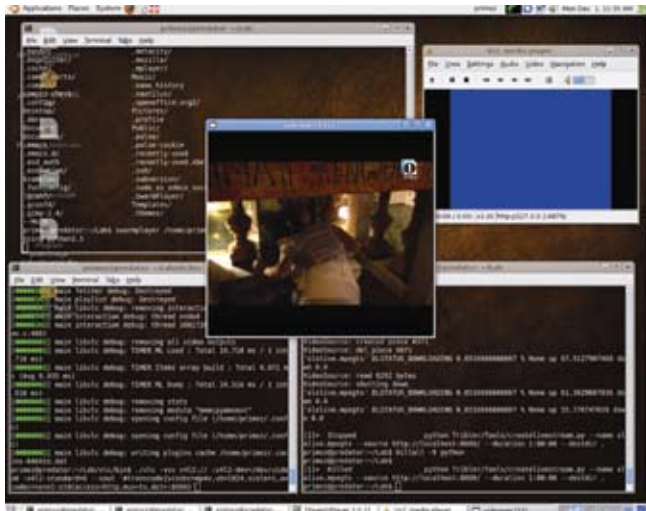


Figure 2: P2P content-delivery platform

delivery, and learner assessment and content evaluation. The main research goal is to create a reference model that will integrate existing and new or improved standards, and describe competency-based learning scenarios in an interoperable way.

The main goal of the project “Towards the Maturation of IT Usability Evaluation” (**MAUSE**) is to bring more science to bear on Usability Evaluation Methods (UEM) development, evaluation, and comparison, aiming for results that can be transferred to industry and educators, thus leading to an increased competitiveness of European industry and benefits to the public.

The “Innovative Remote Laboratory and the E-training of Mechatronics” (**MeRLab**) project, founded by the Leonardo da Vinci Programme – Transfer of Innovation, tries to introduce best practices in the field of vocational training of mechatronics, and further support them with state-of-the-art information-communication technology, as well as with established methodological and didactical approaches. The goal is to improve the quality and efficiency of vocational training; this should result in a greater recognition and attractiveness of the profession and will have a positive influence on the reduction of disparities between the supply and demand of qualified mechatronic staff in the market. A concrete aim of the project is

to prepare an e-course in mechatronics, which will be in our area represented in a completely new way of vocational training of this profile, because both the theoretical and practical training will be entirely conducted online. Practical work will be done through an innovative virtual laboratory for practical work, based on web technology that allows the performance of real mechanical-electrical and programming-related experiments in the physical laboratory, which is crucial in the training of mechatronics.

An important part of the laboratory's scientific research work is an empirical study that links the fields of technology-enhanced learning, organizational learning, and financial and non-financial business performance. The study focuses on the conceptualization of a research model (structural and measurement) that has been developed to test the impact of technology-enhanced organizational learning on the business performance of companies with more than 50 employees. In accordance with stakeholder theory and a balanced scorecard, both financial and non-financial aspects of the performance are considered. In the research, special attention is given to the presentation of the definitions of the four main constructs of the research model: technology-enhanced learning, organizational learning, financial and non-financial business performance, and their operationalization. The results of the study indicate the strong impact of ICT and technology-enhanced learning on organizational learning and non-financial business performance.

The purpose of the **iDotik** project was to develop a prototype of interactive awareness and information e-service in public places with the assistance of artificial-intelligence technologies. The key effect and, at the same time, the biggest project innovation was the development of a web-based application “**Scenarist**”, which allows, on the one hand, simplification of the process of building e-content, streamlining costs and raising quality, and, on the other hand, shortening the length of time of the whole process of the development of e-content. The integration of intelligent technologies allows the implementation of “**Pametnega skladišča e-vsebin**” (Intelligent e-content repository), which forwards e-content on a multimedia touch screen, depending on the user profile, which is determined with the presence of sensors on the screen. This represents the enormous impact of information on the user, because the e-content storage forwards the e-content, which is, according to his or her profile, the most appropriate. The loss of information in this mode of information transmission is much less than with a conventional mode.



Figure 3: Knowledge transfer by means of a videoconference system

Security, dependability and privacy in information systems

Information security, dependability and privacy are some of the most important research fields of the laboratory. Besides the research of privacy aspects in the field of technology-enhanced learning we addressed security in the EU 6FP Integrated Project “System Engineering for Security & Dependability” (**SERENITY**) and in the **VIZIPIN** project financed by TIA. The main properties of modern heterogeneous communication systems, like pervasive systems, systems with ambient intelligence or the Internet of Things, are ubiquitous and complex interconnections of services and devices, the dynamic nature and adaptability of the systems and services’ awareness of the user's context. Privacy, security and dependability issues of

such systems are being investigated in the SERENITY project. Here, research is focused on issues such as interoperability and the development of standardized security patterns for embedding in network services and applications. The results have been accepted for publication in a book that is being published by Springer. In SERENITY we have also addressed the standardization issues of dynamic security solutions and proposed some potential for standardization. Dynamic security management and control was the core of our work in the VIZIPIN project, where we have adapted the research challenges of the field to potential modern military needs.

In 2008 we continued with our research on security economics, where we analyse the assessment of the appropriate investment that is economically affordable and provides enough protection for enterprise information systems. The results, i.e., an approach for the quantification of the necessary investment and a recommendation for a standard approach to security-information investment assessment, have been published in two scientific journals with an SCI impact factor, one of them in the first half of the journals in the field of informatics and management.

Monitoring and promoting the development of telecommunications

Our original research contribution in this area of research is a techno-economic model that provides a tool for designing and applying an appropriate measure for fostering broadband communications and related e-services. The results were published in three journal papers with SCI or SSCI impact factors. The created knowledge was also used in the design of a wireless broadband network for the city of Ljubljana.



Figure 4: President of Republic of Slovenia at the MeRLab project stand.

Some outstanding publications in the past three years

1. Peter Trkman, Borka Jerman-Blažič, Tomaž Turk. Factors of broadband development and the design of a strategic policy framework. *Telecommun. policy*. [Print ed.], 2008, vol. 32, no. 2, pp. 101-115.
2. Effie Lai-Chong Law, Borka Jerman-Blažič, Matija Pipan. Analysis of user rationality and system learnability: performing task variants in user tests. *Behav. inf. technol.* [Print ed.], 2007, vol. 26, no. 5, pp. 421-436.
3. Borka Jerman-Blažič, Effie Lai-Chong Law, Tanja Arh. An assessment of the usability of internet based education system in a cross-cultural environment: the case of interreg crossborder program in Central Europe. *Journal of the American Society for Information Science and Technology*. [Print ed.], 2007, vol. 58, no. 1, pp. 66-75.

Organization of conferences, congress and meetings

1. Organization of workshop, COST294-MAUSE, Bled, Slovenia, 3-4 Mar. 2008
2. Organization of conference The Future of the Internet, Bled, Slovenia, 31 Mar. to 2 Apr. 2008
3. Organization of PROLEARN Summer School, Ohrid, Macedonia, 13-21 Jun. 2008

INTERNATIONAL PROJECTS

1. Next Generation Peer-to-Peer Content Delivery Platform
P2P-Next
7. FP, 216217
EC; Jari Ahola, VTT - Valtion Teknillinen Tutkimuskeskus, Espoo, Finland
Dr. Dušan Gabrijelčič
2. Global Linkage Over Broadband Links
GLOBAL
7. FP, 223120
EC; Zentrum für Soziale Innovation, Vienna, Austria
Prof. Borka Jerman Blažič
3. Evolved Internet Future for European Leadership
EIFFEL
7. FP, 216068
EC; Rheinisch-Westfälische Technische Hochschule Aachen (RWTH - Aachen), Lehrstuhl für Mobilfunknetze, Aachen, Germany
Prof. Borka Jerman Blažič
4. Innovative, Inclusive, Interactive & Intercultural Learning Campus
iCAMP
6. FP, 027168
EC; Claudia Magdalena Fabian, Zentrum für Soziale Innovation, Vienna, Austria
Prof. Borka Jerman Blažič, Asst. Prof. Tomaž Klobučar
5. Towards the Maturation of IT Usability Evaluation - MAUSE
COST 294
EC
Prof. Borka Jerman Blažič
6. Enhancing, Empowering and Emphasizing E-learning in Vocational Education and Training
e4 VET Community Portal
Leonardo da Vinci Programme
2008-5772-LdV-TOI, LLP-LDV-TOI-2008-SI-2
Tanja Arh, M. Sc.
7. Innovative Remote Laboratory in the E-training of Mechatronics
MeRLab
Leonardo da Vinci Programme
2007-5050-LdV-TOI
Julija Lapuh Bele, B2, d.o.o., Ljubljana, Slovenia
Matija Pipan, M. Sc.
8. Interoperable Content for Performance in a Competency-driven Society
ICOPER
eContentplus
ECP-2007-EDU-417007
EC; Dr. Bernd Simon, Wirtschaftsuniversität Wien, Institut für Wirtschaftsinformatik und Neue Medien, Vienna, Austria
Asst. Prof. Tomaž Klobučar
9. European Association for Technology-Enhanced Learning (EATEL) Summer School
2008
EATEL
EC; Nunzio Santoro, Délégue à la Valorisation, Direction de la Recherche, Telecom & Management SudParis, Evry, France
Asst. Prof. Tomaž Klobučar

R & D GRANTS AND CONTRACTS

1. Security, dependability and privacy in pervasive systems
Prof. Borka Jerman Blažič
2. Building blocks of educational networks
Asst.prof. Tomaž Klobučar
3. Technical and economical models of development of broadband communications and their use in rural areas in Slovenia
Prof. Borka Jerman Blažič
4. Technical and economical models of development of broadband communications and their use in rural areas in Slovenia
Prof. Borka Jerman Blažič
5. Knowledge centre for e-learning and convergent multimedia content
Tanja Arh, M. Sc.
6. iDotik - The development of an e-service prototype for interactive inquiring and informing in public places with innovative technology of artificial intelligence, e-content development and multimedia touch screens
Tanja Arh, M. Sc.

7. Developing integral e-learning model of the Slovene national educational system - Min.si
Tanja Arh, M. Sc.

RESEARCH PROGRAM

1. Technologies, services and business in the next generation networks
Prof. Borka Jerman Blažič

NEW CONTRACTS

1. Building blocks of educational networks
Nevron d. o. o., Ljubljana
Asst.prof. Tomaž Klobučar
2. Study: "Challenges of Future Internet"
Agenda d. o. o., Maribor
Prof. Borka Džonova Jerman Blažič

VISITORS FROM ABROAD

1. Martin Mihajlov, Ad Futura, Skopje, Macedonia, 1 Jan. 2008 to 30 Jun. 2008
2. Gabriela A. Tobias Cárdenas, IAESTE students interchange, Poza Rica, Mexico, 1 Jan. to 15 May 2008
3. Dr. Joao da Silvo, Director, Directorate Converged Networks and Services, 28 Mar. 2008
4. Risteovski Pece, Director, Bureau for Metrology Macedonia and representatives of Iskraemeco, 3 Dec. 2008

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7. Aleksej Jerman-Blažič*, M. Sc.
8. Tomaž Klančnik, B. Sc.
9. Matija Pipan, M. Sc.

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10. Tatjana Martun

Note:

* part-time JSI member

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ORIGINAL ARTICLES

1. Tanja Arh, Borka Jerman-Blažič, "A case study of usability testing - the SUMI evaluation approach of the EducaNext Portal", *WSEAS transactions on information science and applications*, vol. 5, no. 2, pp. 175-181, 2008.
2. Tanja Arh, Rok Kokalj, Dejan Dinevski, Borka Jerman-Blažič, "Pregled stanja na področju e-izobraževanja v Sloveniji", *Organizacija (Kranj)*, vol. 41, no. 3, pp. A155-A167, 2008.
3. Rok Bojanc, Borka Jerman-Blažič, "An economic modelling approach to information security risk management", *Int. j. inf. manage.*, vol. 28, no. 5, pp. 413-422, 2008.
4. Rok Bojanc, Borka Jerman-Blažič, "Towards a standard approach for quantifying an ICT security investment", *Comput. stand. interfaces*, vol. 30, no. 4, pp. 216-222, 2008.
5. Peter Dolog, Bernd Simon, Wolfgang Nejdil, Tomaž Klobučar, "Personalizing access to learning networks", *ACM trans. Internet technol.*, vol. 8, no. 2, pp. 8-1-8-21, 2008.
6. Helena Halas, Jan Porekar, Tomaž Klobučar, Aleksej Jerman-Blažič, "Organizational aspect of trusted legally valid long-term electronic archive solution", *WSEAS transactions on information science and applications*, vol. 5, no. 6, pp. 939-948, 2008.
7. Andrej Jerman Blažič, Borka Jerman-Blažič, Tanja Arh, "Odločitveni model za izbiro spletnega gostovanja - primer uporabe na slovenskem trgu", *Uporab. inform. (Ljublj.)*, vol. 16, no. 1, pp. 69-77, jan./feb./mar. 2008.
8. Borka Jerman-Blažič, "The development of research and innovation policies based on a benchmarking assessment: the case of mobile communications technology R&D in the new member states of the EU", *Technol. anal. strateg. manag.*, vol. 20, no. 2, pp. 201-216, 2008.
9. Borka Jerman-Blažič, "Techno-economic analysis and empirical study of network broadband investment: the case of backbone upgrading", *Information systems frontiers*, vol. 10, no. 1, pp. 103-110, 2008.
10. Borka Jerman-Blažič, "Web-hosting market development status and its value as an indicator of a country's e-readiness", *Telecommun. policy*, vol. 32, no. 6, pp. 422-435, 2008.
11. Tomaž Klobučar, "iCamp Space - an environment for self-directed learning, collaboration and social networking", *WSEAS transactions on information science and applications*, vol. 5, no. 10, pp. 1470-1479, 2008.
12. Matija Pipan, Tanja Arh, Borka Jerman-Blažič, "Evaluation cycle management - model for selection of the most applicable learning management system", *WSEAS transactions on advances in engineering education*, vol. 5, no. 3, pp. 129-136, 2008.
13. Matija Pipan, Borka Jerman-Blažič, "New innovative e-way of vocational training in the field of mechatronics", *WSEAS transactions on advances in engineering education*, vol. 5, no. 11, pp. 719-727, 2008.
14. Peter Trkman, Borka Jerman-Blažič, Tomaž Turk, "Factors of broadband development and the design of a strategic policy framework", *Telecommun. policy*, vol. 32, no. 2, pp. 101-115, 2008.
15. Tomaž Turk, Borka Jerman-Blažič, Peter Trkman, "Factors and sustainable strategies fostering the adoption of broadband communications in an enlarged European Union", *Technol. forecast. soc. change*, vol. 75, no. 7, pp. 933-951, 2008.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Tanja Arh, Vlado Dimovski, Borka Jerman-Blažič, "Model of impact of technology-enhanced organizational learning on business performance", In: *Collaboration and the knowledge economy: issues*,

- applications, case studies, (Information and communication technologies and the knowledge economy, vol. 5), Paul Cunningham, ed., Miriam Cunningham, ed., Amsterdam ... [etc.], IOS Press, 2008, zv. 2, pp. 1521-1528.
2. Matija Pipan, Borka Jerman-Blažič, "Enhanced E-training in the field of mechatronics: the Slovenian case study", In: *Collaboration and the knowledge economy: issues, applications, case studies*, (Information and communication technologies and the knowledge economy, vol. 5), Paul Cunningham, ed., Miriam Cunningham, ed., Amsterdam ... [etc.], IOS Press, 2008, zv. 2, pp. 1543-1548.
 3. Anna Danielewska-Tulecka, Robert Koblics, Tomaž Klobučar, "Searching the net", In: *How to use social software in higher education: A handbook from the iCamp project*, ed. Karolina Grodecka, Fridolin Wild, Barbara Kieslinger, 2008, pp. 92-101
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 5. Andrej Jerman Blažič, "Umetna inteligenca in igralni bot-i v računalniških igrovih tipa "prvoosebna streljanka"", In: *Zbornik 11. mednarodne multikonference Informacijska družba - IS 2008, 13.-17. oktober 2008: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 45-48.
 6. Tomaž Klančnik, "Privacy protection in new generation peer-to-peer applications", In: *The future of identity in the information society, challenges for privacy and security: FIDIS/IFIP internet security & privacy summer school, Masaryk University, Brno Czech Rep., 1-7 September 2008: pre-proceedings*, [S. l., s. n.], 2008, pp. 147-151.
 7. Tomaž Klobučar, "Learning environment for self-directed learning, collaboration and social networking", In: *Distance learning, multimedia and video technologies, proceedings of the 8th WSEAS International Conference on Multimedia, Internet and Video Technologies (MIV '08): proceedings of the 8th WSEAS International Conference on Distance Learning and Web Engineering (DIWEB '08), Santander, Cantabria, Spain, September 23-25, 2008*, (Recent advances in computer engineering), José Ma Zamanillo Sáinz de la Maza, ed., [S. l.], World Scientific and Engineering Academy and Society, 2008, pp. 91-96.
 8. Matija Pipan, Tanja Arh, Borka Jerman-Blažič, "Innovative remote laboratory in the enhanced E-training of mechatronics", In: *Circuits, systems, electronics, control and signal processing: proceedings of the 7th WSEAS International Conference on Circuits, Systems, Electronics, Control and Signal Processing (CSECS'08), Puerto De La Cruz, Tenerife, Canary Islands, Spain, December 15-17, 2008*, (Electrical and computer engineering series, A Series of reference books and textbooks), Stamatios V. Kartalopoulos, ed., [S. l.], WSEAS Press, cop. 2008, pp. 93-97.
 9. Matija Pipan, Tomaž Klobučar, Tanja Arh, "Virtual learning space iCamp", In: *Znanje za trajnostni razvoj: zbornik 27. mednarodne znanstvene konference o razvoju organizacijskih znanosti, Slovenija, Portorož, 19.-21. marec 2008: proceedings of the 27th International Conference on Organizational Science Development, Slovenia, Portorož, March, 19th-21th, 2008*, 27. mednarodna znanstvena konferenca o razvoju organizacijskih znanosti, Slovenija, Portorož, 19.-21. marec 2008, Vladislav Rajkovič, ed., Eva Jereb, ed., Tomaž Kern, ed., Miroljub Kljajič, ed., Milan Pagon, ed., Goran Vukovič, ed., Kranj, Moderna organizacija, 2008, pp. 113-120.

PUBLISHED CONFERENCE PAPERS

Regular papers

1. Tanja Arh, Vlado Dimovski, Borka Jerman-Blažič, "Model vpliva tehnološko podprtega organizacijskega učenja na uspešnost poslovanja podjetij", In: *Znanje za trajnostni razvoj: zbornik 27. mednarodne znanstvene konference o razvoju organizacijskih znanosti, Slovenija, Portorož, 19.-21. marec 2008: proceedings of the 27th International Conference on Organizational Science Development, Slovenia, Portorož, March, 19th-21th, 2008*, 27. mednarodna znanstvena konferenca o razvoju organizacijskih znanosti, Slovenija, Portorož, 19.-21. marec 2008, Vladislav Rajkovič, ed., Eva Jereb, ed., Tomaž Kern, ed., Miroljub Kljajič, ed., Milan Pagon, ed., Goran Vukovič, ed., Kranj, Moderna organizacija, 2008, pp. 113-120.
2. Rok Bojanc, Borka Jerman-Blažič, "Standard approach for quantification of the ICT security investment for cybercrime prevention", In: *The Second International Conference on the Digital Society, ICDS 2008: February 10-15, 2008, Sainte Luce, Martinique*, Lasse Berntzen, ed., Asa Smedberg, ed., Piscataway, Institute of Electrical and Electronics Engineers, 2008, pp. 7-14.
3. Helena Halas, Jan Porekar, Tomaž Klobučar, Aleksej Jerman-Blažič, "Towards secure legally valid long-term electronic archive using pattern approach", In: *Advances on applied computer and applied computational science: proceedings of the 7th WSEAS International Conference on Applied Computer & Applied Computational Science (ACACOS '08), Hangzhou, China, April 6-8, 2008*, (Electrical and computer engineering series), Qing Li, ed., [S. l.], WSEAS Press, 2008, pp. 793-798.
4. Aleksej Jerman-Blažič, "Elektronsko varnostno označevanje - rokovanje z zaupnimi dokumenti v e-arhivih", In: *DOK SIS 2008*, 17. posvetovanje Sistemi za upravljanje z dokumenti, Kranjska gora, 24. - 26. september 2008, Milan Selan, ed., Stanko Čufer, ed., Marko Hartman, ed., Samo Maček, ed., Marko Jurečič, ed., Ljubljana, Media.doc

DEPARTMENT OF COMMUNICATION SYSTEMS

E-6

The Department of Communication Systems is concerned mainly with the research, development and design of next-generation telecommunications networks, wireless networks and new algorithms for parallel and distributed computing in computer simulations. Other research activities include the development of methods and software tools for the modelling, simulation, analysis and synthesis of communication systems, security services in communication networks, the development of sensor networks, advanced bio-signal processing, the education of young researchers, and the transfer of knowledge and new technologies to industry.

R&D activities at the department are carried out in two groups, one specialising in *telecommunications systems* and the other in *parallel and distributed systems*. With the convergence of telecommunications and information systems, the work in both groups is becoming increasingly interconnected, bringing about synergy effects, particularly in applied projects.

Telecommunications Systems

Most of our research activities in 2008 related to telecommunications systems were concentrated with wireless sensor networks and with advanced terrestrial, stratospheric and satellite access networks, enabling the end-user to access new services and applications and new multimedia content. We also initiated research activities in the area of cognitive networks. The research emphasis was in the areas of: radio transmission; multiple input multiple output (MIMO) systems based on multiple antennas; access architectures for heterogeneous wireless networks; the management of radio and network resources; and mobile, personal and emergency communications. We continued the work on cross-layer design and the optimisation of communication protocols in wireless communication systems, in order to improve the utilization efficiency of scarce radio resources and to support the provision of quality of service. We have been developing advanced and innovative concepts and technologies enabling interworking, the convergence of networks and the mobility of terminals and networks, with a special emphasis on solutions providing network robustness, security and quality of service.

We studied the radio interface and signal propagation in the radio channel, taking into account terrain configuration. The main emphasis was on the development and implementation of adaptive modulation and coding schemes, synchronization and equalization techniques, and methods to predict the status and assess the quality of the radio channel. Particular attention was given to the modulation and coding schemes specified in the DVB-S2 communication standard, which were extensively investigated in the satellite and stratospheric fixed and mobile radio channels. We developed a methodology for the optimal sub-selection of transmission modes in a satellite communication system with adaptive coding and modulation and proposed enhanced decoder-assisted switching between different modulation and coding schemes. We were also investigating transmission techniques that make use of space diversity during the transmission and reception and are providing an increase in the system capacity and/or link reliability without any additional bandwidth and transmission-power requirements. In particular, we implemented the virtual MIMO (V-MIMO) method in a system made up of a constellation of stratospheric platforms for the provision of broadband wireless access to the passengers onboard fast trains. We showed that the utilisation of the V-MIMO method notably improves the link availability as well as the spectral efficiency compared to a simple selection diversity method, making use of the best received signal only.



Head:
Prof. Gorazd Kandus

- We developed a methodology for the optimal subselection of transmission modes in a DVB-S2/RCS-based satellite-communication system and proposed an enhanced LDPC-decoder-assisted switching between different modulation and coding schemes.
- We proposed the advanced access architecture SmartA for an efficient service delivery in heterogeneous wireless networks based on the general concept of cognitive networks.



Figure 1: Mobile integrated device for the measurement, recording, presentation and analysis of a signal level in mobile radio systems for emergency communications ZARE, ZARE+, DMR and TETRA

- **For the implementation of seamless vertical handover in heterogeneous wireless networks we proposed an adaptation of the existing SIP communication protocol by the inclusion of additional messages that enable collision detection in the target network.**
- **We developed and implemented a mobile integrated device for the measurement, recording, presentation and analysis of the signal level in different mobile-radio systems for emergency communications.**

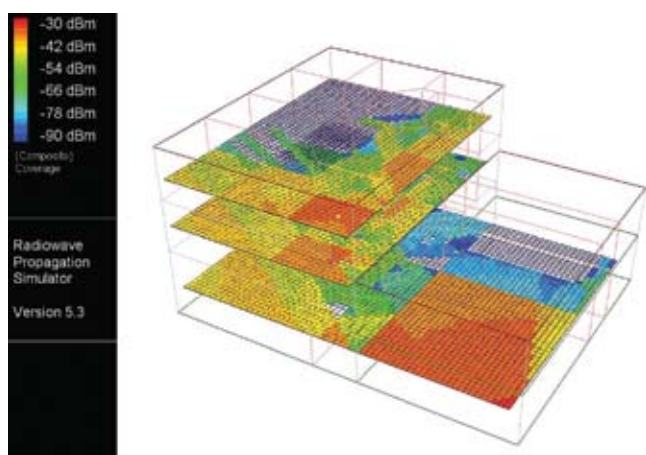


Figure 2: Simulation of TETRA radio signal coverage in building N at the JSI

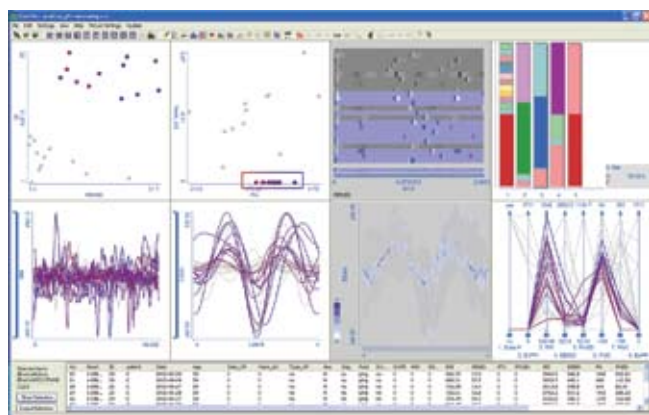


Figure 3: Interactive visual analysis of blood pressure, breathing frequency and ECG measurements by patients with a transplanted heart.

We co-edited the book *Parallel Computing: Numerics, Applications, and Trends*, which will be published in May 2009 by Springer, and contributed two chapters. We have published three papers in journals from the top-25% category.

We initiated research work on cognitive networks that will make use of new approaches in the telecommunications area, such as the cross-layer design and optimisation of communication protocols, and technologies for machine learning and decision making from the area of artificial intelligence. The initial research activities are following two directions. We started the investigation of machine-learning methods suitable for the recognition of the current state and the short-term prediction of the future state of a mobile radio channel, which could be used for decision support in the selection of the most suitable fade-mitigation technique, depending on the cause, duration and depth of the signal fade. As such, these methods are expected to notably improve the link availability. The other direction is concerned with the development of the advanced access architecture SmartA for an efficient service delivery in heterogeneous wireless networks based on the general concept of cognitive networks. For this architecture we investigated the multi-objective optimization problem of the optimal mapping of application requirements to a wireless interface, while minimizing the monetary costs and maximizing satisfaction with respect to QoS metrics.

On the network layer we continued our investigation of fixed–mobile convergence and hierarchical mobility. The emphasis in fixed–mobile convergence was on mobility management in convergent networks, in particular on the seamless vertical handover between networks based on different access technologies. We were focusing on the minimisation of the handover-execution time and the provision of the requested quality-of-service level in the target network. We proposed an adaptation of the existing SIP communication protocol by the inclusion of additional messages that make possible collision detection in the target network. For a more detailed performance evaluation and analysis of the proposed procedures and protocols for seamless handover we developed a simulation model of the communication system composed of WLAN and HSDPA networks using the discrete-event simulation tool OPNET modeller. In addition, we included in the simulation model measurement data from a real network in order to provide as realistic a simulation as possible. With such input parameters we verified and evaluated the proposed procedures for a seamless handover. We also continued the investigation of the optimisation procedures for hierarchical mobility management. We improved the previously built simulation model for the evaluation of the algorithms for the selection of mobility anchor points, so as to allow the evaluation of those algorithms also in realistic internet network models. Particular attention was given to the analysis of these algorithms in realistic synthetically designed networks using a previously developed model of business relationships between autonomous systems. Analytically and by simulations, we proved that the tree topologies intrinsically have an important limitation that is not present in realistic topologies. Using a method based on evolutionary algorithms we showed the relationship between the network topology characteristics and the possibility for the improvement of algorithms for the selection of mobility anchor points that are independent of the user parameters.

With our research work in the areas of stratospheric and satellite communication systems and wireless sensor networks we participated in the EU 6FP and 7FP projects “Satellite Communications Network of Excellence” (SatNEx) and “Wireless Sensor Networks and Remote Sensing - Foundation of a modern agricultural infrastructure in the region” (AgroSense). In 2008 we successfully concluded a multi-annual R&D of the pilot TETRA network for the Ministry of Defence. For the Administration for Civil Protection and Disaster Relief we developed and implemented a mobile, integrated device for the measurement, recording, presentation and analysis of the signal level in mobile radio systems for the emergency

communications ZARE, ZARE +, DMR and TETRA. We also established a collaboration with the Department of Low and Medium Energy Physics (F-2) in the field of communication architectures for data-acquisition systems needed in the detector systems for particle experiments. Joint research activities also took place in the field of digital signal processing, where numerically lightweight methods for a real-time pile-up correction using field-programmable arrays were investigated.

Parallel and Distributed Systems

Computer algorithms for an efficient and secure implementation on parallel and distributed computers were investigated. Software tools for cluster computing were tested on a 32-processor cluster computer, which runs at our department, and on a grid recently installed in cooperation with the Faculty of Computer and Information Science of the University of Ljubljana and a hi-tech company Xlab d.o.o. A computer simulation for medical applications was investigated and applied to several practical examples. We have developed new numerical methods which, unlike, e.g., the finite-element method, are based on meshless computing. We investigated the computational complexity of mesh-free methods and the possibilities for their parallelization. The work resulted in two papers in eminent journals: *Engineering Analysis with Boundary Elements* and *Computers and Structures*. Team members are also contributing to the book *Parallel Computing: Numerics, Applications, and Trends* (edited by Roman Trobec, Marian Vajteršič and Peter Zinterhof), which is to be published in May 2009 by Springer, in the Computer Communications and Networks (CCN) series.

We succeeded in joining the EU FP7 project consortium “Promote, mobilize, reinforce and integrate wireless sensor networking research and researchers: Towards pervasive networking of WBC and the EU” (ProSense). In this way we entered into a new research area, founded on the theory of parallel and distributed computing and communications.

In the field of medical research, the spatial model of a human knee with a resolution of 1 mm was finalized in cooperation with colleagues from the Ljubljana University Clinical Centre (UCC). We improved the simulation of the heat transfer in biological tissues, including the heat transfer in the surrounding fluids. In the model we also included the heat transfer over capillaries and the metabolic heat source. A parallel simulation program was finalized using advanced numerical methods (multigrid and meshless). Parallel programs for the simulation of human-knee cooling were developed and employed for comparing the results of various post-operative knee-cooling methods, which were selected by the UCC team members. A paper on the subject was published in the journal *Computers in Biology and Medicine* and a paper reporting results obtained with the improved methods is already in review.

It would be unethical to perform measurements on the human-heart muscle just to explain a specific phenomenon. With the help of a simulation, however, we were able to investigate the cause of the so-called U-wave, a feature of electrocardiograms (ECG), which has been waiting for an explanation since the beginnings of electrocardiography. We discovered a yet unknown possibility for the genesis of the wave and reported it in the *Journal of Cardiovascular Electrophysiology*. Together with colleagues from the Ljubljana UCC and the Maribor UCC, we analyzed the heart-beat dynamics of patients before and after a heart operation and obtained promising knowledge for the prediction of post-operative arrhythmias. A paper on this subject was published in the journal *Heart Surgery Forum* and two others are in review.

In the field of formal methods for discrete-systems modelling and development, we adapted our generic test-generation method for deterministic finite-state machines to support segment-based test synthesis. As its specialization, we then developed a method which generalizes a large family of established methods for checking the sequence construction and facilitates synthesis of cheaper tests also for distributed testing with no coordination between the testers.

We improved our simulation software based on mesh-free methods to the extent of facilitating the simulation of moving domains, such as a beating heart. Digitalized spatial models of the human knee and hand were finalised and prepared for template medical simulations. We simulated the action potentials in ECG and investigated how the shape, the structure, the motion and the tissue inhomogeneities represented in the adopted heart model influence the simulated ECG.

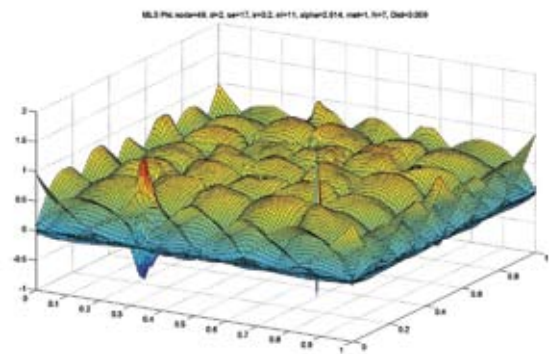


Figure 4: Non-polynomial shape functions of the mesh-less local Petrov-Galerkin method (MLPG) for the numerical solution of partial differential equations in computer simulations of moving domains

We developed a new, generic method for the segment-based synthesis of tests for deterministic finite-state machines and specialized it as a method for checking sequence construction, which facilitates the synthesis of cheaper tests also for distributed testing with no coordination between the testers.

Some outstanding publications in 2008

1. Andrej Vilhar, Roman Novak. Policy relationship annotations of predefined AS-level topologies. *Comput. networks*, vol. 52, no. 15, 2008, 2859-2871.
2. T. Aljaž, B. Imperl, A. Švigelj. Border gateway function performance requirements for the lawful intercept of voice at IMS architecture. *AEÜ, Int. J. Electron. Commun.*, vol. 62, no. 8, 2008, 610-621.
3. Srečo Plevel, Sašo Tomažič, Tomaž Javornik, Gorazd Kandus. MIMO : Wireless Communications. V: *Encyclopedia of wireless and mobile communications*. Borivoje Furht, ed., Boca Raton, New York, Taylor & Francis Group, Auerbach Publications, cop. 2008, vol. 1, 604-612.
4. Matjaž Depolli, Viktor Avbelj, Roman Trobec. Computer-simulated alternative modes of U-wave genesis. *J. Cardiovasc. Electrophysiol.* 19(1), 2008, 84-89.
5. Marjan Šterk, Roman Trobec. Meshless solution of a diffusion equation with parameter optimization and error analysis. *Eng. Anal. Bound. Elem.* 32(7), 2008, 567-577.

Organization of conferences, congress and meetings

1. SenZations'08 3rd Summer School on Applications of Wireless Sensor Networks and Wireless Sensing in the Future Internet, Ljubljana, Slovenia, 1-5 Sep. 2008
2. Project meeting 7FP AgroSense, Ljubljana, Slovenia, 2-5 Dec. 2008
3. Project meeting 7FP ProSense, Ljubljana, Slovenia, 18-21 Dec. 2008

INTERNATIONAL PROJECTS

1. Promote, Mobilize, Reinforce and Integrate Wireless Sensor Networking Research and Researchers: Towards Pervasive Networking of WBC and the EU
ProSense
7. FP, 205494
EC; Alex Gluhaw, LM Ericsson Ltd., Dublin, Ireland
Asst. Prof. Roman Trobec
2. Trans-national Cooperation among ICT NCPs
IDEALIST2011
7. FP, 231367
EC; Deutsches Zentrum für Luft- und Raumfahrt E. V. (DLR), Köln, Germany
Asst. Prof. Mihael Mohorčič
3. Wireless Sensor Networks and Remote Sensing - Foundation of a Modern Agricultural Infrastructure in the Region
AgroSense
7. FP, 204472
EC; University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia
Prof. Kandus Gorazd
4. Support for Participants in ICT Priority by Network for IST under the Transition to the 7th Framework Programme
Idealist7fp
6. FP, 045059
EC; Dr. Mohsine Chefki, Deutsches Zentrum für Luft- und Raumfahrt E. V. (DLR), Köln, Germany
Asst. Prof. Mihael Mohorčič
5. Satellite Communications Network of Excellence - Phase II
SatNEx- II
6. FP, 027393
EC; Dörthe Gottschalk, Deutsches Zentrum für Luft- und Raumfahrt E. V. (DLR), Köln; Weßling, Germany
Prof. Gorazd Kandus
6. Prevasive Mobile & Ambient Wireless Communications
COST 2100
EC; Prof. Roberto Verdone, DEIS- Università degli Studi di Bologna, Bologna, Italy
Dr. Tomaž Javornik
7. Quality of Service in Future Wireless Systems
COST 290
EC; Prof. Yevgeni Koucheryavy, Tampere University of Technology, Tampere, Finland
Prof. Gorazd Kandus
8. High Altitude Platforms for Communications and other Services
COST 297, HAPCOS
EC; Prof. Tim C. Tozer, University of York, York, Great Britain
Asst. Prof. Aleš Švigelj
9. A Telecommunications Economics COST Network - Econ @ Tel
COST IS0605
EC; Prof. Burkhard Stiller, Institut für Informatik - IFI, University of Zürich, Zürich, Switzerland
Prof. Denis Trček
10. Teledoctorate Project
UNESCO-ROSTE Grant
Silvano Pupolin, Università di Padova, Dipartimento di Ingegneria dell'Informazione, Padova; Dr. Paola Magri, Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Parma, Italy
Prof. Gorazd Kandus
11. Interactive Visual Analysis of BIO - signals
SEE ERA NET
ID 9909, 1000-07-380018
Asst. Prof. Roman Trobec
12. Third International Summer School on Applications of Wireless Sensor Networks and Wireless Sensing in the Future Internet, senzations'08
Asst. Prof. Roman Trobec
13. Advanced Technologies for Digital Forensics
Dr. Asmund Skomedal, Norwegian Computing Center, Oslo, Norway
Prof. Denis Trček

R&D GRANTS AND CONTRACTS

1. Lightweight Services for Security, Privacy and Trust Management
Asst. Prof. Roman Novak
2. Multiple antennas system for mobile WiMAX
Prof. Gorazd Kandus
3. Development of advanced digital mobile system TETRA for MOD
Prof. Gorazd Kandus
4. IT development and data gathering, maintenance and management strategy
Asst. Prof. Igor Ozimek
5. Computational Grid technologies for efficient usage of computer resources in companies
Asst. Prof. Roman Trobec

RESEARCH PROGRAMS

1. Telecommunication systems
Prof. Gorazd Kandus
2. Parallel and Distributed Systems
Asst. Prof. Roman Trobec

NEW CONTRACTS

1. Security Evaluation of Java Card Applets in Renewed ZZS Health Insurance Card System
The Health Insurance Institute of Slovenia, Ljubljana
Asst. Prof. Roman Novak
2. Multiple antennas system for mobile WiMAX
Telekom Slovenije, d. d., Ljubljana
Prof. Gorazd Kandus

3. Multiple antennas system for mobile WiMAX
Telsima d. o. o., Trzin
Prof. Gorazd Kandus
4. Uninterrupted provision of communication services in emergency situations
Telekom Slovenije, d. d., Ljubljana
Asst. Prof. Mihael Mohorčič
5. Hardware and software tool for signal level measurement of public protection and disaster relief wireless communication systems.
Administration of the Republic of Slovenia for Civil Protection and Disaster Relief, Ljubljana
Asst. Prof. Tomaž Javornik

VISITORS FROM ABROAD

1. Prof. Veljko Milutinović, Faculty of Electronic of Belgrad, Belgrade, Serbia, 10 Apr. 2008
2. Prof. Vejan Tosić, Faculty of Electronic of Belgrad, Belgrade, Serbia, 10 Apr. 2008
3. Klaus Jereb, Comfact, Dusseldorf, Germany, 20-24 May. 2008
4. Jozef Krahulac, University of Technology, Kosice, Slovakia, 20-30 May 2008
5. Prof. Erich Leitgeb, University of Technology, Graz, Austria, 3-29 Aug. 2008
6. Asst. Prof. Andrey Dolmatov, Finance Academy under the Government of the Russian Federation, Moscow, Russia, 27-28 Jul. 2008
7. Asst. Prof. Zorica Suvajdjin, University of Novi Sad, Novi Sad, Serbia, 25-4 Oct. 2008
8. Iosif Androulidakis B. Sc., Network Operations Center, University of Ioannina, Ioannina, Greece, 17 Oct. 2008
9. Prof. Dragana Bajić, University of Novi Sad, Novi Sad, Serbia, 17 Oct. 2008
10. EE Boris Antić M. Sc., University of Novi Sad, Novi Sad, Serbia, 17 Oct. 2008
11. Prof. Branko Marinković, Faculty of Agriculture Novi Sad, Novi Sad, Serbia, 21 Oct. 2008
12. Prof. Vladimir Crnojević, University of Novi Sad, Novi Sad, Serbia, 21 Oct. 2008
13. Prof. Jovan Crnobarac, Faculty of Agriculture Novi Sad, Novi Sad, Serbia, 21 Oct. 2008
14. Asst. Prof. Denis Stajniko, Faculty of Agriculture and Life Sciences, Maribor, Slovenia, 21 Oct. 2008
15. Kristjan Vrečko, Ministry of Agriculture, Forestry and Food, Ljubljana, Slovenia, 21 Oct. 2008
16. Tatjana Lončar-Turukalo, University of Novi Sad, Novi Sad, Serbia, 25 Nov. 2008
17. Prof. Dragana Bajić, University of Novi Sad, Novi Sad, Serbia, 25 Nov. 2008
18. Prof. Vladimir Crnojević, University of Novi Sad, Novi Sad, Serbia, 2-5 Dec. 2008
19. Borislav Brunet M. Sc., Ministry of Agriculture, Forestry and Food, Novi Sad, Serbia, 2-5 Dec. 2008
20. Vladan Minić, University of Novi Sad, Novi Sad, Serbia, 2-5 Dec. 2008
21. Prof. Liljana Gavrilovska, Faculty of Electrical Engineering and Information Technologies, Skopje, Makedonia, 18-21 Dec. 2008
22. Prof. Veljko M. Milutinović, School of Electrical Engineering, Belgrade, Serbia, 18-21. Dec. 2008

STAFF

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1. Dr. Viktor Avbelj
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4. Prof. Monika Kapus Kolar
5. Asst. Prof. Mihael Mohorčič
6. Asst. Prof. Roman Novak
7. Asst. Prof. Igor Ozimek
8. Asst. Prof. Aleš Švigelj
9. Asst. Prof. Roman Trobec
10. Prof. Matjaž Veselko*, left 1. 4. 2008

Postdoctoral associates

11. Dr. Srečo Plevel*
12. Dr. Marjan Šterk*

Postgraduates

13. Kemal Alič, M. Sc.

14. Tine Celcer, B. Sc.
15. Matjaž Depolli, B. Sc.
16. Carolina Fortuna
17. Andrej Hrovat, M. Sc.
18. Miha Smolnikar, B. Sc.
19. Andrej Vilhar, B. Sc.

Technical officers

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Technical and administrative staff

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Note:

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23. Ivan Tomašić, Karolj Skala, Roman Trobec, "Principal component analysis and visualization in optimization and personalization of lead's set for generation of standard 12-lead ECG", In: *MIPRO 2008: 31st International Convention on Information and Communication Technology, Electronics and Microelectronics, May 26-30, 2008, Opatija Croatia = [31. međunarodni skup MIPRO]: proceedings. [vol. 1], Microelectronics, electronics and electronic technologies, MEET, Grid and visualizayion systems, GVS*, Petar Biljanović, ed., Karolj Skala, ed., Rijeka, MIPRO, 2008, pp. 307-313.
24. Roman Trobec, Krešimir Matković, Karolj Skala, Silvia Samarin Lovrič, Matjaž Depolli, Viktor Avbelj, "Visual analysis of heart reinnervation after transplantation", In: *MIPRO 2008: 31st International Convention on Information and Communication Technology, Electronics and Microelectronics, May 26-30, 2008, Opatija Croatia = [31. međunarodni skup MIPRO]: proceedings. [vol. 1], Microelectronics, electronics and electronic technologies, MEET, Grid and visualizayion systems, GVS*, Petar Biljanović, ed., Karolj Skala, ed., Rijeka, MIPRO, 2008, pp. 283-288.

THESES

M. Sc. Theses

1. Kemal Alič, *Razvoj koncepta sistema za pripravo interaktivnih multimedjskih učnih vsebin v okolju DVB-T: magistrsko delo*, Ljubljana, [K. Alič], 2008.
2. Andrej Hrovat, *Ocena motenj med sosednjimi kanali v sistemu TETRA pri neposrednem načinu delovanja: magistrsko delo*, Ljubljana, [A. Hrovat], 2008.

The Department for Computer Systems is concerned primarily with the design automation of computing structures and systems. Within this broad area we concentrate particularly on a metaheuristic approach to engineering design and logistics problems as well as system design and testing. As an integral part of our research activity, members of the department have close contacts and collaborations with scientists world-wide, through academic links and industrial contacts, thus enabling us to maintain our position at the forefront of this rapidly developing field.

An important part of our research activities is related to the development of metaheuristic optimization methods and their applications. We have developed efficient self-setting and self-adapting evolutionary algorithms and ant-stigmergy-based optimization algorithms. These approaches were used for solving various combinatorial and numerical optimization problems. The evolutionary algorithms were tested on constrained numerical optimization problems. The multiple ant-colonies approach can be successfully used to solve mesh-partitioning problems that arise in mechanical, civil, automobile, and aerospace engineering. The multilevel ant-stigmergy approach was applied to solving discrete numerical optimization problems. We have proposed a novel general approach to transforming a multi-parameter optimization problem into a finding-the-minimum-path problem. We have also developed a differential ant-stigmergy approach, suitable for solving discrete as well as continuous numerical optimization problems.

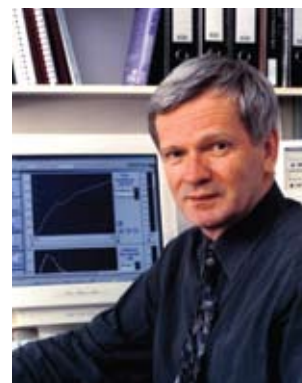
The multilevel and differential ant-stigmergy approaches were used in several real-world applications. In collaboration with Domel d.d., Železniki, Slovenia, we reduced the production costs of an electro-motor and optimized the aerodynamic power of a dry vacuum-cleaner impeller. Within the project "The Role of Luka Koper in the Logistic Support of the Slovenian Armed Forces and Allies" in the frame of the Target Research Programme (CRP MIR) "Science for Peace and Security 2006-2010" we developed software components for the optimization of logistic procedures for equipment and material transportation. Within the project "Secure Infrastructure for Implementing Command and Control" in the frame of the Technology Program (TP MIR) "Technology for Peace and Security 2006-2012" we optimized the structure of an absorber used in telecommunications systems.

In the research area of computer-based menu planning, collaborating with the Department of Environmental Sciences (JSI), CINDI Slovenia and the Slovenian Society for Clinical Nutrition we performed the following activities:

- We upgraded the web application Optijed with a module for planning nutrition for children, adolescents and patients with special nutritional needs. In addition, we extended the food composition database with new data and described data by using the standardized LanguaL method;
- We finished the project "Nutrition for Special Needs" (M4-0119), in which we analysed and optimized menus for people working in extreme conditions;
- In the project "Slovenian Web-based Food Composition Tables", we associated with the European Network of Excellence on Food Composition Databank Systems European Food Information Resource Network (EuroFIR FP6-CT-2005-513944).

In the project "Enhancing Elementary Mathematics Pedagogy Competencies by e-Learning" that is part of a large ESS project "Evaluation of Slovenian Education", we developed a web application for e-learning grammar-school mathematics. The decision-making system, which we formalized as a combinatorial optimization problem of graph colouring, is based upon a metaheuristic optimization method.

Within the EU 6FP project ARFLEX the work was focused on the preparation of three demonstrators that should have proven the advantages of a sensor control in industrial robotics over the classic approach and the



Head:
Prof. Franc Novak

We successfully completed the European project ARFLEX, developing a platform to precisely establish the capabilities of a robot-vision system, such as accuracy and repeatability.

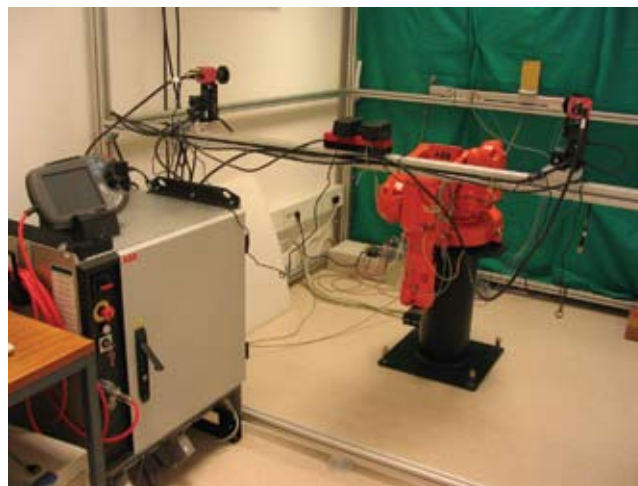


Figure 1: Arflex FP6 project: experimental platform for robot vision

We upgraded the web application Optijed with a module for planning the nutritional requirements for children, adolescents and patients with special nutritional needs.



Figure 2: Arflex FP6 project result: embedded robot-vision system (smart camera)

advantage of the embedded implementation over the non-embedded. Two of them were prepared at Comau Sp.A. in Italy and the third one was put together in our laboratory. The first demonstrator consisted of four embedded (smart) video cameras produced within the Arflex project with infrared (IR) light sources able to process images in real time and to communicate over the network with other devices, an industrial robot equipped with passive IR markers and a calibration rig composed of a set of passive markers placed in three perpendicular spatial directions. The cameras were able to measure the 3D position of a robot's tool centre point (TCP) in real time and to control the robot performing different tasks. The second demonstrator presented the advantage of a force sensor in robot control. The application was prepared with a robot's TCP smoothly following the contour of an unknown object. Within this demonstrator, another application simulated the behaviour of a fish during a fish hunt, also using the force sensor. The third demonstrator prepared in our lab was the Arflex non-embedded experimental platform consisting of four 1Mb 75Hz cameras, IR light sources, an industrial robot, active and passive markers and a precise motorized linear guide. The platform was used to precisely establish the capabilities of a robot-vision system, like the accuracy and repeatability of 3D positioning with IR active and passive markers.

The main purpose of the EUREKA project DIPIMAM is to improve the quality of the production of ceramic parts with powder injection moulding (PIM) technology at Hidria AET, Tolmin, Slovenia. The variation of the technological process used in this particular plant is called low-pressure injection moulding (LPIM), which consists of the following stages: feedstock preparation, mould filling, debinding, sintering, machining and glazing. The project investigates the impact of a combination of different feedstock binders on the mould-filling and debinding stages. Our role in the project is to use advanced methods to model the relationship between the quality of the ceramic part before and after debinding, and the composition of the binders using the experimental data. In 2008 we investigated the relationship between the mechanical properties of the ceramic parts before debinding and the four technological parameters: tool temperature, ceramic suspension temperature, time and pressure of the injection phase.

In the field of electronic testing we investigated the possibility of implementing a traditional mixed-signal test and measurement techniques in a built-in self-test as a part of a system-on-chip test infrastructure. We performed case studies of histogram-based ADC built-in self-test implementations in FPGAs. The objective was to assess the performance and test time of the embedded test solution where a considerable part of the testing is performed within a test wrapper. The impact of MOS switches on static parameter measurements is considered. The ultimate goal is to develop a solution suitable for implementations in the IEEE Std 1500 test wrapper.

In the frame of the Target Research Programme (CRP MIR) "Science for Peace and Security 2006-2010" we developed software components for the optimization of logistic procedures for equipment and material transportation.

SRAM-based FPGA circuits are relatively sensitive to single-event upsets (SEUs), which limits their widespread adoption in safety- or mission-critical applications. Depending on the required level of reliability and the availability the system is tested concurrently or occasionally. Since FPGA circuit resources are normally not 100% occupied by the design, the defects located in some areas of the chip that are not used by a particular design may be tolerated. Hence, a strategy of testing the resources of an FPGA with respect to a specific design to be implemented on it has been proposed. This type of test is called an application-dependent test. Currently, we are working on application-oriented test solutions for testing processor cores. We have developed an efficient approach that combines the whole instruction-set test into a compact test sequence, which can then be repeated with different input test patterns. This considerably improves the fault coverage with no additional memory requirements. The concept is being tested on experimental case studies on selected processor cores

In the scope of the multiconference Information Society we organized the third biennial international conference on "Bioinspired Optimization Methods and their Applications - BIOMA 2008". The areas of interest at the conference included genetic algorithms, evolution strategies, evolutionary programming, genetic programming, ant-colony optimization, particle-swarm optimization and related bio-inspired methods, and their applications in science, engineering and business. Members of our research programme actively participated in the International Program Committee and Organizing Committee of the conference.

In collaboration with FERI, University of Maribor, we implemented a lossless compression technique for volumetric data sets in FPGA using the Celoxica RC1000 development system. The purpose of the prototype version is to gain experience in the optimisation of hardware resources for prospective applications.



Figure 3: Menu planning for children with special needs

Some outstanding publications in the past three years

1. G. Papa, B. Koroušič Seljak, "An artificial intelligence approach to the efficiency improvement of a universal motor", *Engineering Applications of Artificial Intelligence*, 2005, vol. 18, pp. 47-55.
2. D. Torkar, S. Novak, F. Novak, "Apparent viscosity prediction of alumina-paraffin suspensions using artificial neural networks". *J. mater. process. technol.*, 2008, vol. 203, no. 1/3, pp. 208-215.
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5. K. Oblak, P. Korošec, F. Kosel, J. Šilc, "Multi-parameter numerical optimization of selected thin-walled machine elements using a stigmergic optimization algorithm", *Thin-walled structures*, 2007, vol. 45, no. 12, pp. 991-1001.

Awards and appointments

1. Peter Korošec: Jozef Stefan Golden Emblem Prize for 2008 for Ph. D., Ljubljana, 26 Mar. 2008

Organization of conferences, congress and meetings

1. Information society 2008, organization of sub-conference: BIOMA 2008, 13-14 Oct. 2008

INTERNATIONAL PROJECTS

1. Adaptive Robots for Flexible Manufacturing Systems
ARFLEX
6. FP, NMP2-CT-2005-016680
EC; Dr. Gabriella Caporaletti, EICAS Automazione S.p.A., Torino, Italy
Dr. Drago Torkar
2. EIE-Surveyor
225997-CP-1-2005-1-FR-ERASMUS-TNPP
EC; Prof. Jean-Marc Thiriet, Université Joseph Fourier Grenoble, Institut Universitaire de Technologie 1 de Grenoble, Département Réseaux et Télécommunications, Saint Martin d'Hères, France
Prof. Franc Novak
3. European Food Information Resource Network
EuroFIR
6. FP, NoE
MOU, 513944
EC; Dawn Wright, Paul Finglas, Institute of Food Research, Norwich, Great Britain
Asst. Prof. Barbara Koroušič Seljak
4. Development and Implementation of New PIM Binder System Using Advanced Methods
DIPIMAM
EUREKA
Hidria AET d.o.o., Tolmin, Slovenia
Dr. Drago Torkar
5. New Approaches to SRAM-based FPGA Testing
PROTEUS
BI-FR07-PROTEUS-016
Dr. Michel Renovell, LIRMM, Montpellier, France
Prof. Franc Novak

R & D GRANTS AND CONTRACTS

1. The role of Luka Koper in logistic support of the Slovenian Armed Forces and allies
Asst. Prof. Jurij Šilc
2. Nutrition for special needs - POVIR
Asst. Prof. Barbara Koroušič Seljak
3. Optimization of packaging, loading and transportation of pre-fabricated building elements
Asst. Prof. Peter Korošec
4. Open platform for Scalable e-Service Systems: OPSESS
Prof. Franc Novak

RESEARCH PROGRAM

1. Computing structures and systems
Prof. Franc Novak

NEW CONTRACT

1. Slovene Web-based Food Composition Tables
Ministry of Health, Government of the Republic of Slovenia
Asst. Prof. Barbara Koroušič Seljak

VISITORS FROM ABROAD

1. Dr. Jan-Olaf Gustavsson, Blekinge Institute of Technology, Karlskrona, Sweden, 25 Apr. 2008
2. Dr. Conny Johansson, Blekinge Institute of Technology, Karlskrona, Sweden, 25 Apr. 2008
3. Dr. Richard Torkar, Blekinge Institute of Technology, Karlskrona, Sweden, 13 Sept. to 16 Oct. 2008

STAFF

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1. Asst. Prof. Anton Biasizzo
2. Asst. Prof. Barbara Koroušič Seljak
3. **Prof. Franc Novak, Head**
4. Asst. Prof. Gregor Papa
5. Asst. Prof. Jurij Šilc

Postdoctoral associates

6. Dr. Uroš Kač*
7. Asst. Prof. Peter Korošec
8. Dr. Drago Torkar

Postgraduates

9. Uroš Legat, B. Sc.
 10. Katerina Tashkova, B. Sc.
 11. Vida Vukašinović, B. Sc.
 12. *Mariusz Jerzy Węgrzyn, M. Sc., left 1 May 2008*
- Technical and administrative staff**
13. Jolanda Jakofčič

Note:

* part-time JSI member

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4. Uroš Legat, Anton Biasizzo, Franc Novak, "Some approaches to partial reconfiguration of FPGA", In: *Proceedings, 44th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Plasma Technologies, September 17. - September 19, 2008, Fiesca, Slovenia*, Slavko Amon, ed., Miran Mozetič, ed., Iztok Šorli, ed., Ljubljana, MIDEEM - Society for Microelectronics, Electronic Components and Materials, 2008, pp. 125-128.
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7. Gregor Papa, Peter Korošec, "Constrained transportation scheduling", In: *Bioinspired optimization methods and their applications: proceedings of the Third International Conference on Bioinspired Optimization Methods and their Applications, BIOMA 2008, 13-14 October 2008, Ljubljana, Slovenia*, Bogdan Filipič, ed., Jurij Šilc, ed., Ljubljana, Jožef Stefan Institute, 2008, pp. 141-147.
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PUBLISHED CONFERENCE PAPERS

Regular papers

1. Darko Čerepnalkoski, Katerina Taškova, Ljupčo Todorovski, Sašo Džeroski, "Inducing process-based models of dynamic systems from

DEPARTMENT OF KNOWLEDGE TECHNOLOGIES

E-8

The Department of Knowledge Technologies performs research in advanced information technologies, aimed at acquiring, storing and managing knowledge to be used in the development of knowledge-based applications. The established areas of knowledge technologies include intelligent data analysis (machine learning, data mining, knowledge discovery in databases), text and web mining, the semantic web, social network analysis, language technologies and computational linguistics, as well as decision support and knowledge management. The research areas of the department also include Web 2.0, the management of virtual organizations, new media and e-science. In addition to knowledge technologies research, we also develop applications in environmental sciences and ecology, medicine and health care, biomedicine and genetics, as well as the economy and marketing.



Head:
Prof. Nada Lavrač

In 2008 the Knowledge Technologies research programme was evaluated as the best research programme in ICT (for the period 2004–2008) by the Slovenian Research Agency (ARRS). In terms of our collaboration in EU projects, our programme group is the most successful in Slovenia. In 2004–2008 we collaborated in 28 FP6 and FP7 projects, the most important being our successful coordination of the STREP project “Inductive Queries for Mining Patterns and Models” (IQ) and our collaboration in six large Integrated Projects (IPs) and two Networks of Excellence (NoEs).

In the area of **intelligent data analysis** we have developed a conceptual framework of supervised descriptive rule induction and have shown that methods for subgroup discovery, contrast set mining and emerging pattern mining represent special cases of supervised descriptive rule induction methods. An algorithm for closed-sets mining was published in the prestigious Journal of Machine Learning Research. A lemmatizer for Slovene, constructed by the Ripple-Down rule learning algorithm, was published in the journal AI Communications. We have continued the development of semantic data mining, which enables the use of ontologies in machine learning. On the one hand, ontologies can be used as background knowledge of the application domain (our paper published in the Journal of Biomedical Informatics presents the analysis of gene expression based on the ontology of gene functions, processes and interactions). On the other hand, an ontology of data mining methods can be used for the automated planning of data-mining workflows in the framework of a novel service-oriented data-mining architecture (three workshop papers were published and a workshop, Service-Oriented Knowledge Discovery, was organized at the ECML/PKDD-08 conference in Antwerp in September 2008). In collaboration with the National Institute of Biology, Ljubljana, Slovenia, we have continued the development of a cost-optimization system for micro-array testing for genetically modified organisms in food and feed samples.

We have developed a model of the Slovenian Health Care network for the Ministry of Health of Slovenia in the scope of the MediNet and MediNet+ projects. In 2008, the project results were upgraded with a web portal that enables querying for analysis results and which offers numerous reporting and visualization facilities. As a result, it can be used to support decision making, monitoring and planning of the Slovenian health-care network.

We successfully concluded the coordination of the FP6 project “Inductive Queries for Mining Patterns and Models” (IQ), which was concerned with developing techniques and applications for inductive databases and queries. Besides data, inductive databases contain generalizations (patterns and models) valid in the data, which are generated, accessed and manipulated by inductive queries. In its final evaluation, the IQ project received much praise, both for its outstanding scientific content and our excellent management. Among our scientific contributions to the project, we wish to highlight the proposed general framework for data mining, which has led to the development of an ontology for data mining. We have also developed many specific approaches to mining complex data, such as ensembles of decision trees for hierarchical multi-label classification, which were applied to

In 2008 the Knowledge Technologies research programme was evaluated as the best research programme in ICT (for the period 2004–2008) by the Slovenian Research Agency (ARRS).

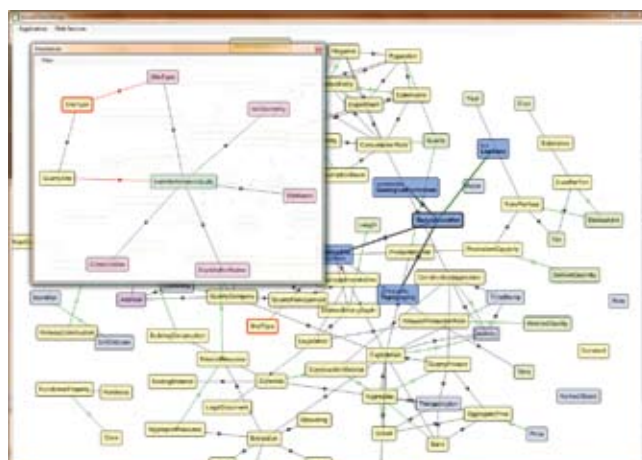


Figure 1: The main window of Visual OntoBridge: the software being developed by our department in the European project SWING. The software provides facilities for annotating web resources with entities from the domain ontology with the purpose of establishing semantic descriptions based on a common vocabulary.

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Figure 2: An example of concordances for the corpus targeted at learners of Japanese. Available at <http://nl.ijs.si/jaslo/cqp/>.

The successfully completed IQ project, which we coordinated, received much praise from the EU reviewers for outstanding scientific content and excellent management.



Figure 3: Prototype speech synthesiser developed in the project "BMT: development of a text speech reader for mobile telephones for blind and partially sighted users".

In 2008 we started to collaborate in eight new EU projects (3 IPs, 2 STREPs, 1 NoE, 1 CSA) and acquired about 30% of the Slovenian FP7 ICT funds (over €2.5 m), which makes our department one of the most successful in Europe and by far the most successful in Slovenia.

problems in bioinformatics (e.g., functional genomics) and environmental sciences. In addition, the IQ project addressed the problem of using equation discovery for systems biology, which will be further studied in one national and in one FP7 research project that started this year. A national applied research project that deals with the problem of estimating the state of forest ecosystems from remote sensing data was also successfully completed. The forest-vegetation height and the canopy cover are predicted from satellite images. To this end, ensembles of predictive models are used, which are learned from a combination of 2D satellite images and 3D LIDAR data. Maps of forest-vegetation height and canopy cover can now be produced for much larger areas than with previous pilot studies.

In the area of **decision support**, our long-term goal is to develop methods and techniques for decision modelling, support them with software and integrate them with data-mining systems. In 2008 we have improved our software for qualitative multi-criteria decision making, DEXi. We have added three methods for the analysis of decision options: a comparison of options, a selective explanation and a "plus-minus-1 analysis". DEXi 3.0 is freely available from the web page: <http://kt.ijs.si/MarkoBohanec/dexi.html>.

The developed decision-support methods and tools were successfully used in the EU projects SIGMEA, Co-Extra and HEALTHREATS. The first two projects are focused on the analyses of impacts of producing and using genetically modified (GM) plants in Europe: SIGMEA from the viewpoint of ecological and economic impacts, and Co-Extra from the viewpoint of co-existence and traceability in production and supply chains. We concluded our contribution

to SIGMEA with a publication in the journal Ecological Modelling, where we described our model for the assessment of the ecological and economic impacts of growing GM maize. In the ongoing Co-Extra project we have developed three multi-criteria models for the assessment of analytical and sampling methods, as well as for the assessment of the likelihood of the emergence of unapproved GM organisms in food and feed products. In the EU project HEALTHREATS, which aims to develop a decision-support system for the rapid, efficient and coordinated response to threats to health (such as epidemics), we have developed models for an internal evaluation of the work and the results of the project.

In the area of **text and web mining** our work in the FP6 project "Statistical Multilingual Analysis for Retrieval and Translation" (SMART) was focused on testing and using our automatic evaluation system (of machine translation and cross lingual information retrieval) by the project partners, coordination of a user-evaluation study (with different user groups, tasks, datasets and evaluation measures) and an extension of the KCCA method for cross-lingual data analysis in terms of scalability and performance in collaboration with the FP6 project PASCAL. The developed component was integrated into the existing system for contextual search SearchPoint and applied to the problem of cross-lingual information retrieval (demo at SIGIR-2008). As a part of our activities in the FP6 project "Image-based Navigation in Multimedia Archives" (IMAGINATION) we have developed software components to help enrich the existing textual metadata. In particular, the developed software components support three functionalities: (1) annotations of images, (2) discovery of duplicate candidates for ontology concepts and (3) proposing new concepts and relations between them. (1) The annotation of images is based on using textual information that is provided for each image in order to annotate the image with concepts of a predefined ontology. Each image has a very limited amount of text associated with it, usually just a handful of keywords. In some cases additional content is provided via a link to external web pages. Thus, in the proposed approach we handle these two cases separately. (2) The discovery of potential duplicates in an ontology is based on representing each ontology concept by text that can be associated with it, originating either from the concept name and metadata, from external web pages or from the name of an associated URL. (3) The proposing of new ontology concepts and some relations between them is based on using external web pages providing information on particular concepts.

We have successfully concluded two FP6 projects, PASCAL and KDUbiq, where our research in the past year included (1) the development of the visualization of named entities in time based on the use of Wikipedia for extracting named entities and relating them over time, (2) the development of SearchPoint – a system for interfacing an existing search engine that

organizes its results into groups or shows the search results in the context of some existing ontology or classification schema, and (3) the development of Semantic Pointer – a system for social browsing with semantic context that enables real-time identification of the visitors to semantically similar web pages and real-time interaction between them. We have obtained a new FP7 Network of Excellence “Pattern Analysis, Statistical Modelling and Computational Learning 2” (PASCAL2) for the period 2008–2013 where our work will be mainly on research in text mining and natural language processing.

In the area of the **Semantic Web** we have successfully concluded two National Targeted Research projects on “Statistical Semantic Web Systems” (Sistemi za statistični semantični splet) and “Metaservices – Semantic Reasoning Grid Services” (MetaStoritev - Semantično sklapanje Grid storitev, 2006–2008), where our main contributions are: the development of methods and components for (1) knowledge acquisition, (2) cross-modal data analysis, (3) handling cross-lingual data and several support components for (4) supporting scalability, visualization and evaluation. Our activities in the FP6 project “Lifecycle Support for Networked Ontologies” (NeOn) in the past year resulted in an extension of the NeOn Toolkit with: (1) an alignment server incorporating our pragmatic approach to using large-scale ontologies as contexts (based on a lightweight ontology model and grounding of the ontology concepts in textual documents), (2) a system for ontology visualization in the context of a predefined landscape. Work in the FP6 project “Transitioning Applications to Ontologies” (TAO) resulted in a methodology for cross-modal data analysis focused on connecting textual data and graph/network. We have also designed an evaluation of the methodology on three real-world case studies. In the FP6 project “Semantic Web Services Interoperability for Geospatial Decision Making” (SWING) we have developed the semantic annotation engine OntoBridge and designed several evaluation scenarios on real-world data. We have obtained a new large FP7 IP project “Enabling the Knowledge Powered Enterprise” (ACTIVE) for the period 2008–2011, where our work is mainly in the direction of modelling informal knowledge processes in an organization.

We represent the Jožef Stefan Institute in the World Wide Web Consortium (W3C), which develops and recommends future web standards. We actively participate in the Rule Interchange Format (RIF) working group. The group has so far produced a working draft and last-call recommendations for a number of standards: RIF Core, Basic Logic Dialect, Framework for Logic Dialects, RDF and OWL Compatibility, Datatypes and Built-Ins, Production Rules Dialect, Use Cases and Requirements.

In the area of **knowledge management** we have successfully concluded three FP6 research projects: “European collaborative networked organizations leadership initiative” (ECOLEAD), “Extended Enterprise management in Enlarged Europe” (E4) and “Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshops” (Tool-East). The project results have already been transferred to new projects as well as to industrial applications for KOGAST, EMO, the High-Tech cluster, the Toolmakers cluster and the Slovenian automotive cluster. We are continuing the R&D work in the areas of networked organizations, interoperability and collaboration in the FP7 integrated project “Collaboration and INteroperability for networked enterprises” (COIN). We are very successful in the development of Intelligent Cargo Transport in the FP7 project “European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics” (EURIDICE), where we have already demonstrated some prototypes and in the FP7 project “Enabling the Knowledge Powered Enterprise” (ACTIVE) with the tools and methods for enterprise “hidden” knowledge formalization.

In the area of **language technologies** we have continued work on the basic research project “Linguistic annotation of Slovene language: methods and resources” (JOS) in the scope of which we are developing automatic inductive methods for the annotation of morphosyntax, syntax and semantics and use these methods to produce freely available linguistically annotated corpora of Slovene.

We finished work on the SEE.ERA-NET project “Building Language Resources and Translation Models for Machine Translation focused on South Slavic and Balkan Languages”, where we produced a parallel and linguistically annotated corpus of EU legal documents, which contains aligned texts in English, Slovene, Serbian, Bulgarian and Romanian.

Our knowledge transfer to industry is demonstrated by the help given to twelve Slovenian companies in becoming partners of EU projects, thus securing approximately €2 m of co-financing.

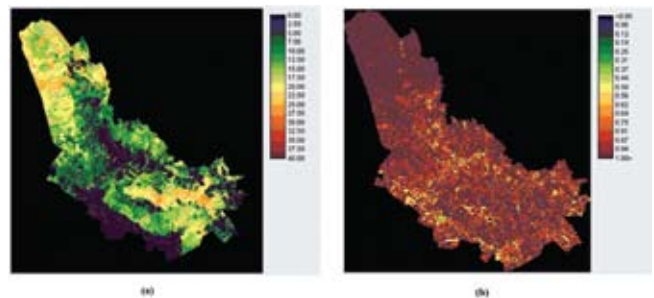


Figure 4: Forest-vegetation height in m (a) and canopy cover in % (b) for the Slivnica region of Slovenia, as predicted from satellite images by ensembles of predictive models learned from a combination of 2D satellite images and 3D LIDAR data.

The Videlectures.net web portal, which we co-manage with the CT3 department, has started to host lectures from the MIT portal “Open Course Ware” and the Opencast community.

The software we developed is used by the EU Commission, the New York Times, Microsoft and many other international companies.

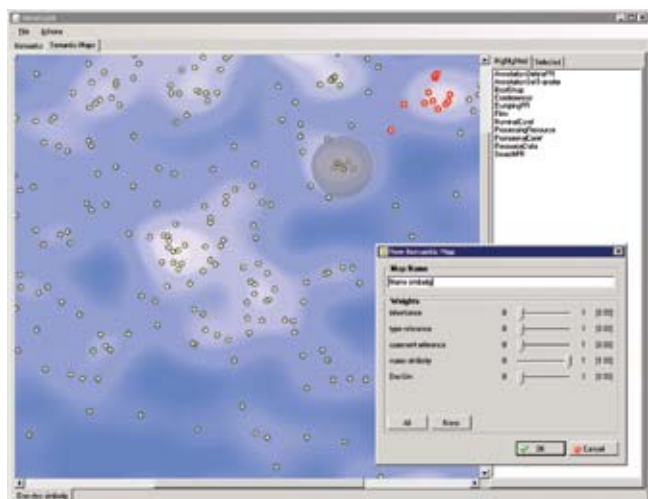


Figure 5: OntoSight: visualization of software components (specifically, Java classes) in the form of a semantic map. This visualization is made by projecting high-dimensional multi-modal data instances onto a 2D canvas by employing multi-dimensional scaling (MDS) and a least-squares solver. The projection preserves distances between instances as much as possible.

We have successfully completed work on a six-month R&D project from the area of eContent and eServices “BMT: development of a text speech reader for mobile telephones for blind and partially sighted users” under the coordination of the company Alpineon R&D, where the JSI was in charge of the development of a morphosyntactic tagger and lemmatiser that improves the quality of the speech synthesis. For Alpineon we also completed the XML_FED project, where we developed the XML specifications for use with a speech synthesiser.

We started work on several new EU projects. In the scope of the project “Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and Their Digital Resources” (MondiLex) and in cooperation with the F-9 department we are investigating the possibilities of using grid technologies for the processing and dissemination of large corpora. In the project “Fostering Language Resources Network” (FlareNet) we are working on the compilation of language resources for Slovene.

In the scope of the bilateral Japanese-Slovenian cooperation with Tokyo International University, we compiled, on the basis of the previously produced jpWaC corpus, a corpus of sentences appropriate for learners of Japanese, where the words are annotated with their difficulty level. The corpus is freely available for use via a web concordancer.

Some outstanding publications in the past three years

1. John Davies (Ed.), Marko Grobelnik (Ed.), Dunja Mladenić (Ed.). Semantic Knowledge Management: Integrating Ontology Management, Knowledge Discovery, and Human Language Technologies. Springer, 2008.
2. Igor Trajkovski, Nada Lavrač, Jakub Tolar. SEGS: search for enriched gene sets in microarray data. Journal of biomedical informatics, 2008, vol. 41, no. 4, pp. 588-601.
3. Gemma C. Garriga, Petra Kralj Novak, Nada Lavrač. Closed sets for labeled data. Journal of machine learning research, 2008, vol. 9, no. 4, pp. 559-580.
4. Sašo Džeroski, Ljupčo Todorovski. Equation discovery for systems biology: finding the structure and dynamics of biological networks from time course data. Current opinion in biotechnology, 2008, 19: 360-368.
5. Marko Bohanec, Antoine Messean, Sara Scatata, Frédérique Angevin, Bryan Griffiths, Paul Henning Krogh, Martin Žnidaršič, Sašo Džeroski. A qualitative multi-attribute model for economic and ecological assessment of genetically modified crops. Ecol. model., 2008, vol. 215, no. 1/3, pp. 247-261.

Awards and appointments

1. Sašo Džeroski, ECCAI fellow – ECCAI award. Awarded by European Coordination Committee for Artificial Intelligence

Organization of conferences, congress and meetings

1. Information Society 2008, organization of subconferences: SiKDD-2007, Intelligent Systems, 13-17 Oct. 2008

INTERNATIONAL PROJECTS

1. Systems Biology of Phagosome Formation and Maturation, Modulation by Intracellular Pathogens
PHAGOSYS
7. FP, 223451, HEALTH-F4-2008-223451
EC; Anne-Marie Fish, Imperial College of Science, Technology and Medicine, London, Great Britain
Prof. Sašo Džeroski
2. Bisociation Networks for Creative Information Discovery
BISON
7. FP, 211898
EC; Universität Konstanz, Konstanz, Germany
Prof. Nada Lavrač
3. Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and Their Digital Resources
MONDILEX
7. FP, 211938

4. Enabling the Knowledge Powered Enterprise
ACTIVE
7. FP, 215040
EC; Philip Hewitt, British Telecommunications plc, London, Great Britain
Marko Grobelnik, B. Sc., Asst. Prof. Dunja Mladenić, Mitja Jermol, M. Sc.
5. Pattern Analysis, Statistical Modelling and Computational Learning 2
PASCAL 2
7. FP, 216886
EC; Eileen Simon, University of Southampton, Highfield, Southampton, Great Britain
Asst. Prof. Dunja Mladenić, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
6. European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics
EURIDICE
7. FP, 216271
EC; INSIEL - Informatica per il Sistema degli Enti Locali s.p.a., Trieste, Italy
Marko Grobelnik, B. Sc., Asst. Prof. Dunja Mladenić, Mitja Jermol, M. Sc.

7. Collaboration and INteroperability for networked enterprises
COIN
7. FP, 216256
EC; Claudia Guglielmina, TXT e-Solutions Spa, Milano, Italy
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
8. GM and non-GM supply chains: their CO-Existence and TRAceability
Co-Extra
6. FP, 007158
EC; Institut National de la Recherche Agronomique, Paris, France
Prof. Marko Bohanec
9. European Embryonal Tumor Pipeline
E.E.T. -Pipeline
6. FP, 037260
EC; Angelika Eggert, Universitaet Duisburg-Essen, Essen, Germany
Prof. Sašo Džeroski
10. Stimulating Policy Debate on Women and Science Issues in Central Europe
WS DEBATE
6. FP, 036651
EC; Dr. Dora Groo, Eszter Papp, Hungarian Science and Technology Foundation; Tudományes Technológiai Alapítvány, Budapest, Hungary
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
11. Statistical Multilingual Analysis for Retrieval and Translation
SMART
6. FP, 033917
EC; Nicola Cancedda, Xerox Research Centre Europe, Meylan; Xerox, Aulnay-Sous-Bois, France
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
12. Image-based Navigation in Multimedia Archives
IMAGINATION
6. FP, 034626
EC; Clemens van Dintner, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc., Prof. Marko Mikuz
13. Extended Enterprise Management in Enlarged Europe
E4
6. FP, 027282
EC; Roberto Tarditi, Centro Ricerche Fiat Societa Consortile per Azioni, Orbassano (TO), Italy
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
14. Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshop
Tool-East
6. FP, 027802
EC; dr.-ing. Volker Stich, Forschungsinstitut fuer Rationalisierung (FIR) and der RWTH Aachen, Research Institute for Operations Management at Aachen Univerity, Aachen, Germany
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
15. Semantic Web Services Interoperability for GoeSpatial Decision Making
SWING
6. FP, 026514
EC; Arne J. Berre, SINTEF - Stiftelsen for Industriell OG Teknisk Forskning Ved Norges Tekniske Hoegskole, Trondheim; SINTEF ICT, Oslo, Norway
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc., Prof. Marko Mikuz
16. Lifecycle Support for Networked Ontologies
NEON
6. FP, 027595
EC; Prof. Enrico Motta, Kmi, The Open University, Milton Keynes, Great Britain
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
17. Transitioning Applications to Ontologies
TAO
6. FP, 026460
EC; Dr. Kalina Bontcheva, University of Sheffield, Department of Computer Science, Sheffield, Great Britain
Asst. Prof. Dunja Mladenič, Marko Grobelnik, B. Sc., Mitja Jermol, M. Sc.
18. Inductive Queries for Mining Patterns and Models
IQ
6. FP, 516169
EC; Prof. Sašo Džeroski, Institut "Jožef Stefan", Ljubljana, Slovenia
Prof. Sašo Džeroski
19. European Collaborative networked Organizations LEADership initiative
ECOLEAD
6. FP, 506958
EC; Martin Ollus, Technical Research Centre of Finland, Espoo, Finland
Prof. Nada Lavrač, Mitja Jermol, M. Sc.
20. Pattern Analysis, Statistical Modelling and Computational Learning
PASCAL
6. FP, 506778
EC; Prof. John Shawe-Taylor, The University of Southampton, School of Electronics and Computer Science, Highfield, Southampton, Great Britain
Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc.
21. KD-ubiq - A Blueprint for Ubiquitous Knowledge Discovery Systems
KD-ubiq
6. FP, 021321
EC; Dr. Michael May, Stephan Kollmer, Fabian Perpeet, Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung e.V., München; Sankt Augustin, Germany
Asst. Prof. Dunja Mladenič
22. Integrated Decision Support System for HEALTH THREATS and Crises Management
HEALTHTHREATS
Public Health program (PHEA), e-Contentplus
2006203
EC; Executive Agency for Public Health (PHEA - HTC), Luksembourg; Azienda Sanitaria Locale di Brescia (ASL Brescia), Brescia, Italy
Prof. Nada Lavrač, Dr. Martin Znidaršič
23. Fostering Language Resources Network
FLaReNet
e-Contentplus
ECP-2007-LANG-617001
EC; CNR-ILC, Consiglio Nazionale delle Ricerche, Rome, Italy
Asst. Prof. Tomaž Erjavec
24. Building Language Resources and Translation Models for Machine Translation focused on South Slavic and Balkan Languages
SEE-ERA.NET
1000-07-380024
Radoslav Pavlov, Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria
Asst. Prof. Tomaž Erjavec
25. The Use of a Dedicated Service on the Http Server of IJS <http://nl.ijs.si> to be used by FP for Up-loading and Storing Texts which Constitute the FP Corpus of IX Century Translated Books
Forschungsprojekt: Deutsch-slowenische/kroatische Übersetzung 1848 bis 1918
Agreement, dated 3.5.2007
Prof. Erich Prunč, Graz, Austria
Asst. Prof. Tomaž Erjavec
26. Information Fusion for Data Mining in Bioinformatics and Biomedicine
BI-CZ/08-09-007
Prof. Olga Štěpánková, Czech Technical University in Prague, Prague, Czech Republic
Prof. Nada Lavrač
27. Inductive Databases for Genomics and Proteomics
BI-HR/07-08-029
Dr. Tomislav Šmuc, Rudjer Boskovic Institute, Zagreb, Croatia
Prof. Sašo Džeroski
28. Japanese/Slovene Resources for Second Language Learners
BI-JP/08-10/006
Prof. Yoshiko Kawamura, Tokyo International University, Saitama, Japan
Asst. Prof. Tomaž Erjavec
29. Knowledge Discovery for Ecological Modeling of Lake Ecosystems
BI-MK/07-08-017
Prof. Kosta Mitreski, Faculty of Electrical Engineering, Skopje, The Republic of Macedonia
Prof. Sašo Džeroski
30. Landscape Functioning under Different Management Regimes
LANDECO
SCRI, Living Technology, Dundee, Scotland, Great Britain
Asst. Prof. Marko Debeljak
31. Analysis of Dynamic Networks with Graph and Text Mining Methods
BI-US/06-07-032
Faloutsos Christos, Carnegie Mellon University, Pittsburgh, PA, USA
Asst. Prof. Dunja Mladenič

R & D GRANTS AND CONTRACTS

1. Advanced ML methods for automated modeling of dynamic systems
Prof. Sašo Džeroski
2. Linguistic annotation of Slovene language: methods and resources
Asst. Prof. Tomaž Erjavec
3. Methodological aspects of cognitive process research-learning and decision-making
Prof. Andrej Ule, Prof. Marko Bohanec
4. Unknown 17th and 18th century manuscripts of Slovenian literature: information-technology aided register, scholarly editions and analyses
Dr. Matija Ogrin, Asst. Prof. Tomaž Erjavec
5. Slovene Terminology Web Portal
Prof. Vojko Gorjanc, Simon Krek
6. Methodology for producing a detailed digital map of the height and density of vegetation cover
Prof. Sašo Džeroski
7. VoiceTRAN II - Multilingual mobile speech communicator for 21.th century warriors
Dr. Jerneja Žganec Gros, Asst. Prof. Tomaž Erjavec
8. Crisis management simulator
Dr. Matej Penca, Asst. Prof. Dunja Mladenič
9. Development of Knowledge Management System for SV
Asst. Prof. Jaroslav Berce, Marko Grobelnik
10. Statistical semantic web systems
Asst. Prof. Dunja Mladenič
11. Metaservices - Semantic reasoning Grid services
Dr. Gregor Pipan, Asst. Prof. Dunja Mladenič
12. Digital text centre with multimedia communication
Dr. Matija Ogrin, Asst. Prof. Tomaž Erjavec

13. Harmonisation of technologies for following genetically modified organisms in food and feed production chain and its co-existence with conventional and ecological production chains
Asst. Prof. Vladimir Meglič, Prof. Nada Lavrač
14. Guidelines for national strategy of preservation of forest trees genefond due to introduction of genetically modified organisms in agriculture
Dr. Robert Brus, Prof. Marko Debeljak
15. Harmful factors for contemporary forests: methods for monitoring and ecological modelling, the impact of exploitation, and strategies for management
Prof. Maja Jurc, Prof. Sašo Džeroski
16. Analysis and scenario of development and exploration of forests in Slovenia
Dr. Andrej Bončina, Prof. Marko Debeljak
17. Influence of gene transfer, genetic diversity and cultivation technology on sustainability and tracing methods
Asst. Prof. Vladimir Meglič, Prof. Marko Debeljak
18. European Uniform System for Linking Digital Information of Public Nature: DUNE
Marko Grobelnik

19. Development of a text speech reader for mobile telephones for blind and partially sighted users: BMT
Asst. Prof. Tomaž Erjavec

RESEARCH PROGRAM

1. Knowledge Technologies
Prof. Nada Lavrač

NEW CONTRACT

1. Systems Biology Tools Development for Cell Therapy and Drug Development - SYSTHER
National Institute of Biology
Prof. Nada Lavrač, Petra Kralj Novak

VISITORS FROM ABROAD

1. Prof. Luis Torgo, Faculty of Economics, University of Porto, Portugal, 5-8 Jan. 2008 and 10-14 Dec. 2008
2. Jeroen Sebastian de Bruin, Leiden University of Advanced Computer Science, Leiden, The Netherlands, 8-20 Jan. 2008
3. Tricia Jenkins, University of Liverpool, Liverpool, United Kingdom, 22-23 Jan. 2008
4. Margaret Evans, University of Liverpool, Liverpool, United Kingdom, 22-23 Jan. 2008
5. Prof. Joost Kok, Leiden University, Leiden, The Netherlands, 21-24 Jan. 2008
6. Prof. John Shawe Taylor, School of Electronics and Computer Science, University of Southampton, Southampton, United Kingdom, 31 Jan. 2008
7. Dr Hendrich Blockeel, Katholieke Universiteit Leuven, Belgium, 4-8 Feb. 2008
8. Prof. Suzana Loskovska, Faculty of Electrical Engineering and Information, Skopje, Macedonia, 15-22 Feb. 2008
9. dr. John Davies, British Telecom, Ipswich, United Kingdom, 16. Feb. 2008
10. Delia Rusu, Technical University of Cluj-Napoca, Cluj-Napoca, Romania, 18 Feb. to 7 Jun. 2008
11. Lorand Dali, Technical University of Cluj-Napoca, Cluj-Napoca, Romania, 18 Feb. to 7 Jun. 2008
12. Christophe Schwartz, ENSAIA/INRA Nancy, France, 25-29 Feb. 2008
13. Jerome Cortet, ENSAIA/INRA Nancy, France, 25-29 Feb. and 6-10 Oct. 2008
14. Rayid Ghani, Accenture Labs, Chicago, USA, 14 Mar. 2008
15. Elena Mitreska, Faculty of Electrical Engineering and Information, Skopje, Macedonia, 16-23 Mar. 2008
16. doc. dr. Kosta Mitreski, Faculty of Electrical Engineering and Information, Skopje, Macedonia, 16-23 Mar. 2008
17. Andreja Naumoski, Faculty of Electrical Engineering and Information, Skopje, Macedonia, 16-23 Mar. 2008
18. dr. Paul B. Losiewicz, European Office of Aerospace Research and Development, United Kingdom, 21-22 Apr. 2008
19. Florence Leprince, ARVALIS-Institut du végétal 21 chemin de Pau, Montradon, France, 22 Apr. 2008
20. dr. Neel Sundaresan, eBay Research, San Jose, USA, 15 May 2008
21. Walter Scholger, Karl-Franzens-Universität, Graz, Austria, 18 May 2008
22. Brita Luber, Karl-Franzens-Universität, Graz, Austria, 18 May 2008
23. Petra Schikler, Karl-Franzens-Universität, Graz, Austria, 18 May 2008
24. Dr Hubert Stigler, Department of Information Processing in the Humanities, Karl-Franzens-Universität, Graz, Austria, 19 May 2008
25. Dr Nataša Milić-Frayling, Microsoft Research, Cambridge, United Kingdom: 11-12 Jun. 2008
26. r. Arno Knobbe, Utrecht University, Utrecht, The Netherlands: Exceptional Model Mining, 17 Jun. 2008
27. dr. Michael Witbrock, Cypcorp, Inc., Austin, USA, 26 Jun. to 6 Sept. 2008
28. Alexandra Moraru, Technical University of Cluj-Napoca, Cluj-Napoca, Romania, 7 Jul. 15 Sept. 2008
29. Titus Moldovan, Technical University of Cluj-Napoca, Cluj-Napoca, Romania, 7 Jul. 15 Sept. 2008
30. Paul-Valentin Borza, Technical University of Cluj-Napoca, Cluj-Napoca, Romania, 13 Jul. to 21 Sept. 2008
31. dr. Hubert Stigler s Karl-Franzens-Universität, Graz, Austria, 25 Jul. 2008 and 18 May 2008
32. Dr Stefano Bertolo, European Commission, Brussels, Belgium, 19 Aug. 2008
33. Mandarić Domagoj, FirstData International, Zagreb, Croatia, 14 Aug. 2008
34. Timo Aho, Tampere University of Technology, Tampere, Finland, 1 Oct. 2008 to 31 Mar. 2009
35. Monika Žakova, Czech Technical University Prague, Prague, Czech Republic, 13-24 Oct. 2008
36. Dr John Bullas, Atkins Highways & Transportation, London, United Kingdom, 16-19 Oct. 2008
37. Mirjana Ivanović, Faculty of Science University of Novi Sad, Novi Sad, Serbia, 16-19 Oct. 2008
38. Dr Tomislav Šmuc, Institut Rudjer Bošković, Zagreb, Croatia, 21 Nov. 2008
39. dr. Dragan Gamberger, Institut Rudjer Bošković, Zagreb, Croatia, 21 Nov. 2008
40. Mislav Malenica, Institut Rudjer Bošković, Zagreb, Croatia, 21 Nov. 2008
41. Ivica Dimitrovski, Faculty of Electrical Engineering and Information, Skopje, Macedonia, 28 Sept. to 18 Oct. 2008

STAFF

Researchers

1. Prof. Marko Bohanec
2. Dr. Damjan Bojadžiev
3. Dr. Bojan Cestnik*
4. Prof. Marko Debeljak
5. Prof. Sašo Džeroski
6. Asst. Prof. Tomaž Erjavec
7. **Prof. Nada Lavrač, Head**
8. Asst. Prof. Dunja Mladenić
9. Prof. Tanja Urbančič*

Postdoctoral associates

10. Dr. Branko Kavšek*
11. Dr. Bernard Ženko
12. Dr. Martin Žnidaršič

Postgraduates

13. Janez Brank, M. Sc.
14. Darko Čerepnalkoski, B. Sc.
15. Jure Ferlež, M. Sc.
16. Blaž Fortuna, B. Sc.
17. Valentin Gjorgjioski, B. Sc.
18. Miha Grčar, B. Sc.
19. Mitja Jermol, M. Sc.
20. Dragi Kocev, B. Sc.

21. Petra Kralj Novak, B. Sc.
22. Simon Krek*, B. Sc.
23. Blaž Novak
24. Panče Panov, B. Sc.
25. Vid Podpečan, B. Sc.
26. Jan Rupnik, B. Sc.
27. Mitja Trampuš, B. Sc.
28. Dr. Miha Volovšek*
29. Miha Vuk, B. Sc.

Technical officers

30. Milica Bauer, B. Sc.
31. Dr. France Dacar
32. Dr. Damjan Demšar
33. Dr. Igor Mozetič
34. Nina Novinec, M. Sc.

Technical and administrative staff

35. Tina Anžič
36. Marko Grobelnik
37. Jolanda Jakofčič
38. Boštjan Pajntar

Note:

* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

- Nataša Atanasova, Ljupčo Todorovski, Sašo Džeroski, Boris Kompare, "Application of automated model discovery from data and expert knowledge to a real-world domain: Lake Glumsø", In: *Proceedings of The Fifth European Conference on Ecological Modelling ECEM 2005, Pushchino, Russia, September 19-23*, (Ecological modelling, Vol. 212, no. 1/2, 2008), Alexander S. Komarov, ed., Amsterdam, Elsevier Scientific Publ. Co., 2008, vol. 212, no. 1/2, pp. 92-98, 2008.
- Marko Bohanec, Antoine Messean, Sara Scatasta, Frédérique Angevin, Bryan Griffiths, Paul Henning Krogh, Martin Žnidaršič, Sašo Džeroski, "A qualitative multi-attribute model for economic and ecological assessment of genetically modified crops", In: *Proceedings of ICEM 2006, International Conference on Ecological Modelling, Mamaguchi, Japan: 28 August - 1 September 2006, Yamaguchi University, Japan*, (Ecological modeling, Vol. 215, no. 1/3, 2008), Amsterdam, Elsevier Scientific Publ. Co., 2008, vol. 215, no. 1/3, pp. 247-261, 2008.
- Janez Brank, Dunja Mladenič, Marko Grobelnik, Nataša Milič-Frayling, "Feature selection for the classification of large document collections", *J. univers. comput. sci. (Online)*, vol. 14, no. 10, pp. 1562-1596, 2008.
- Marko Debeljak, Geoff Squire, Damjan Demšar, Marc W. Young, Sašo Džeroski, "Relations between the oilseed rape volunteer seedbank, and soil factors, weed functional groups and geographical location in the UK", In: *Proceedings of The Fifth European Conference on Ecological Modelling ECEM 2005, Pushchino, Russia, September 19-23*, (Ecological modelling, Vol. 212, no. 1/2, 2008), Alexander S. Komarov, ed., Amsterdam, Elsevier Scientific Publ. Co., 2008, vol. 212, no. 1/2, pp. 138-146, 2008.
- Sašo Džeroski, Ljupčo Todorovski, "Equation discovery for systems biology: finding the structure and dynamics of biological networks from time course data", *Curr. opin. biotechnol.*, vol. 19, no. 4, pp. 360-368, 2008.
- Blaž Fortuna, Nada Lavrač, Paola Velardi, "Advancing topic ontology learning through term extraction", In: *PRICAI 2008: trends in artificial intelligence: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, vol. 5351), 10th Pacific Rim International Conference on Artificial Intelligence, Hanoi, Vietnam, December 15-19, 2008, Tu-Bao Ho, ed., Berlin, Heidelberg, Springer, 2008, vol. 5351, pp. 626-635, 2008.
- Dragan Gamberger, Nada Lavrač, Johannes Fürnkranz, "Handling unknown and imprecise attribute values in propositional rule learning: a feature-based approach", In: *PRICAI 2008: trends in artificial intelligence: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, vol. 5351), 10th Pacific Rim International Conference on Artificial Intelligence, Hanoi, Vietnam, December 15-19, 2008, Tu-Bao Ho, ed., Berlin, Heidelberg, Springer, 2008, vol. 5351, pp. 636-645, 2008.
- Gemma C. Garriga, Petra Kralj Novak, Nada Lavrač, "Closed sets for labeled data", *J. mach. learn. res.*, vol. 9, no. 4, pp. 559-580, 2008.
- Marko Grobelnik, Janez Brank, Blaž Fortuna, Igor Mozetič, "Contextualizing ontologies with ontolight: a pragmatic approach", *Informatica (Ljublj.)*, vol. 32, no. 1, pp. 79-84, 2008.
- Kristina Hmeljak Sangawa, Tomaž Erjavec, "A low cost approach to building a Japanese-Slovene parallel corpus", *Denshi Jōhō Tsūshin Gakkai gijutsu kenkyū hōkokoku*, vol. 108, no. 50, pp. 7-10, 2008.
- Aneta Ivanovska, Celine Vens, Nathalie Colbach, Marko Debeljak, Sašo Džeroski, "The feasibility of co-existence between conventional and genetically modified crops: using machine learning to analyse the output of simulation models", In: *Proceedings of ICEM 2006, International Conference on Ecological Modelling, Mamaguchi, Japan: 28 August - 1 September 2006, Yamaguchi University, Japan*, (Ecological modeling, Vol. 215, no. 1/3, 2008), Amsterdam, Elsevier Scientific Publ. Co., 2008, issues 1-3, vol. 215, pp. 262-271, 2008.
- Simon Krek, "FrameNet in slovenščina", *Jez. slovst. (Tisk. izd.)*, vol. 53, no. 5, pp. [37]-54, sep.-okt. 2008.
- Jana Laganis, Aleksandar Pečkov, Marko Debeljak, "Modeling radial growth increment of black alder (*Alnus glutinosa* (L.) Gaertn.) tree", In: *Proceedings of ICEM 2006, International Conference on Ecological Modelling, Mamaguchi, Japan: 28 August - 1 September 2006, Yamaguchi University, Japan*, (Ecological modeling, Vol. 215, no. 1/3, 2008), Amsterdam, Elsevier Scientific Publ. Co., 2008, issues 1-3, vol. 215, pp. 180-189, 2008.
- Nada Lavrač, Domen Jesenovec, Nejc Trdin, Neža Mramor Kosta, "Mining spatio-temporal data of traffic accidents and spatial pattern visualization", *Metodol. zv. (Tisk. izd.)*, vol. 5, no. 1, pp. 45-63, 2008.
- Aleksandar Pečkov, Sašo Džeroski, Ljupčo Todorovski, "A minimal description length scheme for polynomial regression", In: *Advances in knowledge discovery and data mining: 12th Pacific-Asia Conference, PAKDD 2008, Osaka, Japan, May 20-23, 2008: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, vol. 5012), Takashi Washio, ed., Berlin, New York, Springer, cop. 2008, vol. 5012, pp. 284-295, 2008.
- Ingrid Petrič, Tanja Urbančič, Bojan Cestnik, Marta Macedoni-Lukšič, "Literature mining method Rajolink for uncovering relations between biomedical concepts", *Journal of biomedical informatics*, 9 pp., Avg. 2008.
- Sandrine Pivard, Damjan Demšar, Jane Lecomte, Marko Debeljak, Sašo Džeroski, "Characterizing the presence of oilseed rape feral populations on field margins using machine learning", In: *Proceedings of The Fifth European Conference on Ecological Modelling ECEM 2005, Pushchino, Russia, September 19-23*, (Ecological modelling, Vol. 212, no. 1/2, 2008), Alexander S. Komarov, ed., Amsterdam, Elsevier Scientific Publ. Co., 2008, vol. 212, no. 1/2, pp. 147-154, 2008.
- Joël Plisson, Nada Lavrač, Dunja Mladenič, Tomaž Erjavec, "Ripple down rule learning for automated word lemmatisation", *AI commun.*, vol. 21, no. 1, pp. 15-26, 2008.
- Irena Srdanović Erjavec, Tomaž Erjavec, Adam Kilgarriff, "A web corpus and word skelches for Japanese", *Shizen gengo shori*, vol. 15, no. 2, pp. 137-159, 2008.
- Igor Trajkovski, Nada Lavrač, Jakub Tolar, "SEGS: search for enriched gene sets in microarray data", *Journal of biomedical informatics*, vol. 41, no. 4, pp. 588-601, 2008.
- Igor Trajkovski, Filip Železný, Nada Lavrač, Jakub Tolar, "Learning relational descriptions of differentially expressed gene groups", *IEEE trans. syst. man cybern., Part C Appl. rev.*, vol. 38, no. 1, spec. issue, pp. 16-25, 2008.
- Veronika Velenšek Prestor, Uroš Mazič, Ciril Kržišnik, Damjan Demšar, Janez Jazbec, Berta Jereb, "Cardiac damage after treatment of childhood cancer: a long-term follow-up", *BMC Cancer*, vol. 8, pp. 141-141-8, 2008.
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- Bernard Ženko, "Learning predictive clustering rules", *Informatica (Ljublj.)*, vol. 32, no. 1, pp. 95-96, 2008.
- Bernard Ženko, Sašo Džeroski, "Learning classification rules for multiple target attributes", In: *Advances in knowledge discovery and data mining: 12th Pacific-Asia Conference, PAKDD 2008, Osaka, Japan, May 20-23, 2008: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, vol. 5012), Takashi Washio, ed., Berlin, New York, Springer, cop. 2008, vol. 5012, pp. 454-465, 2008.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

- Luis Camarinha-Matos, Ana Ines Oliveira, Damjan Demšar, Michele Sesana, Arturo Molina, Fabiano Baldo, Toni Jarimo, "VO creation assistance services", In: *Methods and tools for collaborative networked organizations*, Luis Camarinha-Matos, ed., Hamideh Afsarmanesh, ed., Martin Ollus, ed., New York, Springer, 2008, pp. 155-189.
- Sašo Džeroski, "Data mining", In: *Encyclopedia of ecology*, Sven Erik Jørgensen, ed., Amsterdam, London, Elsevier, 2008, zv. 2, pp. 821-30.
- Toni Jarimo, Peter Ljubič, Jiří Hodík, Marko Bohanec, Nada Lavrač, "Multi-criteria partner selection in virtual organizations", In: *Encyclopedia of networked and virtual organizations*, Goran Putnik, ed., Hershey (PA) [etc.], Information Science Reference, cop. 2008, pp. 964-970.
- Dunja Mladenič, Nada Lavrač, "A European virtual enterprise on collaborative data mining and decision support", In: *Encyclopedia of networked and virtual organizations*, Goran Putnik, ed., Hershey (PA) [etc.], Information Science Reference, cop. 2008, pp. 524-529.
- Joël Plisson, Peter Ljubič, Igor Mozetič, Nada Lavrač, "Ontologies for collaborative networked organizations", In: *Encyclopedia of networked and virtual organizations*, Goran Putnik, ed., Hershey (PA) [etc.], Information Science Reference, cop. 2008, pp. 1128-1135.

- Martin Žnidaršič, Marko Bohanec, Blaž Zupan, "Data-driven revision of decision models", In: *Encyclopedia of data warehousing and mining. Volume II*, John Wang, ed., 2nd ed., Hershey, New York, Information Science Reference, 2008, pp. 617-623.

PUBLISHED CONFERENCE PAPERS

Invited Papers

- Sašo Džeroski, "Inductive process modeling for systems biology", In: *European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases, EMMIL/PKDD 2008: proceedings of Induction of process models, IPM'08, 15 September, 2008, Antwerp, Belgium*, Will Bridewell, ed., Toon Calder, ed., Ana Karla de Medeiros, ed., Stefan Kramer, ed., Mykola Pechenizkiy, ed., Ljupčo Todorovski, ed., [S. l., s. n.], 2008, pp. 3-4.

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- Darko Aleksovski, Martin Erwing, Sašo Džeroski, "A functional programming approach to distance-based machine learning", In: *Zbornik 11. mednarodne multikonference Informacijska družba - IS 2008, 13.-17. oktober 2008: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 161-165.
- Marko Bohanec, "Učenje in odločanje: analiza definicij osnovnih konceptov v Wikipediji z metodo analize besedil in omrežij", In: *Zbornik 11. mednarodne multikonference Informacijska družba - IS 2008, 13.-17. oktober 2008: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 305-308.
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- Jeroen de Bruin, Joost N. Kok, Nada Lavrač, Igor Trajkovski, "On the design of knowledge discovery services design patterns and their application in a use case implementation", In: *Third generation data mining: towards service-oriented knowledge discovery*, European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases, EMMIL/PKDD 2008, 15-19 September, 2008, Antwerp, Belgium, Nada Lavrač, ed., Joost N. Kok, ed., Jeroen de Bruin, ed., Vid Podpečan, ed., [S. l., s. n.], 2008, pp. 43-57.
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 27. Jan Rupnik, Miha Grčar, Tomaž Erjavec, "Improving morphosyntactic tagging of Slovene by tagger combination", In: *Zbornik Šeste konference Jezikovne tehnologije, 16. do 17. oktober 2008, Ljubljana, Slovenia: zbornik 11. mednarodne multikonference Informacijska družba - IS 2008, zvezek C: proceedings of the 11th International Multiconference Information Society - IS 2008, volume C*, (Informacijska družba), Tomaž Erjavec, ed., Jerneja Žganec Gros, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 110-115.
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TEXTBOOKS AND LECTURE NOTES

1. Nataša Atanasova, Marko Debeljak, Sašo Džeroski, Andrej Kobler, Boris Kompare, Ljupčo Todorovski, Bernard Ženko, *Analysis of environmental data with machine learning methods: Ljubljana, March 17-21, 2008. Part 2*, Ljubljana, Jožef Stefan Institute, Center for Knowledge Transper in Information Technology, 2008.
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THESES

B. Sc. Theses

1. Blaž Novak, *Odkrivanje tematik v zaporedju besedil in sledenje njihovim spremembam: diplomatska naloga*, Ljubljana, [B. Novak], 2008.
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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, evolutionary computing, data mining, search algorithms, language and speech technologies, decision support, intelligent sensors, distributed supervisory systems and network services. The department collaborates closely with the Faculty of Computer and Information Science of the University of Ljubljana on the joint research programme "Artificial Intelligence and Intelligent Systems", led by Prof. Ivan Bratko.



Head:
Prof. Matjaž Gams

Intelligent systems simulate intelligence so that a typical user seemingly perceives them as truly intelligent. In reality, these systems use complex mechanisms and implement them on digital computers to imitate human behaviour as well as possible, and combine them with raw, exponentially growing computer power.

Ambient intelligence is a relatively new research area. It aims at introducing technology into our everyday environment in a friendly and unobtrusive way, making it usable without special knowledge. Due to the rapid aging of the population, one of the area's main goals is care for the elderly. The department has been developing methods for posture and movement recognition with an emphasis on fall detection. We were also investigating the recognition of common patterns of behaviour in general. To do this, we first needed to tackle the problem of the representation of human motion. The purpose of this research is the recognition of unusual events, be it signs of health problems or security threats.

Evolutionary computing deals with theoretical research, design and applications of search and optimization algorithms inspired by biological evolution. Our work in this area included the development and analysis of evolutionary algorithms for solving two demanding problems: the construction of markers for the production of clothes and vehicle assignment in cargo transportation. In the first problem, a sequence of markers needs to be found such that the production costs are as low as possible. In real problems the developed algorithm outperforms the algorithms used in practice up until now. The algorithm and its empirical evaluation were presented in the journal *Engineering Applications of Artificial Intelligence*. In the second problem, cargo of various types and amounts has to be transported between two sites, and the task is to assign cargo, loading positions at the origin, and unloading positions at the destination to the vehicles of various capacities in such a way that the total transportation time is minimised. The current version of our evolutionary algorithm improves the results of an available greedy heuristic algorithm for several problem instances, and we plan further improvements of its vehicle-assignment strategies.

Using **data-mining** techniques we tackled two tasks: genre identification and modelling of a tablet-manufacturing process. As part of a doctoral research in automatic web-genre identification, we used style-based categorization to identify genres of web pages. The impact of various types of features on the quality of identification was explored. Results showed that complex features - concepts - can be beneficial. We continued our research on an analysis of a pharmaceutical tablet-manufacturing process. For this purpose we developed a new method for process analysis. The method was successfully implemented on the data from the tablet-manufacturing process. We also developed an application for process visualization and modelling. The application contributed to a better understanding of the manufacturing process and achieving a higher quality for the produced tablets.

We study **search algorithms** for path-finding and other applications. We explained many cases of pathological behaviour of these

We have been developing an intelligent system for the surveillance of the movement of personnel and equipment in buildings that require high security. The project is called "Commander's Right Hand" and is financed as a Targeted Research Project by the research program "Science for Security and Peace 2006-2010".

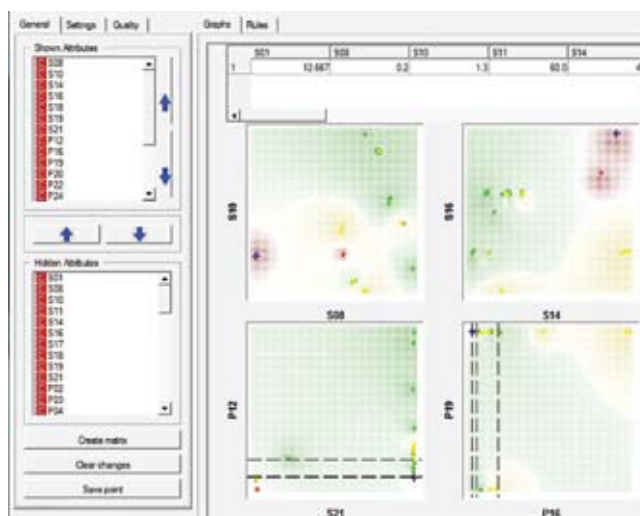


Figure 1: We have developed an application for the visualization and modelling of a pill-manufacturing process. It uses machine learning to achieve a high-quality product.

The European project Confidence aims at helping the elderly stay independent for longer at home and providing them with a better quality of life. The system is based on new, ambient intelligence methods and tags attached to the ankles. With this unobtrusive surveillance, the system can detect falls or illnesses and call for help.



Figure 2: The intelligent virtual assistant answers inquiries about the Jožef Stefan Institute on the web page www.ijs.si.

In collaboration with the companies INEA, Elektro Ljubljana and Količevo Karton we carried out the project "Development of an e-service for power flow optimization in the distribution network by adaptable power consumption and power generation" (OPEDiOm). The service supports coordinated actions to reduce the gaps between the predicted and the actual power consumptions.

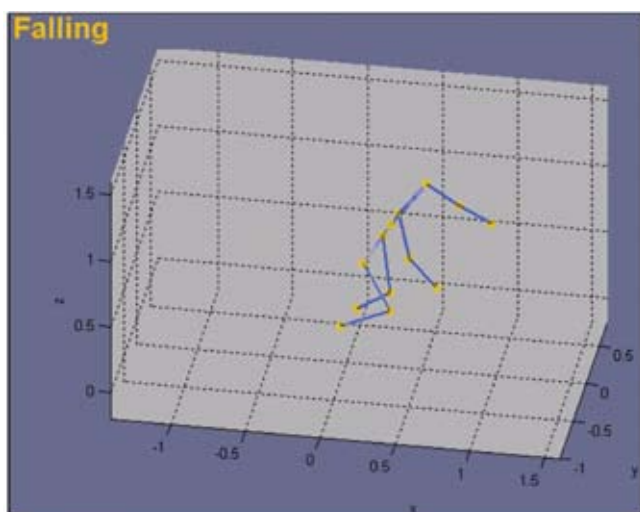


Figure 4: Visualization of the detection of a falling person, using the system for prolonging the independency of the elderly.

algorithms, i.e., achieving worse results at a greater search depth. We also identified several factors that influence the benefits of a deeper search. For path-finding algorithms we developed methods for the automatic selection of the optimal search depth and waypoints.

In the field of **speech and language technologies** we deal with speech synthesis, forensic speaker recognition and syntactic parsing. In cooperation with the Amebis company, a new speech synthesizer for Slovene has been developed. In speaker recognition the influence of the sound quality transmitted over phone lines on biometric/forensic speaker recognition has been studied. During syntactic parsing, standard algorithms have been

upgraded and adapted for Slovene. Into the process of parsing, clause and intra-clausal identification were included to decompose complex sentences into smaller, more easily manageable parts. With the upgrade, the parsing accuracy for Slovene has been increased.

The EU 7FP project **Confidence** intends to extend the independent living of the elderly by increasing their security at home and outdoors. Confidence users will wear a number of tags on their bodies. The locations of the tags will be detected by radio sensors, and from these locations, body posture and movement will be reconstructed. This will make it possible to detect falls, which are one of the main reasons for nursing-home admissions. Changes in behaviour that may indicate a disease or a similar problem will also be detected.

We have been developing an intelligent system for the surveillance of movement of personnel and equipment in buildings that require high security. This work is performed in collaboration with the Špica International company and the Faculty of Electrical Engineering, University of Ljubljana. The project is called "**Commanders Right Hand**" and is financed as a Targeted Research Project by the research program "Science for Security and Peace 2006–2010". The key novelty of the system is its ability to distinguish between usual and unusual (suspicious) behaviour based on patterns seen by the system in the past and directions and rules provided by the user. The system learns and adapts to the observed behaviour while notifying the user about unusual situations, such as thefts, infiltration, staff negligence and insubordination, etc. The system offers a suitable level of alarm, live video, graphical explanation and messages in natural language, describing the reason(s) for the alarm. We also implemented an applied version of the intelligent system developed in the successfully

concluded research project "**CIVaBiS**". It enables the intelligent control of people's movement in a building. The system will be marketed by the Špica International company.

In collaboration with the companies INEA, Elektro Ljubljana and Količevo Karton we carried out the project "**Development of an e-service for power flow optimization in the distribution network by adaptable power consumption and power generation**" (OPEDiOm). The project is funded by the Ministry of Higher Education, Science and Technology of the Republic of Slovenia, and the European Regional Development Fund. The result of the project is a prototype implementation of an innovative e-service intended for power distributors and industrial consumers. It supports coordinated actions to reduce the gaps between predicted and actual power consumption.

Within the "**Intelligent Home Telekom**" project we have developed a universal virtual interface for interactive user communications in various services and applications of the national telecom operator Telekom Slovenije. The virtual interface is implemented in a web-based intelligent conversational robot prototype and is experimentally available on the Jožef Stefan Institute's web page at <http://www.ijs.si>. The conversational robot interactively answers visitors' questions in natural language. The main advantage of our virtual user interface over similar commercially available applications is its adaptability for quick implementation in various applications where any kind of user interaction takes place, such as television, telemedicine, technical support help desks, web portals, etc.

A traditional activity of the Department of Intelligent Systems is the **organization of the International Multiconference Information Society**. In October 2008, the 11th multiconference was held in Ljubljana, consisting of eight independent conferences.

Some outstanding publications in the past three years

1. I. Fister, M. Mernik, B. Filipič, Optimization of markers in clothing industry, *Engineering Applications of Artificial Intelligence*, 21 (2008), 669–678
2. A. Pivk, P. Cimiano, Y. Sure, M. Gams, V. Rajkovič, R. Studer, Transforming arbitrary tables into logical form with TARTAR, *Data & Knowledge Engineering*, 60 (2007), 567–595
3. M. Možina, J. Žabkar, I. Bratko, Argument based machine learning, *Artificial intelligence*, 171 (2007), 922–937
4. A. Bratko, G. V. Cormack, B. Filipič, T. R. Lynam, B. Zupan, Spam filtering using statistical data compression models, *Journal of Machine Learning Research*, 7 (2006), 2673–2698
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Awards and appointments

1. Jožef Stefan Institute and Špica International d. o. o: Award for placement among 30 selected innovations in 2008, Ljubljana, 3. Slovenian Forum of Innovations, Public Agency of the Republic of Slovenia for Entrepreneurship and Foreign Investments, Innovation “Device for intelligent entry control”.
2. Boštjan Kaluža: Faculty Prešeren award, Faculty of Computer and Information Science, Ljubljana, Bachelor thesis: Analysis of pathological models of minimax and Pearl’s game.

Organization of conferences, congress and meetings

1. 11th Workshop “Nature-Inspired Algorithms”, Jožef Stefan Institute, Ljubljana, Slovenia, 17 Jun. 2008
2. 11th International Multiconference Information Society IS 2008; independent conferences:
 - Intelligent Systems
 - Data Mining and Data Warehouses
 - Cognitive Sciences
 - Slovenian Demographic Challenges of the 21st Century
 - Collaboration, Software and Services in Information Society
 - Education in Information Society
 - BIOMA 2008 – The 3rd International Conference on Bioinspired Optimization Methods and their Applications
 - Language Technologies
 Jožef Stefan Institute, Ljubljana, 13–17 Oct. 2008
3. Meeting of the European FW7 project Confidence, Jožef Stefan Institute, Ljubljana, 13–14 Nov. 2008

We participate in the European project WeGo, aimed at promoting e-government services, thus joining the efforts of the Western Balkan countries towards an easier transition into the European Union. Major applied projects are conducted for the Tax Administration of the Republic of Slovenia, Telekom Slovenije, and the Ministry of Defence of the Republic of Slovenia.

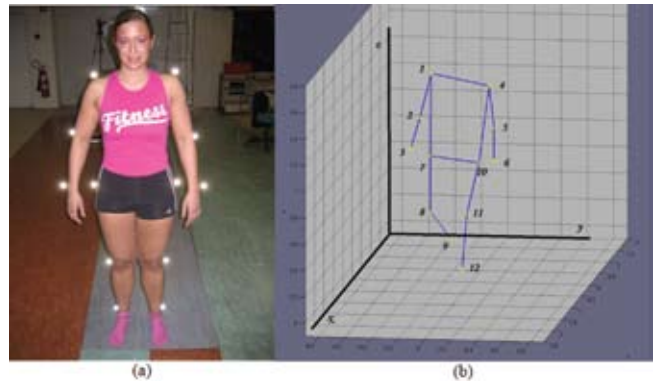


Figure 4: Placement of tags on the body (a) and visualization of the tags on the computer screen (b) of the system for prolonging the independence of the elderly, which we developed in the FP7 project Confidence and other research studies in the field of ambient intelligence. The methods that we develop, automatically and in real time detect falls and other health-related changes in the behaviour of the elderly, using the locations of tags on the body of the elderly.

INTERNATIONAL PROJECTS

1. Ubiquitous Care System to Support Independent Living
CONFIDENCE
7. FP, 214986
EC; Centro de Estudios e Investigaciones Tecnicas de Guipuzcoa, San Sebastian, Spain
Prof. Matjaž Gams, Prof. Leon Zlajpah
2. Enhancing Western Balkan eGovernment Expertise
We-Go
6. FP, 045472
EC; Dr. Klaus Josef Gschwendtner, ARC Seibersdorf Research GmbH, Vienna, Austria
Prof. Matjaž Gams
3. New Methods for Automatic Identification Based on Intelligent Devices and Intelligent Agents –IntelliDAM
BI-RO/08-09/0015
Dr. Vlad Madalin Stefan, Faculty of Automatic Control and Computer Science, University Politehnica, Bucharest, Romania
Prof. Matjaž Gams

R & D GRANTS AND CONTRACTS

1. Forensic Speaker Identification
Dr. Tomaž Šef
2. Intelligent home Telekom
Prof. Matjaž Gams
3. The role of Luka Koper in logistic support of the Slovenian Armed Forces and allies
Asst. Prof. Bogdan Filipič
4. AuID: Audio Visual IDentification and Detection of Speaker Credibility to Give an Assurance of Secure Communication
Dr. Tomaž Šef
5. Commanders right hand
Prof. Matjaž Gams
6. Knowledge technology and decision support in medical information portals
Prof. Matjaž Gams

7. Knowledge technology and decision support in medical information portals
Prof. Matjaž Gams
8. MEANING: Semantic analyser (for Slovenian language): POMEN
Dr. Tomaž Šef
9. Development of an e-service for power flow optimization in the distribution network by adaptable power consumption and power generation: OPEDIOM
Asst. prof. Bogdan Filipič

RESEARCH PROGRAM

1. Artificial Intelligence and Intelligent Systems
Prof. Matjaž Gams

NEW CONTRACTS

1. Intelligent home Telekom
Telekom Slovenije, d. d., Ljubljana
Prof. Matjaž Gams
2. Intelligent home Telekom
Telekom Slovenije, d. d., Ljubljana
Prof. Matjaž Gams
3. A prototype application of Slovenian text to speech system GOVOREC
Src.si, d. o. o., Ljubljana
Prof. Matjaž Gams

VISITORS FROM ABROAD

1. Prof. Veljko Milutinović, Faculty of Electrical Engineering, University of Belgrade, Serbia, 2-4 Apr. 2008
2. Bojana Milasinović, Faculty of Electrical Engineering, University of Belgrade, Serbia, 15 Jun. 2008
3. Prof. dr. Kalyanmoy Deb, Helsinki School of Economics, Faculty of Business Tehnology, Helsinki, Finland, 12-14 Oct. 2008
4. Dr. Tanja Schultz, Carnegie Mellon University, Pittsburgh, USA 15-17 Oct. 2008
5. Dr. Marco Baroni, Center for Mind/Brain Sciences, University of Trento, Trento, Italy, 15-18 Oct. 2008
6. Martin Doolan, Lancon d. o. o., Zagreb, Croatia, 19-22 Oct. 2008
7. Carlos Canto, Ikerlan, Arrasate-Mondragón, Spain, 13 Nov. 2008
8. Iñaki Val, Ikerlan, Arrasate-Mondragón, Spain, 13 Nov. 2008
9. Dr. Igone Vélez, Centro de Estudios e Investigaciones Técnicas de Gipuzkoa, San Sebastián, Spain, 13-14 Nov. 2008
10. Naiara Arrue, Centro de Estudios e Investigaciones Técnicas de Gipuzkoa, San Sebastián, Spain, 13-14 Nov. 2008
11. Dr. Michal Pietrzyk, Fraunhofer Institute for Integrated Circuits IIS, Erlangen, Germany, 13-14 Nov. 2008
12. Dr. Matthias Schaefer, Fraunhofer Institute for Integrated Circuits IIS, Erlangen, Germany, 13-14 Nov. 2008
13. Kristina Larsson, Umeå Municipality, Umea, Sweden, 13-14 Nov. 2008
14. Eva Bergstrom, Umeå Municipality, Umea, Sweden, 13-14 Nov. 2008
15. Dr. Claudio Sdogati, COOSS Marche Onlus, Ancona, Italy, 13-14 Nov. 2008
16. Dr. Narciso González Vega, University of Jyväskylä, Jyväskylä, Finland, 13-14 Nov. 2008
17. Stephane Gomes, eDevice, Mérignac, France, 13-14 Nov. 2008
18. Stefan Gonnet, eDevice, Mérignac, France, 13-14 Nov. 2008
19. Patrik Karlsson, ZENON S.A. Robotics & Informatics, Athens, Greece, 13-14 Nov. 2008

STAFF

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3. **Prof. Matjaž Gams, Head**
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7. Dr. Aleš Dobnikar*
8. Dr. Matija Drobnič*
9. Dr. Mitja Luštrek
10. Dr. Aleksander Pivk*

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11. Andrej Bratko*, B. Sc.
12. Erik Dovgan, B. Sc.
13. Boštjan Kaluža, B. Sc.
14. Dr. Domen Marinčič

15. Matej Ožek, M. Sc.
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18. Tea Tušar, M. Sc.

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20. Dr. France Dacar
21. Mitja Kolbe*, B. Sc.
22. Gašper Pintarič*, B. Sc.
23. Peter Reinhardt*, B. Sc.

Technical and administrative staff

24. Liljana Lasič
25. Mitja Lasič

Note:

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BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Vadim Bulitko, Mitja Luštrek, Jonathan Schaeffer, Yngvi Björnsson, Sverrir Sigmundarson, "Dynamic control in real-time heuristic search", *J. artif. intell. res. (Print)*, vol. 32, pp. 419-452, maj-avg. 2008.
2. Andreja Cundrič, Tomaž Kern, Vladislav Rajkovič, "A qualitative model for road investment appraisal", *Transp. policy (Oxf)*, vol. 15, no. 4, pp. 225-231, jul. 2008.
3. Iztok Fister, Marjan Mernik, Bogdan Filipič, "Optimization of markers in clothing industry", *Eng. appl. artif. intell.*, vol. 21, no. 4, pp. 669-678, 2008.
4. Matjaž Gams, Jana Krivec, "Demographic analysis of fertility using data mining tools", *Informatica (Ljublj.)*, vol. 32, no. 2, pp. 147-156, 2008.
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9. Gregor Leban, Jure Žabkar, Ivan Bratko, "An experiment in robot discovery with ILP", In: *Inductive logic programming: 18th International Conference, ILP 2008, Prague, Czech Republic, September 10-12, 2008: proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, LNAI 5194), 18th International Conference, ILP 2008, Prague, Czech Republic, September 2008, Filip Zelezny, ed., Nada Lavrač, ed., Berlin, Heidelberg, New York, Springer, cop. 2008, pp. 77-90.
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2. Gregor Leban, Minca Mramor, Blaž Zupan, Janez Demšar, Ivan Bratko, "Finding patterns in class-labeled data using data visualization", In: *Data mining patterns: new methods and applications*, Pascal Poncelet, ed., Maguelonne Teisseire, ed., Florent Masseglia, ed., Hershey, New York, Information Science Reference, cop. 2008, pp. 106-123.

PUBLISHED CONFERENCE PAPERS

Regular papers

1. Robert Blatnik, "Inteligentni vodniki po TV programih", In: *Zbornik 11. mednarodne multikonference Informacijska družba - IS 2008, 13.-17. oktober 2008: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 7-10.
2. Robert Blatnik, Tomaž Šef, "Meritve kakovosti zvoka v telefoniji za verifikacijo govorcev v forenzične namene", In: *Zbornik 11. mednarodne multikonference Informacijska družba - IS 2008, 13.-17. oktober 2008: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 53-56.
3. Borut Čampelj, Vladislav Rajkovič, "Primer indikatorjev za (samo)evalvacijo e-kompetentnosti šole", In: *Mednarodna konferenca Splet izobraževanja in raziskovanja z IKT, SIRIKT 2008, Kranjska Gora, 16.-19. april 2008*, Mojca Orel, ed., Ljubljana, Arnes, 2008, pp. 134-142.
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17. Dejan Hrnčič, Bogdan Filipič, Marjan Mernik, "Uglaševanje parametrov rotacijskega gozda in klasifikatorjev v paketu Weka z genetskim algoritmom", In: *Zbornik sedemnajste mednarodne Elektrotehniške in računalniške konference ERK 2008, 29. september - 1. oktober 2008, Portorož, Slovenija*, (Zbornik ... Elektrotehniške in računalniške konference ERK ...), Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2008, zv. B, pp. 111-114.
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- 19.-21. marec 2008, Vladislav Rajkovič, ed., Eva Jereb, ed., Tomaž Kern, ed., Mirosljub Kljajič, ed., Milan Pagon, ed., Goran Vukovič, ed., Kranj, Moderna organizacija, 2008, pp. 1238-1254.
24. Jana Krivec, Matjaž Gams, "Računalniški sistemi za avtomatski dialog", In: *Zbornik 11. mednarodne multikonference Informacijska družba - IS 2008, 13.-17. oktober 2008: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenič, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 26-29.
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- Ivan Bratko, Sašo Džeroski, *Analysis of environmental data with machine learning methods: Ljubljana, March 17-21, 2008. Part 1*, Ljubljana, Jožef Stefan Institute, Center for Knowledge Transfer in Information Technology, 2008.

THESES

Ph. D. Thesis

- Domen Marinčič, *Strojno razčlenjevanje besedila z iskanjem stavkov in naštevanj: doktorska disertacija: doctoral dissertation*, Ljubljana, [D. Marinčič], 2008.

M. Sc. Thesis

- Matej Ožek, *Numerične metode za redukcijo modela: magistrsko delo*, Ljubljana, [M. Ožek], 2008.

PATENT APPLICATION

- Matjaž Gams, Tea Tušar, Andrija Pušič, Mitja Kolbe, *Procedure and device for intelligent entry control: patent application P-200800160*, Ljubljana, Urad RS za intelektualno lastnino, 2008.

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 of the research activities are part of international cooperation programs. The research results are incorporated into projects for industry and for regulatory authorities, and in graduate studies programmes.

Modelling of basic thermal-hydrodynamic phenomena

In the field of fluid mechanics and heattransfer research, the computer codes NEPTUNE_CFD and CFX were used to analyze inter-phase heat, mass, and momentum transfer in a horizontally stratified flow of cold liquid and hot steam. The emphasis of the work was on the NEPTUNE_CFD code, which is being specially developed for multi-dimensional simulations of two-phase flow in nuclear facilities. A horizontal pipe filled with hot steam and flooded with a cold liquid, and a horizontal pipe partially filled with a cold liquid with an injection of hot steam were described. The activities were part of the EU 6FP project NURESIM, which will continue in 2009 within the new 7FP project NURISP.

Research activities were carried out for the post-ITER generation of fusion reactors in cooperation with Forschungszentrum Karlsruhe (Germany) within the frame of the European Fusion Development Association (EFDA). The design of a helium-cooled divertor was optimized using computational fluid dynamics. The heat transfer characteristics and pressure drop were analysed and compared with experimental data.

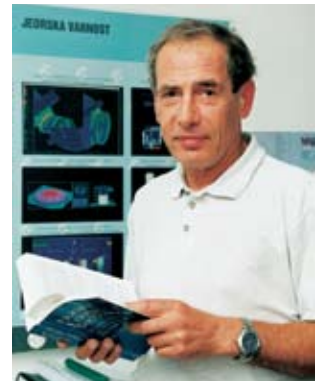
In the field of research on water-hammer transients, the computer code WAHA, which was developed within the EU 5FP project WAHALoads, has been upgraded. The following new models were tested: the valve model, the unsteady friction model and the boundary conditions with a time dependent state at the inlet or outlet of the pipe.

A steam explosion might occur during a hypothetical severe accident in a nuclear plant if the molten reactor core were to pour into the water in the reactor cavity. Within the OECD project SERENA, where we are leading the analytical activities, we performed comprehensive pre-test calculations of the first two steam-explosion tests with the European code MC3D. The experiments are being performed on the complementary KROTOS (Commissariat à l'Énergie Atomique - CEA, France) and TROI (Korea Atomic Energy Research Institute) facilities. The main purpose of the pre-test calculations was to establish the optimal water subcooling and the optimal triggering time, maximizing the steam-explosion strength. We have also been developing appropriate melt droplets solidification models and the corresponding melt-droplets fragmentation criteria. These activities are being carried out within the EU 6FP SARNET Network of Excellence.

Thermal-hydraulic safety analyses

Best-estimate calculations with the RELAP5/MOD3.3 thermal-hydraulic computer code were performed to estimate the operator-action success criteria time windows. The time windows were needed for an updated human-reliability analysis for events in which human actions are supplemented to safety systems actuations. These were small or medium loss of coolant accidents (LOCAs) requiring a manual auxiliary feedwater (AFW) start, a loss of normal feedwater requiring an AFW start, and a LOCA requiring manual actuation of the safety injection.

An animation model of the Krško nuclear power plant was developed using SNAP, which is a suite of integrated applications designed to simplify safety analyses. The model allows a better understanding of the simulated physical phenomena and processes during an accident, and represents a useful tool for training new users of thermal-hydraulic codes.



Head:
Prof. Borut Mavko

We have simulated an experiment of containment-atmosphere stratification break up using sprays.

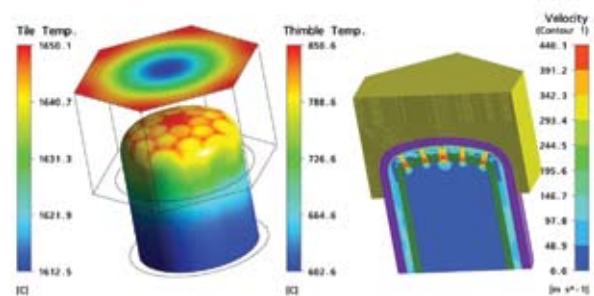


Figure 1: Numerical simulations of helium-cooled divertor: Left: temperature field of structures Right: velocity field of helium

Multi-scale simulations are used to predict the propagation of short cracks in polycrystalline materials.

In the field of modelling containment phenomena, which is also being carried within the SARNET network, simulations of experiments on containment sprays, performed on the TOSQAN facility at the Institut de Radioprotection et de Sureté Nucléaire, France, with the Computational Fluid Dynamics code CFX, have been concluded. The emphasis was on the experiment TOSQAN 113 on atmosphere stratification break up. A

blowdown experiment, which was performed in the Marviken Boiling Water Reactor containment experimental facility in Sweden, was simulated with the codes CONTAIN and ASTEC CPA.

Structural safety analyses

The long term research focus is the development of multi-scale computational simulation tools for polycrystalline metallic materials. An advanced constitutive model of crystal plasticity is combined with random grain sizes and shapes, represented by the Voronoi tessellation. The microscopic stress fields in randomly oriented and shaped grains are then obtained using the finite-element solver ABAQUS.

In 2008 we began the development of physical grain structures, based on experimental data. The purpose of the research is the development of computer models and codes for the prediction of intergranular crack initialization and growth. The spatial structure of grains is obtained using the diffraction-contrast tomography method, which has been developed together by the University of Manchester, UK, and the European Synchrotron Radiation Facility. Grain shapes must first be reconstructed from experimental data. The influence of the grain structure on the behaviour of the material is then estimated using the finite-element method. The crystallographic orientation and anisotropic behaviour of the grains are taken into account. Also, the development of three-dimensional models of aggregates was started in cooperation with CEA, France. These models will enable us to obtain a more complete picture of the influence of the microstructure on short cracks.

A method for the realistic estimation of the use of nuclear-power-plant components was conceived in 2008. The method can be used to support a possible life-time extension of the Krško nuclear power plant.

The list of research partners includes the EU Joint Research Center in Petten, The Netherlands; Forschungszentrum Karlsruhe, Germany; and

AIB-Vinçotte Nucléaire, Belgium. We are also members of the EU Network of Excellence on nuclear-plant lifetime prediction NULIFE.

Probabilistic safety assessment

Models for the probabilistic safety assessment of nuclear power plants were developed for modes other than full power operation; these include low-power operation mode, hot-standby mode and hot-shutdown mode. The results enable a more detailed assessment of nuclear power plant safety.

A procedure for the assessment of ageing and its application within probabilistic safety assessment models was developed. Probabilistic models that are based on a constant failure rate were modified, based on models that may include the time dependent increase of the failure rate as a consequence of ageing. The problem in new models is the large uncertainty of the results, which is caused by a lack of the necessary input data.

The new method for the assessment of power system reliability was investigated in two case studies: the standard IEEE (Institute of Electrical and Electronics Engineers) test problem and the Slovenian transmission power system. Both studies included an assessment of power-system reliability, its sensitivity to changes such as the insertion of new power lines or the addition of new power plants or both, and the contribution of power system reliability to the safety of nuclear power plants included in the system.

Technical cooperation, consulting services and education

In 2008 the Reactor Engineering Department researchers also cooperated in projects for industry and the state administration. The JSI issues permissions for recriticality and the regular operation of the Krško NPP after each regular outage. Members of the department are also actively involved in the Nuclear Engineering Graduate Programme at the Faculty of Mathematics and Physics at the University of Ljubljana. The programme is associated with the European Nuclear Education Network (ENEN) and the European project ENEN-II.

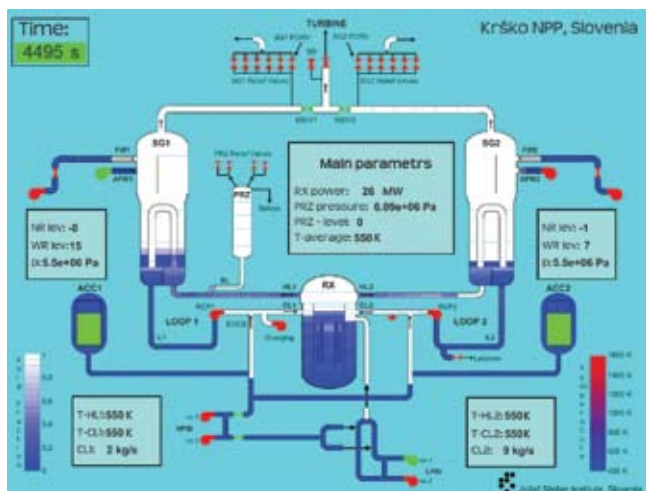


Figure 2: Krško nuclear power plant animation model for displaying thermal-hydraulic simulations

Models for the probabilistic safety assessment of a nuclear power plant were developed for modes other than full-power operation.

Some outstanding publications in the past three years:

1. L. Cizelj, B. Končar, M. Leskovar, Vulnerability of a partially flooded PWR reactor cavity to a steam explosion, *Nuclear Engineering and Design* 236 (2006) 1617-1627
2. I. Simonovski, L. Cizelj, The influence of grains' crystallographic orientations on advancing short crack, *International Journal of Fatigue* 29 (2007) 2005-2014
3. M. Babić, I. Kljenak, B. Mavko, Prediction of light gas distribution in experimental containment facilities using the CFX4 code, *Nuclear Engineering and Design* 238 (2008) 538-550
4. A. Prošek, M. Leskovar, B. Mavko, Quantitative assessment with improved fast Fourier transform based method by signal mirroring, *Nuclear Engineering and Design* 238 (2008) 2668-2677
5. J. Gale, I. Tiselj, Godunov's method for simulations of fluid-structure interaction in piping systems, *Journal of Pressure Vessel Technology* 130 (2008) 031304-1-031304-12
6. B. Končar, E. Krepper, CFD simulation of convective flow boiling of refrigerant in a vertical annulus, *Nuclear Engineering and Design* 238 (2008) 693-706
7. M. Čepin, DEPEND-HRA-A method for consideration of dependency in human reliability analysis, *Reliability Engineering and Systems Safety* 93 (2008) 1452-1460

Organization of conferences, congress and meetings

1. SARNET Annual Review Meeting, Bled, 21–25 Jan. 2008
2. SARNET Containment Atmosphere Mixing 5th Workshop, Bled, 28–29 Feb. 2008
3. SARNET Governing Board Meeting, Bled, 14 Mar. 2008
4. Analytical Working Group Meeting of the OECD/NEA SERENA Project, Ljubljana, 4 Jun. 2008

INTERNATIONAL PROJECTS

1. BK - Fusion - Modelling of High Flux Helium Cooling - Divertor Design - 4.5.1.
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Dr. Boštjan Končar
2. Consolidation of European Nuclear Education, Training and Knowledge Management
ENEN-II
6. FP - EURATOM
036414
EC; Dr. Peter De Regge, ENEN Association, Centre CEA de Saclay, Gif-sur-Yvette, France
Prof. Leon Cizelj
3. Sustainable Nuclear Fission Technology Platform
SNF-TP
6. FP, 036410
EC; Prof. Dan G. Cacuci, CEA Saclay, DEN/DIR, Gif-sur-Yvette; Paris, France
Prof. Borut Mavko
4. Nuclear Plant Life Prediction
NULIFE
6. FP, 036412
EC; Valton Teknillinen Tutkimuskeskus (VTT), Espoo, Finland
Prof. Leon Cizelj
5. European Platform for Nuclear Reactor Simulations
NURESIM
6. FP, 516560
EC; Maryline Rougier, CEA Saclay, DEN/DSOE, Gif-Sur-Yvette, France
Prof. Iztok Tiselj
6. Network of Excellence for Sustainable Integration of European Research on Severe
Accident Phenomenology and Management
SARNET
6. FP, FIGO-CT-2004-509065
EC; Institut de Radioprotection et de Surete Nucleaire, Clamart, France
Dr. Matjaž Leskovar
7. Full Condensation-Induced Water Hammer in Vertical Vessels
INTAS
Ref. No.: 05-1000008-8086
INTAS - International Association for the promotion of co-operation with scientists
from the New Independent States of the former Soviet Union, Brussels, Belgium; Prof.
Francesco D'Auria, Dr. A. Bousbia Salah, University of PISA, Facoltà di Ingegneria,
Dipartimento di Ingegneria Nucleare Meccanica e della Produzione (DIMNP), Pisa, Italy
Prof. Iztok Tiselj
8. Steam Explosion Resolution for Nuclear Applications
SERENA
OECD/NEA
Jean Gauvain, OECD Nuclear Energy Agency, Issy-les-Moulineaux, France
Dr. Matjaž Leskovar
9. SETH-2 Project to Resolve Key Computational Issues for the Simulation of Thermal-
Hydraulic Conditions in Water Reactor Containments
SETH-2
OECD/NEA
Jean Gauvain, OECD Nuclear Energy Agency, Issy-les-Moulineaux, France
Prof. Borut Mavko, Dr. Ivo Kljenak
10. Code Applications and Maintenance Program (CAMP) Thermal-Hydraulic Code
Applications and Maintenance International Research Project
Dr. Andrew J. Szukiewicz, Reactor and Plant Systems Branch, Division of Systems
Technology, Office of Nuclear Regulatory Research; Dr. Ashok C. Thadani, Donna-
Maria Perez, Office of Nuclear Regulatory Research, United States Nuclear Regulatory
Commission (US NRC), Washington, USA
Prof. Borut Mavko
11. PHEBUS Fission Products Agreement
SLO-F-2003-2008
Daniel Queniat, Acting Director, Institut de Radioprotection et de Surete Nucleaire
(IRSN), Clamart, France
Dr. Matjaž Leskovar
12. Incorporation of Age-dependent Reliability Parameters and Data into Probabilistic
Safety Assessment Models
IE.B104899
Sylvia Zamana, European Commission-Directorate General JRC, Institute for Energy,
Petten, The Netherlands
Asst. Prof. Marko Čepin
13. Modelling of Intergranular Damage in Polycrystalline Metals
BI-GB/08-010
The University of Manchester, Department of Materials Performance Centre, School of
Materials, Manchester, Great Britain
Dr. Igor Simonovski

R & D GRANTS AND CONTRACTS

1. Direct Contact Condensation in Stratified Two-Phase Flow
Prof. Iztok Tiselj
2. Multiscale model of Small Crack Initialization and Propagation in Pressure Boundary
Components of a NPP
Dr. Igor Simonovski

3. Modeling of Fluid Transport in Nanotubes
Dr. Ivo Kljenak
4. Simulations of Two-phase Thermohydraulic Phenomena in Nuclear Engineering by Computational Fluid Dynamics Methods
Dr. Boštjan Končar
5. Application of methods and techniques to assess ageing and support safe operation of nuclear installations and radiation facilities
Prof. Leon Cizelj
6. Improvement of Nuclear Safety with the Probabilistic Safety Assessment
Asst. Prof. Marko Tomaž Čepin
7. Strategic Role of Nuclear Power Production in Comparison with other Sources and Impact on the Slovenian Economy
Dr. Miloš Pantoš, Asst. Prof. Marko Tomaž Čepin
8. Development of Knowledge Indispensable for Evaluation, Assessment and Surveillance of Ageing Management in Nuclear Facilities
Prof. Leon Cizelj
9. Conception of a Method for Monitoring of the Usage of NPP Components
Dr. Boštjan Zafošnik
10. Use of CFD approach for safety analysis of nuclear reactor systems
Dr. Boštjan Končar
11. Simulation of MISTRA containment tests with computational fluid dynamics and lumped-parameter codes
Dr. Ivo Kljenak

12. Prediction of ex-vessel steam explosion pressure loads in reactor cavity
Dr. Matjaž Leskovar
13. The influence on microstructural features on the short cracks
Dr. Igor Simonovski
14. Influence of melt droplets solidification on steam explosion
Dr. Matjaž Leskovar

RESEARCH PROGRAM

1. Nuclear engineering
Prof. Borut Mavko

NEW CONTRACT

1. Cooperation in the international research program CAMP (Code Applications and Maintenance Program)
Ministry of the Environment and Spatial Planning, Slovenian Nuclear Safety Administration, Ljubljana
Dr. Andrej Prošek

VISITORS FROM ABROAD

1. Dr. Yuriy Parfenov, Electrogorsk Research and Engineering Centre of NPPs Safety, Moscow, Russia, 9-23 Jan. 2008
2. Prof. dr. Michel Giot, Université Catholique de Louvain, Belgium, 19-20 Jun. 2008

3. Dr. Andrej Rodionov, JRC, Petten, The Netherlands, 25-26 Aug. 2008
4. Dr. Mark Reinhart, International Atomic Energy Agency, Vienna, Austria, 15-19 Sept. 2008
5. Prof. dr. Sandro Paci, University of Pisa, Italy, 6-8 Oct. 2008
6. Prof. dr. Anton Čauševski, University of Skopje, Macedonia, 18-21 Dec. 2008

STAFF

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21. Tanja Klopčič
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Note:

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ORIGINAL ARTICLES

1. Miroslav Babič, Ivo Kljenak, Borut Mavko, "Prediction of light gas distribution in experimental containment facilities using the CFX4 code", *Nucl. Eng. Des.*, vol. 238, no. 3, pp. 538-550, 2008.
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9. Stanislav Pehan, Janez Kramberger, Jože Flašker, Boštjan Zafošnik, "Investigation of crack propagation scatter in a gear tooth's root", *Eng. fract. mech.*, vol. 75, iss. 5, pp. 1266-1283, Mar. 2008.
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REACTOR INFRASTRUCTURE CENTRE

RIC

The TRIGA Mark II Reactor at the Jožef Stefan Institute has been operating since 1966. It is used for neutron research, training and for producing radioactive isotopes. Besides operating and maintaining the reactor, the members of the reactor's staff cooperate in other activities requiring specialists skilled in working with sources of radiation and in reactor technology, such as the servicing of industrial radioactive sources and the surveillance of the fuel management in NPP Krško. A detailed technical description of the reactor is available at <http://www.rcp.ijs.si/~ric/>



Head:
Prof. Matjaž Ravnik

In 2008 the reactor operated for 128 days. A total of 1295 samples were irradiated: 1071 of them in the rotary specimen rack and 224 in the pneumatic post system.

The reactor mainly operated in steady-state mode. There were no serious operational problems or events influencing nuclear or radiological safety. The reactor operators performed regular maintenance inspections and works according to the annual plan.

The Hot Cell Laboratories, mainly used for work with strong radioactive sources, were formally included in the reactor as a nuclear installation by the decree of the SNSA. The maintenance work in the hot cells was continued and accomplished in the first half of 2008. The operating license was issued by the SNSA. In the second half of 2008, the hot cells were commercially hired by the Slovenian Rad-Waste Agency for the EU project "Improvement of the management of institutional radioactive waste in Slovenia" within the framework of the EU project "Transition Facility". The staff at the reactor and of the JSI health-physics services participated in a project carried out by the Belgian company LENIKO.

The reactor was mainly used for neutron-activation analysis. The reactor operated mainly for the needs of the Jožef Stefan Institute's research departments: the Department of Environmental Science, the Department of Reactor Physics, the Department of Experimental Particle Physics and the Department for Nanostructured Materials. The reactor was used in the following research:

- neutronics and reactor physics,
- activation analysis,
- neutron dosimetry and spectrometry,
- neutron radiography,
- activation of materials, nuclear waste and decommissioning,
- irradiation of materials for fusion reactors.

The reactor operators support the researchers by performing the operations and services for which the researchers are not qualified and authorized, such as operating the reactor, performing irradiations and manipulation with radioactive samples.

The results of this research were published in approximately 20 scientific papers, and 3 young researchers performed their research at the reactor.

Practical exercises were completed by students of physics at the University of Ljubljana. Post-graduate students of nuclear engineering attended some of these exercises as well. For these purposes the reactor operated for approximately 10 days. The reactor was also used for practical exercises within the training program of the NPP Krško reactor operators. Also, some post-graduate students of nuclear engineering at the Faculty of Mathematics and Physics of the University of Ljubljana participated in the exercises. The exercises were prepared and carried out by the reactor's personnel in cooperation with ICJT and F-8.

In 2008 there were more than 50 short group visits to the reactor. The visitors were mainly foreign scientists, students and school children. Their total number was more than 500.

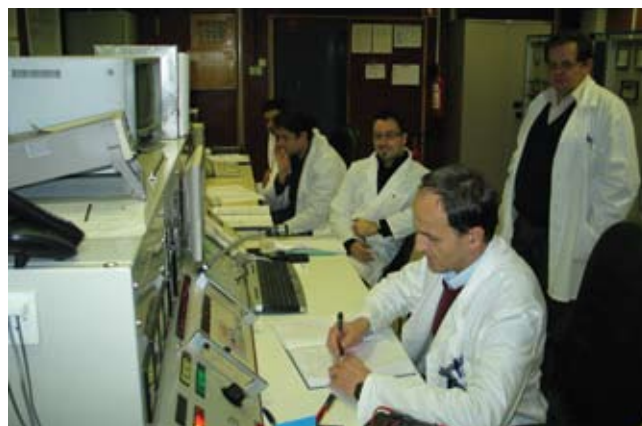


Figure 1: Krško NPP operators during practical exercises at the TRIGA reactor

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INTERNATIONAL PROJECT

1. Improvement of the Management of Institutional Radioactive Waste in Slovenia
11145406-06-01-0001
Agency for Radwaste Management, Ljubljana, Slovenija; Leniko bvba, Antwerp, Belgium
Bojan Huzjan, Dr. Gašper Tavčar, Bogdan Pucelj, M. Sc., Dr. Borut Smodiš

CENTRE FOR NETWORKING INFRASTRUCTURE

CNI

The basic function of the Centre for Network Infrastructure (CNI) is the management and maintenance of the JSI computer network, including planning, development, upgrades, maintaining contact with public networks, and providing security. CNI also houses and supports the local SiGNET GRID cluster.

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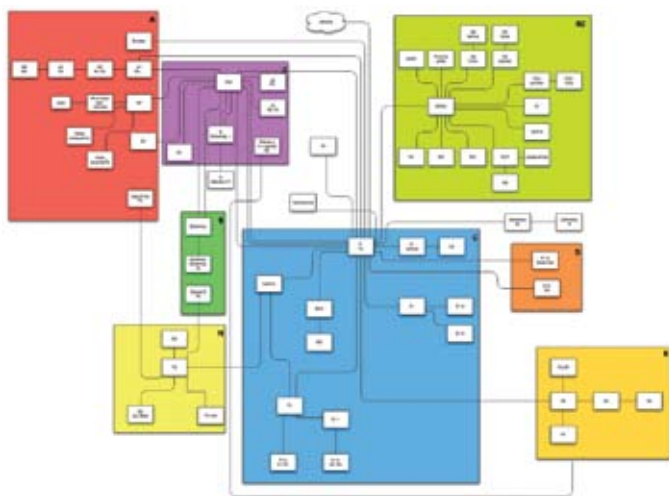


Figure 1: JSI connectivity structure



Figure 2: Layout of JSI communication network

SCIENCE INFORMATION CENTRE

SIC

The Jožef Stefan Institute's Science Information Centre is the central Slovenian physics library and one of the largest specialist libraries 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.

Our collection covers the fields of physics, chemistry, biochemistry, electronics, information science, artificial intelligence, nuclear technology, energy management and environmental science. We are a full member of the Slovenian library cooperative, COBISS, and use their services to catalogue and loan our materials. You can check what is new in the library, browse our online catalogue, or send inter-library loan requests using our website.

We supplement our comprehensive print collection of core journals with the electronic editions, offered through our website. We subscribe to the electronic collections offered by ScienceDirect, Springer Link, Stanford HighWire Press, ACS online editions, AIP electronic editions, IoP online journals, Wiley Interscience. We provide access to the SCOPUS, INSPEC, Crossfire Beilstein, and Web of Science databases, and the Dialog online database services.

We manage a bibliographic database of the Institute's production. This database contains about 80,000 records, going back to the Institute's inception in 1949. The records for 2008 are included as part of this report.



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Figure 1: poster presented by A. Štante at 74th IFLA General Conference and Council

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 EEC's activities is thus cooperation with state institutions in the field of efficient energy use, energy planning, environmental taxes and emission trading; nevertheless, it still remains strongly connected, by its consulting role in energy, with industrial companies and institutions.

Energy and the environment

In 2008 the key activities of the Energy Efficiency Centre were focused on different professional tasks in energy and on the reduction of the impact of energy use on the environment, especially in the field of greenhouse-gas emissions. The EEC has long experience in the fields of energy, energy use, electricity production and, in recent years, on the impact of the production and use of energy on the environment. As a result, in 2008 the EEC prepared various strategic studies for the Ministry of Environment and Spatial Planning and the Ministry of the Economy, necessary for the decisions of both ministries. These studies are from the fields of greenhouse-gases-emissions reduction, the introduction of cogeneration and renewable energy sources, the preparation of an overview for carrying out energy policy in Slovenia and similar.

In 2008 the Energy Efficiency Centre prepared a proposal for long-term energy balances of the Republic of Slovenia up to 2026, which has to be accepted by the government, according to the Energy Law. At the end of the year the centre started to prepare two documents based on these results: the Green Book, as a discussion document for a wider professional discussion, and the preparation of the starting points for the elaboration of a new National Energy Programme in 2009.

In autumn, the centre, in a consortium of ten research institutions, successfully started with a greater target development project "Slovenia, low-carbon society", which should, in view of a new technological development and the guidelines of environment energy policy, map the direction for the future development of Slovenia. Regarding the planned budget for the project (€480,000 in three years), it is one of the largest of such projects, which is financed by the Research Agency of the Republic of Slovenia, the Government Office for Development, the Ministry of the Environment and the Ministry of the Economy.

In 2008, Slovenia entered in the first year of the target period of the Kyoto Protocol, when it has to, in accordance with the ratified protocol, reduce greenhouse-gases emissions by 8% compared to the base year, 1986. Due to negative trends in the fulfilling of the goal, the preparation of the document "Monitoring of the Carrying Out of the Operative Programme of Greenhouse-Gases-Emissions Reduction" for the Ministry of Environment was one of key documents which, based on a transparent quantitative analysis of the situation and the carrying out of planned measures of the programme, presented an integral insight in the problems and a good starting point for the planning of future activities. The development of efficient indicators of the situation estimation and achieving of the set goals and identification of the key factors of emissions growth is here a key instrument for the support of the ministry decisions.

The Directive on Energy Services and Accepted Climate - Energy Package also set obligatory goals for Slovenia regarding the increase of energy efficiency up to 2016 and 2020. In 2008 the centre started to carry out a greater project of preparation of methodologies for the evaluation of carrying out of efficient energy-use measures, that will be a key instrument for proving the fulfilment of set goals. The project, financed by the Ministry for Environment and Spatial Planning, is incorporated into other European projects for the preparation of evaluation methodologies. The EU wants to establish harmonized approaches in all member states in this field.

In the annual review of the Slovenian energy sector for 2007 the EEC drew attention to the fact that all energy use and supply indicators, despite the appeasing of some trends, show movements which are worse than energy politics' expectations. This means that political energy mechanisms



Head:
Stane Merše, M. Sc.

The R&D work of the Energy Efficiency Centre's staff was an important contribution in the preparation of key documents in Slovenia in the field of energy efficiency and the transition of Slovenia to a low-carbon society, at the same time supporting industry to increase competitiveness and development restructuring.



Figure 1: Training of European Energy Managers - EUREM

have not so far achieved the expected results and were not carried out as planned. That does not lead to the achievement of demanding goals of the energy-climate EU package up to 2020 (especially the increase in the share of renewables to 25% in the end energy, and the increase of energy efficiency by 20%). In the future, with active EEC participation, it will be necessary to focus on the execution of the mechanisms for energy-use management to improve competitiveness, reliability and the environment, which is one of key development directions in the current economic crisis.

Efficient support for electricity production from renewable sources and cogeneration with high efficiency is a key condition for the further development of electricity production that can significantly contribute to ensure supply reliability, the balanced development of Slovenia and to fulfil the goals of energy-climate policy. In 2008, cooperation with the Ministry of the Economy continued with the execution of two support studies to prepare a new support scheme that should start to function at the beginning of 2009.

Promotion of efficient energy use and energy consulting

The activities of the Energy Efficiency Centre in 2008 in the field of the promotion of efficient energy use and energy consulting in industry and institutions were particularly characterized by the establishment and carrying out of the first cycles of the training of energy managers in the framework of the European programme EUREM, which was successfully concluded in December by the first 24 participants. In October, the second cycles of education had already started. Due to a very positive reaction of the participants and their interest, 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.

In 2008 the Energy Efficiency Centre carried out several consulting tasks in industry and a series of energy audits of enterprises to reduce energy use and costs as well as emissions. An important milestone was the beginning of the execution of the energy audit in Thermopower Plant Ljubljana, which confirmed the supposition that in larger units for electricity production there is still a great potential for energy-efficiency increases. Cooperation in the project "Impact of Demand Side Management (DSM) on the Use in the Transfer Network" (client ELES) represented an important step in establishing the active role of system operators in carrying out measures of directing consumption and the inclusion of demand-side management into network planning and development.

The centre also prepared the programme of the tenth jubilee of the largest Slovenian conference for energy managers "Energy Managers' Days", the annual meeting of energy managers, with more than 200 participants, which confirms the quality and public profile of the EEC's professional work. The centre continues to issue the Energy Efficiency Newsletter for the Ministry of the Environment and Spatial Planning. Individual EEC experts published numerous articles in magazines and newspapers and took part in radio and television broadcasts.

International cooperation

In 2008 the EEC carried out as many as 11 international projects, financed from European Union resources in the 6FP and the European Commission programme "Intelligent Energy for Europe".

Projects cover activities in the fields of:

- new technologies and energy efficiency in EU research programmes – Scientific Reference Systems on New Energy Technologies and Energy End-Use Efficiency and Energy RTD (SRS NET & EEE),
- establishment of a European network for energy managers' training – Training and network of European Energy Managers (EUREM.NET),
- compiling and elaboration of current data on renewable energy sources use – EurObserv'ER Barometer,
- carrying out of European programme of efficient lighting "New Greenlight" in Slovenia – The European Greenlight Programme in New Member States (New Greenlight),
- carrying out of the directive on energy services and the evaluation of energy-efficiency measures – Concerted Action – Energy Service Directive (CA – ESD)

Projects include cooperation with R&D organisations from Europe with a strong emphasis on concrete applications and the promotion of energy efficiency. In the framework of each project EEC staff took part in numerous foreign professional meetings and visits. For Intelligent Energy for Europe projects, the EEC acquired partial co-financing from the Ministry for the Environment and Spatial Planning.

Some outstanding achievements in 2008

1. Preparation of several key support documents for the Government of the Republic of Slovenia in the field of energy efficiency (National Action Plan for Energy Efficiency), climate policy (Operative programme of GHG emissions reduction up to 2012) and energy policy (Proposal for Long-Term Balances of RS up to 2026)
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, Cinkarna Celje, Litostroj, TE-TOL etc.).
3. Cooperation in different international projects in the framework of European Commission programmes in the fields of energy efficiency, energy management, combined production of electricity and heat, promotion of energy-efficient technologies, external costs in energy, exploitation of wood biomass and others.

Organization of conferences, congress and meetings

1. Energy Managers Days 2008 – 10th Meeting of Energy Managers of Slovenia, Portorož, 8-9 Apr.2008
2. European Energy Manager Training, Ljubljana, 7-9 May, 18-20 Jun., 24-26 Sept., 12-14 Nov. and 17 Dec.2008

INTERNATIONAL PROJECTS

1. Network for Promotion of RT Results in the Field of Eco-building Technologies, Small Polygeneration and Renewable Heating and Cooling Technologies for Buildings ProEcoPolyNet, PEP-Net
6. FP
TREN/05/FP6EN/S07.54455/020114
EC; Michael Geißler, Berliner Energieagentur GmbH (BE), Berlin, Germany
Tomaž Fatur, M. Sc.
2. Scientific Reference System on New Energy Technologies, Energy End-use Efficiency and Energy RTD
SRS NET & EEE
6. FP, 006631
EC; Dr. John Psarras, National Technical University of Athens, Zografou, Greece
Tomaž Fatur, M. Sc.
3. New Energy Externalities Development for Sustainability
NEEDS
6. FP, 502687
EC; Adele Vendetti, Istituto di studi per l'Integrazione dei sistemi, Rome, Italy
Dr. Mihael Gabrijel Tomšič
4. EurObserv`ER Barometer
EurObserv`ER
IEE Programme
EIE/07/056/SO2.466834
EC; Observatoire des Energies Renouvelables (Observ`ER), Paris, France
Polona Lah, B. Sc.
5. Monitoring of Energy Demand Trends and Energy Efficiency in the EU
ODYSSEE MURE (EU-29)
IEE Programme
EIE/07/297/SI2.466291
EC; Didier Bosseboeuf, Agence De l'Environnement et de la Maitrise de l'Energie (ADEME), Angers, France
Dr. Fouad Al-Mansour
6. Training and Network of European EnergyManagers
EUREM.NET
IEE Programme
EIE/06/041/SI2.447404
EC; Dr. Robert Schmidt, Tom Ankirchner, B. Sc., Industrie-und Handelskammer Nürnberg für Mittelfranken Geschäftsbereich, Innovation/Umwelt, Nürnberg, Germany
Tomaž Fatur, M. Sc., Barbara Petelin Visočnik, M. Sc.
7. The European GreenLight Programme in New Member States
NEW GREENLIGHT
IEE Programme
EIE/05/192/SI2.419684
EC; Juraj Krivošik, SEVEn, Stredisko pro efektivni využívani energie, o.p.s., The Energy Efficiency Center, Prague, Czech Republic
Evald Kranjčević, M. Sc.
8. Cogeneration Observatory and Dissemination Europe
C.O.D.E
IEE Programme
EIE/07/564/SI2.499462
EC; COGEN EUROPE, Brussels, Belgium
Stane Merše, M. Sc.
9. Concerted Action Supporting Transposition and Implementation of Directive 2006/32/EC of the Council
CA ESD
IEE Programme
EIE/CA/08/001/SI2.503473
EC; Rob Boeree, SenterNovem, Sittard, The Netherlands
Damir Staničić, M. Sc.
10. Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services
EMEEES
584
Dr. Fritz Unterpentinger, Österreichische Energieagentur - Austrian Energy Agency, Vienna, Austria
Evald Kranjčević, M. Sc.
11. The Review of Permits, Monitoring, Plans, and Verification Reports in the EU Greenhouse Gas Emissions Trading Scheme at the Level of Member States
SA DTD 15-1-2008 NO1
Günter Schock, TÜV Rheinland Immissionsschutz und Energiesysteme GmbH (TIE), München, Germany
Evald Kranjčević, M. Sc.

R&D GRANTS AND CONTRACTS

1. Slovenia - Low Carbon Society
Andreja Urbančič, M. Sc.
2. Determination of Applied Potential of Agricultural Biomass and Definition of Environment Friendly Technologies Used for its Exploitation
Dr. Fouad Al-Mansour
3. Establishment of an EnGIS system for Stimulation of Renewables and Preparation of a Multi-Sectoral Analysis of Energy Potentials
Tomaž Fatur, M. Sc., Dr. Fouad Al-Mansour

RESEARCH PROGRAM

1. Environment Impact - Modelling and Assessment
Dr. Borut Smodiš, Dr. Fouad Al-Mansour

NEW CONTRACTS

1. Advising on the Coordination of Standpoints in the Field of Climate Changes
Ministry of the Environment and Spatial Planning, Ljubljana
Andreja Urbančič, M. Sc.
2. Monitoring of Energy Use and Energy Efficiency Trends in Slovenia
Ministry of the Environment and Spatial Planning, Ljubljana
Dr. Fouad Al-Mansour
3. Effect of Demand Side Management (DSM) on the Use in the Transfer Network
University of Ljubljana, Electrotechnical Faculty, Ljubljana
Stane Merše, M. Sc.
4. Development and Testing of Methods for Monitoring and Evaluation of Effects of Instruments and Measures for Energy Efficiency Increase
Ministry of the Environment and Spatial Planning, Ljubljana
Evald Kranjčević, M.Sc.

5. Energy Audit of Combined Heat and Power Production Plant Ljubljana
Combined Heat and Power Plant Ljubljana, Ljubljana
Damir Staničič, M. Sc.
6. Editing of Energy Efficiency Newsletter
Ministry of the Environment and Spatial Planning, Ljubljana
Barbara Petelin Visočnik, M. Sc.
7. Methodology of Determining Referential Costs for By-Law Acts Regarding Subsidies
Ministry of the Economy, Ljubljana
Stane Merše, M. Sc.
8. Forecast of Conditions in the Energy Market for Determining Necessary Subsidies for Electricity Producers from RES and from Combined Electricity Production with High Efficiency
Ministry of the Economy, Ljubljana
Stane Merše, M. Sc.
9. Annual Energy Review for 2007
Ministry of the Economy, Ljubljana
Polona Lah, B. Sc.
10. Preparation of a Green Book for the RS National Energy Programme 2009
Ministry of the Economy, Ljubljana
Andreja Urbančič, M. Sc.

VISITORS FROM ABROAD

1. Joris Thijssen, anti coal global action head, Greenpeace International, Amsterdam, the Netherlands, 8 Apr.2008
2. Alan Ryan, industrial programmes head, Sustainable Energy Ireland, Dublin, Ireland, 8 Apr.2008
3. Dr. Wolfram Herppich, project manager, RWE Energy AG, Dortmund, Germany, 8 Apr.2008
4. Kevin Geoghegan, M. Sc., energy saving programme head, Intel Ireland, Leixlip, Ireland, 8 Apr.2008
5. Dr. Susanne Geissler, buildings and heating department head, Austrian Energy Agency, Vienna, Austria, 8 Apr.2008
6. Roberto Bini, vice president, Turboden, Brescia, Italy, 9 Apr.2008
7. Gordana Lučić, M. Sc., director, HEP ESCO, Zagreb, Croatia, 9 Apr.2008
8. Dr. Reinhard Padinger, renewables research head, Joanneum Research, Graz, Austria, 8-9 Apr.2008
9. Tom Best, energy procurement, Goodyear Europe, Modena, Italy, 20 May 2008
10. Cristiano Cardarelli, financial support manager, Brussels, Belgium, 20 May 2008
11. Dr. Noam Lior, professor and chief editor Energy Journal, University of Pennsylvania, Philadelphia, Pennsylvania, USA, 9 Jul. 2008
12. Dr. Na Zhang, research professor, Chinese Scientific Academy, Beijing, China, 9 Jul. 2008
13. Dr. Ahmed Karim, international programme director, National Council for Science and the Environment, Washington, USA, 22 Sept.2008

STAFF

Postgraduates

1. **Tomaž Fatur, M. Sc., Head, left 15 Sept.2008**

2. Evald Kranjčević, M. Sc.

3. **Stane Merše, M. Sc., Head**

Technical officers

4. Dr. Fouad Al-Mansour

5. Matjaž Česen, B. Sc.

6. Polona Lah, B.Sc.

7. Marko Pečkaj, B. Sc.

8. Barbara Petelin Visočnik, M. Sc.

9. Damir Staničič, M. Sc.

10. Andreja Urbančič, M. Sc.

Technical and administrative staff

11. Roza Pergarec, B. A.

12. Igor Ribič

13. Milan Simončič

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Tomaž Fatur, "Energetski manager v vsako slovensko vas", *Finance (Online)*, 17. junij, 2 pp., 2008.
2. Tomaž Fatur, "Prihajajo standardi na področju energetskega menedžmenta", *Sporoč. - Urad Repub. Slov. stand. merosl.*, no. 4, pp. 14-16, 2008.
3. Barbara Petelin-Visočnik, "Evropski energetski menedžer", *EGES, Energ. gospod. ekol. Slov.*, no. 1, pp. 132-133, 2008.
4. Barbara Petelin-Visočnik, "Izobraževanje "Evropski energetski menedžer""", *Energetik (Maribor)*, no. 67, pp. 30, 2008.
5. Barbara Petelin-Visočnik, "Kako ustrezneje gospodariti z energijo", *ER (Ljubl.)*, no. 1, pp. 30-33, 2008.
6. Barbara Petelin-Visočnik, "Usposabljanje za evropske energetske menedžerje tudi pri nas", *Naš stik*, februar, pp. 42-43, 2008.
7. Mihael Gabrijel Tomšič, "Je elektrika prepoceni ali predraga?", *Finance (Online)*, no. 183, 2 pp., 2008.

REVIEW ARTICLES AND CHAPTERS IN BOOKS

1. Urška Lavrenčič Štangar, Evald Kranjčević, "Renewable energy sources in Slovenia: facts and plans", In: *Sustainable energy technologies: options and prospects*, Kemal Hanjalić, ed., R. van de Krol, ed., Alija Lekić, ed., Dordrecht, Springer Verlag, cop. 2008, pp. 251-259.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Evald Kranjčević, "Družbena odgovornost in podnebne spremembe", In: *Družbena odgovornost: zbornik referatov*, Blanka Kaker, ed., Ljubljana, Slovenski inštitut za kakovost in meroslovje, 2008, pp. 63-68.

Regular papers

1. Fouad Al-Mansour, "Sosežig biomase: pregled stanja in tehnologij", In: *Komunalna energetika*, 17. mednarodno posvetovanje Komunalna energetika, 13. do 15. maj 2008, Maribor, Jože Voršič, ed., Maribor, Fakulteta za elektrotehniko, računalništvo in informatiko, 2008, pp. 1-11, 2008.
2. Franko Nemas, Nataša Lambergar, Matjaž Blokar, Aleš Lončarič, Andrej Maležič, Fouad Al-Mansour, Tomaž Fatur, "EnGIS: geografski informacijski sistem za pomoč OVE", In: *Komunalna energetika*, 17. mednarodno posvetovanje Komunalna energetika, 13. do 15. maj 2008, Maribor, Jože Voršič, ed., Maribor, Fakulteta za elektrotehniko, računalništvo in informatiko, 2008, 9 pp.
3. Damir Staničič, Stane Merše, "Načrtovanje in delovanje soproizvodnje na lesno biomaso v novih razmerah, ki jih določa direktiva o soproizvodnji", In: *Zbornik prispevkov*, Konferenca daljinske energetike 2008 Slovenskega društva za daljinsko energetiko = Conference on District Energy 2008, Portorož, 16-18. marec 2008, Boštjan Bibič, ed., Ljubljana, Slovensko društvo za daljinsko energetiko, 2008, pp. 51-59, 2008.

CENTRE FOR ELECTRON MICROSCOPY

CEM

The Centre for Electron Microscopy (CEM) has the function of a supporting infrastructure center at the JSI that comprises the equipment for electron microscopy which is necessary for the research work of the departments K5, K6, K7, K8 and K9. Other JSI departments, research institutes, universities and industry also have access to the equipment. The users of the CEM equipment are the researchers in the field of materials science that are involved in the chemical and structural analysis of materials on the micro and atomic scales. The major pieces of equipment at the CEM are two scanning electron microscopes (JSM-840A and JSM-5800) and two transmission electron microscopes (JEM-2000FX and JEM-2010F).



Head:
Asst. Prof. Miran Čeh

Scanning electron microscopy (SEM) is used for morphological studies of either fractured or polished surfaces. Since both scanning electron microscopes are equipped with X-ray spectroscopy (EDXS, WDXS), qualitative and quantitative chemical analyses on the micro-scale are also possible. Since only a few μm^3 of the material are nondestructively analyzed, the term electron-probe microanalysis (EPMA) is used for such analytical work.

When structural features on the nanoscale are investigated, however, various techniques of transmission electron microscopy (TEM) are used. In particular, the JEM-2010F is a state-of-the-art TEM/STEM microscope with a FEG (field-emission gun) electron source and with a point-to-point resolution below 0.19 nm, which is more than sufficient to observe the atomic columns in crystalline materials. The JEM-2010F is also equipped with an annular dark-field detector (HAADF-STEM) for so-called Z-contrast imaging, which enables chemical analyses of a single atomic column on the basis of the measured intensities. Both transmission electron microscopes are additionally equipped with analytical systems for chemical analyses (EDS, EELS). The CEM also comprises the equipment for SEM and TEM specimen preparation, which is the first step for all electron-microscopy observation procedures. Of particular importance are the high- and low-energy ion-millers, which are used to prepare thin foils that are transparent to high-energy electrons.

The analytical work that is performed on the CEM equipment varies, concerning both investigated materials and/or electron-microscopy techniques. While scanning electron microscopy is used mainly for the microstructural characterization and chemical analysis of polycrystalline ceramic materials (functional ceramics, engineering ceramics, bio-ceramics, and composites), magnetic materials, glasses, metals, alloys, etc., transmission electron microscopy is used for the structural and chemical investigations of grain boundaries, planar faults, dislocations and

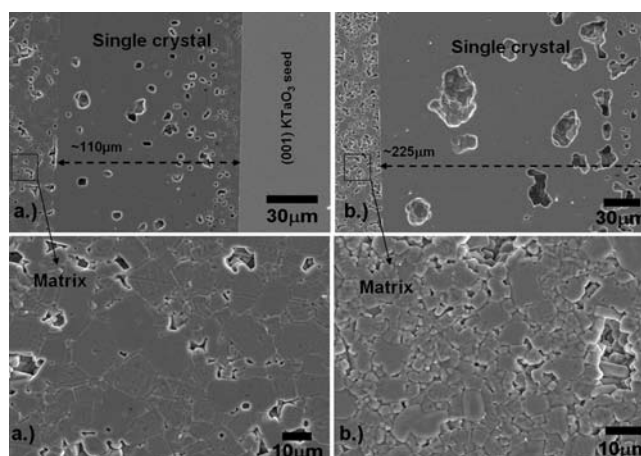


Figure 1: SEM-SEI micrographs of $\text{K}_{0.5}\text{Na}_{0.5}\text{NbO}_3$ (KNN) single crystals and matrix grains with: a) 0.5 and b) 2 mol % $\text{K}_4\text{CuNb}_8\text{O}_{23}$ after annealing at 1100°C for 10 hours. The microstructures show the effect of the addition of a $\text{K}_4\text{CuNb}_8\text{O}_{23}$ liquid-phase sintering aid on the growth of the matrix grains and KNN single crystals. (Journal of the European Ceramic Society 28, 2008, 1657-1663). The research was part of the EU 6FP project IMMEDIATE. (photo: A. Benčan Golob, K-5)

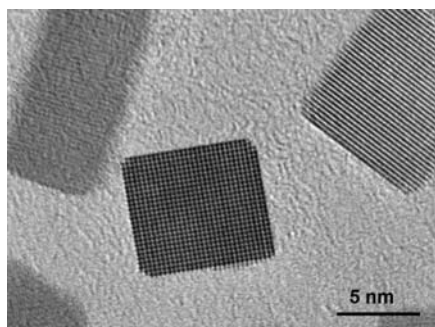


Figure 2: HRTEM image of idiomorphic PbSe nanocrystals (rock-salt structure), prepared by mechanochemical treatment (Dr. M. Achimovicova, Slovak Academy of Sciences). {100} interplanar spacing: 0.3 nm. (photo: N. Daneu, K-7)

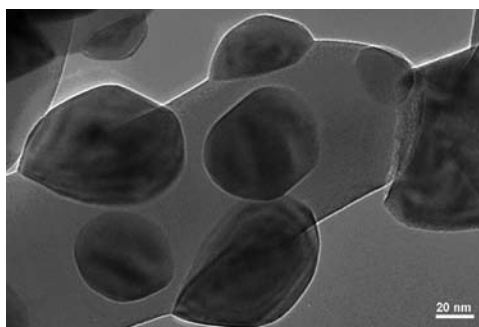


Figure 3: TEM micrograph of Si_3N_4 particles coated by nanosized ZrN particles after calcination at 1600°C , 2 h in flowing N_2 . (photo: A. Maglica, K-6)

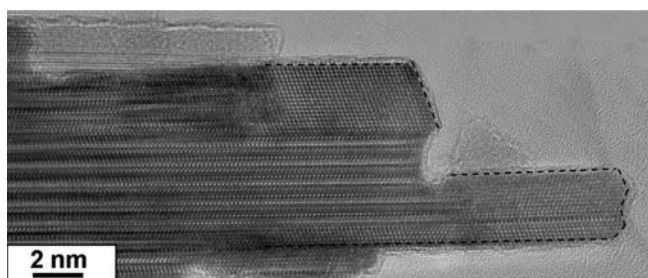
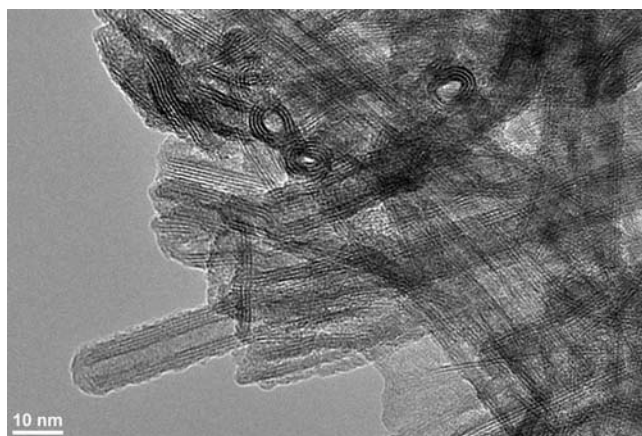


Figure 4: High-resolution electron micrograph of nanocomposite particle composed of magnetite (marked with broken line) intergrown into Ba-hexaferrite. The particle was prepared using hydrothermal decomposition of $BaFe_{12}O_{19}$ (photo: D. Makovec, K-8)

Figure 5: CTEM micrograph of multiwalled Ca-Ti-based nanotubes prepared by hydrothermal synthesis (100°C, 12 hours). EDXS analysis showed the presence of ~11at% of calcium in the nanotubes (photo: I. Bračko, K-9).

precipitates within the same materials. The structural and chemical analyses of grain boundaries are especially important since the final physical properties of a material, to a large extent, depend on the structure and chemistry of grain boundaries.

In order to be able to perform electron microscopy investigations it is imperative that the equipment in the CEM is well maintained. With regard to this, one of the center's main tasks is to attain the maximum possible operational time for the microscopes. This complex and expensive equipment needs regular daily maintenance in addition to specialized servicing. Other activities of the CEM include the organization of training courses for operators and the implementation of new analytical methods, which is realized with the help of CEM co-workers.



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 the direct exchange of information and experience between researchers and the users of their research results.

By partnering and actively engaging in various European research projects the centre successfully extends its activities to R&D. 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 2008 the centre was active in several European projects from the EU FP6: "Pattern Analysis, Statistical Modelling and Computational Learning" (PASCAL), "Lifecycle Support for Networked Ontologies" (NEON), "Extended Enterprise management in Enlarged Europe" (E4), "Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshops" (ToolEAST), "Semantic Web Services Interoperability for Geospatial Decision Making" (SWING), "Image-based Navigation in Multimedia Archives" (IMAGINATION), "Transitioning Applications to Ontologies" (TAO), and "Statistical Multilingual Analysis for Retrieval and Translation" (SMART); and from the EU FP7: "Pattern Analysis, Statistical Modelling and Computational Learning 2" (PASCAL2), "Enabling the Knowledge Powered Enterprise" (ACTIVE), "Collaboration and Interoperability for networked enterprises" (COIN) and "European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics" (EURIDICE).

We prepare and organize carefully designed educational events, such as conferences, seminars, workshops, and summer schools. These 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 the network organizations, ecology, medicine, business decisions, finance, marketing, automation and process control. A special consideration is given to the managers and decision makers who are aware of the strengths and benefits of the success of their business.

All educational events are designed to transfer basic, additional and the latest expert knowledge to companies, research institutes and educational organizations. 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/>, which now offers more than 6000 recorded tutorials from different scientific events and is visited daily by an average of 3500 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. This year we have started a successful collaboration with some of the top ten American universities, including MIT (Massachusetts Institute of Technology), the University of California - Berkeley, YALE and CMU, as well as with the European CERN and ETH from Zurich.

The centre also operates a web portal <http://www.ist-world.org> that offers services for automatic data collection and analyses of European research. The user can perform several simple and complex analyses, predictions and detect trends in research. The database currently contains data from about 100,000 research organizations, 42,500 research projects and around 2 million experts from Europe. This is an exceptional web service that is being visited daily by an average of 15,000 unique visitors.

In 2008 we organized the "PASCAL Symposium" with 90 participants from around the world, the 3rd Student Competition in Computer Science, attended by 130 students from Slovenian secondary schools, and four seminars for participants from industry. We have also organized an international seminar "Analysis of Environmental Data with Machine



Head:
Mitja Jermol, M. Sc.

The centre is operating two web portals. The first one is <http://videolectures.net/>, which is now becoming a reference portal, presenting high-quality scientific lectures, and the second one is <http://www.ist-world.org>, which offers services for automatic data collection and analyses of European research.

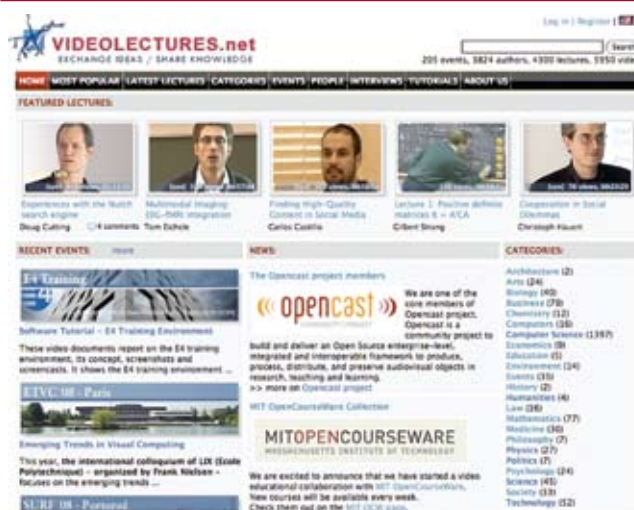


Figure 1: Portal Videolectures <http://videolectures.net/>

From 2008 onwards the portal <http://videolectures.net/> will be collaborating with the Massachusetts Institute of Technology (MIT), YALE, the University of California - Berkeley, the University of Ljubljana, and with the European Organization for Nuclear Research (CERN).



Figure 2: Educational collaboration with MIT OpenCourseWare



Figure 3: Portal IST World <http://www.ist-world.org>



Figure 4: Events organized by CT3 in 2008

Learning Methods”, and six project meetings for various EU projects. We have started with intensive preparation activities for ECML/PKDD 2009, which will take place from 7 to 11 September 2009 in Bled <http://www.ecmlpkdd2009.net/>.

Our role in the FP7 Integrated Projects “Collaboration and Interoperability for networked enterprises” (COIN), “European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics” (EURIDICE), “Enabling the Knowledge Powered Enterprise and in one network of excellence” (ACTIVE) and “Pattern Analysis, Statistical Modeling and Computational learning” (PASCAL2) is to coordinate all the educational and dissemination activities as well as knowledge transfer.

Some outstanding publications in past three years:

1. N. Lavrač, P. Ljubič, T. Urbančič, G. Papa, M. Jermol, S. Bollhalter. Trust modeling for networked organizations using reputation and collaboration estimates. *IEEE trans. syst. man cybern., Part C Appl. rev.*, May 2007, vol. 37, no. 3, pp. 429-439, ilustr.
2. M. Jermol, B. Jórg, H. Uszkoreit, M. Grobelnik, J. Ferlež, A. Kiryakov, Analytical information services for the European research area. V: Cunningham, Paul (ed.), Cunningham, Miriam (ed.). *Exploiting the knowledge economy: issues, applications and case studies*, (Information and communication technologies and the knowledge economy, Vol. 3). Amsterdam: IOS Press, (2006), 1367-1395
3. M. Jermol, M. Jurančič, Von der leichtigkeit Last des Neustarts : Forschungsk Kooperation nach dem Kommunismus: Slowenien. V: Gögl, Hans-Joachim (ed.), Schleder, Clemens Theobert (ed.). *Wissen schafft Unternehmen : erfolgreiche Kooperationsmodelle zwischen Universitäten und Unternehmen in Europa*, (Landschaft des wissens, band 2). Bern; Stuttgart; Wien: Haupt, (2006), 330-367

Organization of conferences, congress and meetings

1. Meeting of the EU project TAO (Transitioning Applications to Ontologies), Bled, 21–23 Jan. 2008
2. PASCAL Symposium and Review Meeting, Bled, 26–31 Jan. 2008
3. Project meeting of the EU project NeON, Bled, 19–22 Feb. 2008
4. Seminar “Modelling and simulation of control systems”, Ljubljana, 28 Jan. to 1 Feb. 2008
5. Project meeting of the EU project ACTIVE, Bled, 10–12 Mar. 2008
6. International seminar “Analysis of environmental data with machine learning methods”, Ljubljana, 17–23 Mar. 2008
7. 3rd Student competition in computer science, Ljubljana, 29 Mar. 2008
8. Seminar “Industrial regulation systems”, Ljubljana, 7–11 Apr. 2008
9. Conference on Creative women in science and public life, Ljubljana, 15–16 May 2008
10. Project meeting of the EU project ACTIVE, Dubrovnik, 17–19 Jun. 2008
11. Seminar “Advanced control methods”, Ljubljana, 2–6 Jun. 2008
12. Project meeting of the EU project NeON, Dubrovnik, 24–27 Jun. 2008
13. Seminar “Software for process control”, Ljubljana, 20–24 Oct. 2008
14. Project meeting of the EU project EURIDICE, Ljubljana, 2–3 Nov. 2008

INTERNATIONAL PROJECTS

1. European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics
EURIDICE
7. FP, 216271
EC; INSIEL - Informatica per il Sistema Degli Enti Locali s.p.a, Trieste, Italy
Mitja Jermol, M. Sc., Marko Grobelnik, Asst. Prof. Dunja Mladenič
2. Enabling the Knowledge Powered Enterprise
ACTIVE
7. FP, 215040
EC; Philip Hewitt, British Telecommunications plc, London, Great Britain
Mitja Jermol, M. Sc., Marko Grobelnik, Asst. Prof. Dunja Mladenič
3. Pattern Analysis, Statistical Modelling and Computational Learning 2
PASCAL 2
7. FP, 216886
EC; Eileen Simon, University of Southampton, Southampton, Great Britain
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
4. Collaboration and Interoperability for networked enterprises
COIN
7. FP, 216256
EC; Claudia Guglielmina, TXT e-Solutions Spa, Milan, Italy
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
5. Stimulating Policy Debate on Women and Science Issues in Central Europe
WS DEBATE
6. FP, 036651
EC; Dr. Dora Groo, Eszter Papp, Hungarian Science and Technology Foundation; Tudományos és Technológiai Alapítvány, Budapest, Hungary
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
6. Statistical Multilingual Analysis for Retrieval and Translation
SMART
6. FP, 033917
EC; Nicola Cancedda, Xerox Research Centre Europe, Meylan; Xerox, Aulnay-Sous-Bois, France
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
7. Image-based Navigation in Multimedia Archives
IMAGINATION
6. FP, 034626
EC; Clemens van Dinther, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Prof. Marko Mikuz
8. Extended Enterprise Management in Enlarged Europe
E4
6. FP, 027282
EC; Roberto Tarditi, Centro Ricerche Fiat Societa Consortile per Azioni, Orbassano (TO), Italy
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
9. Open Source Enterprise Resource Planning and Order Management System for Eastern European Tool and Die Making Workshop
Tool-East
6. FP, 027802
EC; Dr. Volker Stich, Forschungsinstitut fuer Rationalisierung (FIR) und der RWTH Aachen, Research Institute for Operations Management at Aachen University, Aachen, Germany
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
10. Semantic Web Services Interoperability for Geospatial Decision Making
SWING
6. FP, 026514
EC; Arne J. Berre, SINTEF - Stiftelsen for Industriell OG Teknisk Forskning Ved Norges Tekniske Hoegskole, Trondheim; SINTEF ICT, Oslo, Norway
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik, Prof. Marko Mikuz
11. Lifecycle Support for Networked Ontologies
NEON
6. FP, 027595
EC; Prof. Enrico Motta, KMI, The Open University, Milton Keynes, Great Britain
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
12. Transitioning Applications to Ontologies
TAO
6. FP, 026460
EC; Dr. Kalina Bontcheva, University of Sheffield, Department of Computer Science, Sheffield, Great Britain
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
13. European Collaborative networked Organizations LEADership initiative
ECOLEAD
6. FP, 506958
EC; Martin Ollus, Technical Research Centre of Finland, Espoo, Finland
Mitja Jermol, M. Sc., Prof. Nada Lavrač
14. Pattern Analysis, Statistical Modelling and Computational Learning
PASCAL
6. FP, 506778
EC; Prof. John Shawe-Taylor, The University of Southampton, School of Electronics and Computer Science, Southampton, Great Britain
Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
15. Set-up of a Collaborative Permanent Network for Boosting the Participation of Incubated SMEs in Innovation Processes under FP6 Activities
Boost-IT
6. FP, 023437
EC; Eurique Neves, Inovamais - Servicos de Consultadoria em Inovacao Technologica, Matosinhos, Portugal
Mitja Jermol, M. Sc., Prof. Peter Stegnar

VISITORS FROM ABROAD

1. Francesco Mugnai, University of Florence, Italy, 3 Jun. 2008
2. Giovanni Gigli, University of Florence, Italy, 3 Jun. 2008
3. Malte Sussdorff, Cognovis, Germany, 14-18 Jan. 2008
4. Manuel Nunes, BIBA, Germany, 14-18 Jan. 2008
5. Giandomenico Ginosi, CRF, Italy, 14-18 Jan. 2008
6. Domenico Talarico, TXT, Italy, 14-18 Jan. 2008
7. Malte Sussdorff, Cognovis, Germany, 31 Mar. to 2 Apr. 2008
8. Fulvio Sansone, Oracle, Poland, 21 Apr. 2008
9. Paolo Paganelli, Insiel, Italy, 21 Apr. 2008
10. Michael Witbrock, Cycorp, USA, 21 Apr. 2008
11. Marco Mamei, University of Modena, Italy, 16 Jun. to 15 Jul. 2008
12. Matúš Mišák, PAK, Slovakia, 29-30 Jan. 2008
13. Roman Ondra, PAK, Slovakia, 29-30 Jan. 2008
14. Margherita Forcolin, Insiel, Italy, 4-5 Feb. 2008
15. Ivano Tomaino, Insiel, Italy, 4-5 Feb. 2008
16. Ivan Popov, IT partners, Bulgaria, 4-5 Feb. 2008
17. Radoslav Kolev, IT partners, Bulgaria, 4-5 Feb. 2008
18. Michael Witbrock, Cycorp, Inc, USA, 15-26 Oct. 2008
19. Ugo Negretto, ENICMA, Italy, 23 Sept. 2008
20. Paul-Valentin Borza, Technical University in Cluj-Napoca, Romania, 7 Jul. to 21 Sept. 2008

STAFF

Postgraduates

1. Jure Ferlež, M. Sc.
2. **Mitja Jermol, M. Sc., Head**

Technical officers

3. Marjana Plukavec*, B. Sc.
4. Špela Sitar, B. Sc.

Technical and administrative staff

5. Tina Anžič
6. Sebastjan Mislej

Note:

* part-time JSI member

MILAN ČOPIČ NUCLEAR TRAINING CENTRE

ICJT

The mission of our training centre is training in the field of nuclear technologies and radiation protection. In addition, we are actively informing the public about those technologies.

Training in the area of nuclear technologies is our primary mission. After a couple of relatively modest years, the demand for this type of training has increased substantially this year. Two courses, Basics of nuclear technology, were conducted. These courses are intended for non-control-room personnel of NPPs, and there were also many participants from other organizations working in the area. The course Nuclear technology, which is the initial training of future control-room operators, started in the autumn. This course will end in the spring of 2009.

There were 17 **radiological protection training** courses for the medical, industrial and research use of radioactive sources. Among them there was a course for officers of the Slovenian Army and a course on the security of nuclear materials during transport.

Public information is becoming an increasingly important part of our activities. Groups of children and other visitors were coming regularly, and in large numbers, to listen to a lecture about nuclear technology, about radioactive waste, or about fusion, and to visit our exhibition. Altogether, there were 167 groups or 7606 visitors this year. Since 1993 our information centre has been visited by a total of 111,813 pupils, teachers and other visitors. We have started to monitor and analyze media reports on nuclear energy, and we have also published a leaflet "The future of nuclear energy in Slovenia".

We have prepared a study "Technologies of potential reactors for the project of a second unit of Krško nuclear power plant - Krško 2".



Head:
Prof. Igor Jencič

In 2008, the demand for training in nuclear technologies has increased substantially, and our public information activity has intensified as well.



Figure 1: A demonstration of radioactivity is always very interesting for the youngsters.



Figure 2: Young cyclists are surprised at the effort necessary to light a few light-bulbs.



Figure 3: Explaining fusion is a challenge for both the lecturer and the listeners.

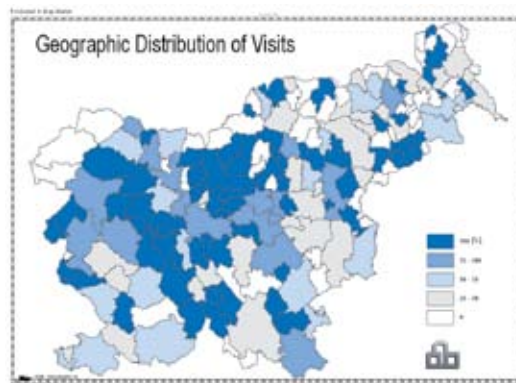


Figure 4: The visitors to the Information Centre come from all over Slovenia

Table of training activities at Nuclear Training Centre in 2008

Date	Title	Partici- pants	Lecturers	Weeks	Participant x weeks
10.-14.3.	Radiation protection for medical and veterinary workers - Nuclear medicine workers	3	11	1.0	3.0
10.-12.3.	Radiation protection for industrial and other practices (unsealed sources)	3	5	0.6	1.8
10.-12.3.	Radiation protection for industrial and other practices (sealed sources)	8	4	0.6	4.8
18.3.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	3	4	0.2	0.6
18.3.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	2	5	0.2	0.4
18.3.	Radiation protection for industrial and other practices (radiography) - Refresher Course	3	4	0.2	0.6
20.3.	Training Extension for RP Officers	3	2	0.2	0.6
31.3.-25.4.	Basics of nuclear technology, theory	18	9	4.0	72.0
15.-16.4.	Training for Slovenian Army officers (2008)	26	6	0.4	10.4
5.-30.5.	Basics of nuclear technology, systems	19	9	4.0	76.0
16.6.	Radiation protection for industrial sources - Refresher	6	3	0.2	1.2
4.9.	Security during transport of nuclear materials - refresher course	12	5	0.2	2.4
15.9.-10.10.	Basics of nuclear technology, theory	20	9	4.0	80.0
13.10.-7.11.	Basics of nuclear technology, systems	23	8	4.0	92.0
13.-15.10.	Radiation protection for industrial and other practices (sealed sources)	19	4	0.6	11.4
13.-15.10.	Radiation protection for industrial and other practices (unsealed sources)	7	5	0.6	4.2
13.-17.10.	Radiation protection for medical and veterinary workers - radiological diagnostic	7	6	0.6	4.2
21.10.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	2	2	0.2	0.4
21.10.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	8	1	0.2	1.6
23.10.	Training Extension for RP Officers	7	2	0.2	1.4
10.11.- (27.3.09)	Nuclear technology, theory	13	18	6.6	85.8
18.-22.12.	Radiation protection for workers of JSI RP group - Refresher course	4	2	0.4	1.6
TOTAL		216	124	29.2	456.4

INTERNATIONAL PROJECTS

1. Permanent Fusion Exhibition at JSI Nuclear Training Centre - 6.1.1-FU
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC, RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Prof. Igor Jenčič
2. Fusion Expo Activities under an EFDA
EURATOM - MHEST
7. FP, EURATOM, Slovenian Fusion Association - SFA
3211-08-000102, FU07-CT-2007-00065
EC, RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
Melita Lenošek, B. Sc., Sabina Markelj, B. Sc., Dr. Igor Lengar, Asst. Prof. Saša Novak
Krmpotič, Štefan Kolenko

NEW CONTRACTS

1. Co-financing of the Nuclear Information Centre in 2008
Gen d. o. o., Krško
Prof. Igor Jenčič
2. Implementation of 2008 Training Program for Krško NPP
Krško Nuclear Power Plant
Prof. Igor Jenčič
3. Operation of the Nuclear Information Centre in 2008
Agency for Radwaste Management, Ljubljana
Prof. Igor Jenčič
4. Preparing a study »Technologies of possible reactors for the project of the Krško-2 Nuclear Power Plant«
Gen d. o. o., Krško
Prof. Igor Jenčič

STAFF

Researcher

1. **Prof. Igor Jenčič, Head**

Technical officers

2. Rado Istenič, B. Sc.
3. Peter Jan, B. Sc.
4. Matejka Južnik, M. Sc.
5. Andrej Kavčič, B. Sc.

6. *Jernej Kovačič, B. Sc., left 1 Oct. 2008*

7. Matjaž Koželj, M. Sc.

8. Melita Lenošek, B. Sc.

9. Tomaž Skobe, B. Sc.

Technical and administrative staff

10. Saša Bobič

11. Borut Mavec, B. Sc.

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1. Radko Istenič, "Prenehajmo si zatiskati oči pred prednostmi jedrske energije", *Ampak (Ljubl.)*, vol. 9, no. 3, pp. 13-15, 2008.
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2. Igor Jenčič, "Activities of the Milan Čopič nuclear training centre in Slovenia", In: *NESTet 2008*, Nuclear Engineering Science and Technology, Budapest, Hungary, 4 -8 May 2008, ENS, 2008.
3. Igor Jenčič, "Information strategy in Nuclear training center Ljubljana in the area of radioactive waste management - 8250", In: *WM 2008 Conference: Moving forward in waste management, Feb 27-28, 2008, Phoenix*, WM 2008 Conference, Moving Forward in Waste Management, Feb 27-28, 2008, Phoenix, Phoenix, WM Symposia, 2008, 10 pp.
4. Andrej Kavčič, Igor Jenčič, Radko Istenič, "Analysis of media reports on nuclear energy in Slovenia", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2008, Portorož, Slovenia, September 8-11, Stane Rožman, ed., Bojan Žefran, ed., Ljubljana, Nuclear Society of Slovenia, 2008, 6 pp.

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Regular papers

1. Radko Istenič, Igor Jenčič, "15 years of the Nuclear Information Centre in Ljubljana", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2008, Portorož, Slovenia, September 8-11, Stane Rožman, ed., Bojan Žefran, ed., Ljubljana, Nuclear Society of Slovenia, 2008, 8 pp., 2008.

THESES

B. Sc. Theses

1. Peter Jan, *Obratovalne in tehnično tehnološke lastnosti jedrskih reaktorjev za novo enoto jedrske elektrarne Krško-Krško 2: diplomsko delo*, Ljubljana, [P. Jan], 2008.
2. Andrej Kavčič, *Izračun kinetičnih parametrov reaktorja TRIGA z metodo Monte Carlo: diplomsko delo*, Ljubljana, [A. Kavčič], 2008.

RADIATION PROTECTION UNIT

SVPIIS

The SVPIIS has been involved in ionizing-radiation measurements and radiation protection since the beginning of TRIGA Reactor's operation in 1966. The responsibility of the SVPIIS is the radiation control of all the activities at the Institute dealing with ionizing radiation. So our main task is the supervision of Reactor and the 17 laboratories that use sources of radiation in their research work. More than a hundred different sources are used, such as sealed sources, open sources, X-ray units and the accelerator TANDETRON, which need regulatory control.

The SVPIIS is qualified to perform control in medical, industrial and research institutions dealing with open and sealed sources. In industry and research we are also qualified to control X-ray units. The measurements of dose rate and contamination are performed with an accredited method (EN ISO/IEC 17025).

Personal dosimetry

Personal doses of around 120 workers that regularly or occasionally deal with ionizing radiation were monitored with Thermo Luminescent Dosimeters (TLDs). The maximum individual yearly dose was 0.86 mSv. This is only 4 % of the regulatory limit for occupational workers (20 mSv per year) and less than the limit for the general public (1 mSv per year).

Supervision of reactor and laboratories

The controlled area of the Reactor, the Hot Cell facility and the Department of Environmental Sciences were 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). In 2008 we performed 18 inspections of radiation levels and contamination in the JSI laboratories. At present, 101 sources of radiation are used, which require regulatory control of the Nuclear Safety Administration. A large number of low-activity sources are also used. For each laboratory a dose-assessment report and the required radiation-protection measures were prepared. All the workers were categorized according to potential and normal working conditions.

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. Gamma spectrometry was used to monitor solid, liquid, aerosol and gas samples as well as radioactive waste.

Environmental measurements

Environmental monitoring of the Reactor Center was performed by measurements of external radiation levels, measurements of environmental samples and effluent measurements (gas discharges from the reactor operation and liquid discharges in the Sava River).

With environmental TLDs the radiation levels in the surroundings of the reactor and all the buildings on the site were monitored. Outside of the controlled area only normal, natural background radiation levels could be measured.

Based on the effluent measurements and a conservative, environmental transfer model the effective dose to the reference group in the public was estimated to be less than one micro-Sievert per year. The public exposure in 2008 due to activities at the Reactor Center was insignificant.

Radiological measurements for outside customers

The Radiation Protection Unit is qualified for radiological control in other institutions. In the past year 15 radiological control investigations were carried out in industrial, medical and research institutions. Some exposure assessment reports for occupational workers were prepared as well.



Head:

Matjaž Stepišnik, M. Sc.

Performing radiation protection and measurements during the transport of spent fuel originating from Research Reactor in Budapest. Transport route: border crossing Hodoš to the Port of Koper (Figure 2)



Figure 1: Surface-contamination measurements

Performing radiation protection and characterization of radioactive waste in the scope of the project: "Improvement of the Management of Institutional Radioactive Waste in Slovenia". In cooperation with the Department of Inorganic Chemistry and Technology at the JSI and other partners (LENIKO, IRE and TECHNABEL from Belgium) repacking, conditioning and characterization of radioactive waste from the Central Interim Storage for Radioactive Waste was carried out.



Figure 2 : Handling of transport containers containing spent fuel

INTERNATIONAL PROJECT

1. Improvement of the Management of Institutional Radioactive Waste in Slovenia
11145406-06-01-0001
Agency for Radwaste Management, Ljubljana, Slovenia; Leniko bvba, Antwerp, Belgium
Bogdan Pucelj, M. Sc., Dr. Gašper Tavčar, Bojan Huzjan, M. Sc., Prof. Borut Smodiš

STAFF

Technical officers

1. Emira Bašič, B. Sc.
2. Thomas Breznik, B. Sc.
3. Dr. Tinkara Bučar
4. Bogdan Pucelj, M. Sc.
5. **Matjaž Stepišnik, M. Sc., Head**

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1. Tinkara Bučar, Borut Smodiš, "Computer-assisted uncertainty assessment of k_{eff} -NAA measurement results", *Nucl. instrum. methods phys. res., Sect. A, Accel.*, vol. 595, pp. 647-652, 2008.
2. Tinkara Bučar, Borut Smodiš, Radojko Jačimovič, Zvonka Jeran, "Quality assessment of k_{eff} -NAA by statistical evaluation of CRM results", *Acta chim. slov.*, vol. 55, pp. 166-171, 2008.
3. Tinkara Bučar, Borut Smodiš, Primož Pelicon, Jurij Simičič, Radojko Jačimovič, "Micro-PIXE characterisation of reference samples intended for QA/QC of k_{eff} -NAA", *J. radioanal. nucl. chem.*, vol. 278, pp. 789-794, 2008.

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2. Bogdan Pucelj, "Izveček", In: *Meritve radioaktivnosti v okolici Nuklearne elektrarne Krško: poročilo za leto 2007*, Denis Glavič-Cindro, ed., Boštjan Črnič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 1-154-8-154.
3. Bogdan Pucelj, "Doza zunanlega sevanja", In: *Meritve radioaktivnosti v okolici Nuklearne elektrarne Krško: poročilo za leto 2007*, Denis Glavič-Cindro, ed., Boštjan Črnič, ed., Ljubljana, Institut "Jožef Stefan", 2008, pp. 87-154-96-154.
4. Matjaž Stepišnik, "Reka Sava", In: *Meritve radioaktivnosti v okolici Nuklearne elektrarne Krško: poročilo za leto 2007*, Denis Glavič-Cindro,

ur., Boštjan Črnič, ur., Ljubljana, Institut "Jožef Stefan", 2008, pp. 11-154-26-154. [COBISS.SI-ID 21624615]

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THESES

Ph. D. Thesis

1. Tinkara Bučar, *Vsestranska ocena merilne negotovosti nevtronske aktivacijske analize, temelječe na faktorjih k_0* , Ljubljana, [T. Bučar], 2008.

M. Sc. Thesis

1. Matjaž Stepišnik, *Analiza aktivnosti primarnega hladila pri delovanju raziskovalnega reaktorja TRIGA MARK II: magistrsko delo*, Ljubljana, [M. Stepišnik], 2008.

TECHNOLOGY TRANSFER OFFICE

U-9

The core activities of the Technology Transfer Office include assistance in technology and knowledge transfer from the Institute to businesses, the implementation of expert projects, the implementation of specific technology projects, communication and the promotion of science.

The Technology Transfer Office's mission is:

- *the continuous creation of partnerships between the Jožef Stefan Institute's researchers, industry and education,*
- *supporting knowledge and technology transfer from research to the business and educational spheres,*
- *raising the awareness of the importance of research and intellectual property protection, enabling a higher rate of commercialization for the JSI's intellectual property.*

In 2008 we continued with activities for technology and knowledge transfer to the business and educational spheres as part of the JSI's core mission. The goal of our projects is to establish a comprehensive strategy and procedures for technology and knowledge transfer and assist researchers in the execution of these projects. An overview over the JSI's potentials will enable technology and knowledge management, better visibility and the promotion of scientific research activities. In addition, we want to establish better links with industry and identify their needs for cooperation with the JSI.

Our activities are:

- technology and knowledge transfer to the business and educational systems,
- research in this field.

We carried our work out within the projects "JSI Technology Transfer", "Regions for Research" (R4R), "Communication of Technology", "Enterprise Europe Network", "Form-it", "Lean TTT", "Boost IT", "JSI Cyclotron" and "Research of the State of Innovation Activities in Slovenia" (R.SID) with suggestions for active measures (to improve the current state in business). The newly acquired project "ACT Clean" will enable an overview and the management of environment-friendly technologies in Central Europe and cooperation with the JSI departments O-2 and K-1.

Technology transfer activities

Under technology-transfer research we:

- analysed situations and proceedings for technology transfer at the JSI and in the world. We compared the JSI's situation with North Carolina State University and CERN and presented it at an international conference [PODIM, Maribor, 2008]
- investigated the state of innovation activities in Slovenia and suggested active measures for the improvement of the current state in business. This was done for the Public Agency of the Republic of Slovenia for Entrepreneurship and Foreign Investments [project R.SID]
- developed a model for identifying and modelling the transfer and evaluation of good practice in the field of technology projects for the integration of the academic sphere and the economy [collaboration with Ministry of Higher Education, Science and Technology, project R4R].

These research activities enable our active involvement in the creation of innovation and development policies, knowledge and technology transfer, familiarity with business needs and connection with several Slovenian and international organisations that are active in the same fields.



Head:
Prof. Peter Stegnar



Figure 1: The three key development areas - creating added value in that particular section, where their activities interact (Figure: A. Kornhauser)



Figure 2: Slobodan Sibinčič (Business Angels, Poteza Group) and Maja Remškar (JSI, Nanotul) during the Institute Jožef Stefan roundtable in Cankarjev dom, Ljubljana, at the 3rd Slovenian Forum of Innovation (photo: N. Jarh)

In the field of the JSI's technology and intellectual property commercialisation we are establishing an internet entry point with a list of the JSI's competences for their marketing and for communication with business and the general public. In order to better exploit the innovative potential of the Institute, our office, together with the JSI's Commission for Intellectual Property Protection, looks for appropriate intellectual property commercialisation strategies.

We assisted:

- in the process of writing patent applications,
- in assessing the possibilities of commercialisation,
- in the process of document preparation for acquiring financial sources for patenting abroad,
- in the promotion of some of the JSI's applied results to potential users.

Like with experts for the commercialization of RTD results, other inventors, researchers and entrepreneurs from Slovenia were approaching us for advice. In 2008 we have helped several tens. Of these, we helped four in the signing of contracts on technology transfer.

To connect scientists from the Institute with scientists from abroad we organised seminars and workshops. In addition, we lectured at some of these events.

The most important ones are:

- the meeting "Technology Transfer - the Possibilities and Duties of Researchers - Industrial Partners", for the presentation of technology-transfer activities. Over 100 researches and entrepreneurs attended.
- at the round table "The Transfer of Knowledge from Public Research Institutes to Industry" organised within the 3rd Slovenian Forum of Innovation, we presented three of the Institute's scientists and three experts from the support environment for innovation.
- the seminar "Smart Structures and Intelligent Materials"
- the workshop "New Materials for Medicine", in Zagreb, to connect researchers from the JSI, Ruđer Bošković, Croatia, and Joanneum Research, Austria.
- The workshop "Nanotechnologies" organised together with the institute Veneto Nanotech and Veneto Innovazione, Italy.
- The working visit "7FP" (together with MHEST) to connect researchers from the environmental sciences in the Balkan region.

We also conducted a number of individual promotions of various R&D projects, and together with the Technology Park Ljubljana we plan to extend this activity.

In addition we assisted JSI departments with the preparation and submission of EU projects. In collaboration with the Center for the Transfer of Knowledge in Information Technologies (CT-3) we encouraged the participation of small and medium-sized enterprises and members of technology parks and incubators in the projects for the European Framework Programmes.

Within the project "JSI Cyclotron" we performed a preliminary study of the opportunities and the impact of installing a cyclotron at the JSI. We also organized presentations and working meetings. The results were presented at an international conference [Nuclear Science Symposium, dresden, 2008]. The purchase of the cyclotron would open the way to a series of new research activities in the field of physics, environmental sciences, chemistry and biology, while the cyclotron could also be used for the production of radiopharmaceuticals in medical diagnostics.

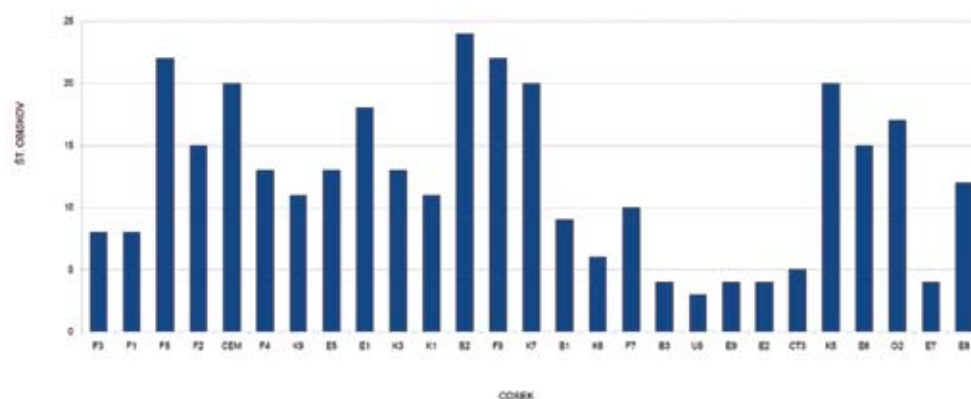


Figure 3: Number of visitors to the Institute's departments during the period 30 September 2007 to 31 October 2008. The average number of visits per department is 12. (Source: K. Žagar and Š. Stres)

Knowledge transfer activities

To expand and facilitate visits to the Institute at Jamova we have established an internet entry point for visits to the JSI and a network of coordinators for these visits. Since 1 October 2007 a total of 331 presentations of different departments were carried out. Each department was visited an average of 12 times (Figure 3). The visits are split according to the type of visitors into different groups:

- enterprises (Danfoss, Iskraemeco, etc.): our researchers met representatives from companies at workshops and/or in their laboratories,
- pupils and students from Slovenia and abroad,
- foreign researchers and different delegations, such as a visit of attachés for the information society within the framework of the Slovenian Presidency to the EU, Ministerial Conference participants, EUREKA, etc.,
- open day in the context of the Jožef Stefan Days, when the Institute was visited by more than 1100 people,
- scientific-cultural events such as the celebration of the 100-year anniversary of the birth of Anton Peterlin.

We are editors of the information centre for journalists, the Institute's online newsletter IJSplet. We regularly publish an online newspaper IJSNewsletter, received by more than 140 journalists. We have prepared and published several hundred press releases, articles and interviews for Slovenian print media and tens of recordings for various television and radio programmes. Our contributions were also published in the media of the European Union. A total of 77 researchers at the Institute, out of 560 recipients, receive eNews Enterprise Europe Network, 36 of the JSI's researchers receive technology offers and requests from the database of the Enterprise Europe Network. We have also participated in the preparation of the process for informing the public in the event of an incident at the Reactor Center.

We organised a training course for teachers from the study group Materials. Key researchers from the JSI lectured to them at the event. We also organised a visit of headmasters from secondary electrotechnical and computer science schools.

We contributed to the collection of best practices in the field of technology transfer – The Way to Success R4R – and to the preparation of the guide, workbook and a video Elimination of Barriers and an Increase of Productivity in Transnational Technology Transfer [Lean TTT]. With a variety of contributions we took part in more economic forums (the European Regional Economic Forum - EREF, the Forum of the University of Udine, the international conference PODIM, etc.) in which we have, with lectures on our activities, spread awareness about the importance of technology transfer from public research institutions to industry and the exchange of experiences on this with the other players from the support environment for innovation in Slovenia. With the presentations of activities in the field of connections of the JSI with the pre-university educational system we have contributed to several workshops for the creation and transfer of good practices in the field of education in engineering and natural science.

We were active as foreign reviewers for the Austrian Ministry of Science on a new scientific program "Sparkling Science". The projects that we recommended were accepted and submitted for our control and supervision. We are ranked among the JAPTI and TIA reviewers and perform the evaluation and control of technology projects. We are enrolled in the voucher system of advisory services.

In 2008 the **NATO RESCA** project was continued jointly with collaborating partners from Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan, according to the project work plan. All of the planned radiological field-assessment missions were carried out and the analytical services of the most important radionuclides in representative specimens of the investigated environments were provided, thus enabling a basis for a preliminary assessment of the radiation doses on populations of the general public living in these environments. The results obtained were favourably evaluated by NATO's committee of radiological experts.

Organization of conferences, congress and meetings

1. NATO Training Course on Radon and Advanced Gamma Spectrometric Measurements, Ljubljana, 12–23 Feb. 2008
2. Seminar "Smart Structures and Intelligent Materials", Ljubljana, 20 Feb. 2008
3. Visit Danfoss Trata Enterprise, Ljubljana, 28 Feb. 2008
4. Educational Workshop and Laboratory Visit for Programme Unit "Material" Graduate School Professors, Ljubljana, 10 Mar. 2008
5. Workshop "Technology Transfer", Possibility – obligations of researchers – industrial partners, Ljubljana, 19 Mar. 2008



Figure 4: Attachés of the information society during a visit to the Jožef Stefan Institute. (photo: M. Smerke.)

6. Visit of French Students from European School of Chemistry, Polymer and Materials Science (ECPM), Strasbourg, Francija, Ljubljana, 26 Mar. 2008
7. Open Doors Day, Ljubljana, 29 Mar. 2008
8. Visit of Dutch Chemistry/Material Students, Ljubljana, 29 May 2008
9. Visit of Korean Delegation, Ljubljana, 3 Jun. 2008
10. Technical Excursion of Ministry Conference for the EUREKA programme, Ljubljana, 5 Jun. 2008
11. Visit of French Delegation, Ljubljana, 12 Jun. 2008
12. Workshop R4R - Trans-regional Meeting Nanotech Framed in Regions for Research Project (R4R), WP4 Exchange of Good Practises: Veneto Nanotech, The Slovenian Cluster Policy, Ljubljana, 16- 17 Jun. 2008
13. Visit of ICT attaches for Slovene presidency, Ljubljana, 23 Jun. 2008
14. Albanian Delegation on a Study Visit, Ljubljana, 25 Sep. 2008
15. The Hundredth Anniversary Birth of Academician Prof. Dr. Anton Peterlin, Founder of Jožef Stefan Institute, Ljubljana, 27 Sep. 2008
16. Scientists from Czech Republic Visiting JSI Laboratories, Ljubljana, 7 Oct. 2008
17. Information Systems Technology (IST) Panel Symposium, Information Assurance for Emerging and Future Military Systems, Ljubljana, 16 Oct. 2008
18. Round table "Knowledge Transfer from Public Research Institutes into Industry" Framed on 3. Slovenian Innovation Forum, Ljubljana, 21-22 Oct. 2008
19. Workshop "FP7 Environment Partnering Event Slovenia and the Western Balkan", Ljubljana, 21-22 Oct. 2008
20. JSI lab Visits for EARTO Conference members, Ljubljana, 23 Oct. 2008
21. Visit Representatives from ETA Cerklje Enterprise, Ljubljana, 6 Nov. 2008
22. Workshop on New Materials in Industry and Medicine and RTD Potential for Collaborative Projects in FP7 in Collaboration of Rudjer Bošković Institute, Joanneum Research, Jožef Stefan Institute, Zagreb, Croatia, 25 Nov. 2008
23. Visit of Korean Delegation, Ljubljana, 20 Nov. 2008
24. Visit of director of Metrology Biro, mr. Pece Ristevski, Macedonia and representatives of Iskraemeco Enterprise, Ljubljana, 3 Dec. 2008
25. Visit of 20 directors of Slovene electrotechnical grade schools, Ljubljana, 11 Dec. 2008

INTERNATIONAL PROJECTS

1. EIC&IRC Services in Support of Business and Innovation
EACI-EIC&IRC Slovenia I
7. FP
European Commission, Executive Agency for Competitiveness and Innovation (EACI), CIP Network Project Management Unit, Brussels, Belgium
Prof. Peter Stegnar
2. Regions for Research
R4R
6. FP, 042981
EC; Joanna Szyfter, Stockholm Region Office, Brussels, Belgium; Stockholmsregionens Europakommitte, Stockholm, Sweden
Dr. Špela Stres, Matjaž Rus, B. Sc.
3. Eliminating Waste and Boosting Productivity in Transnational Technology Transfer
LeanTTT
6. FP, 030648
EC; Bjorn Westling, IVF Industrial Research and Development Corporation, Mölndal, Sweden
Marjeta Trobec, Spec. for International Affairs
4. Set-up of a Collaborative Permanent Network for Boosting the Participation of Incubated SMEs in Innovation Processes under FP6 Activities
Boost-IT
6. FP, 023437
EC; Eurique Neves, Inovamais - Servicos de Consultadoria em Inovacao Technologica, Matosinhos, Portugal
Prof. Peter Stegnar, Mitja Jermol, M. Sc.
5. Innovation Relay Centre of Slovenia
Si-IRC-04-08
6. FP, 510419 (IRC 6)

- Alice Wu, European Commission, DG Enterprises and Industry Innovation Policy D/2, Support for Innovation, Brussels, Belgium
Prof. Peter Stegnar, Prof. Leon Žlajpah
6. Access to Technology and Know-how in Cleaner Production in Central Europe
ACT CLEAN
Central Europe Programme
EC; Jakob Gross, Horst Pohle, Federal Environment Agency, Dessau-Roßlau, Germany
Dr. Andrej Stergaršek, Andrej Gyergyek, B. Sc., Dr. Sonja Lojen
 7. Technological Innovation Network in the Field of Information Systems
TINIS
INTERREG IIIC, West Zone
EC; Veronique Pirot, INFOPOLE Information Systems, Namur, Belgium
Andrej Gyergyek, B. Sc.
 8. Uranium Extraction and Environmental Security in the Central Asian Republics
NATO SPP - Uranium Extraction Legacy
ESP.EAP.SFPP 981742
NATO Public Diplomacy Division, North Atlantic Treaty Organisation, Brussels, Belgium
Prof. Peter Stegnar
 9. Assistance in the Development of Conceptual Design for LILW Repository in Slovenia
2003/5812.08.01
Michael Egan, Quintessa Limited, Oxfordshire; Warrington, Great Britain
Prof. Peter Stegnar

NEW CONTRACT

1. Research of the state of innovation support activities in Slovenia and active measure proposal for innovation and competitiveness increase in Slovene economy
Public Agency of the Republic of Slovenia for Entrepreneurship and Foreign Investments
Dr. Špela Stres

VISITORS FROM ABROAD

1. Björn Westling, Max Maupoix, Eva Troell, Swerea IVF, Mölndal, Sweden, Javier Gabilondo, Arturo Anton, SPRI, Sociedad Para La Promocion Y Reconversion Industrial, Bilbao, Spain, Tania De Roeck, Dirk Otte, IWT, Instituut voor de Aanmoediging van Innovatie door Wetenschap en Technologie in Vlaanderen, Brussels, Belgium, Alessandra Silvestri, Susanna Chericoni, CPR, Consorzio Pisa Ricerche - Centro TETRA, Pisa, Italy, Estelle

- Colmerauer, Adrian Duckworth, CUE, Coventry University Enterprises Limited, Coventry, UK, Pierre Roubaud, European Commission, Brussels, Belgium, 21-22 Feb. 2008
2. Andrea Reichel, European Commission, Brussels, Belgium, 29 Feb. 2008
 3. Bertrand Dessart, IRC Secretariat Luxembourg, Luxembourg, 6 Mar. 2008
 4. Prof. dr. Muzafar Yunusov, Chkalovsk, Tajikistan, 11-18 May 2008
 5. Dr. Christian Hartmann, Andrejka Kodele, Joanneum Research Forschungsgesellschaft mbH, Graz, Austria, 27 Oct. 2008

STAFF

Researchers

1. **Prof. Peter Stegnar, Head**

Technical officers

2. Andrej Gyergyek, B. Sc.
3. France Podobnik, B. Sc.

4. *Matjaž Rus, B. Sc., left 1 Jul. 2008*

5. Dr. Špela Stres

6. Marjeta Trobec, B. Sc.

Technical and administrative staff

7. Sonja Živkovič

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ORIGINAL ARTICLES

1. Meleq Bahtijari, Janja Vaupotič, Asta Gregorič, Peter Stegnar, Ivan Kobal, "Exposure to radon in dwellings in the Sharri community, Kosovo", *Radiat. prot. dosim.*, vol. 130, no. 2, pp. 244-248, 2008.
2. Meleq Bahtijari, Janja Vaupotič, Asta Gregorič, Peter Stegnar, Ivan Kobal, "Exposure to radon in the Gadime cave, Kosovo", *J. environ. radioact.*, vol. 99, no. 2, pp. 343-348, 2008.

PUBLISHED CONFERENCE PAPERS

Regular papers

1. M. Burkitbayev, B. M. Uralbekov, Peter Stegnar, B. Salbu, B. M. Tolongutov, I. A. Shiskov, "The $^{234}\text{u}/^{238}\text{u}$ concentration ratio reflects migration of contaminants from uranium mining areas in Central Asia", In: *Proceedings, oral and oral poster presentations, The International Conference on Radioecology & Environmental Radioactivity*, 15-20 June, 2008, Bergen, Norway, Per Strand, ed.,

- Justin Brown, ed., Østerås, Norwegian Radiation Protection Authority, 2008, zv. 1, pp. 72-79.
2. Matej Forjan, Andrej Gyergyek, Marko Gosak, Matjaž Perc, Samo Kralj, "Stochastic resonance in a polymer stabilized liquid crystal ferroelectric cell", In: *Proceedings of the 2008, SEM XI International Congress and Exposition on Experimental and Applied Mechanics*, June 2-5, 2008, Orlando, Florida, USA, [S. I.], Society for Experimental Mechanics, 2008, pp. [1-9].
3. Špela Stres, "A cyclotron project for medical and research usage at Jozef Stefan Institute", In: *2008 IEEE NSS/MIC/RTSD Conference record: Nuclear science symposium, Medical imaging [and] 16th Room-Temperature Semiconductor Detector Workshop, Dresden, Germany, 19-15, October 2008*, 2008, pp. 3070-3072.
4. Špela Stres, "The effect of networking on technology and innovation management at Jožef Stefan Institute", In: *The power of networking: proceedings of the 28th Conference on Entrepreneurship and Innovation Maribor - PODIM, Maribor, 27th-28th March 2008*, Miroslav Rebernik, ed., Matej Rus, ed., Tadej Krošlin, ed., Barbara Bradač, ed., Maribor, IRP Institute for Entrepreneurship Research, 2008, pp. 273-286.