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Annual Report 2009

60 years

Jožef Stefan Institute, Ljubljana, Slovenia
1949-2009

Annual report 2009

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Ljubljana, March 2010

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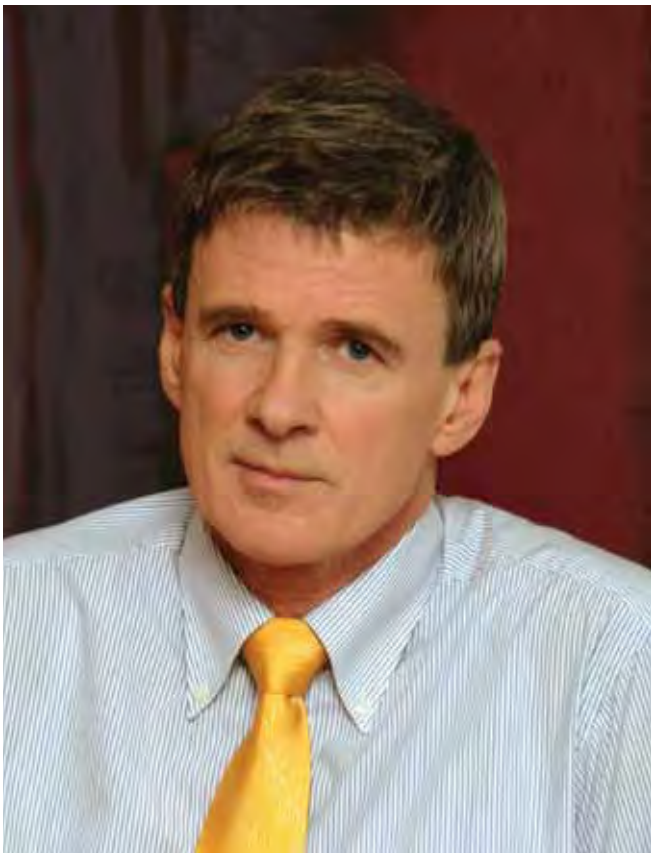
INTRODUCTION

The main focus in 2009 was given to the 60th anniversary of the Jožef Stefan Institute, which today covers many natural sciences, life sciences and technical sciences. The Jožef Stefan Institute was established in 1949 as a physics institute. Academician Prof. Dr Anton Peterlin, the first director, began the process and organised the Institute. Initially, the Slovenian Academy of Sciences and Arts acted as the founder of the Institute, but in 1970 the founder's activities were transferred to the University of Ljubljana. Then, in 1992 the Republic of Slovenia became its statutory founder and the Institute obtained the legal status of an independent public research institution.

At the ceremony marking the 60th anniversary, which took place on 24 March, the birth date of Jožef Stefan, Dr Danilo Türk, the President of the Republic of Slovenia, honoured us by addressing the attendees. All the senior state representatives attended the ceremony, including Dr Pavel Gantar, the President of the National Assembly, Mr Borut Pahor, the Prime Minister, Blaž Kavčič, M. Sc., the President of the National Council, Ministers Mr Gregor Golobič and Dr Boštjan Žekš, as well as many other friends of the Institute from the economy, science and other fields. The JSI is by far the largest research institute in Slovenia, as well as being the country's only multi-disciplinary institute. The Institute helps to create a Slovenian cultural identity and is internationally recognised.



Director of the Jožef Stefan Institute
Prof. Jadran Lenarčič

I believe that the Institute has played an important role in establishing and developing Slovenian natural and technical sciences. In the 1950s the Institute saw the start of the operation of a betatron, an electron microscope, and a Van de Graff accelerator. Later, nuclear magnetic resonance was introduced, one of the first analogue computers was built, the first microcomputers and the first robots in Yugoslavia were created, the internet was adopted, and XeF_6 and stefin were isolated. In 1966, the Triga reactor began to operate in Podgorica and the world's first digital oscilloscope was produced. Today, the JSI develops high-level technologies in all the areas of its operations.

The year 2009 was overshadowed by an economic crisis that, in a way, also helped us to analyse our situation. Here, I cannot overlook the fact that Slovenian science and technological development are still not being recognised as the basis on which Slovenia should build its development policy. Although all the strategic documents mention them, the public can only see these developments as the domain of a small circle of enthusiasts. In our country we do not focus intensely enough, and to a sufficient extent, on science and technological developments, neither do we give enough focus to the wider aspects of knowledge, creativity, innovation, new ideas – in short, on the culture of progress. This culture has not yet become part of our awareness and it seems that we do not know enough about the processes that can help us create original ideas and acquire new knowledge; we do not know how to transform scientific discoveries into cutting-edge technological products that can be successfully sold or integrated, in one way or another, into everyday life.

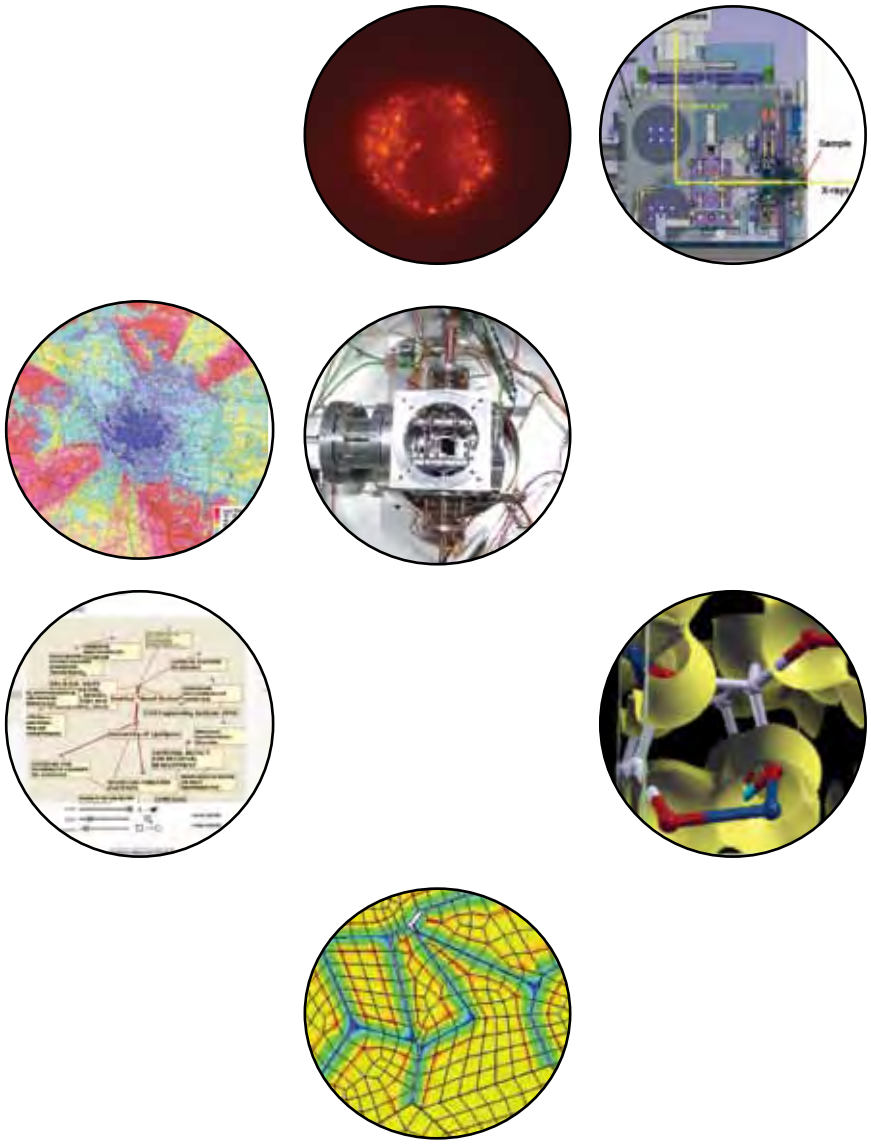
Without joining the efforts made in the areas of science, economics, politics, state administration and society, no real move towards an innovative culture will occur. With this in mind, I would like to mention some of the important guests that visited our Institute

in 2009 – Mr Borut Pahor, the Prime Minister, Mitja Gaspari, M. Sc., the Minister for Development, and Mr Gregor Golobič, the Minister of Higher Education, Science and Technology.

In recent months we have again had great hopes that there will be a start to the construction of a centre for new technologies, which we began planning and designing three years ago. The project will include the completion of an infrastructure that aims to open up the Institute and strengthen the cooperation with our partners, mainly in the economic sector, as well as bringing together different scientific disciplines within the Institute. This new centre is being undertaken in cooperation with the relevant ministry, and the start of this new task fills me confidence and expectation that new breakthroughs, involving all of us, are just ahead.

Such feelings are perhaps similar to those that our predecessors had back in 1949, some 60 years ago, when the Institute was founded and given its place in society, without having the appropriate rooms and equipment, yet filled with great hopes.

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 Zavrtanik, 1992–1996
Prof. Vito Turk, 1996–2005

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Workshops
Bogdan Veber, B. Sc.

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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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Prof. Vito Turk

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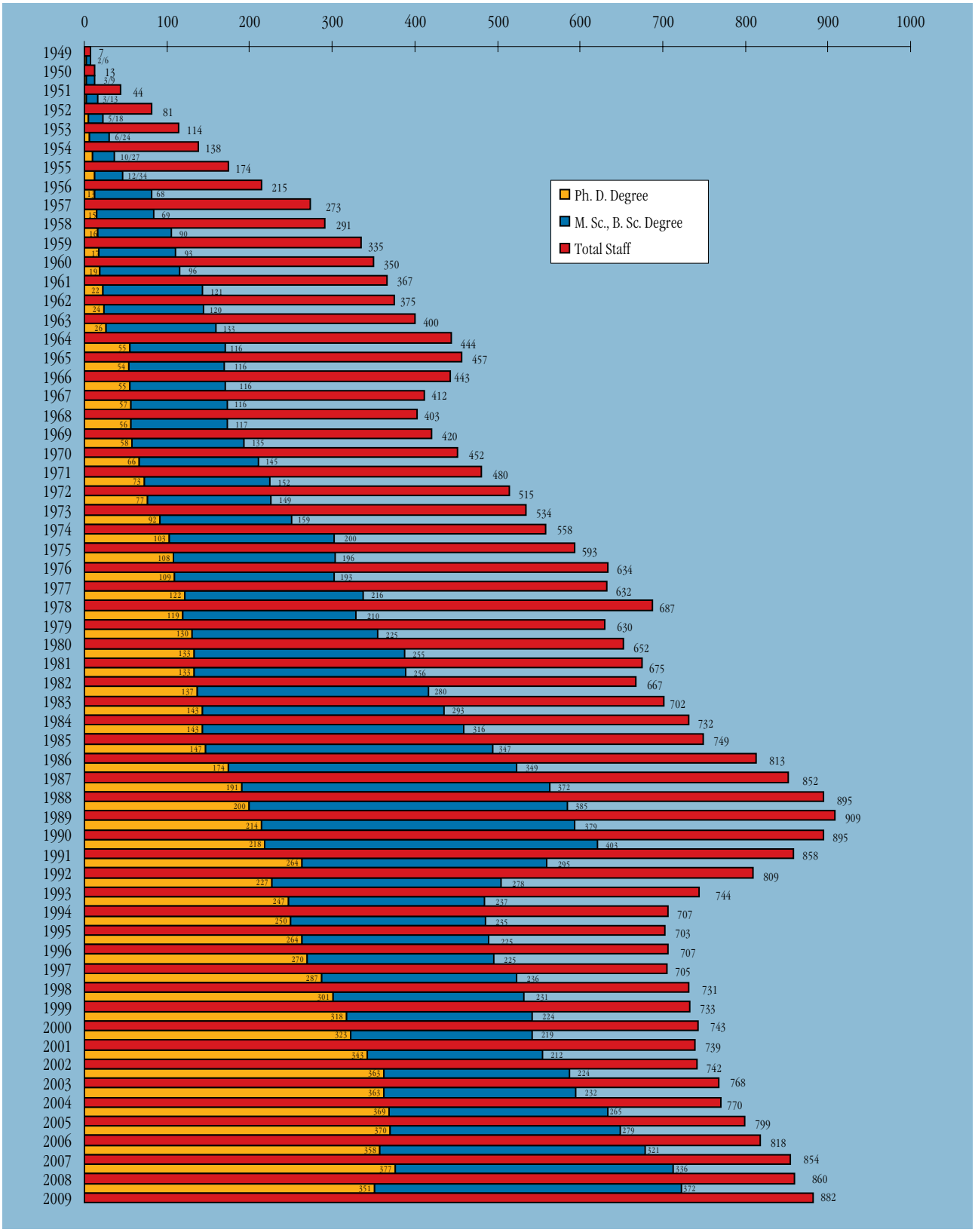
1949-2009



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)

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Prof. H. Eugene Stanley, Boston University, Boston, Massachusetts, USA
Prof. Thomas Walcher, Universität Mainz, Mainz, Germany

INTERNATIONAL COOPERATION AGREEMENTS

In 2009, cooperation agreements were signed between the Jožef Stefan Institute and:

1. Ochanomizu University, Advanced Science Division of the Graduate School of Humanities and Sciences, Tokyo, Japan
2. The Innovation Centre for Advanced Sensors and Sensor Systems, Assen, The Netherlands
3. EURAMET e.V., European Association of National Metrology Institutes, Braunschweig, Germany
4. AGC Flat Glass Europe SA, Brussels, Belgium
5. Chemistry Department of M.V. Lomonosov Moscow State University, Moscow, Russian Federation
6. Sincrotrone Trieste S.C.p.A., Basovizza, Trieste, Italy
7. Institute of Physical Chemistry »Ilie Murgulscu« of Romanian Academy, Bucharest, Romania
8. TISICS Ltd., Hampshire, Great Britain
9. Korea Institute of Ceramic Engineering and Technology, Seoul, Republic of Korea
10. South China University of Technology Department of Electronic Materials Science and Engineering, China
11. Instituto Technologico de Castilla y Leon, Burgos, Spain
12. Fysionix N.V., Beerse, Belgium
13. Hydroplan Ingenieur - Gesellschaft mbH, Worms, Germany

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)	43
7. FP - EURATOM	19
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)	30
6. FP - EURATOM	1
IEE	7
CIP	1
CENTRAL EUROPE	1
LEONARDO DA VINCI	2
E-CONTENTPLUS, PHEA	4
E-PARTICIPATION	1
E-CONTENTS AND E-SERVICES	3
SOCRATES / MINERVA, ERASMUS	1
EUREKA	6
COST	19
NATO (SfP, CLG, RIG)	2
IAEA	15
INTAS	1
ERA-NET (MATERA, MNT, SEE)	6
HFSPO	2
OTHERS (DELPHI, HERA-B, ATLAS, CERN RD-39, CERN RD-42, CERN RD-50, BELLE, BELLE II, CIMA, ARM, FEBS, UNEP, SCOPES, EUROSTARS, MŠŠ, SIM-RIS, SERENA, OECD/NEA, CAMP, EATEL, UNESCO-ROSTE...)	22
TOTAL	**186**

Bilateral cooperation	No. of projects
Albania	1
Argentine	3
Austria	11
Belgium	5
Bulgaria	2
Cyprus	1
Czech Republic	3
Denmark	2
Finland	2
France (PROTEUS - 10)	13
Croatia	8
Italy	9
Japan	8
China	19

Bilateral cooperation	No. of projects
Korea	1
Hungary	4
Macedonia	1
Germany	5
The Netherlands	3
Poland	3
Portugal	6
Romania	3
Russia	1
Serbia	10
Switzerland	1
Ukraine	5
Great Britain	2
USA	18
TOTAL	**150**

DELEGATIONS AND VISITORS

Delegation of the Government of the Republic of Slovenia, 13 February 2009:
Mr Borut Pahor, Prime Minister
Mr Gregor Golobič, Minister for Higher Education, Science and Technology
Mitja Gaspari, M. Sc., Minister for Development and European Affairs
Dr. Jozsef Györkös, State Secretary, Ministry of Higher Education, Science and Technology

Mr Filip Vujanović, President of the Republic of Montenegro, 5 March 2009

Visitors on the 60th anniversary of the JSI, 22-26 March 2009:
Dr. Danilo Turk, President of the Republic of Slovenia
Dr. Pavel Gantar, President of the National Assembly of Slovenia
Mr Borut Pahor, Prime Minister of the Republic of Slovenia
Mr Blaž Kavčič, M. Sc., President of National Council of the Republic of Slovenia
Mr Gregor Golobič, Minister for Higher Education, Science and Technology
Dr. Boštjan Žekš, Minister without Portfolio Responsible for Slovenians Abroad
Mrs Majda Širca, Ministry of Culture

H. E. Mr Shigeharu Maruyama, the Ambassador of Japan in Slovenia, 2 April 2009 and 1 June 2009

H. E. Mr Tone Kajzer, the Ambassador of the Republic of Slovenia in Finland, 2 April 2009

Dr. Boštjan Vasle, the Director of the Institute of Macroeconomic Analysis and Development of the Republic of Slovenia, 10 April 2009

H. E. Mr Roman Kirn, the Ambassador of the Republic of Slovenia in the USA, 14 April 2009

Dr. Marion Tobler, Eurosearch, Bern, Switzerland, 14–16 April 2009

Delegation of the Slovene Human Resources Development and Scholarship Fund, 11 May 2009:
Mrs Romana Tomec, Directress
Mrs Terezija Trupi

Delegation of the European Space Agency (ESA), 13 May 2009:
Mr Chris de Cooker, Head of Department of International Collaboration ESA

H. E. Mr Shigeharu Maruyama, the Ambassador of Japan in Slovenia, 1 June 2009

The Delegation of the Government of the People's Republic of China, 5 June 2009

Dr. Robert Ferko, Skimar, Elan Group, Slovenia, 9 June 2009

Prof. Hugo Tschirky, Swiss Federal Institute of Technology and Director of the ETH Center for Enterprise Sciences, Zürich, Switzerland, 16 June 2009

Delegation of Lakeside Labs, Klagenfurt, Austria, 10 June 2009
Mrs Claudia Pruggler, M. Sc., the Directress
Prof. Christian Bettstetter, the Scientific Director

H. E. Mrs Geršak Jasna, the Ambassadress of the Republic of Slovenia in Ireland, 16 June 2009

Mr Peter Papler, Ministry of Defense of the Republic of Slovenia, 24 June 2009

Mr Boštjan Hočevar, Ministry of Higher Education, Science and Technology of the Republic of Slovenia, 21 July 2009

Delegation of Ruđer Bošković Institute, Zagreb, Croatia, 22 July 2009
Dr. Danica Ramljak, the Directress of the Ruđer Bošković Institute
Prof. Ivo Šlaus, Academician

Prof. Radovan Stanislav Pejovnik, Dean, Faculty of Chemistry and Chemical Technology, University of Ljubljana, 31 August 2009

Dr. Gang Zhang, OECD, Directorate of Science, Technology and Industry, 30 September 2009

Dr. Kenneth A. Goldman, Massachusetts Institute of Technology (MIT), Cambridge, MA, USA, 1–2 October 2009

Mr Mitja Valič, Director General, Directorate of Investment, Ministry of Higher Education, Science and Technology of the RS, 16 October 2009

Dr. Hwan-Uk Kim, Senior Researcher, Korean Basic Science Institute, Daejeon, S. Korea, 19 October 2009

Prof. Jean Jacques Victor, Director, French Institute Charles Nodier, Ljubljana and H. E. Mr Bruno Rousselet, the Attaché of the French Republic in Slovenia, 21 October 2009

Delegation of the Korean Institute of Ceramic Engineering & Technology, S. Korea, 23 October 2009
Dr. Kyung-Hoe Kim, President
Dr. Hyo-Tae Kim, Principal Researcher

Dr. Pavel Gantar, the President of the National Assembly of the RS with Members of the National Assembly of the RS, 3 November 2009

Dr. Joon-Taik Park, the President of the Korean Basic Science Institute, Daejeon, S. Korea, 16 November 2009

H. E. Mrs Nicole Michelangeli, the Ambassadress of the French Republic in Slovenia, 3 December 2009

Mrs Roberta Ferrazza, the Directress of the Italian Institute of Culture in Slovenia, 3 December 2009
Mr Jean-Pierre Chevalier, the Vice President of Thales, 7 December 2009

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Doctoral theses

1. **Miha Andrejašič**, *PURY: a topology and geometry parameter library for small molecules* (mentor Dušan Turk)
2. **Jana Bezjak**, *The synthesis and characterization of BaO-rich phases within the BaO–Nb2O5 and BaO–WO3–Nb2O5 system* (mentor Danilo Suvorov; co-mentor Boštjan Jančar)
3. **Aleksander Drenik**, *The probability of heterogeneous recombination of hydrogen and oxygen atoms on the surfaces of fusion-relevant materials* (mentor Miran Mozetič)
4. **Rok Frlan**, *Design, synthesis and evaluation of sulfonohydrazide inhibitors of Mur ligases* (mentor Slavko Pečar; co-mentor Aleš Obreza)
5. **Andrej Gams**, *Control of periodic and aperiodic robotic motion with the use of nonlinear oscillators* (mentor Jadran Lenarčič)
6. **Zala Jenko Pražnikar**, *Development and use of cell model for studying the molecular mechanisms of snake venom phospholypases A2 neurotoxicity* (mentor Jože Pungerčar)
7. **Aleh Kavalenka**, *Development of alternative approach to membrane protein structure determination based on the analysis of local rotational conformational spaces* (mentor Janez Štrancar)
8. **Jani Kleindienst**, *Monitoring of the product quality in manufacturing industries* (mentor Đani Juričić)
9. **Andraž Kocjan**, *Hydrogen absorption in Ti-Zr-Ni alloys* (mentor Spomenka Kobe; co-mentor Paul J. McGuiness)
10. **Jakob König**, *Na0.5Bi0.5TiO3-based materials with mechanical-stress-dependent dielectric properties* (mentor Danilo Suvorov; co-mentor Boštjan Jančar)
11. **Tina Kosjek**, *Occurrence, fate and removal of pharmaceutical residues in water treatment* (mentor Ester Heath)
12. **Lidija Kovačič**, *Characterization of ammodytoxin's interaction to its binding proteins to explain their role in the process of neurotoxicity* (mentor Igor Križaj)
13. **Petra Kralj Novak**, *Supervised descriptive rule induction* (mentor Nada Lavrač)
14. **Klemen Kunstelj**, *Structural analysis of surface layers with non-linear optical techniques* (mentor Irena Drevenšek Olenik)
15. **Leon Lahajnar**, *Autonomous skiing of a humanoid robot* (mentor Jadran Lenarčič; co-mentor Bojan Nemec)
16. **Zoran Levnajić**, *Modular gene dynamics and network theory at mesoscopic scale* (mentor Bosiljka Tadić; co-mentor Tomaž Prosen)
17. **Manca Logar**, *Polyelectrolyte multilayer template assisted in-situ synthesis of inorganic nanostructures* (mentor Danilo Suvorov; co-mentor Boštjan Jančar)
18. **Jernej Mravlje**, *The influence of phonons on electron transport in nanoscopic systems* (mentor Anton Ramšak)
19. **Miha Nemevšek**, *Various phenomenological aspects of grand unified theories* (mentor Borut Bajc)
20. **Martina Oberžan**, *High-alumina porcelain with improved mechanical and thermal properties* (mentor Marija Kosec; co-mentor Janez Holc)
21. **Jasminka Pavlinac**, *Research on the reaction conditions for the iodo- and fluorotransformation of organic molecules* (mentor Stojan Stavber; co-mentor Marko Zupan)
22. **Ana Petelin**, *Role and significance of cysteine cathepsins in different models of apoptosis* (mentor Boris Turk; co-mentor Vito Turk)
23. **Ingrid Petrič**, *Text mining for discovering implicit relationships in biomedical literature* (mentor Tanja Urbančič; co-mentor Bojan Cestnik)
24. **Ajda Podgoršek**, *Studies of halogenations of organic molecules in water or fluorinated solvents* (mentor Jernej Iskra; co-mentor Marko Zupan)
25. **Jure Pražnikar**, *Calculating electrostatic potentional around proteins* (mentor Dušan Turk)
26. **Boštjan Pregelj**, *Use of hybrid systems for disturbance handling in low-level process control* (mentor Stanko Strmčnik)
27. **Miha Ravnik**, *Colloidal structures in thin nematic layers* (mentor Slobodan Žumer)

28. **Luka Snoj**, *Analysis of physical parameters of TRIGA Reactor* (mentor Matjaž Ravnik)
29. **Zmago Stadler**, *Interaction between friction linings and C/C-SiC composite brake discs* (mentor Tomaž Kosmač)
30. **Luka Štrubelj**, *Numerical Simulations of Stratified Two-phae Flows with Two-fluid Model and Interface Sharpening* (mentor Borut Mavko; co-mentor Iztok Tiselj)
31. **Milovan Šuvakov**, *Network models of self-assembled functional materials* (mentor Bosiljka Tadić)
32. **Andrej Tomeljak**, *Nonequilibrium dynamics of charge and collective modes in charge density wave compounds* (mentor Jure Demšar)
33. **Marko Uplaznik**, *Transport properties of electrons in Mo6Sxl(9-x) nanowire integrated chips* (mentor Dragan Mihailović)
34. **Andrej Vilhar**, *Optimization of procedures for hierarchical mobility management in the internet* (mentor Janez Bešter; co-mentor Gorazd Kandus)
35. **Zoran Vratnica**, *Analysis of bacteria damages caused by treatment with oxygen plasma particles* (mentor Miran Mozetič; co-mentor Uroš Cvelbar)
36. **Danijela Vujošević**, *Plasma sterilization of microorganisms* (mentor Miran Mozetič; co-mentor Uroš Cvelbar)
37. **Daniel Yogev**, *Assessment of behavioural thermoregulation in humans : with particular reference to mild narcosis and prolonged bed rest* (mentor Igor B. Mekjavić)
38. **Sebastjan Zorzut**, *Production control in process industry using key performance indicators* (mentor Gašper Mušič; co-mentor Vladimir Jovan)
39. **Anže Zupanc**, *Measurement of D0 mixing in D0 → ∅ K0 s decays* (mentor Tomaž Podobnik; co-mentor Boštjan Golob)
40. **Suzana Žižek**, *The role of organisms in periphyton and sediments of riverine ecosysems in mercury transformations* (mentor Mihael Jožef Toman; co-mentor Milena Horvat)

Master's theses

1. **Mojca Amon**, *The effect of »Sleep high-train low« hypoxic training on cold induced vasodilatation response in fingers and toes* (mentor Igor B. Mekjavić)
2. **Lucas Benedičič**, *Optimization of common reference channels within network of UMTS* (mentor Peter Korošec)
3. **Matej Forjan**, *Study of stochastic resonance and self organizing criticality in smectic liquid crystals* (mentor Samo Kralj)
4. **Giovanni Godena**, *Model-driven development of process-control software* (mentor Boštjan Brumen; co-mentor Stanko Strmčnik)
5. **Stojan Košti**, *Introducing information systems interoperability in public sector* (mentor Vladislav Rajkovič; co-mentor Bojan Cestnik)
6. **Nika Levovnik**, *Blog: New tools for web based Communication* (mentor Borka Jerman-Blažič)
7. **Martin Mihajlov**, *Evaluating usable security in web-based graphical user authentication* (mentor Borka Jerman-Blažič)
8. **Tine Oblak**, *Application of novel procedures for the preparation of gallium(III) fluoride with specific properties* (mentor Tomaž Skapin)
9. **Tomaž Petan**, *Development of procedures for economic use of waste mineral wool from Trimo processes* (mentor Danilo Suvorov; co-mentor Darija Bahor)
10. **Daniela Stojanova**, *Estimating forest properties from remotely sensed data by using machine learning* (mentor Sašo Džeroski; co-mentor Andrej Kobler)

Specialist theses

1. **Žiga Miklavžin**, *Introduction of e-invoice service into electronic banking with security aspects* (mentor Tomaž Klobučar)
2. **Jan Struhar**, *Cryptographic protection as a basic method for secure use of electronic documents in the insurance business procedures* (mentor Borka Jerman-Blažič)
3. **Andrej Živec**, *Elliptic curve cryptography* (mentor Tomaž Klobučar)

Undergraduate theses

1. **Leon Bedrač**, *Synthesis of dichloroiodates (1) and their use in iodination reactions* (mentor Marko Zupan; co-mentor Jernej Iskra)
2. **Tjaša Berginc**, *Synthesis and characterization of α-MnO2 nanoparticles doped with Fe3+, Cr3+ and Co2+ iones* (mentor Romana Cerc Korošec; co-mentor Polona Umek)
3. **Uroš Bergles**, *Preparation of STM tips with atomic resolution* (mentor Maja Remškar)
4. **Renata Blatnik**, *The distribution study of the ruthenium-containing compound KP1339 in blood serum by chemical speciation methods* (mentor Igor Križaj; co-mentor Janez Ščančar)
5. **Arne Bratkič**, *Seasonal variations of nitrogen species and denitrification in Lake Bled* (mentor Jadran Faganeli; co-mentor Nives Ogrinc)
6. **Miha Butinar**, *Investigation of acute toxicity of superparamagnetic nanoparticles in mice* (mentor Boris Turk; co-mentor Olga Vasiljeva)
7. **Peter Cimermančič**, *Identification of potential drug in the process of HIV virus nucleon import* (mentor Brigita Lenarčič; co-mentor Andrej Šali)
8. **Luka Cmok**, *Dynamic light scattering in ferrofluids* (mentor Alenka Mertelj)
9. **Tomaž Čendak**, *Phase diagram of aggregates of two-dimensional vesicles* (mentor Primož Ziherl; co-mentor Jure Derganc)
10. **Miran Dragar**, *Physics of viruses* (mentor Rudolf Podgornik)
11. **Slavica Ferkolj**, *Detection of blood and urine mercury in Slovenian primary school children* (mentor Joško Osredkar; co-mentor Milena Horvat)
12. **Milan Grkovski**, *Measurement of photon detection efficiency with visible light spectrometer* (mentor Samo Korpar)
13. **Vida Hartman**, *31P NMR determination of phosphorous compounds in eritrocytes* (mentor Janez Dolinšek; co-mentor Janez Plavec)
14. **Miha Jakovac**, *Optimization of mini bioreactors Minucells for cultivation of mammalian cells* (mentor Brigita Lenarčič; co-mentor Miomir Knežević)
15. **Janez Jelenc**, *Atomic scale friction* (mentor Maja Remškar)
16. **Dalija Jesenek**, *Influence of temperature and confinement on smectic liquid crystal layer thickness* (mentor Samo Kralj)
17. **Uroš Jurglič**, *Semantic text annotation with help of linked open data and open source software* (mentor Marko Bajec; co-mentor Dunja Mladenić)
18. **Marina Klemenčič**, *Preparation of epitope-tagged constructs of human proteins SMOC-1 and -2 for study of interprotein interactions in HEK 293* (mentor Brigita Lenarčič)
19. **Manca Kocjančič**, *Using serine protease inhibitor from Clytocybe nebularis as an affinity cromatography ligand for isolation of serine protease* (mentor Janko Kos; co-mentor Jerica Sabotič)
20. **Gašper Kokot**, *Effect of pore-forming mellitin on permeability of membrane of phospholipid vesicle* (mentor Saša Svetina)
21. **Nataša Kovačević**, *The effect of pH value of simulated physiological solutions on the corrosion behaviour of orthopaedic biomaterials* (mentor Boris Pihlar; co-mentor Ingrid Milošev)
22. **Štefan Krek**, *Scanning Tunnelling Microscopy and Spectroscopy of MoS2 crystal and MoS2 nanostructures* (mentor Maja Remškar)
23. **Maja Krošel**, *Measurement of metallothionein gene expression in human glea cells* (mentor Janja Marc; co-mentor Ingrid Falnoga)
24. **Željko Lalić**, *Security evaluation of the cryptographic methods used in travel documents* (mentor Borka Jerman-Blažič)

25. **Ajasja Ljubetič**, *Exploring Local Conformational Spaces with the Use of SDSL-EPR Spectroscopy and Modelling – a Case-Study of Position 18 on Equinatoxin II* (mentor Roman Jerala; co-mentors Janez Štrancar, Franci Merzel)
26. **Anže Lošdorfer Božič**, *Rupture of a charged viral capsid* (mentor Rudolf Podgornik)
27. **Kostja Makarovič**, *The influence of thermal processing on the structural properties of LTCC layers* (mentor Anton Meden; co-mentor Marija Kosec)
28. *Timon Mede*, *The effective potential method in supersymmetry* (mentor Borut Bajc)
29. **Nina Mencin**, *Sumoylation of human papilloma virus L2 coat protein* (mentor Brigita Lenarčič)
30. **Mojca Miklavec**, *Automatic calibration of neutron detectors* (mentor Andrej Likar; co-mentor Matjaž Vencelj)
31. Katarina Mustar, *Using macrocypin from parasol mashroom as an affinity chromarography ligand for isolation of cysteine proteases* (mentor Janko Kos; co-mentor Jerica Sabotič)
32. **Janja Novak**, *Marketing through the web communities: case studies* (mentor Borka Jerman-Blažič)
33. **Oto Pavkovič**, *Characterization of Epitaxial Silicon Detectors* (mentor Igor Mandić; co-mentor Gregor Kramberger)
34. **Želimirko Pavlović**, *Analysis of nuclear utility effects on local community and region* (mentors Jože Voršič, Andreja Lutar-Skerbinjek; co-mentor Tomaž Žagar)
35. **Darja Pečko**, *Electrochemical synthesis and characterization of ironpalladium magnetic thin films* (mentor Boris Pihlar; co-mentor Kristina Žužek Rožman)
36. **Gabrijel Peršin**, *Evaluation of equalisation method on processes with PID controllers* (mentor Gregor Klančar; co-mentor Damir Vrančić)
37. **Marko Pesko**, *Application of Bluetooth technology in wireless sensor networks* (mentor Matej Zajc; co-mentor Mihael Mohorčič)
38. **Dejan Petelin**, *Incremental learning of Gaussian process models* (mentor Janez Demšar; co-mentor Juš Kocijan)
39. **Vladimir Radulović**, *On the influence of the fuel-particle geometry on the multiplication factor of reactors with fuel-pebble cores* (mentor Andrej Trkov; co-mentor Igor Lengar)
40. **Jelena Rajković**, *Preparation of mature recombinant human cathepsin D in bacteria E. coli* (mentor Boris Turk; co-mentor Tatjana Zajc)
41. **Ruben Sipoš**, *Modelling words co-occurrence with machine learning* (mentor Janez Demšar; co-mentor Dunja Mladenić)
42. **Borut Sluban**, *Saturation filter for noise elimination from labeled data* (mentor Nada Lavrač)
43. **Sanja Smirić**, *The effect of cerium coatings on corrosion resistance of stainless steel* (mentor Stane Pejovnik; co-mentor Ingrid Milošev)
44. **Mateja Strmšek**, *The physical science basis of the climate models and application in physics education* (mentor Aleksander Zidanšek)
45. **Martin Strojnik**, *Drawing electrical potential in nanometer resolution using atomic force microscope* (mentor Dragan Mihailović)
46. **Eva Šimunovič**, *Removal of pharmaceutical residues in aerobic and anaerobic environment* (mentor Franci Kovač; co-mentor Ester Heath)
47. **Tadej Štajner**, *Entity resolution in texts using machine learning and background knowledge* (mentor Janez Demšar; co-mentor Dunja Mladenić)
48. **Martin Štefanič**, *Biocompatibility and bioactivity of zironium dioxide ceramics with calcium phosphate coatings* (mentor Metka Renko)
49. **Vesna Tanko**, *Covariance functions for Gaussian process models* (mentor Janez Demšar; co-mentor Juš Kocijan)
50. **Aleš Tavčar**, *Pathology in minimin search* (mentor Ivan Bratko)
51. **Iztok Urbančič**, *Non-ideality of spin labels* (mentor Igor Muševič; co-mentor Janez Štrancar)
52. **Tina Velišček**, *Alpha scintillation cells for radon measurements in the air: their calibration, test of tightness and use in wine cellars* (mentor Janja Vaupotič)
53. **Matej Vizovišek**, *Preparation of recombinant cathepsin V and potential role of cathepsins in degradation of inhibitors of apoptosis* (mentor Boris Turk)
54. **Jaka Vogrinčič Bizjak**, *Quality management in developing information systems for public sector* (mentor Bojan Cestnik)
55. **Domen Zafred**, *Studies of the biochemical properties of the cystatin domain of cathepsin F* (mentor Dušan Turk)
56. **Janez Zorman**, *Holographic patterning of light-sensitive liquid crystal elastomers* (mentor Irena Drevenšek Olenik)
57. **Anton Žumbar**, *Gravitation* (mentor Samo Kralj)

ART EXHIBITIONS AT THE JSI

Črtomir Frelih, 19 January-13 February 2009
Žiga Stanovnik, 16 February-8 March 2009
14. Artists' Colony, Vienna, 9 March-20 March 2009
Jožef Muhovič, 23 March-17 April 2009
Tone Lapajne, 20 April-15 May 2009
France in Rok Slana, 18 May-5 June 2009
Tadej Torč, 16 June-3 July 2009
Ljubljana Fine Artists Society, 6 July-31 July 2009
Viktor Šest, 3 August-10 September 2009
Janez Jelenc, Maja Remškar, 3 August-25 September 2009
Jožef Gorinšek, 14 September-12 October 2009
The Exhibition Fineart Works of Cyprus Children, 13 October-17 October 2009
Stojan Špegel, 19 October-12 November 2009
Gorazd Krnc, 16 November-10 December 2009
Marko Zatler, 14 December-11 January 2010

Jožef Muhovič, Majda Širca, Minister of Culture of the Republic of Slovenia, Prof. Jadran Lenarčič, Director of the JSI, and Milena Zlatar, at the opening of the exhibition of Jože Muhovič's work

INSTITUTE COLLOQUIA

21 January 2009: **Prof. Tomaž Kalin**
J. Stefan Institute
European research and academic computer network - a true success story

30 January 2009: **Dr. Karim Zaghib**
Hydro-Quebec, Montréal (Québec), Canada
HQ Li-ion technologies for power and energy batteries in transportation applications

11 March 2009: **Dr. Mark Johnson**
Institut Laue-Langevin, Grenoble, France
Lattice dynamics studied by inelastic neutron scattering and numerical modelling

23 March 2009: **Prof. Gerd Hirzinger**
Institute of Robotics and Mechatronics, DLR, German Aerospace Center, München, Germany
Robotics and mechatronics – from space to surgery and the virtual World

23 March 2009: **Prof. Bernard Roth**
Institute of Design, Stanford University, USA
Applying design thinking to (almost) everything

24 March 2009: **Prof. Peter Križan**
Faculty of Mathematics and Physics, University of Ljubljana and J. Stefan Institute
Where is antimatter?

25 March 2009: **Prof. Marko Topič**
Faculty of Mathematics and Physics, University of Ljubljana and J. Stefan Institute
With photovoltaic effect to TWh electric energy

26 March 2009: **Prof. James F. Scott**
Department of Physics, Cavendish Laboratory, Cambridge University, UK
Why study insulators?

10 April 2009: **Boštjan Vasle, M. Sc.**
Institute of Macroeconomic Analysis and Development of the Republic of Slovenia
Structural aspects of economic changes during the economic crisis

22 April 2009: **Prof. Joachim R. Krenn**
Institute of Physics, University of Graz, Austria in Institute for Nanostructured Materials and Photonics, Joanneum Research, Weiz, Austria
Surface plasmons meet organic optoelectronics

13 May 2009: **Prof. Giulio Cerullo**
Polytechnic University of Milan, Italy
Tracking primary photoinduced events in biomolecules with few-optical-cycle light pulses

20 May 2009: **Prof. Paolo Nanni**
Inst. Energetics & Interphases, C.N.R., Genoa, Italy
Preparation of core-shell perovskite structures with restricted geometries by soft chemistry methods

5 June 2009: **Prof. Wojciech Grochala**
Faculty of Chemistry, University of Warsaw, Poland
Quest for superconductivity in compounds of divalent silver: 8 years after the prediction

30 September 2009: **Prof. Pietro Carretta**
University of Pavia, Pavia, Italy
NMR and mSR in SmFeAsO1-xFx superconductors

14 October 2009: **Dr. Yukio Sakabe**
Murata Manufacturing Co. Ltd., Kyoto, Japan
Morphology and characteristics of the advanced electro-ceramics

21 October 2009: **Prof. Boris Turk**
J. Stefan Institute
Transport of cellular signals with proteases: a biomedical challenge for 21st century

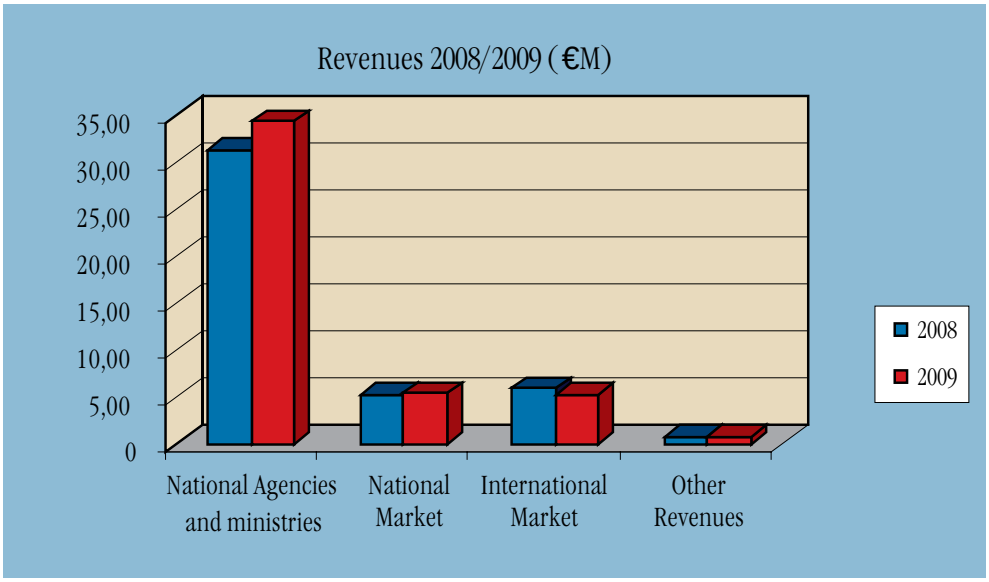
11 November 2009: **Prof. Stefan Thurner**
Complex Systems Research Group, Medical University of Vienna, Vienna, Austria and Santa Fe Institute, Santa Fe, New Mexico, USA
Anatomy of financial crisis

20 November 2009: **Dr. Marcos Bavdaž**
European Space Agency, Science and Robotic Exploration Directorate, Noordwijk, The Netherlands
Space research in Europe

FINANCING

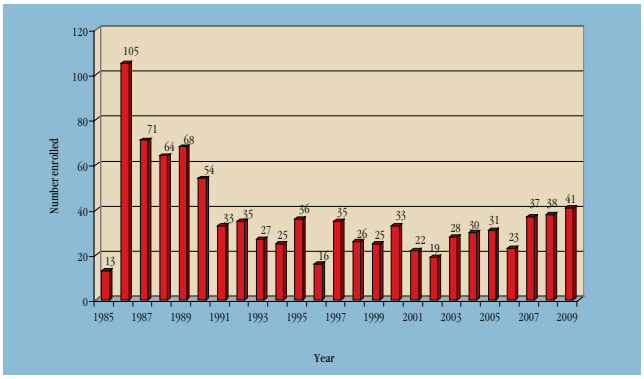
REVENUES JSI (€) AND NUMBER OF PROJECTS

		Contribution		Contribution		No. of Contracts
	2009	2009	2008	2008	Index 2009/2008	in 2009
National Agencies and Ministries	34,400,164	75.2 %	31,284,128	72.5 %	110.0	297
National Market	5,345,020	11.7 %	5,204,442	12.1 %	102.7	329
International Market	5,251,903	11.5 %	5,860,905	13.6 %	89.6	390
Other Revenues	736,082	1.6 %	785,073	1.8 %	93.8	
TOTAL	**45,733,170**	**100.0 %**	**43,134,548**	**100.00 %**	**106.0**	**1016**

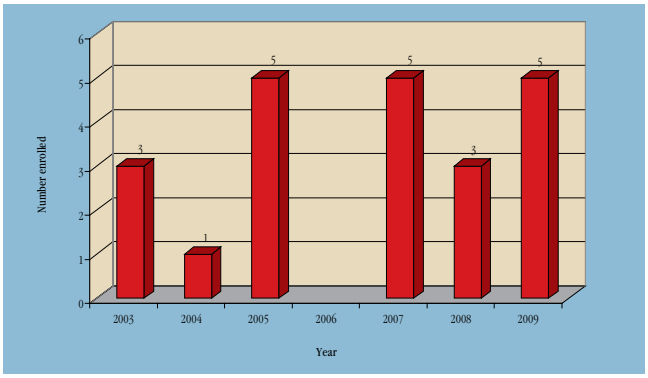


POSTGRADUATES FINANCED 1985-2009

by Slovenian Research Agency



by Industry



JSI UNDERGRADUATE SCHOLARSHIPS

1977-2009

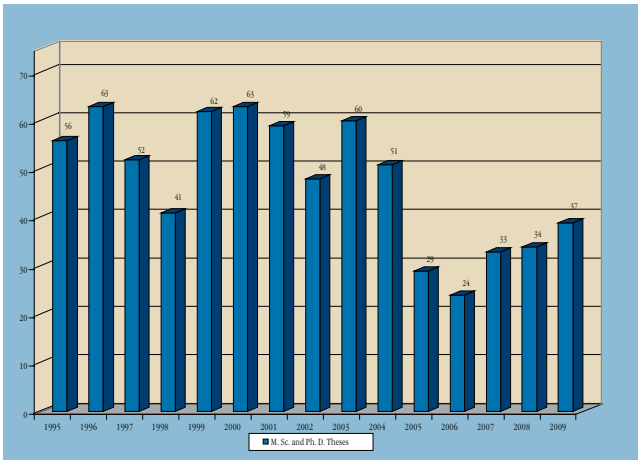
Year	FMF		FKKT UNI LJ	FKKT UNI MB	FFA	FDV	BF	FE and FRI	FS	EF	FG and FERI	MF	UNG	Total
	Physics	Mathematics												
... 1982	115	38	100					50	9	3				315
1983	10	1	5					9			1			26
1984	11	3	7				1	12			1			35
1985	18	4	6				1	19			1			49
1986	16	8	4					22	2					52
1987	20	8	4					23	2					57
1988	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
2009	2	1	17	4		1	5	16			1		2	49
TOTAL	377	89	387	7	6	5	53	435	15	4	18	2	9	1407

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 2009

Year	Ph. D. Theses	M. Sc. Theses	Total
...1962	15	6	21
1963	7		7
1964	7	2	9
1965	16		16
1966	2		2
1967		8	8
1968	4	8	12
1969	3	6	9
1970	2	12	14
1971	7	6	13
1972	11	24	35
1973	8	14	22
1974	21	10	31
1975	10	20	30
1976	6	31	37
1977	5	16	21
1978	10	20	30
1979	7	11	18
1980	13	10	23
1981	12	15	27
1982	13	18	31
1983	5	10	15
1984	14	17	31
1985	6	14	20
1986	8	15	23
1987	18	21	39
1988	12	26	38
1989	15	33	48
1990	16	41	57
1991	22	47	69
1992	19	42	61
1993	28	36	64
1994	27	37	64
1995	34	22	56
1996	38	25	63
1997	29	23	52
1998	21	20	41
1999	33	29	62
2000	36	27	63
2001	31	28	59
2002	29	19	48
2003	41	19	60
2004	31	20	51
2005	22	7	29
2006	22	2	24
2007	26	7	33
2008	29	5	34
2009	30	7	37
TOTAL	821	836	1657



AWARDS AND APPOINTMENTS

AWARDS MADE TO JSI RESEARCHERS BY THE REPUBLIC OF SLOVENIA

Zois Recognitions and Award of the Republic of Slovenia

Prof. Igor Muševič
Presented with the Zois Award for great achievements in the field of soft condensed matter physics

Dr. Ilija Bizjak, Jožef Stefan Institute
Measurement of $|V_{ub}|$ Using Inclusive Semileptonic Decays on a Sample of Reconstructed B mesons with the Belle detector

Dr. Miha Založnik, Graduate School, University of Nova Gorica
Modeling of macrosegregation in direct chill casting

Dr. Tina Pangršič, Faculty of Medicine, University of Ljubljana
Electrophysiological properties of rat cultured astrocytes

The recipients of Zois awards and recognitions

Dr. Nadja Hvala, Dr. Darko Vrečko and Dr. Aljaž Stare
Presented with the Zois Award for great achievements in the field of control of wastewater-treatment processes

Dr. Martina Oberžan, Dr. Janez Holc, Ivan Lavrač, Marjan Buh, M. Sc. and Prof. Marija Kosec
Presented with the Puh Recognition for inventions, research achievemets and the application of the scientific research at development of high alumina porcelain with improved mechanical and thermal properties

JSI AWARDS AND APPOINTMENTS

The Jožef Stefan Golden Emblem Prize

presented to the following for doctoral theses with high impact :

INTERNATIONAL AWARDS TO JSI RESEARCHERS

Prof. Robert Blinc, Ismar Fellow, Ismar Council 2008, for the highest achievements in magnetic resonance

Prof. Robert Blinc, Reward for outstanding contributions to ferroelectricity, Xian, China, 12th IMF Meeting

Carolina Fortuna, 4WARD Innovation Award, Bremen, Germany, FISS 09 Summer school , Essay: "*What can be the biggest networking innovation in the Future Internet, which technologies are required to implement it, and which business ideas would be enabled by it?*"

Matej Gašperin, **Prof. Đani Juričić**, **Dr. Bojan Musizza**, **Prof. Igor Mekjavić**, are the recipients of the 2009 ISA Transactions Best Paper Award for the paper entitled "*A model-based approach to the evaluation of flame-protective garments*". The award was determined by a five-member review committee from 45 papers.

Dr. Nataša Obermajer, L'Oreal-UNESCO fellowship, 'For Women in Science' Award for 2009, L'Oréal, Slovenian National Commission for UNESCO and the Slovenian Science Foundation

Dr. Paula Pongrac, L'Oreal-UNESCO fellowship, 'For Women in Science' Award for 2009, L'Oréal, Slovenian National Commission for UNESCO and the Slovenian Science Foundation

Prof. Samo Kralj, Prometheus Award for Science, Slovenian Science Foundation

Ajasja Ljubetič, Faculty Prešeren award, Faculty of Chemistry and Chemical Technology, Ljubljana, B. Sc. Thesis entitled: *Exploring local conformational spaces with the use of SDSL-EPR spectroscopy and modelling – a case-study of position 18 on Equinatoxin II*

Anže Lošdorfer Božič, Faculty Prešern award, Faculty of Mathematics and Physics, University of Ljubljana

Dr. Nataša Obermajer, Krka award for Ph. D. thesis

The winners of the Jožef Stefan Golden Emblem Prize

Dr. Marina Santo Zarnik, Acknowledgement "Excellent poster Award" for the poster and the contribution of the referate "*FE analyses and prototype testing of a piezoresistive LTCC-based low pressure sensor*", Steering Committee of International Symposium for Design and Technology o Electronics packages SIITME, Gyula, Hungary, 20 September 2009

Videolectures.Net portal, World Summit Award in E-Science & Technology, Monterrey, Mexico, United Nations

AWARDS TO JSI RESEARCHERS BY SLOVENIAN INSTITUTIONS

Matjaž Gams, **Rok Piltaver**, **Erik Dovgan**, **Bogdan Pogorelc**, **Matej Kristan**, **Janez Pers**, **Andrej Planina**, **Gašper Pintarič**, the award for first place between the research and development organizations with the firm Špica International d.o.o. and the Faculty of Electrical Engineering, University of Ljubljana, the 4th Slovenian Innovation Forum in Ljubljana, 1.–2. 12. 2009, the innovation title: Intelligent security system for indoor personnel and equipment monitoring.

Prof. Janko Kos, Slovenian biochemical society, Lapajne award for research work 2009

Dr. Jasminka Pavlinac, Krka award for Ph. D. thesis

Dr. Ajda Podgoršek, Krka award for Ph. D. thesis

Asst. Prof. Maja Remškar, Pregl Award for Outstanding Achievements, National Institute of Chemistry, Ljubljana

Dr. Gaj Stavber, Maks Samec Award for Ph. D. thesis in Chemistry, Faculty for Chemistry and Chemical Technology, University of Ljubljana

Dr. Gaj Stavber, Pregl Award for the Outstanding Ph. D. thesis, National Institute of Chemistry, Ljubljana

Prof. Borut Štrukelj, Mlinarik award 2009, Slovenian pharmaceutical Society

Iztok Urbančič, Faculty Prešeren award, Faculty of Matematics and Physics, University of Ljubljana, B. Sc. Thesis entitled: *Non-ideality of spin labels*

Asst. Prof. Primož Ziherl, Golden Tablet of the University of Ljubljana

Blue supernitride coatings SN-AlTiN (Department of Thin Films and Surface, F-3), Golden award in the category "Products, equipment, procedures and services in support activities of toolmaking", 10th fair Forma tool, Celje

REVIEW OF PUBLICATIONS

FOR 2009

Department	Original Articles*	Books	Patent Appl. and Grants	Theses
Department of Theoretical Physics (F-1)	115	1		1
Department of Low and Medium Energy Physics (F-2)	74	3		2
Department of Thin Films and Surfaces (F-3)	15			
Department of Surface Engineering and Optoelectronics (F-4)	56		4	1
Department of Solid State Physics (F-5)	173	3	10	5
Department for Complex Matter (F-7)	39	2	2	3
Department of Reactor Physics (F-8)	50	2	1	2
Department of Experimental Particle Physics (F-9)	149	1		1
Department of Inorganic Chemistry and Technology (K-1)	27		3	1
Department of Physical and Organic Chemistry (K-3)	30			2
Electronic Ceramics Department (K-5)	66	2	1	1
Engineering Ceramics Department (K-6)	17	1		1
Department for Nanostructured Materials (K-7)	54	1	2	2
Department for Synthesis of Materials (K-8)	18	1	1	
Department for Advanced Materials (K-9)	27			3
Department of Biochemistry, Molecular and Structural Biology (B-1)	23			5
Department of Molecular and Biomedical sciences (B-2)	13	2		2
Department of Biotechnology (B-3)	53		2	1
Department of Environmental Sciences (O-2)	75	8		2
Department of Automation, Biocybernetics and Robotics (E-1)	33	1		2
Department of Systems and Control (E-2)	40			6
Laboratory for Open Systems and Networks (E-5)	15			
Department of Communication Systems (E-6)	54			2
Department of Computer Systems (E-7)	27	4	1	
Department of Knowledge Technologies (E-8)	80	11		4
Department of Intelligent Systems (E-9)	44	3	2	1
Department of Reactor Engineering (R-4)	44	4		1
Science Informaton Centre (SIC)				1
Energy Efficiency Centre (EEC)	5	5		
Centre for Knowledge Transfer in Information Technologies (CT-3)	3	1		
Milan Čopič Nuclear Training Centre (ICJT)	5			
Radiation Protection Unit (SVPIS)	6			
Director's Office (U-1)	18		1	
Technology Transfer Office (U-9)	1	1		
Jožef Stefan Institute	1291	52	23	37

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

PATENTS GRANTED

1. Method and device for modification of implants and vascular grafts made from PET polymer
   Miran Mozetič, Alenka Vesel, Ita Junkar, Uroš Cvelbar, Simona Strnad
   SI Patent 22608
2. Process for synthesising quasi-one-dimensional structures of dichalcogenides and oxides of transition metals
   Aleš Mrzel, Maja Remškar, Marko Viršek, Adolf Jesih
   SI Patent 22623
3. Selective modulators of integrine receptors $\alpha_5\beta_1$ and triple modulators of integrine receptors $\alpha_v\beta_3$, $\alpha_v\beta_5$ and $\alpha_5\beta_1$ 1,3,5-triazine skeleton
   Kristina Nadrah, Marija Sollner Dolenc, Slavko Pečar
   SI Patent 22675
4. Double an triple modulators of integrine receptors $\alpha_v\beta_3$, $\alpha_{IIb}\beta_3$, $\alpha_v\beta_5$ and $\alpha_v\beta_1$ with 3-phenyl-1,2,4-oxsadiasole skeletonKristina Nadrah, Marija Sollner Dolenc, Slavko Pečar
   SI Patent 22676
5. Double and triple modulators of integrine receptors $\alpha_v\beta_3$, $\alpha_{IIb}\beta_3$, $\alpha_v\beta_5$ and $\alpha_v\beta_1$ with 1,2,4-oxsadiasole skeleton
   Kristina Nadrah, Marija Sollner Dolenc, Slavko Pečar
   SI Patent 22677
6. Apparatus and method for transmission of personal nutrition table and nutritional data of foods from computer application into the kitchen scale
   Barbara Koroušić - Seljak, Gregor Papa
   SI Patent 22693 A
7. Adaptive Device for Controlling Household Appliances
   Konrad Steblovnik, Damjan Zazula, Jurij F. Tasič
   SI Patent 22721
8. Procedure and device for intelligent entry control
   Matjaž Gams, Tea Tušar, Andrija Pušić, Mitja Kolbe,
   SI Patent 22822
9. Small field intensity modulated radiation therapy machine
   T.R. Mackie, S. Becker, Robert Jeraj
   Patent No. US7,519,149 B2
10. Thrombin inhibitors
    Lucija Peterlin - Mašič, Danijel Kikelj, Andreja Kranjc, Petra Marinko, Alenka Trampuš - Bakija, Mojca Stegnar, Dejan Đelović, Andrej Preželj, Slavko Pečar
    Patent No. US 7,524,871 (B2)

KNOWLEDGE TRANSFER

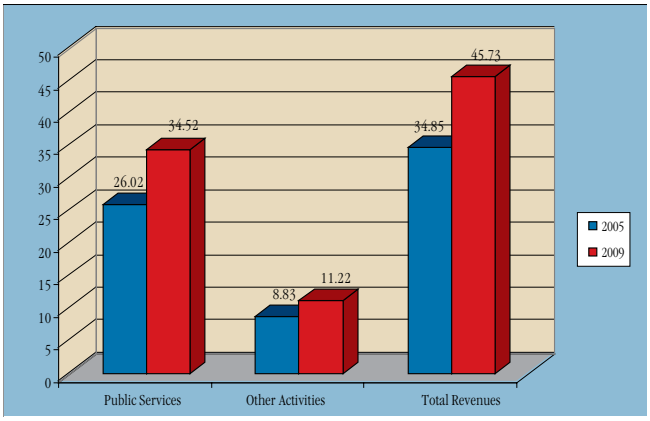
The JSI pays a lot of attention to furthering its links with industry. In keeping with European aims and the objectives of the Slovenian government, the JSI organized several important meetings on the subject of cooperation with enterprises and industry. In this way the JSI introduced a new method of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

R & D PROJECT PARTNERS

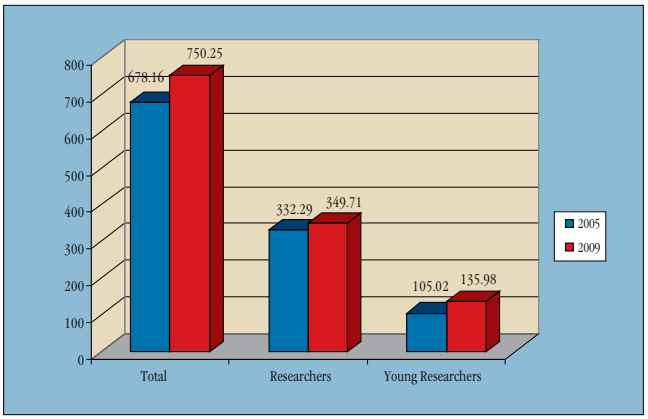
1. 3Tris, d. o. o., Solkan
2. ARAO, Ljubljana
3. ARCTUR, d. o. o., Nova Gorica
4. BIA Separation, d. o. o., Ljubljana
5. Cinkarna Celje, d. d., Celje
6. Cosylab, laboratorij za kontrolne sisteme, d. d., Ljubljana
7. Domel, d. d., Železniki
8. Ecot, d. o. o., Ljubljana
9. Elektroinštitut Milan Vidmar, Ljubljana
10. Elgo - line, d. o. o., Cerknica
11. GEN energija, d. o. o., Krško
12. Geoplin plinovodi, d. o. o., Ljubljana
13. Gorenje gospodinjski aparati, d. d., Velenje
14. Holding Slovenske elektrarne, d. o. o., Ljubljana
15. Induktio, d. o. o., Ljubljana
16. INEA, d. o. o., Ljubljana
17. Instrumentation Technologies, d. d., Solkan
18. Iskra Kondenzatorji Industrija kondenzatorjev in opreme, d. d., Semič
19. Iskra Zaščite, d. o. o., Ljubljana
20. JAPTI-Javna agencija Republike Slovenije za podjetništvo in tuje investicije, Ljubljana
21. Javni zavod RS za varstvo kulturne dediščine, Ljubljana
22. Kolektor group, d. o. o., Idrija
23. Kolektor Magma, d. o. o., Ljubljana
24. Krka, tovarna zdravil, d. d., Novo mesto
25. Ministrstvo za gospodarstvo, Ljubljana
26. Ministrstvo za obrambo, Ljubljana
27. Ministrstvo za okolje in prostor, Ljubljana
28. Ministrstvo za visoko šolstvo, znanost in tehnologijo, Ljubljana
29. Ministrstvo za zdravje, Ljubljana
30. Mobitel, d. d., Ljubljana
31. Nacionalni inštitut za biologijo, Ljubljana
32. Nanotesla Institut Ljubljana, Ljubljana
33. Nuklearna elektrarna Krško, Krško
34. RRA notranjsko-kraške regije, d. o. o.
35. RŽV, d. o. o., Gorenja vas
36. Splošna bolnišnica "dr. Franca Derganca", Šempeter pri Gorici
37. Steklarna Hrastnik, d. d. - Opal, d. o. o., Hrastnik
38. Telekom Slovenije, d. d., Ljubljana
39. Telsima, d. o. o., Trzin
40. Univerza v Mariboru, Maribor
41. Varsi, d. o. o., Ljubljana
42. ŽITO prehrambena industrija, d. d., Ljubljana

INSTITUTE IN NUMBERS 2005–2009

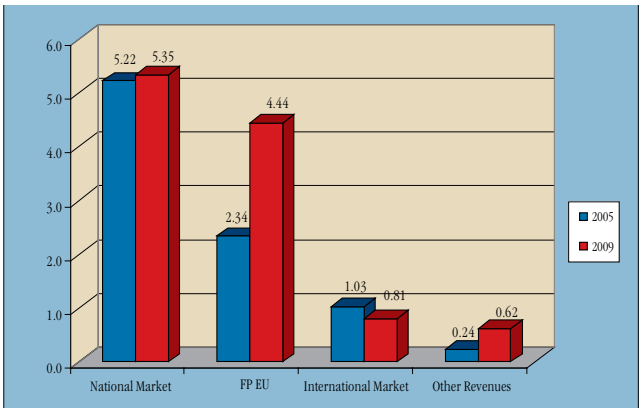
COMPARISON OF REVENUES (€M)



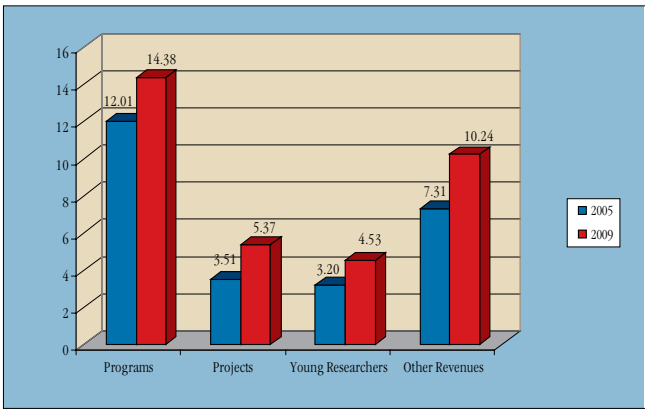
EMPLOYEES (FTE)



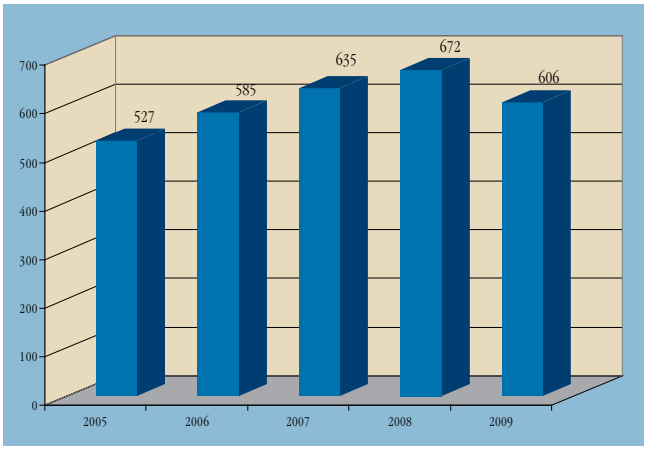
REVENUES FROM OTHER ACTIVITIES (€M)



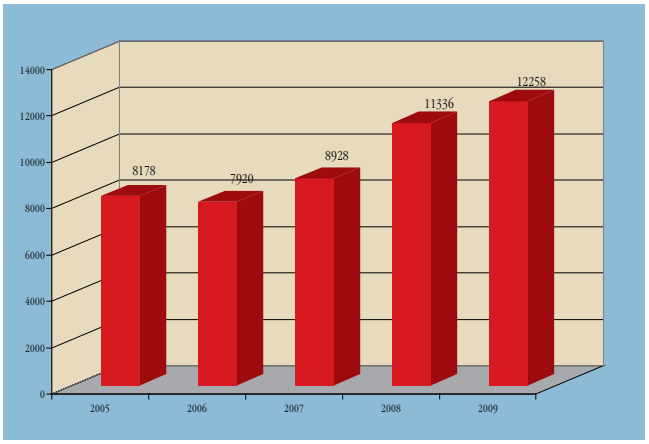
REVENUES FROM PUBLIC SERVICES (€M)



NUMBER OF PUBLICATIONS IN THE WEB OF SCIENCE



NUMBER OF CITATIONS IN THE WEB OF SCIENCE



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 pion electro-production amplitudes in a coupled channel framework incorporating quasi-bound quark-model states. It offers a clear prescription for how to extract the resonant part of the amplitudes, even in the presence of different decay channels. In a chiral quark model we were able to reproduce the relevant amplitudes in the Roper region and pointed out a significant contribution from the pion cloud.

Using a lattice QCD simulation we found an indication that the observed resonances are actually tetraquark states. Tetraquarks are bound states with two valence quarks and two valence antiquarks, which have not been confirmed beyond doubt so far. We determined the Bethe-Salpeter wave function of the pion using lattice QCD.

Within the Higgsless models of electroweak symmetry breaking, we have explored connections between the Drell-Yan production of heavy resonances at hadron colliders and the contributions of these heavy resonances to electroweak precision observables. We have analyzed important, so-far unstudied, long-distance contributions to the rare decays of the B meson to a strange meson and a pair of neutrinos. We have shown that these effects contribute up to 15 percent of the total branching ratios for these processes within the standard model.

In the Higgsless models of electroweak symmetry breaking, the direct production of heavy resonances at the LHC and the Tevatron can be related to electroweak precision measurements at lower energies.

In the past year we studied the role of leptoquarks in the leptonic decays of Ds mesons, where the experiment shows a 2-sigma deviation from the lattice QCD prediction. As it turned out, among many possible leptoquarks only the weak singlet can explain the observed deviation. Later we also studied the forward-backward asymmetry, whose Standard model prediction is not compatible with the measurement during a Fermilab experiment. In collaboration with LPT Orsay, Paris, we studied the electromagnetic background of the semi-leptonic decays of B to D mesons, and presented the results at two conferences.

Using the most general model independent Lagrangian of the new physics we investigated possible experimental signals of the new physics in t –> c(u) l+ l- FCNC top decays. We found that the measurement of two possible asymmetries might provide very important and interesting information about NP.

We have calculated the highly suppressed wrong flavour decays of B mesons to two hadrons and have shown that they can be used during upcoming super flavour factories for new physics searches. We have developed an effective field theory description for the leptophilic dark matter interactions in matter and have shown that the DAMA signal cannot be explained by this large set of models. We have shown that long-lived particles can modify indirect dark-matter detection. We have developed a formalism that generalized the definition of the minimal flavour violation to the nonperturbative regime. We have performed the first global analysis of direct dark-matter searches after the CDMS-II results.

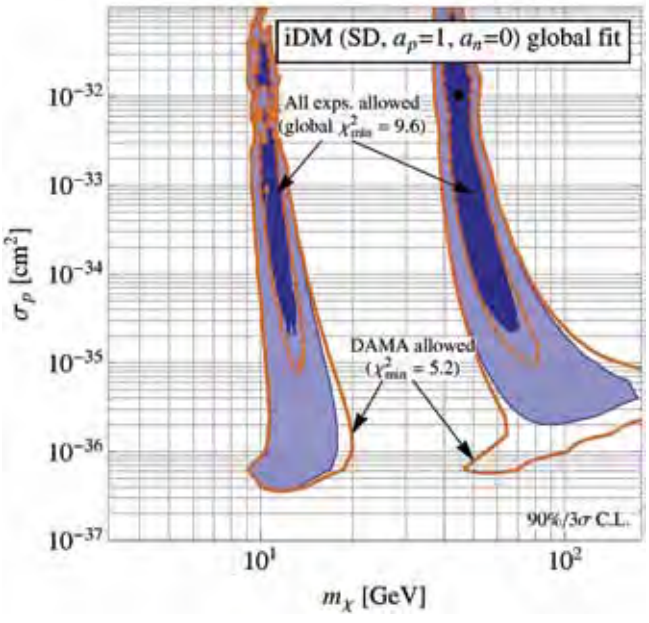


Figure 1: Allowed regions in the mass cross-section plane for inelastic dark matter that predominantly scatters spin-dependently on protons.

We have looked into lepton flavour violation (LFV) in the case of minimal type-I and type-III seesaw scenarios, motivated by a minimal SU(5) grand unified theory. In these setups, the LFV signal is governed by a single real parameter and the ratios of the different channels (electron, muon and tau) are related to the measured neutrino mixing angles. The best bound on this parameter comes from the muon-electron conversion. This precludes any rare tau decays and makes it hard to produce a singlet at the LHC. In the future, the mu-e conversion bound will be improved by 4-6 orders of magnitude by approved experiments, which encouraged us to explore another issue of probing leptonic CP violation in these decays. We showed that for any model with a low-scale seesaw and no other interactions, the CP-odd triple spin correlation is too small to be measured. On the other hand, if parity is restored at a low enough scale (<30 TeV), the CP violating triple-spin correlation can even be maximal.

We have investigated a theory for the relativistic point particle in 8-dimensioanl phase space. We assumed an action that contains an orthogonal and a symplectic form. By introducing a symplectic potential we obtained an action that was invariant under the general coordinate transformations of all eight coordinates. Such a theory has turned out to be a special case of relativity in curved Clifford space with the Clifford algebra Cl(8) as a tangent space.

The group for SOLID STATE THEORY AND STATISTICAL PHYSICS has been investigating the properties of relaxor ferroelectrics, complex networks and self-organised structures, the thermodynamic and transport properties of spin systems, nanosystems and quantum dots as well as models of strongly correlated electrons as relevant to novel materials.

We have explored the influence of two different polarizations of quantum oxygen vibrations on the spacial symmetry of the bound magnetic bipolaron in the context of the t—J model. Electron—phonon coupling to transverse polarization stabilizes the bound bipolar state with the d—wave symmetry. The existence of a magnetic background is essential for the formation of a d—wave bipolaron state.

We have developed a mesoscopic model of crystals possessing both relaxor ferroelectric and relaxor ferromagnetic properties. We have shown that the coexistence of polar and magnetic nanoregions, which interact via lattice strains, leads to a biquadratic coupling between the polarization and magnetization. The relaxation of the polarization in this case obeys a modified Vogel-Fulcher law.

Within the research of complex networks we have introduced a new model of growing networks with mesoscopic inhomogeneities and studied the eigenvalue spectra of the Laplacian diffusion operator on these networks. We have shown that in several classes of such networks one can precisely determine the modular structure on the basis of the spectral properties. We have studied the dynamical 'jamming' transition in transport processes with queuing at the nodes in complex networks. The simulated examples represent the model of information traffic on the internet and the city-traffic model, simulated on a dual graph of the streets in Nanjing. We have continued the study of conduction in nanoparticle films, by using the mapping onto planar graph models and simulating the single-electron tunnelling processes on them. We have demonstrated that the topological inhomogeneities of the film lead to the collective fluctuations of charge at the nanoparticles along the conduction paths through the sample.

Within the broader subject of strong correlation a new numerical method for the calculation of the dynamical properties of strongly correlated systems was developed. It is a combination of the density matrix renormalization group method and a finite-temperature Lanczos method and was tested on the Heisenberg model. The theoretical investigations of the transport properties of spin-chain materials have been also continued. The emphasis was on the influence of impurities and disorder on the thermal and spin transport. It has been shown that even a single impurity qualitatively changes the spectral properties and leads to an incoherent transport.

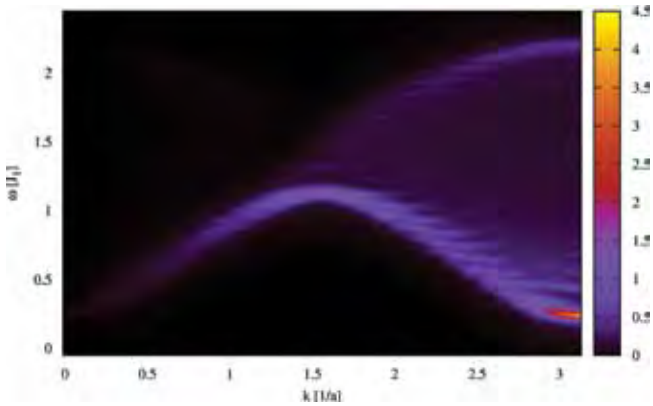


Figure 2: The simulated dynamical spin–structure factor $S(k,\omega)$ at zero temperature for the spin-Peierls compound $CuGeO_3$, which is modelled with the frustrated J_1-J_2 model including dimerization on the one-dimensional chain with site spacing a.

The studies of novel superconductors have been also continued. We have investigated the properties of magnetic-lattice polaron and bipolaron in the framework of the t-J model coupled to vibrational degrees of freedom. We analyzed the optical conductivity for a single doped hole into the antiferromagnetic plane within the t-J Holstein model as well as the behaviour of two doped holes, whereby the holes are coupled to different polarizations of the lattice vibrations. Transverse polarization leads to a bound state with a d-wave symmetry, whereas longitudinal polarization leads to the bipolaron with a p-wave symmetry. We are also investigating the properties of phonon spectral functions and found novel states. Using the memory-function approach to spin dynamics in a doped antiferromagnetic insulator we have explained the anomalous scaling in a broad range. The theory involved was used to analyze recent inelastic neutron-scattering results for underdoped cuprates. We presented a phenomenological theory of quasiparticle scatter-

ing and transport relaxation in the normal state of iron pnictides based on the simplified two-band model coupled via spin fluctuations, revealing a similarity with the physics of cuprates.

The efforts towards the theory of electronic nanosystems have been continued. We investigated the electron-phonon coupling in molecular conductors. We found that quite generally the coupling to electrons softens the vibrational mode, which could account for the asymmetric position of the molecule between the electrical contacts observed in break-junction experiments. We derived a simple expression relating the spin entanglement of a pair of electrons extracted from a many body system to a small set of expectation values. This enabled us to calculate the spin-entanglement in several many-body states.

The group of THEORETICAL BIOPHYSICS AND SOFT MATTER PHYSICS focused on polyelectrolytes, liquid crystals, colloids, and phospholipid and biological membranes

We studied several aspects of electrostatic interactions in soft-matter physics. Using the one-dimensional Coulomb gas as a toy model, we illustrated the validity of the weak and the strong coupling limit compared to the analytically calculated osmotic pressure. We formulated the mean-field theory of Coulombic fluids with specific ion-solvent interactions. We analyzed the role of counterions' multipoles in the interactions between charged surfaces and identified the parts of the parameter space where these effects may be important. We developed a theoretical description of the electrostatic interactions in electrolytes of moderate and large ionic strengths, thereby advancing the understanding of certain highly charged biological systems. We also proposed a simple empirical equation of state for neutral polymers that reproduces the behaviour of a broad range of polymers in water and other solvents.

We proposed a theory of elastic instabilities of icosadeltahedral viral capsids and discovered the scaling relationship between the critical osmotic pressure and the capsid size.

We studied the effect of the frozen disorder of the local dielectric function on Casimir interactions between two semi-infinite dielectric media. We introduced a new method for the evaluation of the van der Waals interaction in multilamellar systems consisting of media with an anisotropic dielectric response. We calculated the retarded van der Waals interactions between carbon nanotubes of various types.

Our studies also included topics in liquid crystals and colloids. We analyzed structures in novel mesogenic materials formed by bent-core molecules. Using both theory and experiments, we found that their columnar liquid-crystal phase consists of a triclinic motif which stabilizes a two-layer mesophase. The x-ray studies of the layered bent-core structure were shown to prove indirectly that the molecules are tilted relative to the polarization direction. We studied two-dimensional colloidal molecules in a periodic potential and explored their phase diagram. Within a collaboration with an experimental laboratory, we explored the behaviour of superparamagnetic, micrometer-size particles in a precessing magnetic field and we showed that this field may induce many-body interactions that lead to the aggregation of colloids into single-particle thick, yet robust, membranes.

We investigated a number of problems in the physics of proteins, viruses, bacteria, cells, and tissues. We showed that the in vivo global structure of membrane proteins can be determined by comparing the free conformational space of residues obtained by the EPR measurements with that predicted by simulations. We proposed a theory of elastic instabilities of icosadeltahedral viral capsids caused by a negative transcapsid osmotic pressure. We argued that the type of motion of a population of E. coli bacteria depends on thermal fluctuations: in some cases, ordinary diffusion is replaced by superdiffusion, which is advantageous in environments that are short of food. We investigated the budding process in a system of a growing vesicle membrane due to the intercalation of oleic acid molecules, and we interpreted it in terms of the bilayer couple model. The investigations of vesicle budding were related to the recently developed model of vesicle self-reproduction. We defined the basic deformational modes of monolayer epithelium. We numerically explored a model of polygonal tilings of a plane, which describes certain single-layer biological tissues, and we found that the polygon aspect ratio controls the transition from the disordered to the ordered hexagonal tiling. We continued with the studies of mechanisms of the airway smooth muscle, where we focused on the effects of Rho-kinase and aspirin. We studied the osmosis at fixed volume as well as the kinetics of cyclic emzyme reactions.

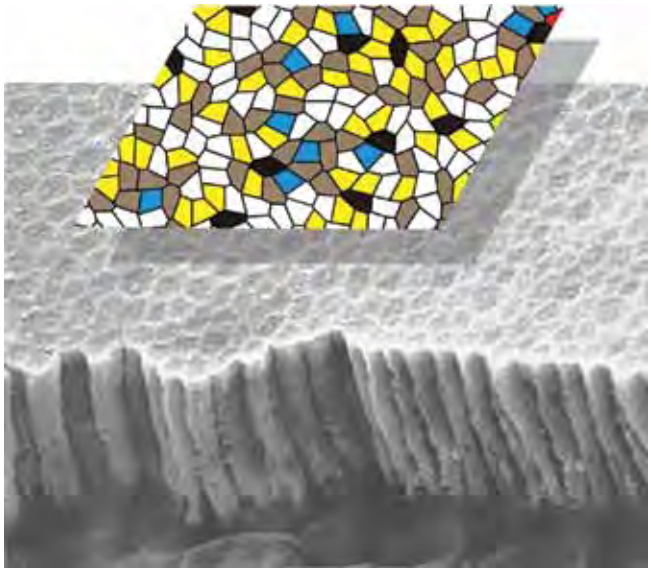


Figure 3: The structure of simple epithelial tissues can be explained by a maximal-entropy polygonal tiling of a plane

Some outstanding publications in the past three years

Theoretical Physics of Nuclei, Particles and Fields

1. B. Bajc and G. Senjanović: Seesaw at LHC, JHEP 0708:014,; hep-ph/0612029 (2007)
2. J. F. Kamenik and F. Mescia: B $\rightarrow$ D τ ν Branching Ratios: Opportunity for Lattice QCD and Hadron Colliders, Phys.Rev. D78, 014003 (2008)

Solid-State Theory and Statistical Physics

1. L. Vidmar, J. Bonča, S. Maekawa in T. Tohyama: Bipolaron in the t-J model coupled to longitudinal and transverse quantum lattice vibrations, Phys. Rev. Lett. 103, 186401 (2009)
2. M. M. Zemljič, P. Prelovšek, T. Tohyama: Temperature and doping dependence of the high-energy kink in cuprates. Phys. Rev. Lett., 100, 036402-1 (2008)

Theoretical Biophysics and Soft Matter Physics:

1. N. Vaupotič, M. Čopič, E. Gorecka and D. Pociecha: Modulated structures in bent-core liquid crystals: two faces of one phase, Phys. Rev. Lett. 98, 247802 (2007)
2. N. Osterman, I. Poberaj, J. Dobnikar, D. Frenkel, P. Ziherl and D. Babić: Field-induced self-assembly of suspended colloidal membranes, Phys. Rev. Lett. 103, 228301 (2009)

Awards and appointments

1. Prof. Dr. Milan Brumen: Prof. dr. Dora Janžekovič Prize for successful pedagogical work and dedicated interaction with students, Faculty of Medicine, University of Maribor.
2. Ana Hočevar: EMBO poster prize, PhysCell2009: From the Edge to the Heart, Primošten, Croatia, 6. – 13. 9. 2009
3. Ana Hočevar: Best poster prize, 1st Paris Interdisciplinary PhD Symposium – From Sparse Entities to Crowded Environments; Numbers in Living Systems, Paris, France, 7. – 9. 12. 2009
4. Anže Lošdorfer Božič: Student Prešern Prize, Faculty of Mathematics and Physics, University of Ljubljana
5. Prof. Dr. Rudolf Podgornik: Award Martin Hirschorn IAC Prize – Best Paper Award
6. Dr. Saša Prelovšek Komelj: Best poster prize, XXIV International Symposium On Lepton Photon Interactions At High Energies (Lepton Photon 2009), 17. – 22. 8. 2009
7. Doc. Dr. Primož Ziherl: Golden Tablet of the University of Ljubljana

Organization of conferences, congresses and meetings

1. Problems in Multi-Quark States, Bled, 29. 6.–6. 7. 2009
2. Physical properties of nanosystems, Yalta, Ukraine, 27. 9.–2. 10. 2009
3. Annual meeting of the "Novmag" EU project and kick-off meeting of "LOTHERM ITN" project, Ljubljana, 23. – 25. 9. 2009

INTERNATIONAL PROJECTS

1. Physics of Complex Colloids: Equlibrium and Driven
   COMPLOIDS
   7. FP
   234810
   EC; Dr. Helmut Schaschl, University of Vienna, Research Services & International Relations, Vienna, Austria
   Asst. Prof. Primož Ziherl
2. Low Dimensional Quantum Magnets for Thermal Management
   LOTHERM
   7. FP
   238475
   EC; Dr. Laura Hemker, Leibniz Institute for Solid State and Materials Research Dresden, Dresden, Germany
   Prof. Peter Prelovšek
3. Collective Emotions in Cyberspace
   CYBEREMOTIONS
   7. FP
   231323
   EC; Warsaw University of Technology, Warsaw, Poland
   Prof. Bosiljka Tadič
4. Minimal Grand Unified Theory
   MUST
   Marie Curie
   6. FP
   MIF1-CT-2006-040907
   EC
   Asst. Prof. Borut Bajc
5. 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
6. 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 Kosec, Dr. Janez Holc

7. Physics of Competition and Conflicts
   COST MP0801
   EC
   Prof. Bosiljka Tadič
8. Emergent Behaviour in Correlated Matter
   COST P16
   EC
   Prof. Peter Prelovšek
9. Aspects of Physics beyond the Standard Model and the Holographic Quantum Field Theory Gravity Correspodence
   BI-AR/09-11-006
   Prof. Adrián René Lugo, Instituto de Física de La Plata, Departamento de Física, Universidad Nacional de La Plata, La Plata, Argentine
   Asst. Prof. Borut Bajc
10. Study of Excited Hadrons and Tetraquark States in Lattice QCD
    BI-AT/09-10-012
    Prof. Christian B. Lang, Inst. für Physik/Theoret. Physik, Karl-Franzens-Universität Graz, Graz, Austria
    Dr. Saša Prelovšek Komelj
11. Self-organization in Soft Matter Physics
    BI-AT/09-10-007
    Dr. Gerhard Kahl, Institut für Theoretische Physik, Technische Universität Wien, Vienna, Austria
    Dr. Primož Ziherl
12. Colloidal Molecular Crystals
    Cristaux colloidaux moleculaires
    PROTEUS 2008 – 2009
    BI-FR/08-09-PROTEUS-012
    Prof. Emmanuel Trizac, Laboratoire de Physique Théorique et Modèles Statistiques, Université Paris-Sud, Orsay, France
    Dr. Jure Dobnikar
13. 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
14. Properties of Baryons in Chiral Soliton Models
    BI-PL/08-09-007
    Prof. Wojciech Broniowski, Institute of Nuclear Physics, Kraków, Poland
    Prof. Bojan Golli
15. 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
16. 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
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17. Physics of Heavy Mesons
    BI-RS/08-09-029
    Prof. Veljko Dmitrašinović, Institut za nuklearne nauke "Vinča", Belgrade, Serbia
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18. Electron Transport in Nanosystems
    BI-UA/09-10-009
    Dr. Sergei Kruchinin, Bogolyubov Institute for Theoretical Physics, Kiev, Ukraine
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19. Supersymmetry and Grand Unification
    BI-US/09-12-036
    Dr. Stephen Barr, University of Delaware, Department of Physics and Astronomy, Newark, USA
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20. Continuum and Discrete Theory of Smectic Liquid Crystals
    BI-US/08-10-028
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21. Effective Theories for LHC
    BI-US/08-10-021
    Prof. Ira Rothestei, Department of Physics, Carnegie Mellon University, Pittsburgh, PA, USA
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22. 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

R &D GRANTS AND CONTRACTS

1. Active media: nanoactuators based on dispersion forces
   Assist. Prof. Andrej Vilfan, Dr. Samir El Shawish
2. Theory of thermal and spin transport in novel materials with correlated electrons
   Prof. Peter Prelovšek
3. Superconductivity and magnetism in novel iron superconductors
   Dr. Peter Jeglič, Prof. Peter Prelovšek
4. Carbon nanotube-based spin qubits
   Prof. Anton Ramšak

RESEARCH PROGRAMS

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

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13. Prof. Dr. John H. Jefferson, Oxford University, QinetiQ, Great Malvern, Great Britain, 12.–19. 4. 2009
14. Prof. Dr. Jan Eeg, Phisycs Department, Oslo University, Oslo, Norway, 4.–8. 5. 2009
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20. Prof. Dr. Geoff Rodgers, Brunel University, London, Great Britain, 21.–26. 6. 2009
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18. Ilja Doršner, Svjetlana Fajfer, Jernej Kamenik, Nejc Košnik, "Can scalar leptoquarks explaind the f_{Ds} puzzle?", *Phys. lett., Sect. B*, vol. 682, pp. 67-73, 2009.
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Theses

Ph. D. Theses

1. Jernej Mravlje, *The influence of phonons on electron transport in nanoscopic systems: doctoral thesis*, Ljubljana, [J. Mravlje], 2009.
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B. Sc. Theses

1. Anže Lošdorfer Božič, *Rupture of a charged viral capsid: undergraduate thesis*, Ljubljana, [A. Lošdorfer Božič], 2009.
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DEPARTMENT OF LOW AND MEDIUM ENERGY PHYSICS F-2

The F2 department conducts basic and applied research in low- and medium-energy physics. Low-energy physics accounts for our atomic physics research, while the part of nuclear physics studied at the department can be classified as intermediate-energy physics. The third research field of the department is radiological environmental protection that is made up of monitoring nuclear objects and environmental radioactivity. In addition, the department operates the Ecological Laboratory with a Mobile Unit as a specialized Civil Protection unit.

Head:
Asst. Prof. Matej Lipoglavšek

Work in the low-energy physics part of the F2 department was mainly driven by the research programme "Study of atoms, molecules and structures with photons and particles" (P1-0112) and two projects that 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 across Europe, where we have conducted research on our own projects and within different collaborations. The MIC has become a member of the European network of ion-accelerator facilities SPIRIT and in 2009, for the first tim,e several international research projects were assigned to us.

In the field of high-resolution x-ray spectroscopy we have published a study about the separation of different modes of inner-shell double excitations (resonant, shake-up, shake-off) on the basis of their characteristic behaviour in spectral maps [1] and presented the results in ESRF Highlights - the summary of important achievements at the European Synchrotron Radiation Facility in Grenoble in 2009. Another contribution was a detailed report about the chemical shift of characteristic sulphur x-ray lines for a large number of different materials, executed in collaboration with the ID26 beamline team at ESRF. We have contributed to the discussion about the generic shape of double photoionization in the asymptotic regime [2]. High-resolution x-ray spectrometry in combination with a well-resolved photon probe also represents an efficient approach towards measurements of the Coster-Kronig coefficients, as shown by us in the case of Pd targets. We have also contributed to a study that demonstrated the extreme sensitivity of small-angle inelastic x-ray scattering to detect the very small amounts of impurities, for example, in semiconductors [3]. In collaboration with prof. dr. M. Simon and his French group we have recorded maps of inelastically scattered photons around the K edge in simple molecules, like Cl_2 and CH_3I. We have studied a generic minimum of the relative intensity of satellite lines in Pd and Ag emitted upon proton impact excitation - the effect is similar to the famous "Cooper minima" in photoionization. In 2009 we have reported the first resolved resonant Auger spectra induced by electron impact excitation of Ar [M. Žitnik, M. Kavčič, K. Bučar, B. Paripas, B. Palasthy, K. Tökesi. "Resonant Auger decay of 2p hole in argon induced by electron impact. Nucl. instrum. methods phys. res., B Beam interact. mater. atoms. Print ed., 2009, vol. 267, no. 2, p. 260-262.]. The work was done in collaboration with prof. dr. B. Paripas from Miskolc University.

The efforts in theoretical atomic physics were directed towards the explanation of the phenomena of multiphoton Xe excitations by a high-intensity photon beam at 93 eV generated by the free-electron laser facility FLASH (Hamburg) [5]. We have also explained the photoelectron spectra generated by photon-impact excitation of metastable helium states in the region of doubly excited states just above the first ionization threshold - even with a relatively small energy resolution of the incoming photon beam, the effects of spin-orbit splitting, itself of the order of 100 μeV, are clearly seen in the angular resolved spectra [6].

The group for x-ray absorption spectroscopy was awarded experimental beamtime at three synchrotron facilities in 2009. Within the allotted beamtime we provided access to the advanced analytic technologies with synchrotron light to a number of collaborating laboratories in Slovenia and abroad. In the 3-year project II-20080058 EC "XAS analysis of transition metals in lead-free piezoelectric thin films and in catalysts based on porous silicates" at Hasylab we performed structure analyses of new mesoporous catalysts, doped with the transition metals Ti, Cr, Mn, Fe and Cu, and of the ferroelectric materials $K(Ta,Nb)O_3$ and crystalline ceramics $BiFeO_3$ together with their precursors, in collaboration with the groups from the Institute of Chemistry and from the department K5 of the JSI. In collaboration with Faculty of Biotechnology of Ljubljana University,

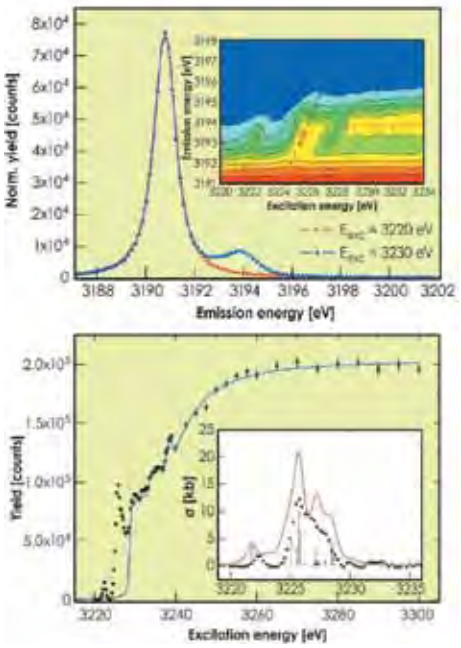

Figure 1: (Above) High-resolution Ar $KM_{2,3}$ X-ray emission spectra recorded below and above the double [1s3p] threshold. The inset shows a 2D RIXS map of the KM-$M_{2,3}$M satellite contribution over the [1s3p] near-threshold region. (Below) Intensity evolution of the KM-$M_{2,3}$M satellite line as a function of the excitation energy. The solid line represents the fit of the phenomenological model adopted for the region above the double [1s3p] threshold. The inset shows the resonant part of the measured [1s3p] spectrum compared with our calculated spectrum.

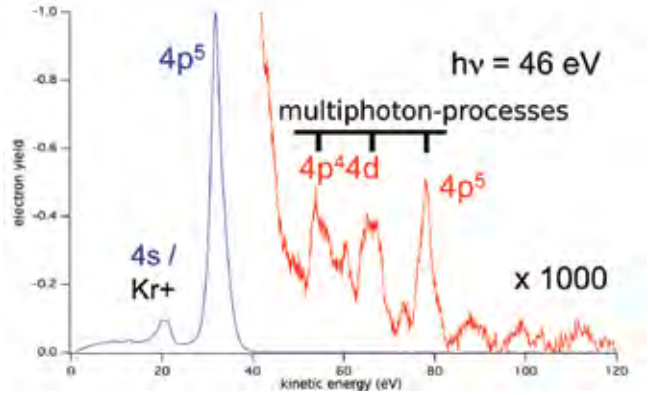

Figure 2: Electron yield obtained by irradiation of Kr atoms with free-electron laser pulses (photon energy 46 eV). Blue is used for the single-photon ionisation signal. Magnification (red) shows the contributions of the following processes: (i) two-photon excitation into $3d^9$ 4d auto-ionising states, which decay into Kr^+ $4p^4$ 4d states; (ii) two-photon above-threshold ionisation (ATI) of Kr atoms resulting in Kr^+ 4p5; (iii) two-photon ATI of the ground-state Kr^+ ion. Experiment: M. Meyer et al., FLASH, Hamburg.

the binding of metals Cd, Zn and Pb in hyperaccumulating plants was studied and the first results are already in the publication procedure. Another study of the interaction of ecotoxic hexavalent Cr with humic acids in contaminated soils [L. Leita, A. Margon, A. Pastrello, I. Arčon, M. Contin, D. Mosetti. "Soil humic acids may favour the persistence of hexavalent chromium in soil". Environ. pollut. (1987). Print ed., jun. 2009, vol. 157, no. 6, p. 1862-1866.] has been chosen for presentation in the HASYLAB Highlights 2009 as one of 15 representative publications of the entire Hasylab research in 2009. Within the project "*In situ* XAS studies of high energy density cathode materials for Li-ion batteries (20085196)" at ELETTRA, an *in situ* x-ray absorption study of structural and valence changes was performed during the charging and discharging of Li-ion batteries containing the new nanostructured cathode materials $Li_2FexMn_{1-x}SiO_4$ and $Li_2FexMn_{1-x}TiO_4$. The additional research on Li-Fe/Mn titanates, Li titanates and vanadates was performed in the experiment at HASYLAB to elucidate the electrochemistry of the batteries and to optimize their capacity. At the beamline XAFS of ELETTRA, we joined a project, with a personal invitation from the beamline science leader dr. Giuliana Aquilanti, to improve the detection techniques in x-ray absorption spectroscopy for the study of multi-electron excitations of atoms related to the K and L shell photo-effect. Our equipment for high-resolution absorption experiments was tested on monoatomic gases, opening a way to new projects on collective atomic excitations, insofar not amenable at the beamline. We re-measured the absorption spectra of Xe L edges and the Ar K edge with an extremely good signal-to noise ratio, surpassing existing data by an order of magnitude. Entirely new details in multi-electron excitations were found, promising new information about the process upon theoretical analysis. The study exposed the beamline limitations and provided clues to improving the characteristics in the low-energy region. In the project HD 370 at the ESRF synchrotron at Grenoble we performed an experiment on the atomic absorption of Ba in the L edge region. Another similar study, the analysis of thermal dissociation of I_2 at temperatures up to 950°C, was completed with the publication [J. Padežnik Gomilšek, I. Arčon, S. Panfilis, A. Kodre. "X-ray absorption in atomic iodine in the K-edge region". Phys. rev., A, 2009, vol. 79, no. 3, p. 032514-1-032514-7].

Within our collaboration at the ALOISA beamline (Elettra synchrotron, Lab. CNR TASC/INFM) we studied the mechanisms of intermolecular recognition and self-assembly of L-methionine and L-tyrosine bio-molecular films, UHV deposited on Ag, Cu and Au substrates [A. Schiffrin, J. Reichert, Y. Pennec, W. Auwaerter, A. Weber-Bargioni, M. Marschall, M. Dell'Angela, D. Cvetko, G. Bavdek, A. Cossaro, A. Morgante, J.V. Barth, "Self-Assembly of L-Methionine on Cu(111): steering chiral organization by substrate reactivity and thermal activation", J. Phys. Chem. C 113 (2009) 12101]. We have shown that specific ionic forms (chemical moieties) manifest on different substrates and account for specific intermolecular recognition and self-assembly schemes, leading to diverse nanostructured bio-architectures on solid surfaces. We have also studied ultrafast charge-carrier dynamics in complex systems like α-MnO_2 nanotubular assembly by X-ray resonant photoemission [P. Vilmercati, D. Cvetko, A. Cossaro, A. Morgante, "Heterostructured organic interfaces probed by resonant photoemission", Surf. Sci. 603 (2009) 1542]. We have determined the ultra-short electron delocalization times from Mn3d* orbitals and resolved the e_g & t_{2g} (Mn 3d*) fast transport channels related to the α-MnO_2 conductive properties.

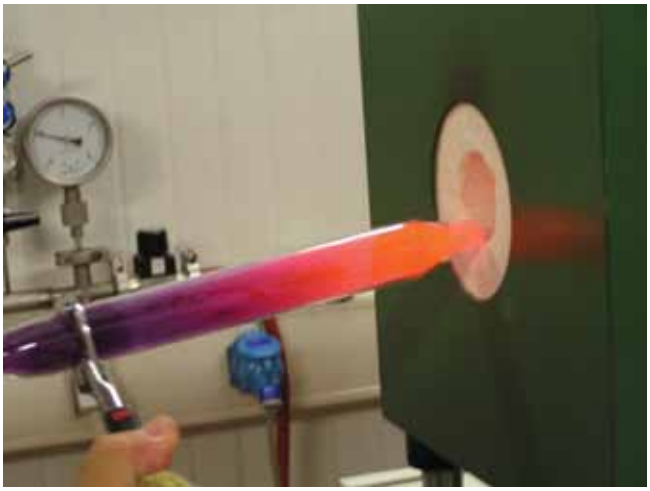

Figure 3: The fused-quartz absorption cell immediately after the experiment on monatomic iodine vapour, prepared by thermal dissociation of molecular iodine at 950° C in a tunnel oven of beamline 29 of ESRF, Grenoble.

In collaboration with the Laboratory for Plasma Physics and prof. dr. Milan Čerček from the F8 department we have started the spectroscopic observation of hydrogen plasma in the region of the Fulcher band of the neutral hydrogen molecule, covering transitions between the $d^3\Pi_u$ and $a^3\Sigma_g^+$ states. The band is relatively strong in hydrogen plasma and with its study one can make conclusions about the distribution of molecules in vibrationally excited states in the molecular (electronic) ground state. To determine the importance of these vibrationally "hot" states formed at surfaces in the near vicinity of the plasma onto the plasma itself we have started the measurements only to discover the necessity of an accurate calibration prior to the final experiment. In the frame of the research programme we have also studied the impact of small hydrocarbon molecules on the vibrational distribution of hydrogen molecular states. In 2009 we dedicated experimental efforts to the observation of the effect generated by ethane (C_2H_6) and ethene (C_2H_4). We have discovered a strong modification of the vibrational distribution and it is not clear yet if this is due to the secondary recombination of hydrogen

atoms in the thermal dissociation of hydrogen molecules on tungsten or if the HC molecules are directly involved in the process.

We studied the properties of different materials by measuring their hyperfine magnetic and electric fields using Mössbauer spectroscopy. Our interest was focused on the properties of magnetic nanoparticles, cathode materials for lithium batteries and multiferroic materials. Most of our research was done on the structural and electronic properties of nanoparticles and the interactions between them. We have investigated the cathode materials for lithium batteries in-situ in order to follow the charge state changes during different charge/discharge states of the battery. In the mutiferroic materials we investigated the nature of magnetic ordering by studying the samples with Mössbauer spectroscopy in external magnetic fields.

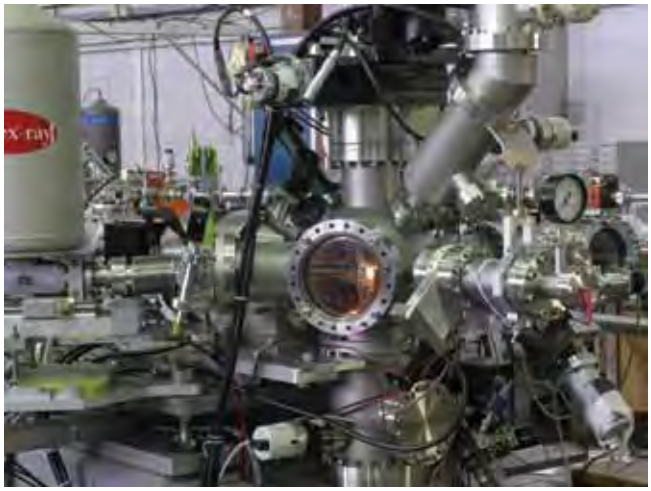

Figure 4: Measuring station with a high-energy focused ion beam at JSI Tandetron. The station supports micro-PIXE in biomedicine (3 MeV proton beam), fusion research with micro-NRA spectroscopy (^{3}He beam with 4.5 MeV energy), hydrogen detection with micro-ERDA in metallurgy (4.5 MeV ^{7}Li beam) and nanolithography with Proton Beam Writing.

In 2009, intense work was continued in the field of Ion Beam Analysis. The installation of a novel type of charge exchange channel at the duoplasmatron ion source enabled us to form a stable focused beam of ^{3}He. By means of the highly deuterium-selective nuclear reaction ^{2}D(^{3}He,p)^{4}He and the focused ^{3}He ion beam, we measured the lateral distribution of deuterium with high isotopic and lateral resolution in materials exposed to deuterium plasma in fusion reactors. In collaboration with CEA, Cadarache, we measured the deuterium distribution in the tiles of "Tore Supra" tokamak. The work was done in the frame of the EU project "EURATOM", EFDA and the Slovenian Fusion Association. We were working on a further improvement of the existing detection systems. At the measuring station with high-energy focused ion beams, a new detection system was developed and put in use for STIM (Scanning Transmission Ion Microscopy). It enables the measurement of ion energy loss in the sample during measurements in high current mode, simultaneously with the micro-PIXE mapping. In collaboration with the institute workshop, a vacuum cryostat was constructed for manipulation of frozen hydrated tissue samples during PIXE analysis. Micro-PIXE was intensively used for the elemental mapping of biological tissue for our collaborators from the biomedical area. We continued the pioneering work at the field of confocal PIXE tomography in collaboration with Demokritos, Athens, and Technical University Berlin [A. Schiffrin, J. Reichert, Y. Pennec, W. Auwaerter, A. Weber-Bargioni, M. Marschall, M. Dell'Angela, D. Cvetko, G. Bavdek, A. Cossaro, A. Morgante, J.V. Barth, "Self-Assembly of L-Methionine on Cu(111): steering chiral organization by substrate reactivity and thermal activation", J. Phys. Chem. C 113 (2009) 12101]. In 2009, we started to work on the project of 7th FP EU "Support of Public and Industrial Research Using Ion Beam Technology, SPIRIT" together with 10 other European laboratories equipped with ion accelerators (www.spirit-ion.eu). Within the project, the JSI Tandetron laboratory is providing transnational access (TNA) to researchers from the European research area. Last year, three TNA projects from the field of plant biology took place at the JSI in close collaboration with the Laboratory for Plant Physiology at the Biotechnical Faculty, University of Ljubljana. Measurements of aluminium uptake in tea plants were done together with dr. Roser Tolra of the Autonomous University of Barcelona. Dr. Nathalie Verbruggen measured the mechanisms of copper hypertolerance in the plant *Haumaniastrum katangense*. The uptake of heavy metals in the plant *Typha latifolia* was studied together with Dr. Lyudmila Lyubenova from Helmholtz Zentrum München.

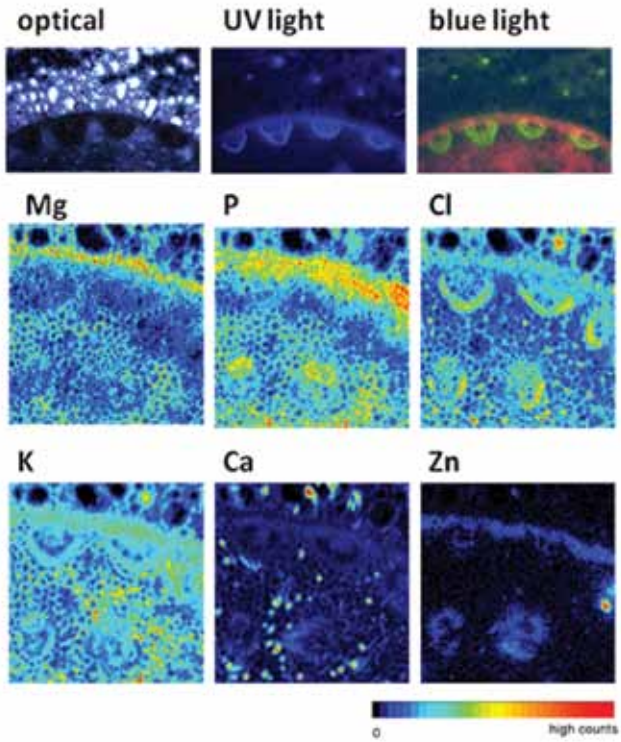

Figure 5: Micro-PIXE lateral scan (frame size 550 x 550 μm^2) of Typha latifolia rhizome reveals the element distribution of the prominent elements in the plant physiology. Results obtained at the JSI micro-PIXE setup within the project SPIRIT "TNA 008" in collaboration with Lyudmila Lyubenova, PhD, Department Microbe-Plant Interactions, Helmholtz Zentrum München, and Biotechnical Faculty, University of Ljubljana.

Ion–beam analytical methods were further used for the analysis of objects of cultural heritage. Specific problems dealt with in 2009 were the composition of glass in the period 9th-12th c. AD, when the Roman glassmaking based on the flux of Egyptian natron was replaced by a new technology using the ash of halophytic plants. Our analyses involved glass objects and raw materials from the Carolingian period, finding mainly glass made in the Roman tradition but also new objects dispersed from the East [Ž. Šmit, D. Jezeršek, T. Knific, J. Istenič, PIXE-PIGE analysis of Carolingian period glass from Slovenia, Nucl. Instr. Meth. B 267 (2009) 121-124]. Another publication is an analysis of Venetian-type glass from Albania, where two production

phases were identified [Ž. Šmit, F. Stamati, N. Civici, A. Vevecka-Priftaj, M. Kos, D. Jezeršek, Analysis of Venetian-type fragments from the ancient city of Lezha (Albania), Nucl. Instr. Meth. B 267 (2009) 2538-2544]. The external beamline was equipped with a system for Rutherford backscattering to study metal-plated layers on historic objects.

In the A1 Collaboration at MAMI (Mainz, Germany) we have performed a series of measurements with the new KAOS spectrometer, which allows for the detection of positively and negatively charged reaction products up to momenta of 1.5 GeV/c. For this spectrometer, our group is developing the second threshold aerogel Cherenkov counter, which is an upgrade of our first version built in 2008. Several calibration experiments were performed with the hadron arm of KAOS almost fully instrumented, devoted mostly to the electroproduction of charged kaons and the formation of hyperons in nuclei. With the standard three-spectrometer setup of the A1 Collaboration, a high-precision double-polarization measurement of eta electroproduction on protons was performed. Some of the polarization observables in this process are particularly sensitive to specific phase rotations between individual electroproduction multipoles.

At the Jefferson Laboratory, in the framework of the Hall A Collaboration, we have performed two extensive experiments. We have collaborated on the E06-014 experiment, dedicated to the determination of the d2 polarized structure function for the neutron in the valence quark regime. But the main focus of our work at this lab was the E05-102 experiment, in which our duty was to set up the trigger electronics for the BigBite spectrometer, to calibrate the magnetic holding field direction for the polarized helium target, to gain-match the scintillation counters, and to solve several ongoing problems of the online analysis. This experiment aims at the determination of the effects of small wave-function components in the ground state of polarized He-3 by a simultaneous measurement of double- and single-polarization observables in the (e,e'd), (e,e'p), and (e,e'n) channels in almost identical kinematics.

In collaboration with the Department of Theoretical Physics at the JSI and the University of Coimbra, we have continued our investigations of the dynamical processes in protons and neutrons in the energy region of the Roper resonance. We have obtained the first results for the complete electroproduction amplitudes (not only the electro-excitation parts) including the phases. We have also completed several data analyses of experiments performed in previous years. Some results from our 2009 research and analyses of older experiments are listed below [14-16].

Members of the Infrastructure Group for Ionizing Radiation Measurements conducted scientific research in connection with the Programmes P1-0102 and P1-0112, on the projects "Quality and genuineness of honey on Slovenian market", and "Natural and anthropogenic gamma and beta emitters in geological waters in Slovenia". The researchers were also involved in other research fields related to ionising radiation and nuclear physics. From the bibliography, it follows that the achievements of the researchers in 2009 were solid. In addition, the group was active in conducting the radiological monitoring of the living environment in Slovenia, radiological monitoring of fodder in Slovenia, regular off-site radiological monitoring around Krško NPP [R. Martinčič, "Padavine in suhi usedi", V: Meritve radioaktivnosti v okolici Nuklearne elektrarne Krško : poročilo za leto 2008, B. Črnič and D. Glavič-Cindro, ed., Ljubljana, Institut "Jožef Stefan", 2009, p. 51-68., K. Vogel-Mikuš, B. Zorko, "Hrana", V: Meritve radioaktivnosti v okolici Nuklearne elektrarne Krško : poročilo za leto 2008, B. Črnič and D. Glavič-Cindro, ed., Ljubljana, Institut "Jožef Stefan", 2009, p. 115-132], independent verification of the regular radiological monitoring around Krško NPP, intercomparisons, proficiency tests, material characterizations, calibrations of the radiation gauges, TLD measurements of the personal and environmental doses. Members of the Infrastructure Group also took part in regular drills and special tasks with the radiological mobile unit.

Some outstanding publications in 2009

1. M. Kavčič. M. Žitnik, K. Bučar, A. Mihelič, M. Štuhec, J. Szlachetko, W. Cao, R. Alonso-Mori, P. Glatzel, "Separation of two-electron photoexcited atomic processes near the inner-shell threshold". Phys. rev. lett., 2009, vol. 102, no. 14, p. 143001-1-143001-4.
2. J. Hoszowska, A. K. Kheifets, J.-Cl. Dousse, M. Berset, I. Bray, W. Cao, K. Fennane, Y. Kayser, M. Kavčič, J. Szlachetko and M. Szlachetko, "Physical mechanisms and scaling laws of K-shell double photoionization". Phys. rev. lett., 2009, vol. 102, no. 7, p. 073006-1-073006-4.
3. J. Szlachetko, D. Banaś, A. Kubala-Kukuś, M. Pajek, W. Cao, J.-Cl. Dousse, J. Hoszowska, Y. Kayser, M. Szlachetko, M. Kavčič, M. Salome and J. Susini, "Application of the high-resolution grazing-emission x-ray fluorescence method for impurities control in semiconductor nanotechnology". J. Appl. Phys., 2009, vol. 105, no. 8, p. 086101-086101-3.
4. M.G. Makris, P. Lambropoulos, A. Mihelič. "Theory of multiphoton multielectron ionization of xenon under strong 93-eV radiation". Phys. rev. lett., 2009, vol. 102, no. 3, p. 033002-1-033002-4.
5. M. Alagia, M. Coreno, H. Farrokhpour, P. Franceschi, A. Mihelič, A. Moise, R. Omidyan, K. C. Prince, R. Richter, J. Söderström, S. Stranges, M. Tabrizchi, and M. Žitnik, "Excitation of 1S and 3S metastable helium atoms to doubly excited states". Phys. rev. lett., 2009, vol. 102, no. 15, p. 153001-1-153001-4.

6. P. Achenbach et al., IEEE Trans. Nucl. Sci. 56 (2009) 316.
7. F. Cusanno et al. (Hall A Collaboration), Phys. Rev. Lett. 103 (2009) 202501.
8. B. Golli, S. "Sirca, M. Fiolhais, Eur. Phys. J. A 42 (2009) 185.

Awards and appointments

1. Iztok Arčon: Award "Zlata plaketa občine Renče", Communty of Renče, for scientific and teaching achievements and activities in the local community Renče
2. Matjaž Korun: Elected to the Associated Member of International Committee for Radionuclide Metrology
3. Paula Pongrac: National Awards "For Women in Science", Ljubljana, L `Oréal, Slovenian National Commission for UNESCO and the Slovenian Science Foundation, research work in a doctoral study

INTERNATIONAL PROJECTS

1. Support of Public and Industrial Research Using Ion Beam Technology
   SPIRIT
   7. FP
   227012, FP7-INFRASTRUCTURES-2008-1
   EC; Prof. Wolfhard Möller, Forschungszentrum Dresden-Rossendorf e.V., Dresden, Germany
   Asst. Prof. Primož Pelicon
2. 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
   Annex No. 1, 3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Primož Pelicon
3. 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
4. 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., Asst. Prof. Igor Lengar, Asst. Prof. Saša Novak Krmpotič, Štefan Kolenko
5. GammaGuru - Efficiency and True Coincidence Summing Corrections Calculation in Gamma Ray Spectrometry of Environmental Samples
   Benchmarking Calibration for Low-Level Gamma Spectrometric Measurements of Environmental Samples
   14894
   IAEA, Vienna, Austria
   Dr. Tim Vidmar
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. Fellowship for Mr Asta Orentiené
   LIT/09010
   IAEA, Vienna, Austria
   Dr. Matjaž Korun
8. Fellowship for Mr Nikola Svrkota
   MNE/08016
   IAEA, Vienna, Austria
   Dr. Benjamin Zorko
9. 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. Civici Nikolla, Institute of Nuclear Physics, Tirana, Albania
   Dr. Peter Kump
10. Installation of XRF Programme for Quantitative-handling (V 5.08)
    MDH 089/2009
    DI Anton Hamer (EKL), .A.S.A. Abfallservice Halbenrain Gesellschaft m.b. H. & Co. Nfg KG, Halbenrain, Austria
    Dr. Peter Kump
11. 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, France
    Dr. Iztok Čadež
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. Industrial Research for Company Pankl
    0854343-2,0950981-2
    Alexander Schneeberger, Pankl Engine Systems GmbH & Co. KG, Bruck an der Mur, Germany
    Asst. Prof. Primož Pelicon
14. Development and Support of Java Applications for Use in DESY Accelerator Control
    Attachment #8, 9
    Dr. M. Clausen, DESY (Deutsches Elektronen Synchrotron), Hamburg, Germany
    Asst. Prof. Matej Lipoglavšek, Dr. Mark Pleško
15. 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
16. 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

R &D GRANTS AND CONTRACTS

1. Development of Cherenkov radiation detector
   Asst. Prof. Simon Širca
2. Electron screening in metals and alloys
   Asst. Prof. Matej Lipoglavšek
3. Novel enviromentally friendly high energy density materials for use in Li-ion batteries
   Dr. Darko Hanžel
4. Maping in tokamak walls and inside biological cells
   Asst. Prof. Primož Pelicon
5. Natural and manmade gamma- and beta-ray emitters in underground waters of Slovenia
   Dr. Matjaž Aleš Korun
6. Natural hydrochemical backgrounds and dynamics of underground waters of Slovenia
   Dr. Jasmina Kožar Logar
7. Quality and authenticity of honey on the 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. Subject as representation: taste, respect, strength (investigation of Slovenian material culture)
   Dr. Marijan Nečemer
4. Mobile archaeological heritage: archaeological and archaeometric investigations
   Prof. Žiga Šmit

NEW CONTRACTS

1. Ecology laboratory with mobile unit 2007-2012
   Krško Nuclear Power Plant
   Ass. Prof. Matej Lipoglavšek
2. Radiological monitoring in Slovenia 2008-2010
   Krško Nuclear Power Plant
   Ass. Prof. Matej Lipoglavšek
3. Digital Pulse Processor
   Instrumentation Technologies, d. d.
   Ass. Prof. Primož Pelicon
4. Dosimetrical service for the period of three years
   Customers in Slovenia
   Boštjan Črnič, B. Sc.
5. Monitoring of radioactivity in the living environment of Slovenia for 2009
   Ministry of Environment and Spatial Planning, Slovenian Nuclear Safety Administration
   Dr. Benjamin Zorko
6. Regular annual review of the RTG appliances and dosimetry of workers dealing with radiation sources
   Customers in Slovenia
   Boštjan Črnič, B. Sc.
7. Participation and consultation in TOF-PET project
   Instrumentation Technologies, d. d.
   Dr. Matjaž Vencelj
8. Professional activities and fulfillment of obligations of the holder of the national measurement standard in the field of ionizing radiation
   Ministry of Higher Education, Science and Technology, Metrology Institute of the Republic of Slovenia
   Matjaž Mihelič, M. Sc., Denis Glavič Cindro, M. Sc.

VISITORS FROM ABROAD

1. Prof. Shigeo Matsuyama, Tohoku University, Sendai, Japan, 08.-12. February 2009
2. Dr. Heinrich Wörtche and dr. John van Pol INCAS3, Assen, Netherlands, 20.-22. April 2009
3. Dr. Tolra Roser, Autonomous University of Barcelona, Barcelona, Spain, 07.-09. May 2009
4. B. Sc. Nikola Svrkota: Center for Ecotoxicological Research of Montenegro, Podgorica, Montenegro, 11. May-10. June 2009
5. Jelena Gajević, student of physics, Faculty of Physics, Belgrade, 20. July – 30. August 2009
6. Prof. Nathalie Verbuggen, Universite Libre de Bruxelles, Brussels, Belgium, 27.-30. July 2009
7. Dr. Lyudmila Lyubenova, Helmholtz Zentrum München, Munich, Germany, 09.-14. August 2009
8. Mr. Vasilis Chatzistauros, Technical University Crete, Crete, Greece, 26.-30. October 2009
9. M. Sc. Asta Orentienė, Radiation Protection Centre, Vilnius, Lithuania, 30. October – 01. December 2009
10. Dr. Deniz Savran, Technical University Darmstadt, Germany, 01. November-20. December 2009
11. B. Sc. Benedetta Cestone, University of Pisa, Pisa, Italy, 01.-06. November 2009
12. B. Sc. Jelena Maljković, Institute of Physics, Belgrade, Serbia, 02.-30. November 2009
13. Prof. Nikola Civici, Institute of Nuclear Physics, Tirana, Albania, 19.-21. November 2009
14. Dr. Timo Dittmar, CEA, Caradache, France, 24. November – 01. December 2009
15. Dr. Bratislav Marinković and B. Sc. Branko Petruševski, Institute of Physics, Belgrade, Serbia, 26. November – 06. December 2009

STAFF

Researchers

1. Prof. Iztok Arčon*
2. Prof. Dean Cvetko*
3. Dr. Iztok Čadež
4. Denis Glavič Cindro, M. Sc.
5. Dr. Darko Hanžel
6. Dr. Matjaž Kavčič
7. Prof. Alojzij Franc Kodre*
8. *Dr. Matjaž Aleš Korun, retired 01.11.09*
9. Dr. Peter Kump
10. Prof. Andrej Likar*
11. **Asst. Prof. Matej Lipoglavšek, Head**
12. Dr. Rafael Martinčič
13. Dr. Marijan Nečemer
14. Asst. Prof. Primož Pelicon
15. Zdravko Rupnik, M. Sc.
16. Asst. Prof. Simon Širca*
17. Prof. Žiga Šmit*
18. *Dr. Tim Vidmar, left 16.06.09*
19. Branko Vodenik, M. Sc.
20. Asst. Prof. Matjaž Žitnik

Postdoctorial associates

21. Dr. Klemen Bučar
22. Dr. Jasmina Kožar Logar
23. Dr. Andrej Mihelič
24. Dr. Paula Pongrac
25. Dr. Matjaž Vencelj
26. Dr. Benjamin Zorko

Postgraduates

27. Luka Debenjak**
28. Nataša Grlj, B. Sc.
29. David Jezeršek, B. Sc.
30. Katarina Kovačič, B. Sc.
31. Sabina Markelj, B. Sc.
32. Miha Mihovilovič, B. Sc.
33. Mojca Miklavec, B. Sc.

Technical officers

34. Boštjan Črnič, B. Sc.
35. Petra Maver Modec, B. Sc.
36. Matjaž Mihelič, M. Sc.
37. Primož Vavpetič, B. Sc.

Technical and administrative staff

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

Note:
* part-time JSI member
** young researcher financed by industry

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Patrick Achenbach, Simon Širca, (21 authors), "Front-end electronics for the KAOS spectrometer at MAMI", *IEEE trans. nucl. sci.*, vol. 56, no. 1, pp. 316-319, 2009.
2. M. Alagia, Andrej Mihelič, Matjaž Žitnik, (13 authors), "Excitation of ^{1}S and ^{3}S metastable helium atoms to doubly excited states", *Phys. rev. lett.*, vol. 102, no. 15, pp. 153001-1-153001-4, 2009.
3. Iztok Arčon, "Bolonjska prenova študijskih programov Univerze v Novi Gorici", *Priložnosti*, [št.] 5, pp. 15, okt. 2009.
4. Maja Berden Zrimec, Jasmina Kožar Logar, Alexis Zrimec, Luka Drinovec, Mladen Franko, Alenka Malej, "New approach in studies of microalgal cell lysis", *Cent. Eur. j. biol.*, issue 3, vol. 4, pp. 313-320, 2009.
5. Robert Blinc, Gašper Tavčar, Boris Žemva, Evgeny A. Goreshnik, Darko Hanžel, Pavel Cevc, Anton Potočnik, Valentin V. Laguta, Zvonko

Trontelj, Zvonko Jagličić, James Floyd Scott, "Electron paramagnetic resonance and Mössbauer study of antiferromagnetic $K_3Cu_3Fe_2F_{15}$", *J. appl. phys.*, vol. 106, no. 2, pp. 023924-1-023924-4, 2009.
6. W. Cao, J. Hoszowska, J.-Cl. Dousse, Y. Kayser, Matjaž Kavčič, Matjaž Žitnik, Klemen Bučar, Andrej Mihelič, J. Szlachetko, K. Slabkowska, "L-subshell Coster-Kronig yields of palladium determined via synchrotron-radiation-based high-resolution x-ray spectroscopy", *Phys. rev., A*, vol. 80, no. 1, pp. 012512-1-012512-9, 2009.
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8. Iztok Čadež, Sabina Markelj, Primož Pelicon, Zdravko Rupnik, "Reemission of neutral hydrogen molecules from tungsten", In: *Proceedings of the 18th International Conference on Plasma Surface Interactions: Toledo, Spain, May 26-30, 2008*, (Journal of nuclear materials, vol. 390/391, 2009), Amsterdam, North-Holland, 2009, vol. 390/391, pp. 520-523, 2009.
9. Robert Dominko, Iztok Arčon, Alojz Kodre, Darko Hanžel, Miran Gaberšček, "In-situ XAS study on Li_2MnSiO_4 and Li_2FeSiO_4 cathode materials", In: *Selected papers presented at the 14th international meeting on lithium batteries: Tianjin, China, 22 -28 June 2008: IMLB-2008*, (Journal of power sources, Vol. 189, Issue 1, 2009), Lausanne, Elsevier, 2009, vol. 189, no. 1, pp. 51-58, 2009.
10. K. Fennane, Matjaž Kavčič, (9 authors), "Double K-shell ionization of Al induced by photon and electron impact", *Phys. rev., A*, vol. 79, no. 3, pp. 032708-1-032708-14, 2009.
11. Denis Glavič-Cindro, Matjaž Korun, "An analysis of the causes of discrepant results in proficiency tests in a testing laboratory", In: *5th International conference on radionuclide metrology: low-level radioactivity measurement techniques ICRM-LLRMT'08: September 22 - 26, 2008, Braunschweig, Germany*, (Applied radiation and isotopes, Vol. 67, issue 5, 2009), Dirk Arnold, ed., Oxford, Pergamom, 2009, vol. 67, no. 5, pp. 683-686, 2009.
12. Bojan Golli, Simon Širca, M. Fiolhais, "Pion electro-production in the Roper region in chiral quark models", *The european physical journal. A, Hadrons and nuclei*, vol. 42, pp. 185-193, 2009.
13. J. Hoszowska, Matjaž Kavčič, (11 authors), "Double K-shell photoionization of low-Z atoms and He-like ions", *Eur. phys. j., spec. top.*, vol. 169, pp. 23-27, 2009.
14. J. Hoszowska, Matjaž Kavčič, (11 authors), "Physical mechanisms and scaling laws of K-shell double photoionization", *Phys. rev. lett.*, vol. 102, no. 7, pp. 073006-1-073006-4, 2009.
15. Burkhard Kaulich, Alessandra Gianoncelli, Alfred Beran, Diane Eichert, Ivan Kreft, Paula Pongrac, Marjana Regvar, Katarina Vogel-Mikuš, Maya Petrova Kiskinova, "Low-energy X-ray flourescence microscopy opening new opportunities for bio-related research", *Journal of the Royal Society interface*, suppl. 5, vol. 6, pp. S641-S647, 2009.
16. Matjaž Kavčič, Žiga Šmit, "Characteristic plateau in the L_1-subshell ionization cross section Ag induced by proton collisions", *Phys. rev., A*, vol. 80, no. 6, pp. 062706-1-062706-5, 2009.
17. Matjaž Kavčič, Žiga Šmit, "Cooper-minimum-type structure in proton-induced L_{1-} and L_3-subshell x-ray lineintensities of Pd measured with high-resolution x-ray spectroscopy", *Phys. rev., A*, vol. 79, no. 5, pp. 052708-1-052708-6, 2009.
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DEPARTMENT OF THIN FILMS AND SURFACES F-3

The main field of research of the department is the development, deposition and characterization of hard protective PVD coatings, while research is also done 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 multi-component, multilayer and nanostructured coatings. As part of the applied research, different coatings are developed for the protection of tools for various production processes in industry.

Head:
Dr. Peter Panjan

The emphasis of the R&D activities remains in the area of hard protective coatings. For a second year we are in possession of the most modern deposition system, a CemeCon CC800/9 sinOx ML, which enables magnetron sputtering in three different regimes: (i) classical DC deposition, (ii) pulsed deposition at middle 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 a low internal stress.

A year ago we developed a blue-colour nanolayer hard coating based on AlTiN. This coating is appropriate for the protection of cutting tools to machine very hard (up to 62 HRC) and tough materials. The distinct colour enables a much quicker identification of wear. In the last year we have further improved it and presented the coating as an innovation at the international tool fair Forma Tool in Celje, Slovenia. For this coating we obtained the golden award in the category "Products, equipment, processes and services in the support activities in tool manufacturing". Since then we have implemented it in industry and it is now used by over 20 different customers in Slovenia.

We developed a new nanolayer TiAlN-based hard coating with a blue color. This coating is appropriate for the protection of cutting tools to machine very hard (up to 62 HRC) and tough materials. A distinct colour enables a much quicker identification of wear. For this coating we obtained the golden award on the international biannual fair Forma Tool in the category "Products, equipment, processes and services in the support activities in tool manufacturing".

Another important achievement is the implementation of the double layer TiAlN/a-CN in industry (the so-called black coating). The coating is composed of a base TiAlN layer and a self-lubricating layer of amorphous carbon with additional nitrogen. It is appropriate for those machining processes where there is a great problem of friction between the tool and the workpiece. Excellent results have been obtained in the protection of tools in the Unior company (department Sinter) in the production of components by metal-powder protection. Using the tools protected by the "black coating", up to eight times more workpieces are produced compared to conventional PVD coatings. Excellent results have also been obtained in the protection of tools for the drawing and blanking of tinned sheet steel, which is used in the Vogel&Noot company in the production of food packaging.

In addition to the protection of tools by hard coatings, we made several advanced analyses of tools, the selection of the appropriate technology and the solving of specific problems. In the last year we made such analyses for the companies PHOS, Kovinos and Unior, program Sinter. A lot of emphasis is given to education of the tool staff in the area of the protection of tools by hard PVD coatings. In the past year we organized seminars for technologists from Kolektor (Idrija), Iskra Avtoelektrika (Šempeter pri Novi Gorici), Lama (Dekani), ETA (Cerkno), Tehcenter (Ptuj), Difa (Škofja Loka), Danfoss Compressors (Črnomelj), Cimos (Koper) and Vogel&Noot (Ljubljana). We also organized lectures on hard PVD coatings for high-school professors of mechanical engineering and in the scope of the 4th Nanotechnological Day for the Chamber of Craft of Slovenia members. In Lithuania we prepared a day-long seminar on the protection of tools and components, organized by the Tool Development Center TECOS.

Among the research work that is not yet ready for implementation in industry we need to mention 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 nanocrystalline

Figure 1: End mills protected by the blue-colour nanolayer hard coating

Figure 2: Golden award, which we received at the international fair Forma Tool

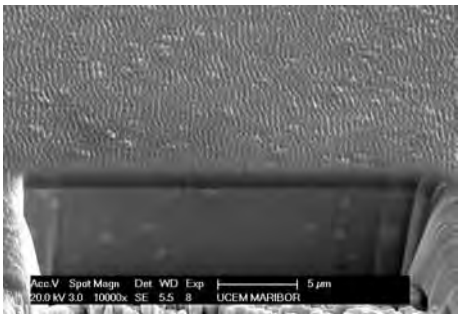

Figure 3: Emergence of the wave-like structure on the surface after laser treatment. This picture was presented in the Europhysics news journal as one of the most outstanding results.

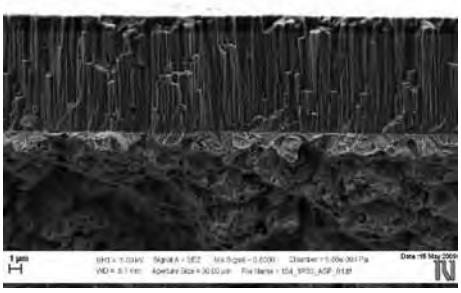

Figure 4: Cross-section of the "black coating" (TiAlN/a-CN) by scanning electron microscope

microstructure and superb adhesion. A millisecond-long pause follows the pulse, and therefore the substrate temperature remains relatively low. Using this process we have so far deposited TiAlN and CrN coatings, and the TiAlN/CrN multilayer structure.

Within the Network of Excellence CMA (Complex metallic alloys) we are leading the preparation of a subproject for the combinatorial analysis of thin films with a lateral compositional gradient. A year ago the project "Development of wear resistant coatings based on complex metallic alloys for functional applications(AppliCMA)" in 7th European framework started. It is to an extent a continuation of the existing Network of Excellence with the purpose of developing applications from these alloys. In 2009 we concentrated on the synthesis and analysis of the AlCuFeB coatings. There are 17 partners from eight countries involved in the project. From the Jožef Stefan Institute the Departments for Solid State Physics, for Engineering Ceramics, and for development of novel materials are collaborating, in addition to our department.

In the project "Hydrogen-impermeable nanomaterial coatings for steels, ERA-NET (Hy-Nano-Im)" we are developing coatings with low hydrogen permeability. The project partner from Austria is Joanneum research, Laser center Leoben, from the Jožef Stefan Institute in addition to our department there are the Department for Nanostructured Materials and the Department for Surface Engineering and Optoelectronics. The most important achievement was, that the deposition of TiAlN reduced the hydrogen permeability of the Eurofer steel (which is used in fusion applications) by four orders of magnitude. Within the program "EURATOM" 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.

Among the bilateral collaborations we should emphasis, in first place, the already finished project with Serbia (Institute for nuclear sciences Vinča, topic: laser treatment of surfaces and subsequent analysis). In the scope of this project we published a high-impact paper in the Journal of Optics A: Pure and applied optics. Based on the decision of the Europhysics news editor this paper was put forward as one of the most important achievements of the past period. Closely connected to the abovementioned ERA-NET project is the bilateral project with Austria (Joanneum research, Laser center Leoben, topic: deposition of diamond-like carbon films by anode layer source). In this project we are tuning the parameters for the low-temperature deposition of diamond-like carbon. The application of diamond-like coatings is also a topic of the ERA-NET project "Improvement of Resurfacing Hip Implants with DLC, TiO2 and DLC-p-h Nanocomposite Coatings", which is conducted with the Department of Physical and Organic Chemistry (Slovenian principle partner), Finish and German partners. 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 from Budapest.

Some outstanding publications in the past three years

1. Modification of multilayered TiAlN/TiN coating by nanosecond and picosecond laser pulses, B. Gaković, M. Trtica, B. Radak, S. Petrović, P. Panjan, M. Čekada, T. Desai, D. Batani, Journal of Optics A: Pure and Applied Optics 11 (2009) 015601
2. 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
3. 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
4. M. Panjan, M. Čekada, P. Panjan, A. Zalar, T. Peterman, The influence of rotation during sputtering on the stoichiometry of TiAlN/CrNx multilayer coating , Vacuum 82 (2007) 158–161
5. M. Kahn, M. Čekada, R. Berghauser, W. Waldhauser, C. Bauer, C. Mitterer, E. Brandstätter, Accurate Raman spectroscopy of diamond-like carbon films deposited by an anode layer source. Diamond and related materials 17 (2008) 1647–1651

Awards and appointments

1. Golden award in the category "Products, equipment, procedures and services in support activities of toolmaking", Celje, Slovenia, 10th fair Forma tool, "Blue supernitride coatings SN-AlTiN"

Figure 5: Tool for metal powder compaction protected by the "black coating"; in the Unior company, program Sinter, it is used in the production of several automotive components

INTERNATIONAL PROJECTS

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
   Asst. Prof. Miha Čekada, Prof. Janez Dolinšek, Dr. Kristoffer Krnel, Dr. Srečo D. Škapin
2. 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
3. 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
4. Hydrogen Impermeable Nano-material Coatings for Steels
   Hy-Nano-IM
   MNT ERA NET
   Asst. Prof. Miha Čekada, Dr. Paul McGuiness, Dr. Vincenc Nemanič
5. Improvement of Resurfacing Hip Implants with DLC, TiO_2 and DLC-p-h Nanocomposite Coatings
   RHSI-DLC-NanoComp
   MATERA ERA NET
   ORTON Research Institute, Helsinki, Finland
   Dr. Darinka Kek Merl, Dr. Ingrid Milošev
6. Deposition of Diamond-like Carbon Coatings by Anode Layer Source for Tribological Applications
   BI-AT/09-10-006
   Dr. Wolfgang Waldhauser, Joanneum Research Forschungsgesellschaft mbH, Laser Center Leoben, Nikklsdorf, Austria
   Asst. Prof. Miha Čekada
7. Characterization of the Selected Coatings
   Dr. Rainer Cremer, CemeCon AG, Coatings, Technology & Processes, Würselen, Germany
   Dr. Peter Panjan
8. 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, Institut za nuklearne nauke "Vinča", Belgrade, Serbia
   Dr. Peter Panjan

R &D GRANTS AND CONTRACTS

1. Development of electronic measurement platform POWERQ8
   Dr. Peter Panjan
2. Development of a new generation of hard coatings by pulse sputtering
   Dr. Peter Panjan
3. Materials and structures for optically variable security devices
   Dr. Peter Panjan
4. PVD-coatings as an alternative for corrosion protection of Fe and Al alloys
   Dr. Darinka Kek Merl
5. Study of the plasma parameters for conditioning of the inner surfaces of a fusion reactor
   Asst. Prof. Miran Mozetič, Dr. Peter Panjan

RESEARCH PROGRAM

1. Thin film structures and plasma surface engineering
   Dr. Peter Panjan

VISITORS FROM ABROAD

1. Dr. Wolfgang Waldhauser, dr. Jürgen Lackner, mag. Markus Kahn, Harald Parizek, Joanneum Research, Laser Center Leoben, Leoben, Austria, 11.–12. 11. 2009
2. Dr. Rainer Cremer, KCS Europe, Aachen, Germany, 7.–8. 4. 2009, 17.–18. 11. 2009
3. Mag. Halil Caliskan, Süleyman Demirel University, Faculty of Engineering and Architecture, Isparta, Turkey, 8. 11. 2009–8. 1. 2010
4. Dr. Ilija Nasov, Hristina Kostadinova, Center for plasma technologies - Plasma, Macedonia, 20.–21. 7. 2009

STAFF

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

Postgraduates
4. Matjaž Panjan, B. Sc.
5. Srečko Paskvale, B. Sc.

Technical and administrative staff
6. Jožko Fišer
7. Damjan Matelič
8. Andrej Mohar
9. Tomaž Sirnik

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Árpád Barna, László Kotis, János L. Lábár, Zoltán Osváth, Miklós Menyhárd, Anton Zalar, Peter Panjan, "Producing metastable nanophase with sharp interface by means of focused ion beam irradiation", *J. appl. phys.*, vol. 105, no. 4, pp. 044305-1-044305-5, 2009.
2. Tihomir Car, Nikola Radić, Peter Panjan, Miha Čekada, Anton Tonejc, "Correlation between hardness and stress in Al-(Nb, Mo, Ta) thin films", *Thin solid films*, vol. 517, no. 16, pp. 4605-4609, 2009.
3. Biljana Gaković, Milan Trtica, Bojan Radak, Suzana Petrović, Peter Panjan, Miha Čekada, Tara Desai, Dimitri Batani, "Modification of multilayered TiAlN/TiN coating by nanosecond and picosecond laser pulses", *J. opt. A, Pure appl. opt. (Print)*, vol. 11, no. 1, pp. 015601-1-015601-6, 2009.
4. Markus Kahn, Miha Čekada, Thomas Schöberl, Roswitha Berghauser, Christian Mitterer, Christoph Bauer, Wolfgang Waldhauser, Elmar Brandstätter, "Structural and mechanical properties of diamond-like carbon films deposited byan anode layer source", *Thin solid films*, vol. 517, no. 24, pp. 6502-6507, 2009.
5. László Kotis, Miklós Menyhárd, A. Sulyok, G. Sáfrán, Anton Zalar, Janez Kovač, Peter Panjan, "Determination of the relative sputtering yield of carbon to tantalum by means of Auger electron spectroscopy depth profiling", *Surf. interface anal.*, vol. 41, no. 10, pp. 799-803, 2009.
6. Matjaž Panjan, Tomaž Peterman, Miha Čekada, Peter Panjan, "Simulation of a multilayer structure in coatings prepared by magnetron sputtering", In: *Proceedings of the CMCTF 2009, 36th International Conference on Metallurgical Coatings and Thin Films, 27 April-01 May 2009, San Diego, California*, (Surface & coatings technology, vol. 204, 6/7, 2009), Y. Pauleau, ed., Lausanne, Elsevier Sequoia, 2009, vol. 204, no. 6/7, pp. 850-853, 2009.
7. Peter Panjan, "Uporaba vakuumske tehnike v sodobni industriji", *IRT 3000*, vol. 4, no. 23, pp. 38-49, 2009.
8. Peter Panjan, Miha Čekada, Matjaž Panjan, "Modre supernitridne prevleke", *IRT 3000*, vol. 4, no. 22, pp. 22-24, 2009.
9. Peter Panjan, Miha Čekada, Matjaž Panjan, Srečko Paskvale, Darja Kek-Merl, "Pulzno magnetronsko napršev anje pri veliki vršni moči", *Vakuumist*, vol. 29, no. 1/2, pp. 31-36, 2009.
10. Suzana Petrović, Biljana Gaković, Dalibor Peruško, Tara Desai, Dimitri Batani, Miha Čekada, Bojan Radak, Milan Trtica, "Picosecond laser ablation of nano-sized WTi thin film", *Laser phys.*, vol. 19, no. 8, pp. 1844-1849, 2009.
11. Jelena Stasić, Milan Trtica, Biljana Gaković, Suzana Petrović, Dimitri Batani, Tara Desai, Peter Panjan, "Surface modifications of AISI 1045 steel created by high intensity 1064 and 532 nm picosecond Nd: YAG laser pulses", *Appl. surf. sci.*, vol. 255, no. 8, pp. 4474-4478, 2009.

PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Peter Panjan, Miha Čekada, Matjaž Panjan, Darja Kek-Merl, Franc Zupanič, Gregor Kapun, Matjaž Godec, "Influence of PVD hard coating topography on its tribological properties", In: *Conference proceedings*, 7th International Conference on Industrial Tools and Material Processing Technologies [also] ICIT & MPT, Ljubljana, Slovenia, October 4th-7th 2009, Gašper Gantar, ed., Celje, TECOS, Slovenian Tool and Die Development Centre, 2009, pp. 189-194.

Regular papers

1. Lidija Ćurković, Peter Panjan, Đurđica Goršćak, Miha Čekada, "Characterisation of craters during GDOES profiling of TiN and TiAlN hard coatings on HSS steel", In: *New challenges in heat treatment and surface engineering: proceedings: conference in honour od prof. dr. Božidar Liščić, 09-12 June, 2009, Dubrovnik, Cavtat, Croatia*, Conference in honour od prof. dr. Božidar Liščić, 09-12 June, 2009, Dubrovnik, Cavtat, Croatia, Božidar Smoljan, ed., Božidar Matijević, ed., Zagreb, Croatian Society fot Heat Treatment and Surface Engineering, = CSHTSE, 2009, pp. 203-206.
2. Peter Panjan, Miha Čekada, Matjaž Panjan, Srečko Paskvale, Darja Kek-Merl, "Deposition of low-temperature Cr-N hard coating by pulsed reactive sputtering", In: *New challenges in heat treatment and surface engineering: proceedings: conference in honour od prof. dr. Božidar Liščić, 09-12 June, 2009, Dubrovnik, Cavtat, Croatia*, Conference in honour od prof. dr. Božidar Liščić, 09-12 June, 2009, Dubrovnik, Cavtat, Croatia, Božidar Smoljan, ed., Božidar Matijević, ed., Zagreb, Croatian Society fot Heat Treatment and Surface Engineering, = CSHTSE, 2009, pp. 185-189.
3. Peter Panjan, Miha Čekada, Matjaž Panjan, Srečko Paskvale, Darja Kek-Merl, "Nizkotemperaturne trde zaščitne Cr-N-prevleke", In: *Trajnostni razvoj - pot iz krize: Portorož, 7-9 oktober 2009: zbornik posvetovanj*, Andrej Polajnar, ed., Branko Bračko, ed., Ljubljana, GZS, Združenje kovinske industrije, Odbor za orodjarstvo in strojegradnjo, 2009, pp. 125-129.

DEPARTMENT OF SURFACE ENGINEERING AND OPTOELECTRONICS F-4

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

Head (from 1. 12. 2009):
Asst. Prof. Miran Mozetič

Head (to 16. 7. 2009):
Prof. Anton Zalar

The Plasma Laboratory covers the field of chemically reactive non-equilibrium plasma created in high-frequency electrodeless gaseous discharges. Several different plasma reactors with a volume between 0.2 and 50 l are powered with radiofrequency and microwave generators with frequencies of 13.56, 27.12 and 2450 MHz and a nominal power up to 15 kW. The plasma is created in oxygen, hydrogen, nitrogen, ammonia, water vapor, methane, carbon dioxide and noble gases, as well as different gas mixtures. The gases are introduced into discharge chambers through gas-flow controllers or manual leak valves. The plasma reactors are pumped with one or more vacuum pumps including rotary, roots and turbomolecular pumps. The pressure is measured with baratrons, Pirani and Penning gauges. Typical working pressures in the plasma reactors are between 1 and several 100 Pa. The plasma is characterized by optical emission spectroscopy, mass spectrometry, electrical and catalytical probes. The kinetic temperature of the neutral gas is between 300 and 1000 K, the electron temperature is between 15,000 and 60,000 K, and the ion temperature is similar to the neutral gas temperature. The Debye length is of the order of 0.1 mm and the difference between the plasma and the floating potentials of the order of 10V. The density of neutral atoms is adjustable up to about 2×10^{22} m^{-3}. The basic research on plasma properties as well as the development of plasma-based technologies is carried on. The technologies include discharge cleaning, selective plasma etching, plasma functionalization, cold plasma ashing, and plasma-based techniques for the synthesis and modification of nanomaterials.

Plasma nanoscience is a new field of low-pressure plasma science and applications. We organized the first international symposium on plasma nanoscience in Fiesa, Slovenia. It attracted prominent world-leading researchers in this field. Our research group has achieved important results in understanding the mechanisms involved in the growth of nanoparticles on materials exposed to highly reactive oxygen plasma. The nanoparticles synthesized using this method includes transitional metal oxides that, depending on the plasma parameters, grow in the form of nanoneedles, nanowires, nanobelts, and more complex shapes. These nanoparticles are usually single crystalline, although vacancies in the crystalline structure may appear. The nanoparticles are growing at high rates, often several g/min, making the technique suitable for the synthesis large quantities that are applied in photovoltaics. Furthermore, the iron oxide particles are perfectly soft magnetic materials so they are suitable for application in advanced magnetic beads for the adsorption of selected proteins from body fluids. The nanoparticles are captured in liposome, so microscopic beads are formed. The technology has been protected with an appropriate patent application.

The plasma functionalization of organic materials has become a common method for the modification of the surface properties of polymer materials. Many polymers become hydrophilic after treatment with oxygen plasma, mainly due to the incorporation of polar oxygen-rich functional groups into the surface layer of the polymers. The technique is environmentally benign and ensures the improved wettability of products made from polymers and polymer-matrix composites. The surface free energy, however, is limited by the structure of the material as well as the limitations in the plasma treatment. Our group elaborated the functionalization mechanisms for a few polymer materials with different degrees of crystallinity, and found important differences in the plasma–polymer interaction. Furthermore, the treatment of many polymers results in an increase of the surface roughness, which in combination with the surface functional groups, leads to a super hydrophilic character of the materials. An application of such a treatment is for the modification of vascular grafts (artificial blood vessels). Plasma-treated grafts express an improved affinity for bonding the endothelial cells as well as the repulsion of platelets. The appropriate technology has been protected with a patent application.

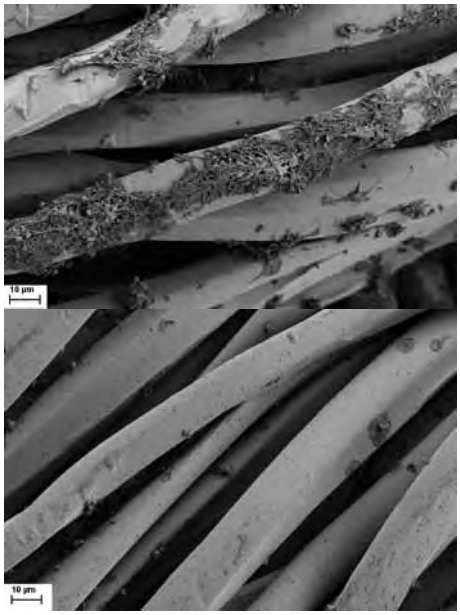

Figure 1: SEM image of a vascular graft before (a) and after (b) treatment with an oxygen plasma. Huge differences in the platelets' adsorption are observed.

Surface analytical techniques are indispensable for the characterization of the surfaces and interfaces of bulk materials, layered structures and nanomaterials. In the Laboratory for Surface and Thin Film Analyses, X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy

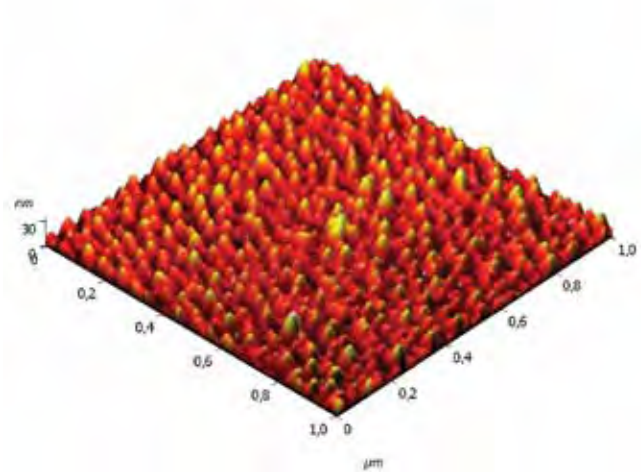

Figure 2: AFM image of oxygen plasma treated, originally flat, polyethyleneteraftelate sample shows extremely rough surface that, in combination with surface polar functional groups, ensures the super hydrophilic character of this material.

Several plasma-based technologies for bio-medical applications have been elaborated and protected with the appropriate patent applications.

Figure 3: A picture representing cotton fabrics after the deposition of a hydrophobic film by the sol-gel method appeared on the cover page of the renowned specialized journal Langmuir. The image obtained by atomic force microscopy is in the frame.

(AES) 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 worldwide for the depth profiling of thin films and multilayers at a high depth resolution.

An X-ray photoelectron spectroscopy investigation was applied to study the kinetics of copper surface segregation in model polycrystalline Ag-2.2 % Cu and Ag-4.9 % Cu alloys during in-situ annealing. The results show the accelerated segregation of copper to the free surface due to the reactive interaction of copper with oxygen. This result is compatible with the proposed mechanism of frequent degradation of the archaeological copper-alloyed silver objects excavated from graves that is based on the localized corrosion of the less-noble copper-segregated regions along the grain boundaries.

In the frame of a study of ion-sputtering-related processes we measured the relative sputtering yield of carbon with respect to tantalum for 1 keV Ar^+ ion bombardment in the angular range of 70°-82° by means of Auger electron spectroscopy depth profiling of C/Ta and Ta/C bilayers. The ion bombardment-induced interface broadening was strongly different for the C/Ta and Ta/C, and whereas the C/Ta interface was found to be rather sharp, the Ta/C interface was unusually broad. Still the relative sputtering yields (Y_C/Y_{Ta}) derived for the two specimens agreed well. The relative sputtering yields obtained were different from those determined earlier on thick layers and calculated by simulation with the SRIM code.

A precise thin-film analysis by AES spectroscopy was applied to study the diffusion processes in Al/Cr, Al/Fe and Cr/Fe intermetallic films of complex metallic alloys deposited by the PVD process and annealed at various temperatures. A detailed analysis of the depth profiles was conducted using the MRI model, which takes into account interface broadening of the measured profile due to three reasons: the ion-induced atom mixing, the roughness, and the information depth of the analyzed electrons. Thus we reconstructed the true depth profile of the as-deposited samples and profiles of the annealed samples that allowed us to extract the diffusion coefficients.

The greatest achievement of the vacuum lab is the refurbishment–upgrading of the ultra-high-vacuum (UHV) system designed for quantitative analysis of the extremely low hydrogen kinetics from metal walls and a subsequent quantitative analysis of the gas compositions. The previous system could not render the sensitivity demands for hydrogen detection which is required for the study of the hydrogen–metal interactions that are occurring in fusion reactors. The new system is designed in such a way that it enables measuring of the retained and released hydrogen or deuterium (H/D) at a stable elevated temperature. Besides this, an additional UHV system is attached to the first one, which enables measurement of extremely low permeation fluxes of H/D through a metal membrane. In our new system, the mass spectrometer (MS) is mounted in a separate vessel where the pressure is ~3×10^{-11} mbar. Such a low pressure and constant pumping speed are attainable only with a magnetically levitated turbomolecular (TM) pump, which uses another standard TM pump as a fore-pump. We can determine the composition of a very small amount of the gas mixture, which resides in the gas-accumulating vessel. Special attention was devoted to the suppression of the hydrogen background from the heated sample holder. This was achieved by a careful selection of materials and pretreatment procedure, and by our original construction.

The quantitative analysis of the composition of the gas mixture by a mass spectrometer is the basic method for giving a rough insight into the reactions in gases and on surfaces which we encounter in atomic physics, nuclear fusion, accelerators, preparations of plasma, etc. The quantitative analysis is a much more demanding procedure as it dictates a consideration of the following key facts: a) the MS's sensitivity is different for each gas due to its individual crossover and ionization energy, b) the speed of flow of the

different components of the gas mixture into the MS depends on their masses, c) during the ionization and detection of the ions, reactions on the walls and in the gas flow might occur. All these facts require an initial calibration of the MS with pure gases.

An investigation of cotton by atomic force microscopy has greatly contributed to our understanding of the hydrophobisation of natural materials by the sol-gel treatment.

This new UHV system is adapted for the education process in quantitative mass spectrometry for final-grade students of physics at the Faculty of Mathematics and Physics, University of Ljubljana. The subject is coordinated and supervised by prof. dr. Peter Križan.

By means of the new UHV system we were able to perform permeation measurements through Eurofer membranes. Eurofer is a special grade of steel, carefully cast to fulfill strict requirements for low nuclear activation in the future fusion reactor DEMO. We were able to confirm published values on the hydrogen permeation fluxes obtained on this material at the stated conditions. Having these values as a good reference of the system performance, we found that TiAlN films have the highest permeation barrier reduction factor (PRF) reported so far. Films of 5 micrometers were deposited at the JSI in the department F3 by magnetron sputtering.

We continued the EU research project within the SFA (Slovenian Fusion Association) related to deuterium retention in beryllium and tungsten at prescribed low pressures and temperatures. These two metals are selected for the first wall in the future improvement in large EU reactors. The data, measured on deuterium, may be treated as complementary to those, obtained by tritium. Namely, the tritium retention is still one of the main unknowns in the prediction of the long-term operating life in fusion reactors applying a D/T mixture fuel. We obtained some new data on the kinetics of evolution and absorption as well as the amount of retained deuterium. Unfortunately, the isotope exchange with residual hydrogen in the bulk represents the reaction channel which decreases the accuracy of the measured data. In the last period of 2009 we started with an investigation of Be films on Eurofer. These films were deposited at the "National Institute for Laser, Plasma and Radiation Physics" in Bucharest in Romania. Identical films, deposition on Inconel tiles, will be applied also in the JET fusion reactor in Culham. So far, no data on the permeation of H/D exist, but also our first experience with these films is negative. A rough Be surface did not enable sealing with the Au gasket, which required polishing of the surface.

We also continued our research on nano-crystalline films on flat metal substrates, applied as thermionic cathodes that may be used in the direct conversion of heat to electricity. We designed a new measuring cell to operate in UHV from room temperature to 500°C. The main purpose was not only to measure the total current, but also to observe the spatial electron emission uniformity on the screen. The main result was that the non-uniformity originates mainly as a result of the non-uniform deposition parameters in the CVD plasma reactor. The conventional method of measuring the total emission was thus inadequate for further improving the deposition parameters. In any case, the direct conversion of heat to electricity remains a hot topic in human attempts to suppress carbon dioxide emissions.

Figure 4: The new, ultra-high-vacuum system for a quantitative analysis of gas mixtures.

Some outstanding publications in 2009

1. K. Eleršič, M. Mozetič, A. Vesel, J. Pavlič, A. Iglič, A. Žnidaršič and A. Košak, A method for synthesis of magnetic liposomes in electric field, patent application 2009/00191, filed on July 17th 2009.
2. I. Junkar, M. Mozetič, A. Vesel, U. Cvelbar, M. Krašna and D. Domanovič, A method for treatment of biomedical polymer prosthesis for improved antithrombogenic properties, patent application 2009/00109, filed on April 20th 2009.
3. U. Cvelbar, K. Ostrikov, I. Levichenko, M. Mozetič, M. K. Sunkara, Control of morphology and nucleation density of iron oxide nanostructures by electric conditions of iron surfaces exposed to reactive oxygen plasmas, Appl. Phys. Lett. 2009, vol. 92, no. 21, p. 211502-1 – 211502-3.
4. A. Vilčnik, I. Jerman, A. Šurca – Vuk, M. Koželj, B. Orel, B. Tomšič, B. Simončič, J. Kovač, Structural properties and antibacterial effects of hydrophobic and oleophobic sol-gel coatings for cotton fabrics. Langmuir, 2009, vol. 25, issue 10, str. 5869-80.

Patent granted

1. Asst. Prof. dr. Miran Mozetič, Asst. Prof. dr. Alenka Vesel, Ita Junkar, Asst. Prof. dr. Uroš Cvelbar, Asst. Prof. dr. Simona Strnad, Method and device for modification of implants and vascular grafts made from PET polymer: patent SI 22608.

Awards and appointments

1. Kristina Eleršič: Development of coated magnetic nanobeads for immuno-diagnostic tests, Piran, Slovenia, Committee president Prof. Dr. Antony Murphy (Australia). The award was granted as the best contribution in the session "Bio-nano technologies for medical applications" at the conference ICAPT 2009.
2. Ita Junkar: Plasma treatment of PET vascular grafts for improved biocompatibility, Piran, Slovenia, Committee president Prof. Dr. David Ruzic (USA). The award was granted as the best contribution in the session "Plasma technologies for treatment of advanced materials" at conference ICAPT 2009.
3. Ita Junkar: Plasma treatment of polymers, Ljubljana, Slovenia. The award was granted as the best contribution of a young researcher at the First student conference of the Jozef Stefan International postgraduate school 2009.

Organization of conferences, congress and meetings

1. 16th International Scientific Meeting on Vacuum Science and Techniques, Bohinj, Slovenia, 4. – 5. 6. 2009
2. 2nd International conference on advanced plasma technologies with 1st International plasma nanoscience symposium, Piran, Slovenija, 29. 9. – 2. 10. 2009

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
   Asst. Prof. Janez Kovač
2. 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
3. Sensitive and Differential Blood and Cerebrospinal Fluid Test for Neurodegenerative Dementia Diagnosis
   NeuroScreen
   6. FP
   EC; Elodie Girardet, HLP Développement SA, Paris, France
   Asst. Prof. Miran Mozetič
4. Plasma Sterilization and Decontamination of Water
   NATO CLG. REF.983580
   Dr. Fausto Pedrazziini, NATO - North Atlantic Treaty Organisation, Brussels, Belgium
   Asst. Prof. Uroš Cvelbar
5. Development of Bioactive Packaging
   BIOPACKAGING
   EUREKA
   Univerza v Mariboru, Inštitut za inženirske materiale in oblikovanje, Maribor, Slovenia
   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 McGuiness, Dr. Miha Čekada
8. Introduction Consulting to define Targets and Specify Methods; Measurement of Three Samples at Room Temperature
   Research Agreement
   Dr. Vincenc Nemanič
9. 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 extêmes
   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, France
   Dr. Alenka Vesel
10. Determination of the Density of Nitrogen and Hydrogen Atoms in Plasma Created in Mixture of both Gases
    Détermination des densités locales d'atoms d'azote et d'hidrogène 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
11. Modification of Cardiovascular Implants by Gaseous Plasma
    BI-HR/09-10-001
    Dr. Slobodan Milošević, Institute of Physics, Zagreb, Croatia
    Asst. Prof. Miran Mozetič
12. Quantum Dots for Solar Cells
    BI-CN/09-11-003
    Dr. Xiaoxia Zhong, Shanghai Jiao Tong University, Minhang, Shanghai, China
    Asst. Prof. Uroš Cvelbar
13. 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, Beijing, China
    Dr. Vincenc Nemanič
14. Study of Ion Mixing caused by FIB
    BI-HU/09-10-004
    PR-02139
    Dr. Miklos Menyhard, Research Institute for Technical Physics and Materials Sciences, Budapest, Hungary
    Asst. Prof. Janez Kovač
15. 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, Institut za nuklearne nauke "Vinča", Belgrade, Serbia
    Asst. Prof. Janez Kovač
16. Thermoionic Energy Conversion
    BI-US/09-12-021
    Prof. Robert Nemanich, Arizona State University, (ASU), Tempe, Arizona, USA
    Dr. Vincenc Nemanič
17. Metal Oxide Nanowire/Nanotube Arrays for Electrochemical Energy Conversion Applications
    BI-US/08-10-030
    Prof. K. Mahendra Sukara, Oddelek za kemijsko inženirstvo, Univerza v Louisvillu, Louisville, KY, USA
    Asst. Prof. Uroš Cvelbar

R &D GRANTS AND CONTRACTS

1. Application of nanoparticles as additives in lubricants and friction materials
   Asst. Prof. Maja Remškar, Asst. Prof. Miran Mozetič
2. Development of diagnostics for certain edge plasma parameters in fusion devices
   Prof. Milan Čerček, Asst. Prof. Miran Mozetič

3. Electron field emission from flat nanosctructured cathodes
   Dr. Vincenc Nemanič
4. Polymer nanocomposities for chemical sensors
   Asst. Prof. Miran Mozetič
5. Development of treatments and procedures for improvement of hemocompatibility of polyethyleneterephtalate surfaces
   Asst. Prof. Miran Mozetič
6. Printed passive electronic components for smart packaging
   Asst. Prof. Alenka Vesel
7. Investigation of gas discharges for introduction of new environmentally friendly technology for semimanufacture functionalization in the production of capacitors
   Asst. Prof. Miran Mozetič
8. Synthesis and functionalization of composite nanobeads for early diagnosis of neurodegenerative diseases
   Asst. Prof. Alenka Vesel
9. Superhydrophylicity and its application to technological processes for industrial manufacture
   Asst. Prof. Uroš Cvelbar
10. Ignition and self-extinguishing of the arc in gas surge arrester at high overvoltages
    Dr. Vincenc Nemanič
11. Multifunctional nanocomposite coatings and paints
    Asst. Prof. Janez Kovač
12. Research of the integrated surge protective system
    Dr. Vincenc Nemanič
13. Oxidation of metals by reactive oxygen plasma
    Asst. Prof. Miran Mozetič
14. Plasma treatment of vascular grafts
    Asst. Prof. Miran Mozetič
15. Field emission cathode from nanomaterials for THz miniature klystron
    Dr. Bojan Zajec
16. Study of gas deuterium retention and release from metals relevant to ITER
    Dr. Bojan Zajec
17. Study of plasma parameters for conditioning of the inner surfaces of a fusion reactor
    Asst. Prof. Miran Mozetič

RESEARCH PROGRAMS

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

NEW CONTRACTS

1. Co-financing L2-9657-0106-06: Oxidation of metals by reactive oxygen plasma
   Kolektor Group, d. o. o.
   Asst. Prof. Miran Mozetič
2. Co-financing L2-0330-0795-08: Development of treatments and procedures for improvement of hemocompatibility of polyethyleneterephtalate surfaces
   Bioiks, d. o. o.
   Asst. Prof. Miran Mozetič
3. Co-financing L2-0858-1538-08: Study of the plasma parameters for conditioning of the inner surfaces of a fusion reactor
   Induktio, d. o. o.
   Asst. Prof. Miran Mozetič
4. Co-financing L2-1222-0106-08: Investigation of gas discharges for introduction of a new environmentally friendly technology for semimanufactures functionalization in the production of capacitors
   Iskra Condensers, Industy of Condensers and Equipment, d. d.
   Asst. Prof. Miran Mozetič
5. Co-financing L7-2139: Plasma treatment of vascular grafts
   BIA Separations, Company for Separation Technologies, d. o. o.
   Asst. Prof. Miran Mozetič
6. Co-financing L2-2204: Superhydrophylicity and its application in technological processes for industrial manufacture
   Kolektor Group, d. o. o.
   Asst. Prof. Miran Mozetič, Asst. Prof. Uroš Cvelbar

VISITORS FROM ABROAD

1. Dr. Slobodan Milošević, Nino Čutić, Nikša Krstulović, Zlatko Kregar, Institute of physics, Zagreb, Croatia, several times
2. Primož Eiselt, Plasmabull, Lebring, Austria, several times
3. Zoran Vratnica and Danijela Vujošević, Institute of public health, Podgorica, Montenegro, several times
4. Ludvik Kumar, Kolektor Group, Idrija, several times
5. Prof. Dr. Karin Stana Kleinschek, Prof. Dr. Simona Strnad, Institute of textiles University of Maribor, several times
6. Prof. Dr. Marian Lehocky, Vladimir Pavlinek, University Tomas Bata, Zlin, Czech Republic, 6. 4. – 8. 4. 2009
7. Prof. Dr. Freddy Gaboriau, University Paul Sabatier, Toulouse, France, 11. 4. - 17. 04. 2009
8. Dr. Nevena Puač, Dr. Željka Nikitović, Institute of Physics, Belgrade, Serbia, 18. 5. – 31. 12. 2009
9. Prof. Dr. Sabu Thomas, Dr. Jesmy Jose, School of Chemical Sciences, Mahatma Gandi University Kottayam, India, 27. 5. - 29. 5. 2009
10. Dr. Boris Chernomodik, University of Louisville, Louisville, Kentucky, USA, 18. 7. – 27. 7. 2009
11. Dr. Momir Milosavljević, Dr. Velimir Milinović and Dr. Davor Peruško, Institute of nuclear sciences Vinča, Belgrade, Serbia, 6. 9. – 20. 9. 2009
12. Dr. Francisco Tabares, Dr. Jose Antonio Fereira, National institute of fusion, CIEMAT, Madrid, Spain, 4. 8. -14. 8. 2009
13. Prof. Dr. Robert J. Nemanich, North Carolina State University, Raleigh, USA, 10. 9. -14. 9. 2009
14. Dr. Jeong Hoom Kim, University of Louisville, Louisville, Kentucky, USA, 27. 9. – 5. 10. 2009
15. Prof. Dr. Xaioxia Zhong, University of Shanghai Jiao Tong, Shanghai, China, 29. 9. – 2. 10. 2009
16. Prof. Dr. Mohan Sankaran , University of Louisville and Case Western University, USA, 2. – 4. 10. 2009
17. Dr. Kinga Kutasi, University of Budapest, Budapest, Hungary, 5.-6. 10. 2009
18. Dr. Attila Sulyok, dr. Miklos Menyhard, Research Institute for Technical Physics and Materials Science, Budapest, Hungary, 30. 11. – 3. 12. 2009
19. Dr. Momir Milosavljević, Dr. Davor Peruško, Institute of nuclear sciences Vinča, Belgrade, Serbia, 6. 12 .- 11. 12. 2009
20. Dr. Corneliu Porosnicu, National Institute for Laser, Plasma and Radiation Physics, Bucharest, Romania, 7. 12. 2009

STAFF

Researchers

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2. Asst. Prof. Janez Kovač
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4. Dr. Vincenc Nemanič
5. Asst. Prof. Alenka Vesel
6. Dr. Bojan Zajec
7. ***Prof. Anton Zalar, Head, died 16.07.09***

Postgraduates

8. Dr. Aleksander Drenik
9. Kristina Eleršič, B. Sc.
10. Ita Junkar, B. Sc.
11. Martina Modic, B. Sc.
12. Borut Praček, B. Sc.
13. Tjaša Vrlinič, B. Sc.
14. Marko Žumer, B. Sc.
15. Rok Zaplotnik**, B. Sc.

Technical and administrative staff

16. Ružica Bolte
17. Tatjana Filipič, B. Sc.
18. *Mihael Kocmur, retired 01.08.09*
19. Janez Trtnik

Note:
** young researcher financed by industry

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ORIGINAL ARTICLES

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26. Vincenc Nemanič, Bojan Zajec, Marko Žumer, "Meritve skrajno majhne permeacije vodika", *Vakuumist*, vol. 29, no. 3, pp. 26-29, 2009.
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PUBLISHED CONFERENCE PAPERS

Invited Papers

1. Janez Kovač, "Application of X-ray photoelectron spectroscopy (XPS) as powerful tool for characterization of plasma treated surfaces and thin organic coatings", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed.,

Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 51-55.
2. Miran Mozetič, Uroš Cvelbar, "Plasma techniques for nanotechnology", In: *IPCIG 2009*, XXIX International Conference on Phenomena in Ionized Gases, Cancún, México, 12-17 July, 2009, [S. l., s. n.], 2009, 8 pp.
3. Alenka Vesel, Miran Mozetič, "Surface functionalization of organic materials by weakly ionized highly dissociated oxygen plasma: [presented at Second International Workshop On Non-Equilibrium Processes In Plasmas And Environmental Science, 23-26 August 2008, Belgrade and Novi Sad, Serbia]", In: *Proceedings of the Second International Workshop On Non-Equilibrium Processes In Plasmas And Environmental Science, 23-26 August 2008, Belgrade and Novi Sad, Serbia*, (Journal of physics, Conference series, vol. 162, 2009), Bristol, Institute of Physics Publishing, 2009, vol. 162, pp. 012015-1-012015-20, 2009.

Regular papers

1. D. Ciolacu, Janez Kovač, Vanja Kokol, "The effect of cellulose-binding domain from clostridium cellulovorans on supramolecular structure of cotton cellulose", In: *Science & technology of biomasses: advances and challenges: from forest and agricultural biomasses to high added value products: processes and materials: proceedings book*, Italic 5, September 1-4, 2009, Varenna (Como), Italy, Marco Orlandi, ed., [S.l., s.n.], 2009, pp. 209-212.
2. Uroš Cvelbar, "Tailoring nanostructures with plasma parameters", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 73-77.
3. Uroš Cvelbar, Simona Strnad, Lidija Fras Zemljič, "Fiber optics catalytic probe for determination of O density in oxygen plasma after glow", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 108-113.
4. Iztok Čadež, Sabina Markelj, Primož Pelicon, Aleksander Drenik, Miran Mozetič, "Studies of interaction of hydrogen atoms and molecules with metals and carbon", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 8 pp.
5. Aleksander Drenik, Alenka Vesel, Miran Mozetič, "Removal of carbon deposits by weakly ionised oxygen plasma", In: *Proceedings*, 45th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Photovoltaic Devices and Technologies, September 9 - September 11, 2009, Postojna, Slovenia, Marko Topič, ed., Janez Krč, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2009, pp. 115-121.
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7. Gorazd Golob, Miran Mozetič, Mladen Lovreček, "Rubber raw material surface energy modification using oxygen plasma treatment", In: *Conference proceedings*, 9 Seminar in Graphic Arts, 23rd and 24th September 2007, Pardubice, Pardubice, University of Pardubice, Department of Graphic Arts and Photophysics, 2009, pp. 22-26.
8. Nina Hauptman, Alenka Vesel, Vladimir Ivanovski, Marta Klanjšek Gunde, "Carbon black powders: morphology, degree of disorder and surface chemical structure", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 99-102.
9. Ita Junkar, Uroš Cvelbar, Alenka Vesel, Miran Mozetič, Marjan Krašna, Dragoslav Domanovič, "Plasma treatment of PET vascular grafts for improved biocompatibility", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 157-160.
10. Matjaž Kunaver, Marta Klanjšek Gunde, Miran Mozetič, Uroš Cvelbar, Matevž Kunaver, "The degree of dispersion of pigments in powder coatings", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 220-223.
11. Miran Mozetič, Uroš Cvelbar, Kristina Eleršič, "Discharge cleaning of polymer coated aluminum substrates in oxygen plasma", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 129-135.
12. Miran Mozetič, Kristina Eleršič, Zdenka Peršin, Karin Stana-Kleinschek, "Low temperature oxidation of plant leaves in late oxygen plasma afterglow", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 123-128.
13. Zdenka Peršin, Simona Strnad, Alenka Vesel, Karin Stana-Kleinschek, Miran Mozetič, "Surface free energy of conventional and oxygen plasma pre-treated regenerated cellulose fabrics", In: *Proceedings of the 9th Autex Conference*, 9th Autex Conference, May 26-28, 2009, Izmir, Turkey, Izmir, Ege University, Engineering Faculty, Department of Textile Engineering, 2009, pp. 1048-1051.
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Patent

1. Miran Mozetič, Alenka Vesel, Ita Junkar, Uroš Cvelbar, Simona Strnad, *Metoda in naprava za modifikacijo implantatov in umetnih žil iz PET polimera: patent SI 22608*, Ljubljana, Urad RS za intelektualno lastnino, 30. apr. 2009.

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1. Kristina Eleršič, Miran Mozetič, Alenka Vesel, Janez Ivan Pavlič, Aleš Iglič, Andrej Žnidaršič, Aljoša Košak, *Metoda za sintezo magnetnih liposomov v električnem polju: patentna prijava P-200900191*, Ljubljana, Urad RS za intelektualno lastnino, 17. jul. 2009.
2. Ita Junkar, Miran Mozetič, Alenka Vesel, Uroš Cvelbar, Metka Krašna, Dragoslav Domanovič, *Metoda obdelave bio-medicinskih polimernih protez za izboljšanje njihovih antitrombogenih lastnosti: patentna prijava no. P-200900109*, Ljubljana, Urad RS Slovenije za intelektualno lastnino, 20. apr. 2009.
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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 tunneling, electronic and atomic force microscopy, as well as dielectric relaxation spectroscopy and dynamic specific-heat measurements.

Head:
Prof. Igor Muševič

The group has investigated important open questions in the physics of magnetically frustrated systems with coexisting ferromagnetic and ferroelectric orders; it has investigated unconventional superconductivity in strongly correlated electron systems; and it has discovered a new family of multiferroic materials and new nanomaterials. The group has also developed a new kind of memory element for digital applications – a thermal memory cell, where the inscription of digital information is achieved by pure thermal manipulation of a specific complex metallic alloy.

The experimental techniques used are:

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

The research program of the Department of Solid State Physics at 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, Institute of Mathematics, Physics and Mechanics and the Jožef Stefan International Postgraduate School. In 2009, the research was performed within three research programs:

- Magnetic Resonance and Dielectric Spectroscopy of Smart New Materials
- Physics of Soft Matter, Surfaces and Nanostructures
- Experimental Biophysics of Complex Systems

I. Research programme "Magnetic resonance and dielectric spectroscopy of smart new materials"

The research of the program group Magnetic Resonance and Dielectric Spectroscopy of Smart New Materials has focused on the study of the structure and dynamics of disordered and partially ordered condensed matter at the atomic and molecular levels, with special emphasis on phase transitions. The purpose of the investigations was to discover 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.

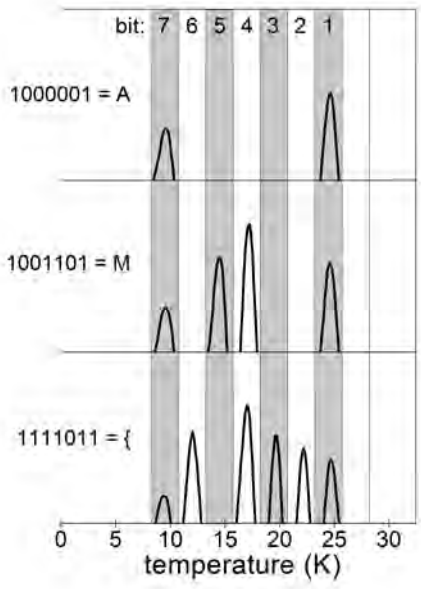

Figure 1: Thermally written ASCII characters A, M and { in a thermal memory cell fabricated from the Cu-Mn spin-glass material.

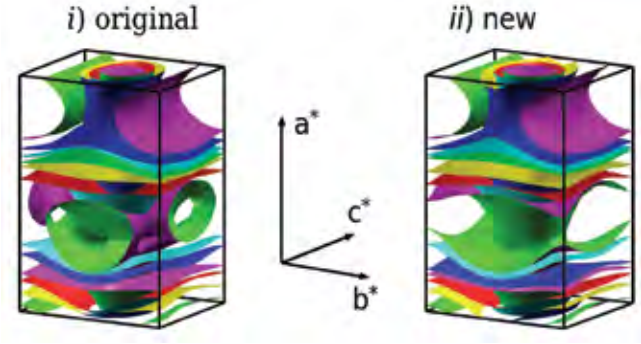

Figure 2: Fermi surface in the first Brillouin zone, calculated ab-initio for (i) the original structural model and (ii) the new model of the o-$Al_{13}Co_4$ by Grin et al.

The knowledge provides the key to the understanding of the macroscopic properties of these systems and is an important condition for the discovery and development of new multifunctional materials and nanomaterials for new applications.

In our research, we used the following experimental techniques:

- Nuclear magnetic resonance (NMR), electron paramagnetic resonance (EPR) and nuclear quadrupole resonance (NQR),
- Nuclear double resonance ^{17}O–H and ^{14}N-H,
- Fast field cycling NMR relaxometry,
- Linear and non-linear dielectric spectroscopy in the range 10^{-2} Hz to 10^{9} Hz,
- Frequency-dependent ac calorimetry,
- Measurement of the electronic transport coefficients,
- Magnetic measurements.
- The research program was performed in close collaboration with the Department of Physics at the Faculty of Mathematics and Physics of the University of Ljubljana, Institute of Mathematics, Physics and Mechanics, and the Jožef Stefan International Postgraduate School.

In 2009, the members of the program group published their research in **55 original publications** in international scientific journals.

Complex metallic alloys and quasicrystals. In the publication J. Dolinšek et al., *J. Appl. Phys.*, 2009, 106, 043917-1-5 we present the concept of a new kind of memory element, a thermal memory cell, where a byte of digital information can be held in the storage medium by pure thermal manipulation. The thermal inscription of the information employs a specific temperature–time profile that involves continuous cooling and isothermal waiting time periods in the absence of any external magnetic or electric fields. Our storage media are magnetically frustrated solids. We succeeded to thermally write arbitrary ASCII characters into the Taylor-phase *T*-Al_3(Mn,Fe) complex intermetallic compound and the Cu-Mn canonical spin glass. In addition to data storage, the concept may be employed for secure data transfer and for retrieving cosmological information from extraterrestrial dust particles.

In our publication J. Dolinšek et al., Anisotropic magnetic and transport properties of orthorhombic $Al_{(13)}Co_4$. *Phys. rev., B, Condens. matter mater. phys.*, 2009, 79, 184201-1-12, we have reported on the anisotropic physical properties (the magnetic susceptibility, the electrical resistivity, the thermoelectric power, the Hall coefficient and the thermal conductivity) of the o-$Al_{13}Co_4$ complex metallic alloy that is an orthorhombic approximant to the decagonal quasicrystal. The crystallographic-direction-dependent measurements were performed along the a, b and c directions of the orthorhombic unit cell. The investigated anisotropic electrical and thermal transport coefficients were reproduced theoretically by *ab-initio* calculation using the Boltzmann transport theory and the calculated anisotropic Fermi surface. The Fermi surface of o-$Al_{13}Co_4$ is displayed in Fig. 2.

Unconventional superconductivity in strongly correlated systems

On 20 March 2009, we published in the journal Science (P. Jeglič, D. Arčon et al., Science 323: 1585-1590 (2009)) the article "The disorder-free non-BCS superconductor Cs_3C_{60} emerges from an antiferromagnetic insulator parent state". We reported on our nuclear magnetic resonance experiments in Cs_3C_{60} and first demonstrated that its ambient pressure ground state is insulating with an antiferromagnetic order below 46 K. This insulating state has all the characteristics of Mott insulators and thus clearly reflects the importance of electronic correlations in fullerides. Applying high hydrostatic pressures (exceeding 3.6 kbar) Cs_3C_{60} becomes a metal and transforms to a superconducting state at low temperatures. The critical temperature first increases with increasing pressure, but then reaches a broad maximum at T_c = 38 K at 8 kbar. In the article we highlighted the surprising similarity between the phase diagrams of the fullerene and high-Tc copper-oxide superconductors (Figure 3). Therefore, Cs_3C_{60} emerges as a simple model system for high-Tc superconductivity where individual electronic effects can be isolated. We next extended our research to other systems where magnetic and superconducting order compete. An exciting example of such systems is the iron-pnictides (P. Jeglič, D. Arčon et al., Phys. Rev. B 79, 094515 (2009)).

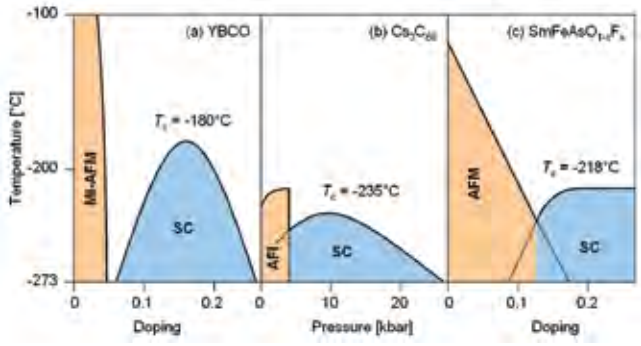

Figure 3: Comparison of phase diagrams for (a) YBCO superconductor as a function of doping level, (b) Cs_3C_{60} as a function of pressure and (c) iron-pnictides as a function of doping. Here, SC = superconducting state, AFM = antiferromagnetic metal, AFI = antiferromagnetic insulator, MI-AFM = Mott insulator with antiferromagnetic ground state.

Highly frustrated magnetic systems

In the case of the two-dimensional highly frustrated system $FeTe_2O_5Br$, a three-dimensional magnetic order sets in below the Néel temperature T_N

= 11 K. The magnetic structure was solved by means of neutron diffraction and nuclear magnetic resonance experiments. We found that the magnetic order is incommensurate where the Fe^{2+} magnetic moments with fixed direction vary periodically in magnitude, in clear contrast to the spiral magnetic structures. The presence of such a magnetic structure breaks the inversion symmetry and opens the possibility for the coexisting ferroelectric order. The latter was indeed found by measurements of the spontaneous polarization. The simultaneous emergence of magnetic and ferroelectric order points to a strong magnetoelectric coupling in this system. $FeTe_2O_5Br$ is the first known magnetoelectric system based on amplitude spin modulated structure. We reported on this work in M. Pregelj et al., *Phys. Rev. Lett.* 103, 147202 (2009). This result was also highlighted in "PSI Facility news". The aatural mineral azurite, $Cu_3(CO_3)_2(OH)_2$, is a model compound for the distorted diamond antiferromagnetic spin-1/2 chain. By means of nuclear magnetic resonance, M. Klanjšek, with colleagues from LNCMI, Grenoble, studied the magnetic structure in the large plateau extending from 11 to 30 T, which corresponds to 1/3 of the saturation magnetization. They demonstrated the quantum type of the 1/3-plateau, consisting of spin dimers in the singlet state and fully polarized spin monomers, a state with no classical analogue. The work was published in *Phys. Rev. Lett.* 102, 127205 (2009).

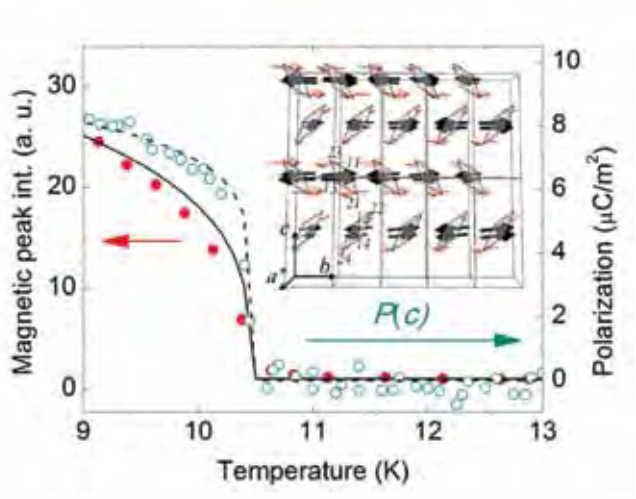

Figure 4: Temperature dependence of the magnetic (left) and ferroelectric (right) order parameters in $FeTe_2O_5Br$. Inset: magnetic structure derived from the neutron-diffraction experiments.

The discovery of a new family of fluoride multiferroics

The great majority of all known multiferroics and magnetoelectrics are oxides. In our search for systems with a larger magnetoelectric coupling at the highest temperatures possible, we started to study fluoride multiferroics. We discovered two corresponding systems, namely $K_3Cu_3Fe_2F_{15}$ and $K_3Fe_5F_{15}$, and determined their electric and magnetic structures. $K_3Fe_5F_{15}$ shows a ferroelectric transition already at 400 K. Both systems are stable in the presence of air and are suitable for certain applications. Published in R. Blinc et al., Electron paramagnetic resonance and Mössbauer study of antiferromagnetic $K_3Cu_3Fe_2F_{15}$. *J. Appl. Phys.*, 2009, vol. 106, no. 2, pp. 023924-1-023924-4 and R. Blinc et al., 39K NMR and EPR study of multiferroic $K_3Fe_5F_{15}$. *J. Phys., Condens. Matter*, 2009, vol. 21, no. 4, str. 045902-1-045902-4.

Size- and misfit-strain-induced ferroelectricity, ferromagnetism and magnetoelectricity in nanosystems with a large enough surface-to-volume ratio. We discovered that in small enough nanosystems with a large surface-to-volume ratio the surface symmetry is dominant and the resulting local fields may induce ferroelectricity, ferromagnetism and magnetoelectricity, even though these phenomena are absent in the bulk samples. Published in M. D. Glinchuk, A. N. Morozovska, E. A. Eliseev, R. Blinc. Misfit-strain-induced magnetoelectric coupling in thin ferroic films. *J. Appl. Phys.*, 2009, vol. 105, no. 8, str. 084108-1-084108-5.

Study of the dielectric, thermal and magnetic properties of multiferoics and soft thermoelastic systems

We observed, for the first time, relaxor behaviour in the novel lead-free thin-film ferroelectrics $KTa_{0.6}Nb_{0.4}O_3$ by utilizing a dielectric spectroscopy. Work is important for the development of new thin-film ferroelectrics, which are interesting for MEMS. By using dielectric spectroscopy we discovered a ferroelectric phase in a multiferroic $FeTe_2O_5Br$. Here we discovered a new class of mutiferroics with spin amplitude modulation driven magnetoelectric coupling. Work is important for the development of new multiferroics with enhanced magnetoelectric coupling. Using high-resolution calorimetry we showed how to control the thermomechanical response in main-chain liquid-crystal elastomers from on-off to continuous type via controlling the critical response. This work is important for the development of new actuators, sensors and artificial muscles. We studied the influence of confinement on the ordering of smectic layers in a liquid crystal, the understanding of which is important in development of novel optical elements and displays. Work was published in several distinguished international scientific journals

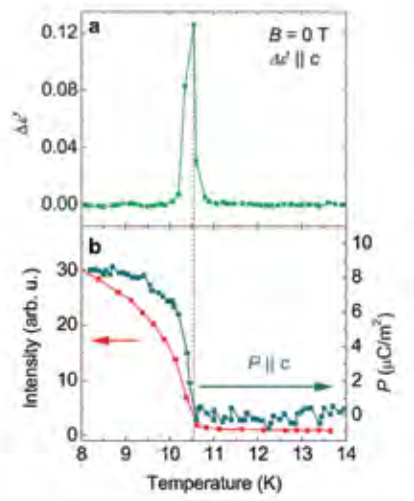

Figure 5: Temperature dependence of the dielectric anomaly and polarization together with the sublattice magnetization in the new multiferroic material $FeTe_2O_5Br$.

Ordering of polarons in $Pr_{0.7}Ca_{0.3}MnO_3$

The $Pr_{0.7}Ca_{0.3}MnO_3$ (PCMO) ceramic is a member of the manganite family that exhibits a colossal magnetoresistance. We studied the perovskite manganite PCMO with EPR, dielectric spectroscopy, and ac electrical conductivity. Activated-type temperature dependence of EPR linewith is a strong signature for a hoping of Jahn-Teller polarons above ~ 150 K. An analysis of the

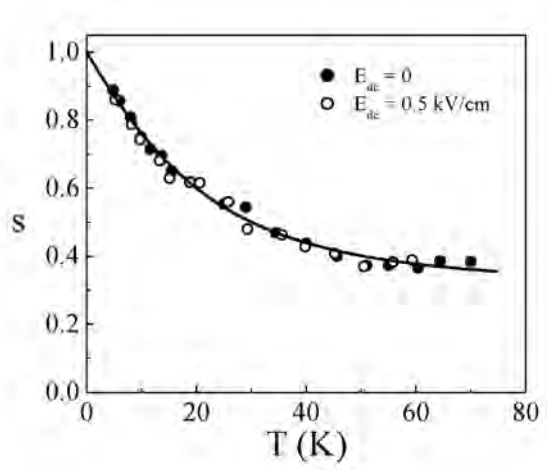

Figure 6: The temperature dependence of the UDR parameter s in PCMO. The solid line is a fit to a model for polaron tunnelling.

electrical conductivity and dielectric constant data suggests the ordering of polarons in the charge-disordered state of PCMO below 60 K. This provides a new understanding of the phase diagrams in PCMO systems.

Published in A. Levstik et al., Ordering of polarons in the charge-disordered phase of $Pr_{0.7}Ca_{0.3}MnO_3$, *Phys. Rev. B 79*, 153110 (2009) and A. Levstik et al., Polarons in magnetoelectric $K_3F^{II}{}_3Cr^{III}{}_2F_{15}$, *J. Appl. Phys.* 106, 073720 (2009).

Synthesis and characterization of all-ceramic percolative composites

In 2009,we have continued our collaboration between researchers from the Condensed Matter Physics Dept. and the Electronic Ceramics Dept. of the JSI, and the first all-ceramic percolative composites (composites comprising conductive filler distributed in a dielectric/ferroelectric matrix) have been developed. We have synthesized and characterized:

(i) Lead-free all-ceramic percolative composite $(K,Na)NbO_3$–RuO_2. Published in V. Bobnar et al., All-ceramic lead-free percolative composite with a colossal dielectric response, *J. Eur. Ceram. Soc.* 29, 725 (2009).

(ii) Composite having relaxor PMN-PT ceramics with a high dielectric constant as a matrix. The developed system, consequently, exhibits a colossal dielectric response. Published in V. Bobnar et al. Colossal dielectric response in all-ceramic percolative composite $0.65Pb(Mg_{1/3}Nb_{2/3})O_3$-$0.35PbTiO_3$–$Pb_2Ru_2O_{6.5}$. *J. Appl. Phys.* 105, 034108 (2009).

Due to an almost an ideal structure – conductive ceramic grains are uniformly distributed throughout the matrix – the dielectric response follows the predictions of the percolation theory: (i) the dielectric constant diverges on approaching the percolation threshold (values higher than 100,000 were detected in the PMN-PT–$Pb_2Ru_2O_{6.5}$ at 1 kHz at room temperature) and (ii) critical exponents and percolation points agree reasonably with theoretical values.

Introduction of a new experiment – high-temperature dielectric spectroscopy

We have introduced a new experimental method - high-temperature dielectric spectroscopy. This technique enables measurements of electrical properties, i.e., polarization and complex impedance with quantities carried out (dielectric constant, electrical conductivity, inductance), from room temperature up to 1400 °C.

In 2009 we have already precisely investigated the high-temperature dielectric properties of classical inorganic relaxors, PMN single crystal and PMN-PT ceramics. Results (which are already submitted for publication) clearly reveal that polar nanoregions do not form at the so-called Burns temperature (approximately 600 K), but are continuously formed in a broad temperature range, starting well above 800 K. Furthermore, a detailed analysis of the intrinsic dielectric response revealed that relaxors adopt critical behaviour associated with universality classes typically found in 3D spin glasses, while the mean-field results can be rejected on a high confidence level.

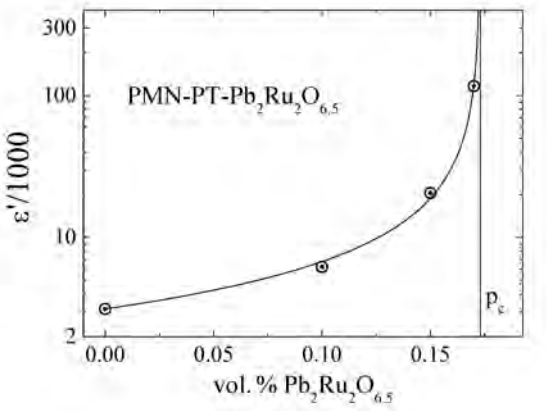

Figure 7: Evolution of the dielectric constant versus the conductive filler volume concentration in the PMN-PT–$Pb_2Ru_2O_{6.5}$ all-ceramic composite. The solid line is the fit of the experimental data to theoretical predictions, while the vertical line indicates the percolation threshold.

New methods for explosive detection

Explosives, either hidden in buried landmines or concealed in passenger baggage, are a serious threat to security in the modern world. To contribute to the solution of this problem, we are developing the nuclear-quadrupole-resonance-based detection of solid explosives. The technique is based on the detection transitions between split levels of nitrogen nuclei in the field of surrounding electrons. The set of these transitions represents a unique "fingerprint" of every nitrogen-based solid material. We have succeeded to significantly improve the detection sensitivity by optimization of the multipulse excitation of quantum transitions and processing of the acquired signals. We have also determined the optimal acquisition parameters in the "super-Q" regime. Published in A. Gregorovič and T. Apih, *Journal of Magnetic Resonance* 198 (2009) 215, and A. Gregorovič and T. Apih, *Journal of Magnetic Resonance* 201 (2009) 131.

Nuclear magnetic resonance of photosensitive liquid crystals in bulk and restricted geometry

We have developed a new methodology, based on the magnetic resonance of deuterium and nitrogen nuclei, which makes it possible to observe the proc-

ess of phase separation between isotropic and nematic phase in azobenzene-based liquid crystals. We demonstrated that trans-cis izomerized systems behave like binary nematic liquids by determining their phase diagram as a function of the concentration of the non-mesogenic cis-component, which was also shown to be easily controlled by varying the intensity of UV light. This binary system was studied both in bulk geometry in which isomerization was partial-only due to a relatively small UV-light penetration depth, as well as in the confined geometries of (i) thin micro-sized planar film and (ii) submicronic cylindrical channels in alumina. We found that alumina, several tens of microns thick, is still transparent for UV light, providing for homogeneous UV-illumination of the sample and in turn for a complete control over the ratio between the nematic and isotropic phases.

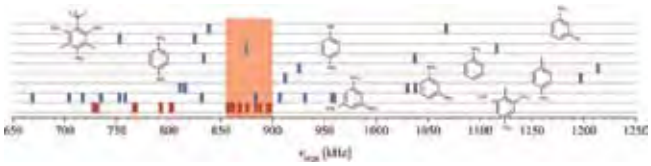

Figure 8: Characteristic NQR transition frequencies of nitrogen ^{14}N represent a unique fingerprint of rather similar nitrogen-based molecules. The NQR spectrum of TNT explosive is shaded red (A. Gregorovič).

Characterization of the thermomechanical behavior of photosensitive liquid-crystal elastomers

Using nuclear magnetic resonance of deuterium we have shown that in liquid single-crystal elastomers the proportionality relation between the mechanical deformation and spatially averaged nematic order parameter is valid for azo-sistems with incomplete orientational order of nematic domains. In order to do that, we have synthesized several new elastomeric networks. Photosensitivity of these networks was achieved either by doping with azomolecules, or by attaching the azomesogens to the polymer backbone during the polymerization. These systems were also successfully employed in the demonstration of tunability applications of laser gratings. Published in V. Domenici et al., "Interplay between nematic ordering and thermomechanical response in a side-chain liquid single crystal elastomer containing pendant azomesogen units", *Polymer* 50, 4837-4844 (2009).

Synthesis and characterization of anorganic nanomaterials

In the laboratory for the synthesis of nano-sized materials we were studying the influence of reaction conditions on the morphology of α-MnO_2 nanoparticles and also the impact of the presence of transition metal ions in the reaction mixture on the magnetic properties of synthesized α-MnO_2 nanoparticles. In cooperation with colleagues from the Institute of Mathematics, Physics and Mechanics we found that the presence of Fe^{3+} changes the transition temperature (T_N) and that this change is in correlation with the concentration of Fe^{3+} ions in the samples. We also continued with the research of titanate nanostructures where we investigated the influence of the presence of transition-metal ions in the reaction mixture on the morphology and also on the adsorption of NO_2(g). In cooperation with the group of dr. Janez Štrancar we have developed a material based on titanate nanotubes with improved photocatalytic activity. We first reported on the synthesis of crystalline α-MnO_2 nanotubues under hydrothermal decomposition of $KMnO_4$ precursor. For the nanotube formation an addition of Fe^{3+} ions into the reaction mixture is essential. SEM and TEM studies reveal that the nanotubes are self-assembled into three-dimensional hollow microstructures where the shell thickness corresponds to the average nanotube length (~370 nm). The diameter of the nanotubes is between 20 and 40 nm. The intercalation of K^+ and Fe^{3+} ions into the α-MnO_2 structure determines the local Mn^{3+}/Mn^{4+} ratio and with this influences on their electric conductivity and magnetic properties. At low temperatures an antiferromagnetic ordering occurs at T_N = 13.6 K, which is substantially lower than in bulk α-MnO_2 phases. The paper was published *Journal of Physical Chemistry C* 2009, vol. 113, p. 14798.

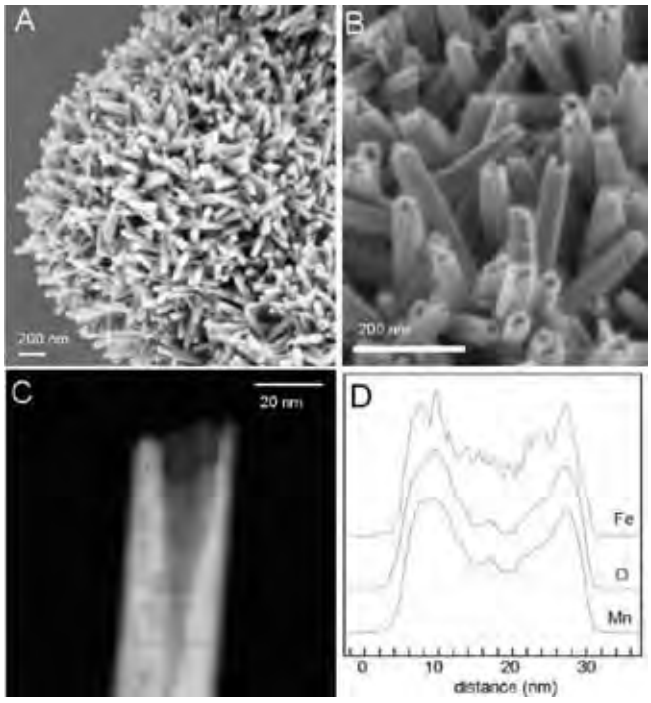

Figure 9. a) and b) FE-SEM images of α-MnO_2-based product doped with Fe^{3+}; a) an individual microsphere with a typical diameter of 3 μm and b) top-view on the microsphere shell that is composed of compactly arranged nanotubes. c) HAADF-STEM image of the end of a nanotube and d) chemical profile obtained from the EELS analysis of the Fe L, O K and Mn L edges along the line shown in figure c). The presence of a cavity is non ambiguous since all three components have decreased intensities in the centre of the tube which matches with the lower contrasted area of the dark field image.

Development of novel double resonance techniques; study of phase transitions in organic ferroelectrics; 14N NQR in pharmaceutical substances

The possibilities of a dynamically polarizing proton-spin system via the quadrupole ^{14}N spin system in a low magnetic field are analyzed. The increase of the proton magnetization is calculated and the polarization rate of the proton spin system is related to the transition probabilities per unit time between the ^{14}N quadrupole energy levels and the proton energy

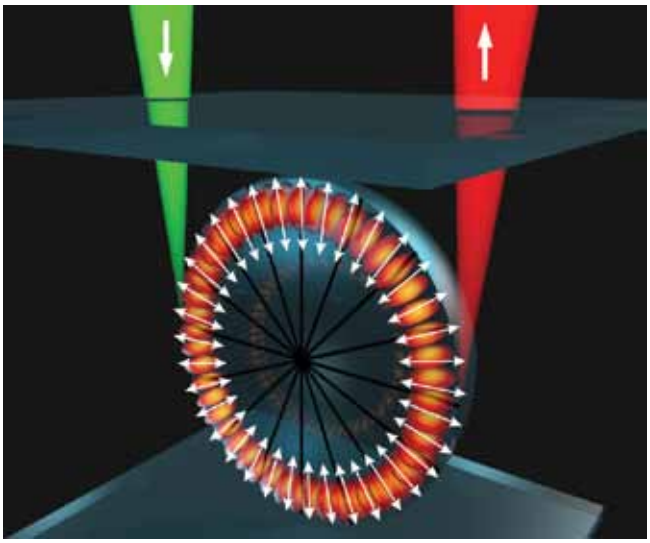

Figure 10: When a liquid-crystal microresonator is excited by a green laser, optical standing waves are formed just under the surface. Part of the light escapes from the droplet and can be detected by a spectrometer. (Author: M. Humar).

levels. The experiments performed in 1,3,5-triazine confirm the results of the theoretical analysis.

A new double-resonance technique is proposed for the measurement of the 14N nuclear quadrupole resonance frequencies of the order of 100 kHz and lower. The technique is based on two-quantum transitions in the proton spin system and single-quantum transitions in the ^{14}N spin system.

The temperature dependence of the ^{14}N nuclear quadrupole resonance frequencies in the ferroelectric and paraelectric phase of pyridazine perchlorate has been measured by double resonance. The temperature and frequency dependence of the proton spin-lattice relaxation time has been measured as well. The experimental results are related to the reorientation of the pyridazinium ions and to the proton ionic mobility.

Protons involved in the H-bond system in 1,2-diazine–chloranilic acid (2 : 1) are assumed to be in jumping motion in the double-minimum potential corresponding to the two extreme electronic states of O–H_ _ _N and O_ _ _H–N$^+$. The proton exchange was studied by the ^{1}H-^{14}N nuclear quadrupole double resonance. The experimental results suggest that not only the population but also the electron distribution of the extreme electronic states itself changes with temperature.

Chemotherapeutic drugs cladribine and 6-thioguanine have been studied by ^{14}N and ^{35}Cl NQR and by the DFT calculations. The complete ^{14}N spectrum has been detected and the NQR frequencies have been assigned to particular nitrogen sites in the molecules. The effects of tautomerism, region-isomerism, conformations and molecular aggregations, related to intermolecular hydrogen bond formation, on the NQR parameters have been analyzed.

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

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

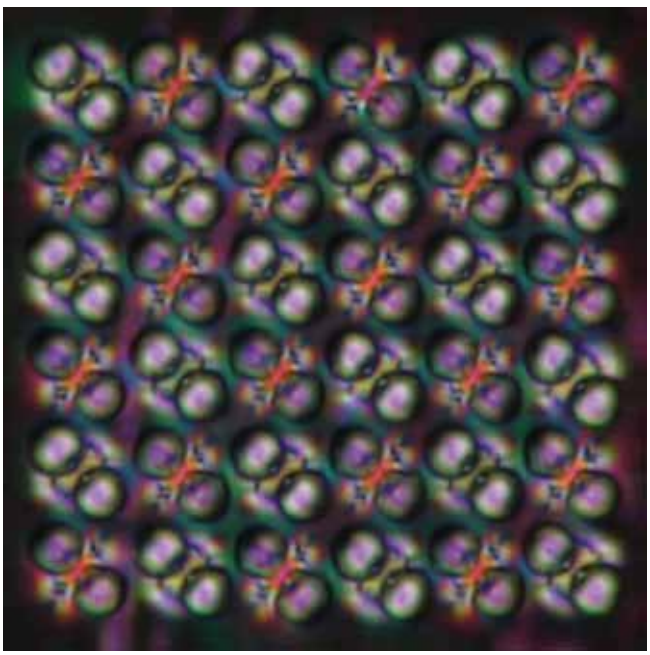

Figure 11: Optical micrograph of 2D nematic colloidal crystal, assembled from chiral dimers using optical tweezers (Author: U. Tkalec).

Optical microresonators

We have studied a new kind of optical microresonators made from droplets of a nematic liquid crystal dispersed in an isotropic polymer. The resonators are usually made from hard materials like silica or transparent polymers. The light is trapped inside these spheres and it circulates around close to the surface. Instead of solid-state microresonators, we have used liquid crystals, since their refraction index can be changed with the external electric field. By applying an electric field to the microresonators we have achieved a tuning range almost a hundred times larger than in solid-state microresonators. This enables the application of liquid-crystal microresonators as tunable lasers, active filters and optical switches. The results were published in *Nature Photonics* 3, 595 (2009).

Nematic colloids. In the field of nematic colloids we have discovered that chiral ordering of the underlying complex fluid strongly influences defect formation and colloidal interactions. Non-singular topological defect loops binding spontaneously formed pairs of colloidal particles have been observed and investigated. Chiral interaction also leads to the optical-tweezers-assisted

assembly of 2D nematic colloidal crystals of pure or mixed chirality, intercalated with a lattice of non-singular vortexlike defects (see Figure).The results were published in the paper "Vortexlike Topological Defects in Nematic Colloids: Chiral Colloidal Dimers and 2D Crystals", *Phys. Rev. Lett.* 103, 127801 (2009). Interparticle interactions of Janus-like particles were analyzed by polarization optical microscopy and explained in the frame of Landau-de Gennes theory (*Soft Matter*, 5, 3905 (2009)). The 2D binary colloidal crystals dispersed in a liquid crystal were assembled and their properties were analyzed (*Langmuir*, 25, 12092 (2009)).

Force measurements in liquid crystals

Using atomic force microscopy, we have measured the nanoscale separation dependence of the force between an atomically flat mica sheet and a micrometer-sized glass sphere immersed in the nematic liquid crystal. We observe that below a critical separation, the system undergoes a structural transition, thus relaxing the distortion. The results are interpreted within the eigenvalue exchange mechanism using the Landau-de Gennes tensorial approach. (*Phys. Rev. Lett.* 103, 167801 (2009)). The new method for Debye screening length measurement was proposed, where the electric field distribution in the electric double layer at a liquid crystal-glass interface was measured (*J. Appl. Phys*. 105, 019405 (2009)).

Modelling of entangled coloidal structures

In two *Soft Matter* papers (M. Ravnik and S. Žumer, Soft Matter 5, 269 and 4520 (2009)) we summarized an advance in the modelling of entangled nematic colloidal structures that we have recently discovered. This colloidal binding where the entanglement of disclination loops provides the ground for the formation of nematic braids where particles are stabilized in multiparticle objects. The observed binding potentials are highly anisotropic showing string-like behaviour and can be of an order of magnitude stronger compared to non-entangled colloids. Controlling the assembly based on entangled disclination lines one can build a colloidal superstructure with potentially useful features (shapes, periodic structure, chirality, etc.) for photonic and plasmonic applications.

Figure 12: Front page of Soft Matter journal announcing the highlighted article: M. Ravnik and S. Žumer, Nematic colloids entangled by topological defects, Soft Matter 5, 269 (2009).

The group has discovered electrically tunable liquid-crystalline microresonators, studied the topology of chiral nematic colloids and investigated the dynamics of the biomimetic cilia of self-assembled superparamagnetic particles.

Anorganic nanotubes

In the Laboratory for Synthesis of Inorganic Nanotubes and Ropes we found that accurate control of the temperature during the synthesis of MoS_2 hybrid nanomaterials enables the specific growth of a particular morphological shape of nanoparticles, like co-axial nanotubes, mama-tubes with encapsulated nano-onions or weak assemblies of nano-onions without nanotubes. Our unique way of synthesis can be applied to other Mo_6 cluster compounds and leads to a new production technology of nanotubes for transition metals.

The applied research of MoS_2 nanotubes was performed in tribology. Testing in a semi-industrial range demands much larger quantities of nanomaterials. We have optimized the synthesis and in collaboration with the company Nanotul d.o.o. we prepared gram-quantities of pure nanotubes. The tests were performed in collaboration with the Faculty for Mechanical Engineering, Laboratory for Cutting, and at the Center for Tribology and Technical Diagnostics. The results showed the clear advantage of MoS_2 nanotubes in comparison with commercial additives.

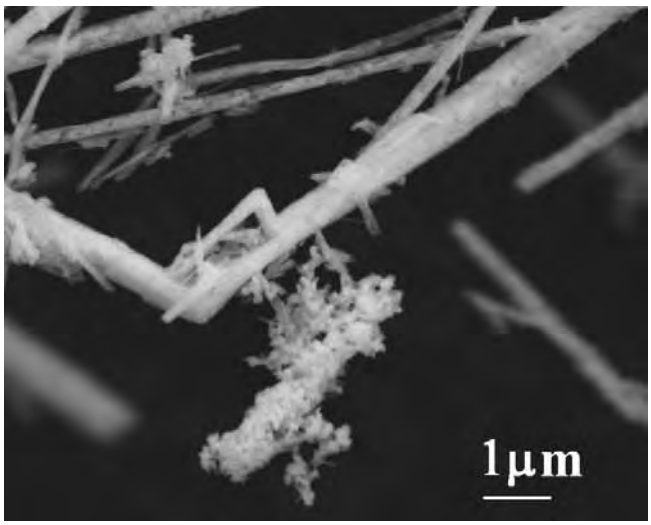

Figure 13: The MoS_2 nano-onions self-assembled in a weakly bonded group. (Appl. Phys. Lett. 95(2009)133122).

Nanosafety

In collaboration with the Ministry of Health, Chemical Office of the Republic Slovenia we organized, in Ljubljana, the international "Conference on Nanosafety". We prepared and distributed a leaflet in 5,000 issues and a

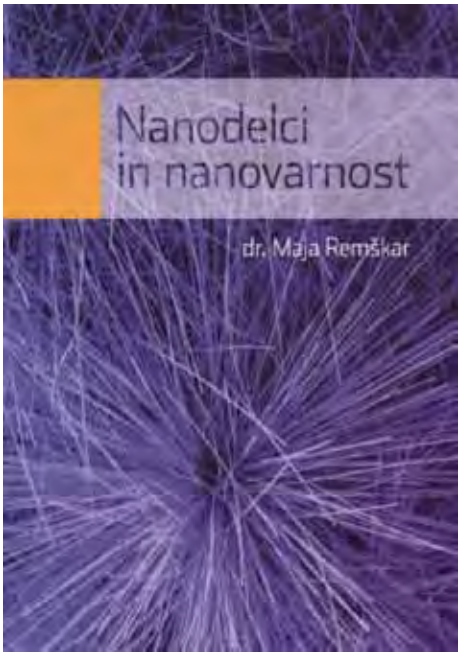

Figure 14. The cover of the book "Nanoparticles and Nanosafety" by M. Remškar.

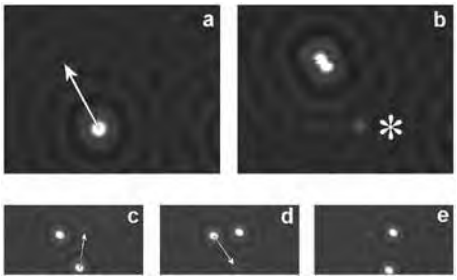

*Figure 15: (a,b) Lateral manipulation of Co reveals the existence of an embedded defect under the pinned adatom (marked with *). The unpinned Co adatoms are unstable at temperatures above 8 K. (c,d,e) The Co adatoms can be reversibly manipulated between embedded defects.*

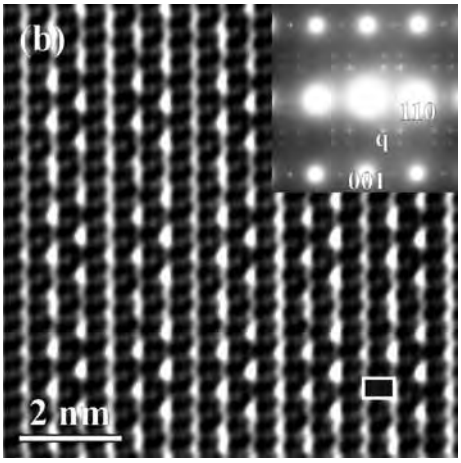

Figure 16: HRTEM image of a thin area of a Nb_3Te_4 crystal, viewed along the <1 $\bar{1}$ 0> direction at 96 K. The CDW modulation with a wave vector q = ± (1/3 a+1/3 b*) + 0.429 c* is clearly visible. The corresponding d SAED image is shown as an inset. The rectangles represent projections of the Nb_3Te_4 unit cell.*

book entitled "Nanoparticles and Nanosafety", with the aim to inform the public about the health risks produced by nanoparticles in the air. Recommendations for safe production, research and the use of nanomaterials are presented together with current regulation status in the field. The electronic version of the book is available at www.kemijskovaren.si

Low-temperature scanning tunnelling microscopy (STM) and spectroscopy (STS)

We were able to show that naturally occurring impurities, which act as pinning centres for deposited Co adatoms, are regularly found embedded in the Cu (111) surface. These defects, identified as substitutional Ag atoms, are hardly observed in topographic STM images and are not accompanied by standing-wave patterns. The binding sites of single Co atoms and their pairs relative to the Ag defects were determined. STS experiments show that the embedded Ag impurities affect the exchange coupling of the Co adsorbate with the substrate electrons only weakly: the Kondo resonances of both, the pinned and the free Co adatoms, show no detectable differences. The embedded Ag defects enable atomic-scale nanostructuring with improved stability at higher temperatures, without significantly affecting their electronic and magnetic properties.

High-resolution transmission electron microscopy (HREM)

HRTEM, resistivity measurements and electronic band structure calculations were performed on quasi one-dimensional compounds $A_xNb_3Te_4$ (A = In, Tl, Zn, Ag, Hg). HRTEM and electron diffraction performed at liquid-nitrogen temperatures reveal both the basic structure and the low-temperature charge-density-wave (CDW) modulation (Fig.2). It is shown that the intercalation of Tl and In results in a flattening of the corresponding Fermi surfaces and that CDW formation is largely dependent on the coincidence between the Fermi level E_F and a small peak in the density of states spectrum, mainly developed from the Nb dz^2 orbitals. (A. Prodan et al., *Solid State Sci.*, 11, 1556-1561 (2009))

Numerical renormalization group

Using the numerical renormalization group technique, we have studied the splitting of the Kondo resonance in Co magnetic impurities on CuN islands on Cu(100) surfaces. In agreement with the experimental measurements, we find that the splitting depends on the direction of the applied magnetic field due to the enhanced magnetic anisotropy on the surface.

Applications of liquid crystals

In the field of applied research of LCD light shutters the novel concept (IJS pat. application: PCTEP/2006/004336) based on the use of two STN LCD cells has been significantly upgraded. It allows for very high, electrically controlled, variable attenuation (>200,000). The EU patent office has accepted the patent application for a granting of the EP patent.

Using significantly upgraded computer modelling software it has been shown that the tandem of two complementary STN LCD light shutters with LC structures rotated by 90° can exhibit a significantly better angular dependence, if higher LC symmetries are included (sense of LC chirality, sense of relative rotation of crossed polarizers and LC structure as well as compensation layers). The "continuation in part" patent application in the USA is being prepared. As the first, and the only one for the time being, the spin-off company of IJS, Balder has been granted the optical quality certificate CE 1/1/1/1 according to the u EN 379 standard for its new-gen product line.

Because of the high performance of the protective light filters, manufactured by the JSI's spin-off company Balder, the International Standard Organization (ISO) has invited the JSI to participate in the preparation of the Eye Protection Standard. Within the ISO workgroup ISO/TC94/SC6/WG2 in WG4 the Institute is preparing a new test method for the light sensitivity of the automatic protective light filters (two lectures at the ISO workshops IJS DP10371 in IJS DP 10389).

Molecular motors

In the field of molecular motors we have developed biomimetic cilia consisting of superparamagnetic particles and driven by a magnetic field. The work was carried out in

collaboration with the group of prof. Igor Poberaj and the department F7. Despite many different concepts that were proposed in the recent years, we were the first to be able to prove the function of biomimetic cilia by detecting the motion of fluid they pump. We have measured the flow velocity and the results show a very good agreement with the prediction of our theoretical model.

We have continued to investigate the helical motion of filaments, driven by molecular motors. We have published the results on actin rotation by myosin motors. After that we have investigated the twirling of microtubules in collaboration with an experimental group from Dresden. We found a quantitative explanation for the velocity-dependence of the twirling pitch, which results from a mechanism that is very different from actin.

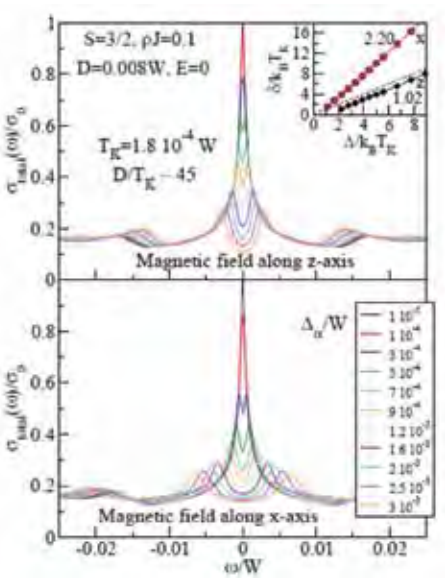

Figure 17: The splitting of the Kondo resonance in Co magnetic impurities on the CuN islands on Cu (100) surface. (R. Žitko, R. Peters, Th. Pruschke, New J. Phys. 11, 053003 (2009))

III. Research programme "Experimental Biophysics of Complex Systems"

Within the program "**Experimental Biophysics of Complex Systems**" we explore 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 the investigation of structural properties of different membrane structures, such as membrane domains, membrane proteins and 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 in complex cell responses. We also started to explore the interaction between new materials and cells, especially from the point of view of bioactivity and biocompatibility. In addition, research in different fields is conducted, for example, the optimization of medical treatment in tumour therapies, magnetic resonance imaging techniques and mathematical modelling of thrombolysis, magnetic resonance microscopy for applications in forestry and wood science, studies of constrained diffusion as well as food processing by magnetic resonance imaging. Another important part of the 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 used molecular spectroscopies in the group within the nanometer spatial and nanosecond time scale and the coupling of the molecular spectroscopies with the microscopical analysis, with the aim to detect interdomain interactions in living cells.

The aggregation of nanoparticles in cells was identified with fluorescence microspectroscopy. A new MRI contrast agent was tested based on ferrous nanoparticles. A 200-times better antimicrobial protection of polyethylene surfaces was achieved using UV-activated titanate nanoparticles compared to protection by UV-light alone.

Within the research of membrane structure and the interactions between (nano)materials and cells we focused on the calibration and optimization of **fluorescence microspectroscopy** experiments as well as on their application to nanoparticles-cell interaction studies. We optimized the labelling and partitioning of fluorescent probes as well as acquisition to increase the level of quantification of microspectroscopic data. Additionally, we started research on hydrogels as artificial tissue scaffolds.

The efficiency of a drug depends on the transcellular transport (transcytosis) of the drug across endothelial, epithelial or outer tumour cell layers. Transcytosis includes the cellular uptake and release of the drug at the basolateral site so that it can be accumulated inside tumour cells. To gain a better knowledge about transbarrier drug delivery more than 25 liposomal formulations were prepared, which varied in their membrane compositions, and as a result, in membrane fluidity and surface charge. The **membrane fluidity** of selected liposomes was characterized using electron paramagnetic resonance (EPR). Cellular uptake of all liposomal formulations containing the hydrophilic fluorescence marker calcein by MDCK cells was quantified and selected liposomes were characterized for transcytosis across a MDCK cell barrier. Transcytosis of liposome encapsulated fluorescent probe, which we used as a model for hydrophilic drug delivery, was positively correlated with membrane fluidity in the outer part of the bilayer.

In collaboration with the Department of Biochemistry and Biophysics at the University of North Carolina at Chapel Hill we have studied the principles of **enzyme kinetics on lipid membrane surfaces**, particularly the mechanism of action of a blood coagulation cascade enzyme factor X_a, which has a prominent role in amplifying inflammation and coagulation cascades. In the coagulation cascade, its main role is catalyzing the proteolytic activation of prothrombin to thrombin, which ultimately leads to a blood clot. We have shown that factor X_a forms inactive dimers on membrane surfaces, and that the transition from monomer to dimer state occurs at the lower end of physiological calcium plasma concentrations. Therefore, our work suggests the previously unknown role of plasma calcium concentration as a regulator of the initiation of blood coagulation and possibly also as a regulator of the initiation of inflammation processes as a response to endothelial injuries.

Figure 18: The optical quality certificate CE 1/1/1/1 according to the u EN 379 standard granted to Balder

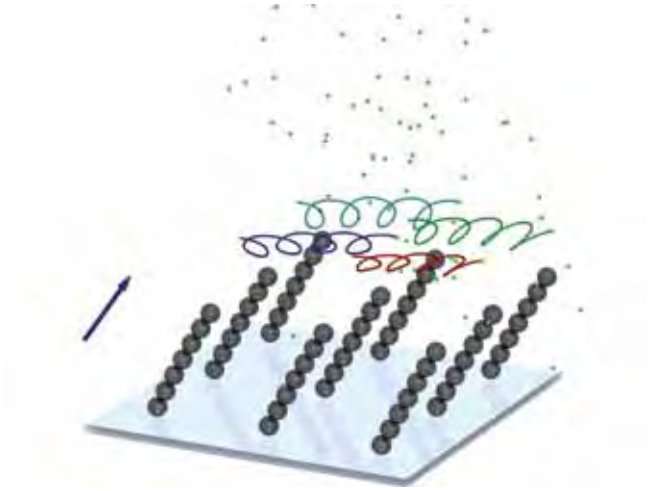

Figure 19: Simulation of a system of artificial cilia comprising of self-assembled superparamagnetic particles, driven by a rotating magnetic field.

Flavonoids are phenolic compounds with antimicrobial action. To get a better insight into the mechanisms involved in the antimicrobial action of these substances the **interaction of four flavonoids** (kaempferol (K), kaempferol-3-glucoside (KG), (-)-epigallocatechin (EGC) or (-)-epigallocatechin-3-gallate (EGCG)) **with model membranes**, liposomes was investigated by electron paramagnetic resonance and fluorescence spectroscopy. All the investigated substances were found to decrease membrane fluidity, which was reflected in the increased order parameter of the most ordered type of membrane domains. The most effective was EGCG, which acts primarily on the membrane surface, while K, which influences the membrane fluidity deeper in the membrane, was less effective.

Our research has addressed the key issue about the effect of confinement on the **structure of water** between lipid bilayers. Among the few possible methods, infrared spectroscopy is especially appropriate, since it is suited to probe hydrogen bonding. The originality of our approach is in the use of attenuated total reflection Fourier transform infrared (ATR-FTIR) spectroscopy. Because of the small light-penetration depth, the ATR-FTIR method enabled us to perform experiments with lipid multibilayers prepared in excess water. In contrast, up to now measurements with infrared spectroscopy were carried out only on partially hydrated samples. Importantly, our results indicate that the hydrogen bonding in interlamellar water strongly depends on the level of hydration and that the hydrogen bonds are weakened in interlamellar water between lipid bilayers in excess water. Moreover, we show that the interlamellar water structure is perturbed throughout the whole interlamellar space. The findings are relevant in the field of the chemistry and physics of confined water and of water at molecular interfaces, which are currently at the forefront of research in solvent-mediated phenomena in biology (e.g., protein folding) and material science (e.g., carbon nanotubes and porous materials).

Within the activities dedicated to **protein structure characterization**, we focused on improvements to the methodology for simulations of rotational conformational space of the protein side-chains. We showed and explained the match and mismatch between the MD, EPR, NMR and X-ray crystallography. The comparison has been derived on the N-terminal end of equinatoxin II and the human pancreatic lipase loop.

We have optimized the **photocatalytic activity of titanate nanotubes** for their deposition on surfaces. We have improved the experimental method for the detection of primary radicals, produced by excited titanate nanotubes and have shown that the photogeneration of free radicals and their trapping is a function of concentration. The spin trapping of radicals and the decomposition of spin-trapped products are interrelated processes, which require a careful selection of the initial conditions in order to efficiently measure the the amount of photo-induced primary radicals by titanate nanotubes. We have also measured significant antimicrobial activity against Listeria innocua of the surface-deposited copper-doped titanate nanotubes excited by UV light as well as by light emitted from ordinary fluorescent lights, which are commonly used for indoor lighting. Fluorescently labelled titanate nanotubes were measured with fluorescence microspectroscopy to answer the question of how nanoparticles enter cells, where they accumulate and how they affect the normal physiology of cells. We were able to detect the presence of nanotubes accumulated in cells. The nanotubes drastically affected cell survival at a concentration of around 0.01 mg/ml.

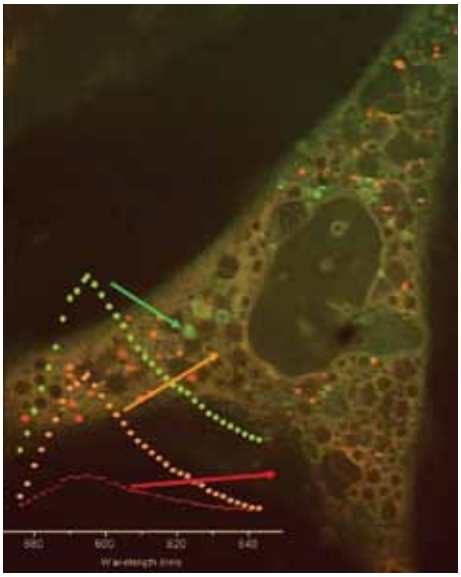

Figure 20: Fluorescence microspectroscopy identification of nanotube accumulation in a living cell (authors: Maja Garvas, Iztok Urbančič, Daniele Biglino, Tilen Koklič, Zoran Arsov and Janez Štrancar).

At the request of the cosmetic company **L'Oreal Paris**, five newly prepared formulations were characterized with respect to the formation of reactive short-lived radicals after application to the skin. The method for the characterization of short-lived radicals in skin with EPR and spin traps was established and the concentration of the radicals in different times after the application to the skin was measured. On the basis of these investigations L'Oreal could make a decision as towhich of the investigated formulations is the most suitable for application.

Controlled drug-delivery systems are widely used in the pharmaceutical industry because of their numerous advantages. For hydrophilic polymers, it is generally accepted that, once in contact with body fluids, they hydrate and swell, forming a gel layer that regulates the penetration of body fluids into the tablet and the dissolution of the incorporated drug. Therefore, a knowledge of the gel layer characteristics is of crucial importance for the use of controlled drug-delivery systems. A new method using MRI for an accurate determination of the penetration, swelling and erosion fronts was developed. The border between the dry and hydrated glassy polymer – the penetration front – was determined from 1D SPI signal intensity profiles. The erosion front was obtained from signal intensity profiles of 2D MR images. The swelling front, where the polymer is transformed from a glassy to a rubbery state (gel formation), was determined from T2 profiles. The new MR methods were used to investigate the effects of pH (pH between 1.2 and 5.7) and ionic strength (0–0.28M) on gel formation

in xanthan tablets. All the media studied, differing in pH and ionic strength, penetrate through the tablet at the same rate and the position of the swelling front was the same. The position of the erosion front, on the other hand, is strongly dependent on the pH and ionic strength, as was reflected in the different thicknesses of the gel layers. The fastest release of the drug was observed in media with a pH of 1.2 and an ionic strength of 0.28 M where the thinnest gel was formed. Experiments simulating physiological conditions showed that changes of pH and ionic strength influence the xanthan gel structure relatively quickly, and consequently the drug release kinetics.

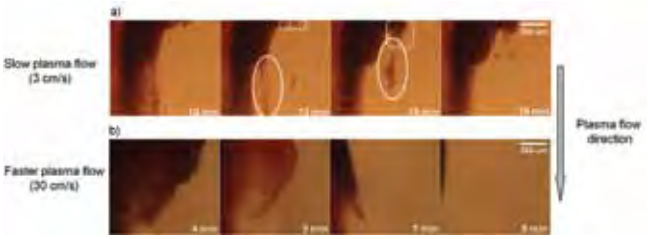

Figure 21: Thrombolysis with fast flow (a) progresses significantly faster than with slow flow (b) (authors: Franci Bajd, Jernej Vidmar, Aleš Blinc and Igor Serša).

MRI contrast properties of a new contrast agent based on ferrite nanoparticles, their encapsulation into the lipid vesicle (ferri-liposomes) and their capability of targeted delivery to the specific site, together with the possible drug, were tested. The contrast properties were tested using 1% agarose with relaxation times that are similar to those of some tumour tissues. The results show that the negative (T2) effect is very strong and therefore the ferrite nanoparticles can be used as an efficient negative MRI contrast agent. Furthermore, nanoparticles encapsulated in the lipid shell have been tested for their MR imaging properties *ex vivo* using primary mouse mammary tumour tissue samples and their negative contrast was also confirmed. To confirm the efficacy of the prepared ferri-liposomes for *in vivo* applications and possible targeting, 200 ml of ferri-liposomes solution was injected *in vivo*. After the injection the tumour was exposed to the 0.33 T magnetic field. MR images clearly showed the preferential accumulation of ferri-liposomes at the region that was exposed to the magnetic field. Thus, the ferri-liposomes demonstrated the potential for *in vivo* use as high effective MRI-visible delivery system, particularly for targeted cancer treatment.

Optical microscopy was used to follow the progression and dynamics of **thrombolysis**. By this method we confirmed our hypothesis that thrombolysis is not only a biochemical process in which fibrin molecules are completely degraded, but rather a combination of biochemical and mechanical processes induced by viscous forces of the shearing blood at the surface of the clot. The forces cause mechanical clot degradation, in which larger parts of the clot composed of blood cells and fibrin molecules are removed from the clot. The sizes of the removed parts range from a few individual blood cells to large agglomerates composed of several hundred blood cells. The experiments (Fig.) also demonstrated that the sizes of the removed clot parts are flow dependent, i.e., in slow flow the removed parts are considerably smaller than in a fast flow. The results also explain why thrombolysis is significantly faster with a fast flow than with a slow flow. Namely, the promotion of thrombolysis with a faster flow is much bigger than can be expected if only biochemical reactions would govern the clot degradation. Based on the results of the study a simple mathematical model was introduced that relates the maximum and the average size of the removed clot fragments with the blood flow velocity. The results of the study are included in two recently submitted scientific papers that are still under review.

A new method of **electric current imaging** by magnetic resonance imaging was developed. The method combines fast image signal acquisition with an increased current sensitivity. The method was verified by a series of experiments on model samples with long T2 relaxation times and low electric conductivity. With the samples it was possible to detect a current density as low as 20 A/m^2, which is almost two orders of magnitude less than in all other currently available methods. This extreme current sensitivity brings the method close to the detection threshold of neuronal currents. However, the T2 relaxation times of most biological tissues are too short to enable the use of this method in its present form in neurology. The results of the study were recently sent to a journal.

The above research has been supported by a number of international projects financed by the European Union within the Fifth and Sixth Frameworks as well as NATO. It was also supported within the bilateral Slovenia–USA, Slovenia–Germany and Slovenia–Greece and other scientific cooperations. 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 Saarbrucken in Germany
- The University of California, the University of Utah and the Liquid Crystal Institute, Kent, Ohio, USA,
- National Institute for Research in Inorganic Materials, Tsukuba, Japan
- NCSR Demokritos, Greece
- Institut für Biophysik und Nanosystemforschung OAW, Graz, Austria
- Bioénergétique et Ingénierie des Protéines, CNRS Marseille, France
- Architecture et Fonction des Macromolécules Biologiques, CNRS Marseille, France
- The Max Delbruck Center for Molecular medicine in Berlin
- The Dartmouth Medical School, Hanover, NH, USA
- The Mayo Clinic, Rochester, USA

made the above studies possible.

Some outstanding publications in 2009

1. Y. Takabayashi, P. Jeglič, D. Arčon, et al., The disorder-free non-BCS superconductor $Cs_3C_{(60)}$ emerges from an antiferromagnetic insulator parent state. *Science* 323, 1585-1590 (2009).
2. M. Humar, M. Ravnik, S. Pajk, I. Muševič, Electrically tunable optical microresonators. *Nat. Phot.* 3, 595, (2009).
3. U. Tkalec, M. Ravnik, S. Žumer, I. Muševič, Vortexlike Topological Defects in Nematic Colloids: Chiral Colloidal Dimers and 2D Crystals, *Phys. Rev. Lett.* 103, 127801 (2009).
4. G. Carbone, G. Lombardo, R. Barberi, I. Muševič U. Tkalec, Mechanically Induced Biaxial Transition in a Nano-confined Nematic Liquid Crystal with a Topological Defect, *Phys. Rev. Lett.* 103, 167801 (2009).
5. M. Pregelj, O. Zaharko, A. Zorko, Z. Kutnjak, P. Jeglič, P. J. Brown, M. Jagodič, Z. Jagličić, H. Berger, D. Arčon. Spin amplitude modulation driven magnetoelectric coupling in the new multiferroic $FeTe_2O_5Br$. *Phys. Rev. Lett*. 103, 147202-1-147202-4 (2009).
6. F. Aimo, S. Kramer, M. Klanjšek, M. Horvatić, C. Berthier, H. Kikuchi. Spin configuration in the 1/3 magnetization plateau of azurite determination by NMR. *Phys. Rev. Lett.* 102, 127205-1-4(2009)
7. J. Dolinšek, M. Feuerbacher, M. Jagodič, Z. Jagličić, M. Heggen, K. Urban. A thermal memory cell. *J. Appl. Phys.* 106, 043917-1-043917-5 (2009).
8. M. Ravnik and S. Žumer, Nematic colloids entangled by topological defects, *Soft Matter* 5, 269 (2009).
9. A. Vilfan. Twirling motion of actin filaments in gliding assays with non-processive myosin motors. *Biophys*. J. 97, 1130-1137 (2009).
10. J. Štrancar, A. A. Kavalenka, I. Urbančič, A. Ljubetič, M. A. Hemminga. SDSL-ESR-based protein structure characterization. *Eur. Biophys. J.*, 13, doi: 10.1007/s00249 (2009).

Some outstanding publications in 2008

1. A. Zorko, F. Bert, P. Mendels, P. Bordet, P. Lejay, J. Robert. Easy-axis kagome antiferromagnet: local-probe study of $Nd_3Ga_5SiO_{14}$. *Phys. Rev. Lett.* 100, 147201(2008).
2. M. Klanjšek, H. Mayaffre, C. Berthier, M. Horvatić, B. Chiari, O. Piovesana, P. Bouillot, C. Kollath, E. Orignac, R. Citro, and T. Giamarchi Controlling Luttinger Liquid Physics in Spin Ladders under a Magnetic Field. *Phys. Rev. Lett.* 101, 137207(2008).
3. J. Dolinšek, J. Slanovec, Z. Jagličič, M. Heggen, S. Balanetskyy, M. Feuerbacher, K. Urban. Broken ergodicity, memory effect, and rejuvenation in Taylor-phase and decagonal Al_3(Mn,Pd,Fe) complex intermetallics. *Phys. Rev.* B77, 064430(2008).
4. A. Zorko, S. Nellutla, J. van Tol, L. C. Brunel, F. Bert, F. Duc, J.-C. Trombe, M. A. de Vries, A. Harrison and P. Mendels. Dzyaloshinsky-Moriya Anisotropy in the Spin-1/2 Kagome Compound $ZnCu_3(OH)_6Cl_2$. *Phys. Rev. Lett.* 101, 026405(2008).
5. M. Remškar, M. Viršek, A. Jesih. WS_2 nanotubes as a new hybrid nanomaterial. *Nano Lett.* 8, 76(2008).
6. U. Ognysta, A. Nych, V. Nazarenko, I. Muševič, M. Škarabot, M. Ravnik, S. Žumer, I. Poberaj, D. Babič. 2D interactions and binary crystals of dipolar and quadrupolar nematic colloids. *Phys. Rev. Lett.* 100, 217803(2008).
7. M. Vilfan, N. Osterman, M. Čopič, M. Ravnik, S. Žumer, J. Kotar, D. Babič, I. Poberaj. Confinement effect on interparticle potential in nematic colloids. *Phys. Rev. Lett*. 101, 237801(2008).
8. A. Vilfan. Myosin V passing over Arp2/3 junctions: brancing 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).
10. M. Chambers, B. Zalar, M. Remškar, H. Finkelmann, S. Žumer. Piezoresistivity and electro-thermodynamical degradation of a conducting layer of nanoparticles integrated at the liquid crystal elastomer surface. *Nanotechnology* (Bristol) 19, 155501(2008).

Some outstanding publications in 2007

1. R. Žitko, J. Bonča, Fermi-liquid versus non-Fermi-liquid behavior in triple quantum dots. *Phys. Rev. Lett.* 98, 047203 (2007).
2. G. Cordoyiannis, A. Lebar, B. Zalar, S. Žumer, H. Finkelmann, Z. Kutnjak, Criticality controlled by cross-linking density in liquid single-crystal elastomers. *Phys. Rev. Lett.* 99, 197801 (2007).
3. D. Homouz, G. Reiter, J. Eckert, J. Mayers, R. Blinc, Measurement of the 3D-Born-Oppenheimer potential of a proton in a hydrogen-bonded system via deep inelastic neutron scattering : the superprotonic conductor $Rb_3H(SO_4)_2$. *Phys. Rev. Lett.*, vol. 98, 15502(2007).

4. A. Nych, U. Ognysta, V.M. Pergamenshchik, B. Lev, V. Nazarenko, I Muševič, M. Škarabot, O.D. Lavrentovich, Coexistence of two colloidal crystal at the nematic-liquid-crystal-air interface. *Phys. Rev. Lett.* 98, 057801 (2007).
5. M. Ravnik, M. Škarabot, S. Žumer, U. Tkalec, I. Poberaj, D. Babič, N. Osterman, I. Muševič, Entangled nematic colloidal dimers and wires. *Phys. Rev. Lett.* 99, 247801 (2007).
6. Hae J. Kim, J. B. Lee, Y.-M. Kim, Myung-Hwa Jung, Z. Jagličič, P. Umek, J. Dolinšek, Synthesis, structure and magnetic properties of βMno_2 nanorods. *Nanoscale Research Lletters* 2, 81(2007).
7. P. Jeglič, M. Komelj, M. Klanjšek, U. Tkalec, S. Vrtnik, M. Feuerbacher, J. Dolinšek. Orientation-dependent NMR study of the giant-unit-cell intermetallics βAl_3Mg_2, Bergman-phase $Mg_{(32)}(Al,Zn)_{(49)}$, and ζ'-$Al_{(74)}Pd_{(22)}Mn_4$. *Phys. Rev. B, Condens. Matter Phys*. 75, 014202(2007).
8. A. Levstik, V. Bobnar, C. Filipič, J. Holz, M. Kosec, R. Blinc, Z. Trontelj, Z. Jagličič. Magnetoelectric relaxor. *Appl. Phys. Lett.* 91, 012905(2007).
9. M. Remškar, A. Mrzel, A. Jesih. Inorganic nanotubes as nanoreactors: the first MoS2 nanopods. *Adv. Mater*. 19, 4276-4278 (2007).
10. G. Pabst, A. Hodžić, J. Štrancar, S. Danner, M. Rappolt, P. Laggner. Rigidification of neutral lipid bilayers in the presence of salts. *Biophys. J.* 93, 2699(2007).

Patents granted

1. Patent no.: SI22677. Ljubljana: Urad Republike Slovenije za intelektualno lastnino, June 30, 2009. 13 f. Double and triple modulators of integrine receptors $\alpha V\beta_3$, $\alpha IIb\beta_3$ $\alpha V\beta_5$ and $\alpha_5\beta_1$ with 1,2,4-oxsadiasole skeleton. Kristina Nadrah, Marija Sollner Dolenc, Slavko Pečar.
2. Patent no.: SI22676. Ljubljana: Urad Republike Slovenije za intelektualno lastnino, June 30, 2009. 16 f. Double an triple modulators of integrine receptors $\alpha V\beta_3$, $\alpha IIb\beta_3$, $\alpha V\beta_5$ and $\alpha_5\beta_1$ with 3-phenyl-1,2,4-oxsadiasole skeleton. Kristina Nadrah, Marija Sollner Dolenc, Slavko Pečar.
3. Patent no.: SI22675. Ljubljana: Urad Republike Slovenije za intelektualno lastnino, June 30, 2009. Selective modulators of integrine receptors $\alpha_5\beta_1$ and triple modulators of integrine receptors $\alpha V\beta_3$, $\alpha V\beta_5$ in $\alpha_5\beta_1$ 1,3,5-triazine skeleton. Kristina Nadrah, Marija Sollner Dolenc, Slavko Pečar.

Awards and appointments

1. Robert Blinc: Ismar Fellow, Ismar Council 2008, for highest achieves in magnetic resonance
2. Robert Blinc: Outstanding Referee for the journals of the American Physical Society, APC physics
3. Robert Blinc: Reward for outstanding contributions to ferroelectricity, Xian, China, 12th IMF Meeting
4. Igor Muševič: Zois Award for great achievements in the field of soft condensed matter physics 2009, Ministry of Higher Education, Science and Technology
5. Iztok Urbančič: Students Prešeren award for B. Sc. Thesis entitled: Non-ideality of spin labels, Faculty of Mathematics and Physics, University of Ljubljana.
6. Maja Remškar: Pregl Award for Outstanding Achievements, 4 Jun. 2009, Ljubljana, Institute of Chemistry
7. Ivan Iskra and Marko Viršek: Gold Medal in the "Evreka! 2009 Competition for Youth Innovation ", Ljubljana, Institute for Innovation and Technology.
8. Samo Kralj: Prometheus Award for Science, Slovenian Science Foundation.
9. Ajasja Ljubetič: Students Prešeren award for B. Sc. Thesis entitled: Exploring Local Conformational Spaces with the Use of SDSLEPR Spectroscopy and Modelling – a Case-Study of Position 18 on Equinatoxin II, Ljubljana, Faculty of Chemistry and Chemical Technology.
10. Brigita Rožič: Award for the effective presentation of research achievements in terms of scientific quality and their usability, Ljubljana, International Postgraduate School Jozef Stefan.
11. Uroš Tkalec: SPIE Best Paper Award, Beijing, China, Summer School I-CAMP 2009, best conference poster.

Organization of conferences, congress and meetings

1. Fourth European School in Material Science: Mechanical Properties of Complex Metallic Alloys, Mons, Ljubljana, 24–31 May 2009
2. Scientific Meeting of Solid State Physics Department, Technical Museum, Bistra, 2 Oct. 2009
3. Slovenia-Japan Symposium, IJS, Ljubljana, 7–8 Sept. 2009

INTERNATIONAL PROJECTS

1. Underwater Coastal Sea Surveyor
   UNCOSS
   7. FP, 218148
   EC; Dominique Vilbois, Patrick Peras, ECA SA, Toulon, France
   Prof. Aleksander Zidanšek
2. 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
3. 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
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, Department of Ceramics & Glass Engineering, Aveiro, Portugal
   Prof. Robert Blinc, Prof. Marija Kosec, Dr. Janez Holc, Prof. Raša Pirc
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. Designing Novel Materials for Nanodevices: From Theory to Practise (NanoTP)
   COST MP0901
   EC
   Dr. Polona Umek
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 d.o.o., Brezovica, Ljubljana, Slovenia
    Asst. Prof. Janez Štrancar
12. Structure and Mechanism of Cytoplasmic Dynein
    HFSP RGP0009/2008-C
    HFSPO - International Human Frontier Science Program Organisation, Strasbourg, France
    Asst. Prof. Andrej Vilfan
13. Field - induced Phenomena in Quantum Spin Systems
    PROTEUS
    BI-FR/09-10-PROTEUS-017
    Dr. Claude Berthier, Grenoble High Magnetic Field Laboratory, CNRS, Grenoble, France
    Dr. Martin Klanjšek
14. Self-assembly of Molecular Nanomagnets in Nanotube
    PROTEUS
    BI-FR/09-10-PROTEUS-007
    Dr. Christopher Paul Ewels, Institut des Matèriaux Jean Rouxel (IMN), CNRS UMR6502, Nantes, France
    Asst. Prof. Denis Arčon
15. EPR Analysis of Formula from L'OREAL
    C080643
    Anne-Laure Bernard, L'OREAL, Moyens Communs, Chevilly-Larue, France
    Dr. Marjeta Šentjurc
16. Manifestation of Gigantic Electrical/magnetic Response Near the Phase Boundary in Complex Oxides
    BI-JP/08-10-001
    Prof. Mitsuru Itoh, Tokyo Institue of Tehnology, Materials and Structures Laboratory, Tokyo Institute of Technology, Nagatsuta, Midori, Yokohama, Japan
    Prof. Robert Blinc
17. 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
18. 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, Lisbon, Portugal
    Asst. Prof. Tomaž Apih
19. 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, Lisbon, Portugal
    Prof. Marija Jamšek Vilfan
20. 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, Romunia
    Prof. Samo Kralj
21. Mechanical Characteristics of Molybdenum-and Tungsten-Disulfide Nanotubes and Nanowires
    BI-RS/08-09-030
    Prof. Milan Danmjanovič, Fizički fakultet, Univerzitet u Beogradu, Belgrade, Serbia
    Asst. Prof. Maja Remškar
22. Transtition Metals Dichalcogenide Nanotubes: Theoretical and Experimental Investigations of Mechanical and Electro-optical Properties
    BI-CS/06-07-007
    Prof. Milan Danmjanovič, Fizički fakultet, Univerzitet u Beogradu, Belgrade, Serbia
    Asst. Prof. Maja Remškar
23. Liquid Crystals Superstructures For Advanced Photonic Applications (SUPERNET)
    BI-UA/09-10-012
    Dr. Andriy Nych, Institute of Physics, National Academy of Science of Ukraine, Kyiv, Ukraine
    Dr. Miha Škarabot
24. Dielectric and Electocaloric Properties of Advanced Relaxor Polymer Films and Nanotubes
    BI-US/09-12-039
    Prof. Zhang Qiming, Office of Sponsored Programs, The Pennsylvania State University, PA, USA
    Asst. Prof. Vid Bobnar
25. Geometrically Frustrated Quantum Magnetism
    BI-US/09-12-040
    Dr. Johan van Tol, National High Magnetic Field Laboratory, Florida State University, FL, USA
    Dr. Andrej Zorko
26. 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
27. 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

R &D GRANTS AND CONTRACTS

1. Patterns, structural self-assemly and multiferroic states in mixtures of nanoparticles and liquid crystals
   Prof. Samo Kralj
2. Physicochemical processes involved in formation of radioactive nanoaerosols
   Asst. Prof. Janja Vaupotič, Dr. Maja Remškar
3. Carbon nanotube-based spin qubits
   Prof. Anton Ramšak, Dr. Rok Žitko
4. Advanced ferroelectric polymeric and inorganic materials: giant electrocaloric effect and transport properties
   Prof. Zdravko Kutnjak
5. Hydrogen storage in zirconium-based metallic glasses
   Prof. Janez Dolinšek
6. New methods for detection of the N-14 nuclear quadrupole resonance
   Asst. Prof. Tomaž Apih
7. Novel ground states and quantum critical points in low-dimensional quantum spin systems
   Dr. Andrej Zorko
8. Molecular motors
   Asst. Prof. Andrej Vilfan
9. 3D colloidal structures in complex mesophases
   Prof. Slobodan Žumer

10. Hybrid nanomaterials for low-friction polymer composites and energy conversion
    Asst. Prof. Maja Remškar
11. Self-ordering of nanomagnets in nanotubes
    Dr. Polona Umek
12. Novel nanostructured materials with giant electromechanical response, soft elasticity and unusual physical properties: thermal, dielectric, transport and self-organization studies
    Prof. Zdravko Kutnjak
13. Organic and inorganic percolative composites with giant dielectric constant
    Asst. Prof. Vid Bobnar
14. Self-assembly of nanoparticles in 2D nematic colloidal crystals: photonic crystals and metamaterials
    Prof. Igor Muševič
15. Study of the structure and dynamics of blood clot dissolution: mathematical modelling supported by magnetic resonance experiments
    Asst. Prof. Igor Serša
16. Dentin evolution detected by spectroscopic means
    Asst. Prof. Janez Štrancar
17. Study of food processing and preparation by magnetic resonance imaging and spectroscopy methods
    Asst. Prof. Igor Serša
18. NQR - nondestructive method for study of polymorphism in pharmacy
    Asst. Prof. Tomaž Apih
19. Applications of nanoparticle - macromolecule complexes for the formulation of biological drugs
    Prof. Igor Muševič
20. Wireless networks with radio over optical fiber
    Prof. Jurij Franc Tasič
21. Numerical detection of nanoparticles in the air
    Asst. Prof. Maja Remškar
22. Eye protection
    Dr. Janez Pirš
23. Rapid two-channel NQR/NMR detection of solid and liquid explosives
    Asst. Prof. Tomaž Apih
24. Antimicrobial surfaces for safe production of food
    Asst. Prof. Janez Štrancar
25. Single magnetic atoms and magnetic nanostructures on metal surfaces
    Dr. Rok Žitko
26. Formulation and characterization of BF fuzogenic nanoparticles for efficent drug delivery into cells
    Dr. Marjeta Šentjurc
27. Nanoparticles as additives in lubricants and low friction materials
    Asst. Prof. Maja Remškar
28. Superconductivity and magnetism in new iron-based superconductors
    Dr. Peter Jeglič
29. Ecotechnological 1D nanomaterials: synthesis and characterization of 1D titanate nanomaterials doped with transition metal ions
    Dr. Polona Umek
30. Active devices - dispersion force based nanoactuators
    Asst. Prof. Andrej Vilfan
31. Elaboration and evaluation of a toxicity test for engineered nanoparticles with terrestrial isopods
    Asst. Prof. Maja Remškar

RESEARCH PROGRAMS

1. NMR and dielectric spectroscopy condensed matter; smart new materials and traslational symmetry breaking
   Prof. Janez Dolinšek
2. Physics of soft matter, surfaces and nanostructures
   Prof. Slobodan Žumer
3. Experimental biophysics of complex systems
   Asst. Prof. Janez Štrancar

NEW CONTRACTS

1. Implementation of the "Unos" project
   Ministry of Defence
   Prof. Igor Muševič
2. Delivery of spectrometers for education and research
   University of Maribor
   Asst. Prof. Janez Štrancar

VISITORS FROM ABROAD

1. Saw Wai Hla, Department of Physics and Astronomy, Ohio University, Athens, OH, USA, 22 Dec. 2008 – 6 Jan. 2009
2. Dr. Jun-ichi Fukuda, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, 5 Jan. – 5 Jul. 2009
3. Oleg D. Lavrentovich, Liquid Crystal Institute and Chemical Physics Interdisciplinary Program Kent State University, Kent, OH 44242, USA, 23 Jan. 2009
4. Dr. Pedro Sebastiao and dr. Luis Pinto, Technical University and Center of condensed matter physics, Lisboa, Portugal, 25– 31 Jan. 2009
5. Dr. Marco Kostadinov, University of Sofia, Faculty of Chemistry, Laboratory of Nanoparticle Science and Technology (LNST), Sofia, Bulgaria, 26 Jan.– 26 Feb. 2009
6. Dr. Ana Smontara, Institute of Physics, Zagreb, Croatia, 16–17 Feb. 2009
7. Oliver Bodensiek, Institute for Theoretical Physics, Univerza v Gottingenu, Gottingen, Germany, 21–27 Mar. 2009
8. Dr. Irene Suarez-Martinez, Institut des Materiaux Jean Rouxel, Nantes, France, 5–12 Mar. 2009
9. Dr. George Cordoyiannis, Laboratorium voor Akoestiek en Thermische Fysica (ATF), Fiysica en Sterrenkunde Department, Katholieke Universiteit Leuven, Leuven, Belgium, 1– 6 May 2009, 16-17 Oct. 2009
10. Dr. Magdalena Wencka, Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland, 1 May 2009 – 31 Jan. 2010
11. Dr. Valentina Domenici, Dipartamento di Chimica e Chimica Industriale, University of Pisa, Pisa, Italy, 4–9 May 2009
12. Prof. Dr. Joon Taek Park, dr. Oc Hee Han, dr. Hwanuk Kim. dr. Hae Jin Kim, Korea Basic Scienc Institute delegation, Daejeon, South Korea, 7–10 May 2009
13. Dr. Andriy Nych and dr. Uliana Ognysta, Institute of Physics, National Academy of Science of Ukraine, Kyiv, Ukraine, 10 May - 9 Jun. 2009
14. Dr. Pedro Sebastiao, Instituto Superior de Tecnico, Lisboa, Portugal, 17.–23. May 2009
15. Dr. Randall M. Erb, 20– 24 May 2009
16. Dr. Reiner Zeizig in Andrea Orthmann, Max-Delbrueck, Center for Molecular Medicine, Department of Experimental Pharmacology, Berlin-Buch, Germany, 26–29 May 2009
17. Prof. Dr. Vlad Popa-Nita, Faculty of Physics, University of Bucharest, Bucharest, Romania, 10–19 Jun. 2009
18. Dr. Andree Jimenez-Dalmaroni, London, Centre for Nanotechnology, 14–17 Jun. 2009
19. Prof. Dr. Valentin Laguta, Institute of Physics, Czech Academy of Science, Prague, Czech Republic, 15–21 Jun. 2009
20. Prof. Bogdan Kotur, Department of Inorganic Chemistry, University of Lviv, Lviv, Ukraine, 12–20 Jul. 2009
21. Mag. Jayasri Dontabhaktuni, University of Hyderabad, Hyderabad, India, 10 Aug. 2009–10 Aug. 2010
22. Jampani Vekanta Subba Rao, India, 1–12 Sept. 2009
23. Prof. Dr. Yoshishiro Ishabiashi, Faculty of Business, Aichi Shukutoku University, Nagakute-cho, Japan, 6– 18 Sept. 2009
24. Yoshiaki Uesu, Makoto Iwata, Akitoshi Koreeda, Hiroki Taniguchi and Hiroko Yokota, Japan, 7– 8 Sept. 2009
25. Prof. Dr. Valentin Laguta, Tetyana Mukhina in Mariia Nizhynska, Institute of Physics, Chech Academy of Science, Prague, Czech Republic, 7 Sept. – 6 Oct. 2009
26. Dr. Stanislav Sykora, Ebyte, external coworker of University of Bologna, Bologna, Italy, 9–12 Sept. 2009
27. Dr. Andriy Nych and Dr. Uliana Ognysta, Institute of Physics, National Academy of Science of Ukraine, Kyiv, Ukraine, 20 Sept.–20 Oct. 2009
28. Prof. Dr. Thomas Pruschke, University of Göttingen, Institute for Theoretical Physics, Göttingen, Germany, 9–16 Oct. 2009
29. Dr. Hae Jin Kim, Korea Basic Science Institute, Daejeon, South Korea, 15– 21 Oct. 2009
30. Dr. W. Dirschl, Vision Engineering Ltd, München, Germany, 17 Nov. 2009
31. Prof. Dr. Joon Taek Park, Dr. Oc Hee Han, dr. Hwanuk Kim. dr. Hae Jin Kim, Korea Basic Science Institute Delegation, Daejeon, South Korea, 15–18 Nov. 2009
32. Dr. Andriy Nych in Dr. Uliana Ognysta, Institute of Physics, National Academy of Science of Ukraine, Kyiv, Ukraine, 29 Nov. – 29 Dec. 2009

STAFF

Researchers

1. Asst. Prof. Tomaž Apih
2. 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, died 27.11.09*
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 Muševič*, Head**
17. Prof. Slavko Pečar*
18. Dr. Janez Pirš

19. Prof. Albert Prodan
20. Asst. Prof. Maja Remškar
21. Prof. Janez Seliger*
22. Asst. Prof. Igor Serša
23. Prof. Janez Stepišnik
24. Asst. Prof. Miha Škarabot
25. Asst. Prof. Janez Štrancar
26. Prof. Jurij Franc Tasič
27. Dr. Polona Umek
28. Dr. Herman Josef Petrus Van Midden
29. Asst. Prof. Andrej Vilfan
30. Prof. Boštjan Zalar
31. Prof. Aleksander Zidanšek
32. Dr. Andrej Zorko
33. Prof. Slobodan Žumer*

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40. Dr. Natan Osterman
41. Dr. Rok Žitko

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42. Franci Bajd, B. Sc.
43. Matej Bobnar, B. Sc.
44. Andreja Eršte, B. Sc.
45. Maja Garvas, B. Sc.
46. Anton Gradišek, B. Sc.
47. Matjaž Humar, B. Sc.
48. Ivan Iskra, B. Sc.
49. Venkata Subba Rao Jampani
50. Andreja Jelen, B. Sc.
51. Dalija Jesenek, B. Sc.
52. Ajasja Ljubetič, B. Sc.
53. Olga Malgina, B. Sc.
54. Bojan Marin*, M. Sc.
55. Špela Markič Dakskobler*, B. Sc.
56. Jana Milenković, B. Sc.
57. Nikola Novak, B. Sc.
58. Anton Potočnik, B. Sc.
59. Matej Pregelj, B. Sc.
60. Brigita Rožič, B. Sc.
61. Uroš Tkalec, B. Sc.
62. Bernarda Urankar, B. Sc.
63. Iztok Urbančič, B. Sc.
64. *Jernej Vidmar, B. Sc., left 01.10.09*
65. Marko Viršek, B. Sc.
66. Bojana Višić, B. Sc.
67. Stanislav Vrtnik, B. Sc.
68. Blaž Zupančič, B. Sc.
69. Jana Mlakar**, B. Sc.

Technical officers

70. Sandra Kure, B. Sc.
71. Ivan Kvasić, B. Sc.
72. Bojan Ložar, B. Sc.
73. Milan Rožmarin, B. Sc.
74. Erik Von Zupanič, B. Sc.

Technical and administrative staff

75. Andreja Berglez, B. Sc.
76. Dražen Ivanov
77. Janez Jelenc, B. Sc.
78. Davorin Kotnik
79. Silvano Mendizza
80. Iztok Ograjenšek
81. Silvija Pirš
82. *Ana Rozman, left 05.05.09*
83. Ana Sepe, B. Sc.
84. Marjetka Tršinar
85. Veselko Tihidrag Žagar, B. Sc.

Note:
* part-time JSI member
** young researcher financed by industry

BIBLIOGRAPHY

Original Articles

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DEPARTMENT FOR COMPLEX MATTER F-7

The research within the Department of 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. Nanomaterials research is focused on investigations into the fundamental properties and applications of MoSI molecular wires, crossing into the physics and nanoscience of macromolecular biological systems, such as DNA and cilia, and venturing into quantum molecular electronics and nano-electronics. These and other materials, such as strongly correlated systems, electronically ordered systems and superconductors were investigated using advanced femtosecond spectroscopy techniques. In many areas we have introduced new materials, technologies and techniques. An exciting new area that developed rapidly this year was 'cosmology in the laboratory', where ultrafast laser systems are used to simulate cosmological transitions, such as the Big Bang on the nanoscale.

MoSI molecular wires have been receiving increasing attention in recent years, and many of laboratories have joined in the work on these unique materials. A review of their properties was recently published in the prestigious journal Progress of Materials Science (54, 309 (2009))

Ultrafast studies of electron dynamics in correlated systems

The field of research in the relaxation processes of photo-excited electrons in correlated electron systems remains one of our main research topics. Several experimental studies of carrier relaxation phenomena in correlated electron systems with various degrees of correlation were 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 different components by their lifetimes. Moreover, the relaxation kinetics can yield valuable information on the mechanism for superconductivity. This year, in collaboration with Politecnico di Milano, we have upgraded our set-up with a broadband non-collinear optical parametric amplifier, which improved our time resolution to below 20 fs.

Significant attention was focused on investigations of dynamic transitions from symmetric to broken symmetry states, mostly in second-order, charge-density wave (CDW) systems. To study the transitions a novel three-pulse method was employed, which is based on a sequence of destruction, pump and probe pulses. Measurements using the three-pulse method were first conducted in $TbTe_3$ and then systematically expanded on other systems, such as: $DyTe_3$, $K_{0.3}MoO_3$, 2H-$TaSe_2$, $NbSe_3$,1T-TaS_2 and $(NbSe_4)_3I$.

In the CDW systems we detected coherent aperiodic undulations of the order parameter (OP), critical slowing down of the collective mode, and evolution of the particle-hole gap that appears through the Peierls-BCS mechanism (akin to the Higgs mechanism) as it evolves through the transition, upon which we quenched the system into the high symmetry state. The numerical modeling, with no fitting parameters, is seen to convincingly reproduce the observations, including the spatio-temporal distortions caused by Higgs-wave-like disturbances arising from the spontaneous annihilation of topological defects (see Figure 1). Measurements on related systems show that the observed behaviour appears to be universal for second-order transitions. A paper with these results was submitted to Nature.

The first systematic studies of photo-induced charge density wave (CDW) – metal phase transition have been performed on a prototype quasi-one-dimensional CDW system $K_{0.3}MoO_3$. 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 the timescale of several 100 fs after 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 was published in Physical Review Letters 102, 066404 (2009).

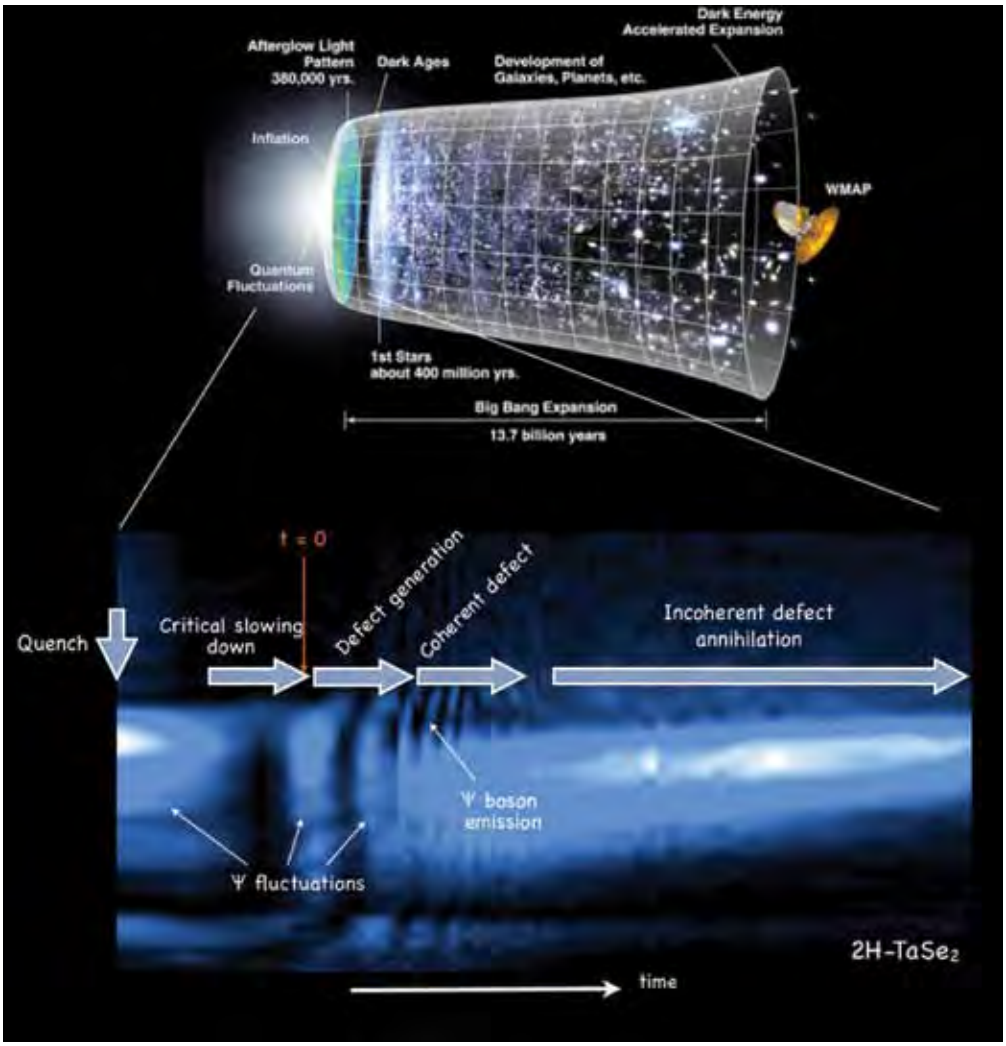

Figure 1: An exciting new research area that developed rapidly this year was 'cosmology in the laboratory', where ultrafast laser systems are used to simulate cosmological transitions, such as the Big Bang on the nanoscale. The figure shows the timeline of a cosmic quench experiment in the laboratory performed on an electronic crystal ($TaSe_2$), compared with the evolution of the Universe. In both cases, the sequence of events is described by the Kibble-Zurek scenario. The bottom part of the figure shows the evolution of the collective mode (Higgs field) as it evolves through the transition (Big Bang). The entire event takes place on a time scale of a few picoseconds and was recorded using a new technique developed at the Department of Complex Matter.

Utilizing an optimized system for a time-resolved reflectivity study with an extremely high signal/noise ratio we have studied the temperature dependence of the photo-induced reflectivity dynamics in a prototype quasi-one-dimensional CDW system $K_{0.3}MoO_3$. The vastly improved sensitivity and stability of the set-up enabled us to measure the temperature dependence of a series of phonon modes (15 modes up to 150 cm^{-1}) with unprecedented sensitivity and energy resolution (< 0.1 cm^{-1}). We have shown that most of the modes, which are present only below T_c, are a result of the linear coupling of the phonon modes at the charge-density wave modulation vector $2k_F$ with the electronic part of the order parameter. A paper has been submitted to Physical Review Letters.

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 $SmFeAsO_{0.8}F_{0.2}$ with $T_c \approx 50$ 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 $\Delta PG = 61 \pm 9$ meV above Tc. Both the SC and PG components show saturation as a function of fluence. The pump photon energy dispersion indicates that the SC and PG components originate from two distinct relatively weakly coupled electronic subsystems. The relaxation of quasiparticles in parent undoped spin-density wave (SDW) SmFeAsO and $SrFe_2As_2$ was also investigated. In both compounds a bottleneck due to the opening of a charge gap concurrent with SDW formation and the critical slowing down near the transition was observed. In SmFeAsO, the second moment of the Eliashberg function was determined, which characterizes electron-phonon coupling. It turned out that the coupling is rather weak.

Figure 2: Non-colinear optical parametric amplifier for the generation of sub-20 fs pulses

Some results have already been published in Physical Review Letters 102, 117002 (2009) and in the Journal of Superconductivity and Novel Magnetism 22, 575 (2009). The publication of further results, including measurements on undoped parent SDW compounds, is in the final stage prior to submission to Physical Review B.

In the framework of the cuprate superconductor research we measured (by means of optical time-resolved spectroscopy) the doping dependence of the optical energy density that is required to destroy superconducting condensate in the prototypical $YBa_2Cu_3O_{7-\delta}$ system. During measurements we found that in $YBa_2Cu_3O_{7-\delta}$ the surface preparation can strongly influence the dynamical response due to induced oxygen chain disorder. The results show that the energy density required to destroy the superconducting condensate increases systematically increases with the critical temperature and that

as in (La,Sr)CuO_4 a major part of the optical energy is transferred to phonons on a sub-ps timescale, indicating a strong electron-phonon coupling. A manuscript describing the results is in preparation.

During this year we successfully finished research on the phase-separation dynamics in (Pr,Ca)MnO_3 system. By means of the photoinduced time-resolved magneto-optical Kerr effect (MOKE) and time-resolved reflectivity we were able to separate the magnetic and nonmagnetic contributions to ultrafast MOKE dynamics and showed that in thin films of (Pr,Ca)MnO_3 the photo-induced formation of insulating phases to the ferromagnetic metallic phase takes place on a 10-picosecond timescale. The results were published in Europhys. Lett. 86 57003, (2009) and Phys. Rev. B 80, 224411 (2009).

The influence of the electronic density of states (DOS) on the relaxation in a decagonal quasicrystal was also investigated. A fast initial diffusion of hot carriers into the sample enhanced by the presence of a wide pseudogap was observed. We also found that DOS is further reduced in the vicinity (~13 meV) of the Fermi energy. The results were published in Phys. Rev. Lett. 102, 086405 (2009).

Femtosecond time-resolved optical spectroscopy was used to systematically study photo-excited carrier relaxation dynamics in the intermediate-valence heavy-fermion system $Yb_{1-x}Lu_xAl_3$ ($0<x<1$). The results imply that in $Yb_{1-x}Lu_xAl_3$ the hybridization gap, resulting from the hybridization of local moments and conduction electrons, persists up to 30% doping. Interestingly, below some characteristic, doping-dependent temperature T^* the relaxation-time divergence, governed by the relaxation bottleneck due to the presence of the indirect hybridization gap, is truncated. This observation is attributed to the competing ballistic transport of hot electrons out of the probed volume at low temperatures. The derived theoretical model accounts for both the functional form of the relaxation dynamics below T^*, as well as the doping dependence of the low-temperature relaxation rate in $Yb_{1-x}Lu_xAl_3$. The paper was published in Physical Review B 80, 085121(2009).

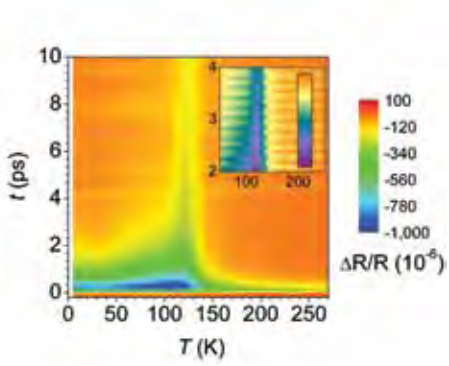

Figure 3: Laser-pulse-induced reflectivity transients as a function of temperature in undoped SmFeAsO. The critical slowing down is clearly observed at the spin-density wave-ordering temperature. In (a) the coherent phonon, shown expanded in the insert, is artificially smeared beyond a 4-ps delay due to a decreased time resolution of the scans.

Organic semiconductors show a strong potential for new technological applications. These 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 published in Physical Review Letters 102, 066404 (2009).

In semiconducting carbon nanotubes we excited and detected coherent phonons via the pump-probe technique with sub-10-fs time resolution. The simulation of the amplitude and the phase profile via time-dependent wave-packet theory yields excellent agreement with the experimental results under the assumption of molecular excitonic states and allows a determination of the electron-phonon coupling strength for the two dominant vibrational modes. This work has been published in Phys. Rev. Lett. 102, 127401 (2009).

The measurement of the electronic transport properties of nanoscale entities (single molecules, single wires etc.) represents a major technological and scientific challenge. Recently, we succeeded in reproducibly measuring the longitudinal transport properties of single MoSI wires with diameters in the range 4–5 nm over distances as large as 200 nm. The circuits were entirely nanofactured within the department using electron-beam lithography techniques and dielectrophoretic deposition. The measurements reproducibly show properties that are characteristic of one-dimensional quantum fluids (i.e., Luttinger liquids), as shown in Figure 5. (Physical Review B 80, 085402 (2009))

Theoretical studies on the nanoscale

We developed the theory of multiple phase slip phenomena in the superconducting ring in an external magnetic field. It is shown that depending on the ratio of the relaxation rates the topological phase transition occurs with many spatially separate phase-slip centres created simultaneously or with a sequence of many phase slip events occurring in one centre consecutively in time. (Physical Review B, 79, 184521 (2009)). In the case of the 2D superconducting film we found the quench condition where the phase slip phenomena are governed by the Kibble-Zurek mechanism. Simulations of the time-dependent Ginzburg-Landau equation were also performed for the charge-density wave system with the quench caused by a short laser pulse. In contrast to superconductors, the quench through the phase transition leads to domain-wall formation and the generation of propagating Higgs-like waves.

We have shown that in metals with relatively short light-penetration depths the initial fast relaxation after the laser-pump pulse is governed by the ballistic transport of hot electrons. The exact solution of the kinetic equation is in excellent agreement with the experimental data on heavy-fermion systems. The theory is also supported by de Haas-van Alphen measurements on these compounds. (Physical Review B, 80, 085121 (2009)).

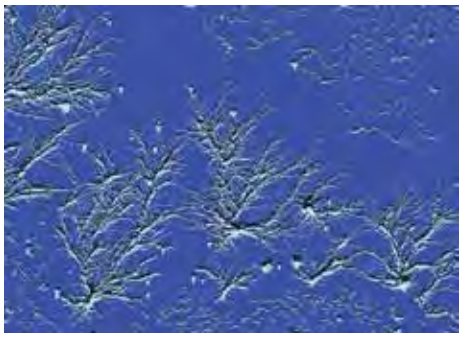

Figure 4: A detail of a large-scale image composed of several high-resolution atomic force microscope images represents self-assembled nanowires on the mica surface. The diameters of the nanowires range down to 1 nm.

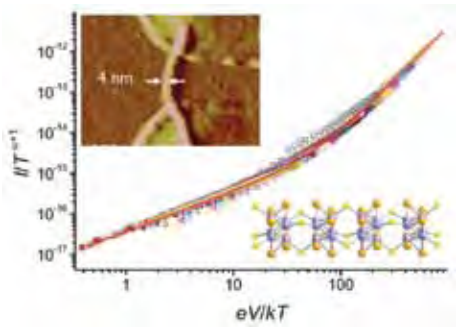

Figure 5: The transport properties of very thin MoSI–636 wires show systematic Luttinger-liquid scaling behaviour. The 4-nm wire diameters are among the thinnest nanowires measured so far. Both Coulomb blockade and Luttinger liquid effects are observed in measurements on a large number of samples.
The circuit was manufactured by E-beam lithography and measured at the JSI.

Nanomaterials

Inorganic molecular wires – particularly molybdenum halide or chalcogenide cluster polymers – have emerged as a new type of one-dimensional materials with remarkable molecular-scale functionality. Their one-dimensional polymer structure gives rise to some very unusual physical properties. Anionic bridges which bind Mo clusters together into one-dimensional chains are extraordinarily strong, yet highly deformable, giving rise to exceptionally high Young's moduli and nonlinear mechanical properties, respectively. The very weak interaction between the individual polymer chains within crystalline bundles leads to the observation of an extremely one-dimensional electronic and magnetic character, on the one hand, and also to the easy dispersion in common polar solvents and ultralow shear moduli, on the other. The sulphur atoms within the structure facilitate a diverse functionalization chemistry to thiol-containing molecules, such as proteins.

Experimental and theoretical progress in the field has been extremely rapid since 2004. Therefore, we published a review on the most important structural, mechanical, electronic and magnetic properties of molybdenum chalco-halide molecular wires in Progress of Materials Science 54, 309 (2009). There we also discuss the functional properties that make these new materials of great interest for a wide variety of diverse applications, including conducting composites, nonlinear optics, field emission, tribology, spin-modulators, molecular and gas sensing and potentially revolutionary applications in molecular electronics.

While the transport properties of one-dimensional systems have been of great interest from the point of view of fundamental physics for some time, recently, further interest in the transport properties of nanoscale one-dimensional systems was aroused because of their importance for the development of molecular electronics, where diverse molecular devices (switches, memory elements, sensors) all need to be self-assembled together with electrically conducting molecular scale wires. To be of practical use, the connectors need to have reliable contacts and also to be able to withstand mechanical deformations while retaining their conducting properties. Until now there has been no recognized material that could be used for this purpose, and this has seriously impeded progress in the development of large-scale molecular electronics in recent years.

Charge-transport measurements on flexible $Mo_6S_3I_6$ (MoSI) nanowires with different diameters in highly imperfect two-terminal circuits reveal the systematic power-law behaviour of the conductivity as a function of temperature and voltage. On the basis of measurements on a number of circuits we conclude that the behaviour in thin wires can be most convincingly described by tunnelling through the Tomonaga-Luttinger liquid segments of MoSI wire, which is in some cases modified by an environmental Coulomb blockade. The latter are proposed to arise from deformations or imperfections of the MoSI wires, which – in combination with their recognitive terminal sulphur-based connectivity properties – might be useful for creating sub-nanometre scale interconnects as well as nonlinear elements for molecular electronics. This work has been published in Physical Review B 80, 085402 (2009).

Scale-free self-organized critical networks are known to show resistance to failure, fast signal processing and are of particular interest for nano-electronics. They are also the basis of information processing in the brain. Self-organized criticality has been recently observed on a molecular scale in $Mo_6S_{9-x}I_x$ (MoSI) and gold nanoparticle (GNP) hybrid networks.

The solution processed attachment of MoSI nanowires to GNPs was used for the self-assembly of the networks, which were deposited onto a mica substrate, examined by atomic force microscope and statistically analyzed. With conversion of the network into a simplified topological graph we were able to perform a detailed analysis on a large part of the network.

We have compared the distributions of lengths of individual nanowires to the lengths of the edges in the network and while the former is log-normal, the latter shows a strong power-law tail, exhibiting scale invariance. This shows that the self-organized critical behaviour is not a property of the nanowire synthesis, but of their self-assembly into networks. This work has been published in Nano Letters 9, 1091 (2009).

We research the temperature-controlled transformation of $Mo_6S_2I_8$ nanowires to MoS_2, which results in a very rich system of MoS_2 nanotube-hybrid structures. The MoS_2 nanotube hybrids represent a family of nanomaterials, where nanotubes serve as nanoreactors and in some cases also as nanocontainers of MoS_2 fullerene-like particles, which have in situ grown in a confined geometry of nanotubes. A simple temperature control of morphology, size, and the inner structure of nanohybrids leads to a selective morphology such as coaxial nanotubes, "mama"-tubes with encapsulated nano-onions, the growth of MoS_2 nanobuds or it facilitates a release of MoS_2 nano-onions, which then form weakly bonded self-assemblies. We assume that the nanotube envelope grows from the outside towards the inside, while the encapsulated nano-onions grow in the opposite way, from the inside towards the outside. The resulting structure can be, therefore, different, especially due to a unequal amount and the stoichiometry of spare material, which is locally available for the growth. The sulphurization process ensures a sufficient amount of sulphur outside of precursor crystals, which prefers a hexagonal

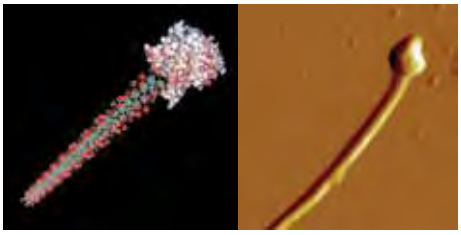

Figure 6: Triglobuline molecule at the end of a MoSI molecular nanowire. Image was taken with an atomic force microscope.

stacking of the MoS_2 layers forming the envelope. Inside the envelope the amount of sulphur is lower and determined by its diffusion through the nanotube wall. Slightly sub-stoichiometric conditions usually lead to a rhombohedral stacking (3R), which explains the stacking of the encapsulated nano-onions. In the high-temperature regime the nano-onions grow outside of nanotubes, so the hexagonal lattice structure (2Hb) is expected. The described synthetic route based on Mo_6 clusters may apply to other transition-metal clusters in combination with different chalcogenides to give rise to a chalcogenide-nanotube technology.

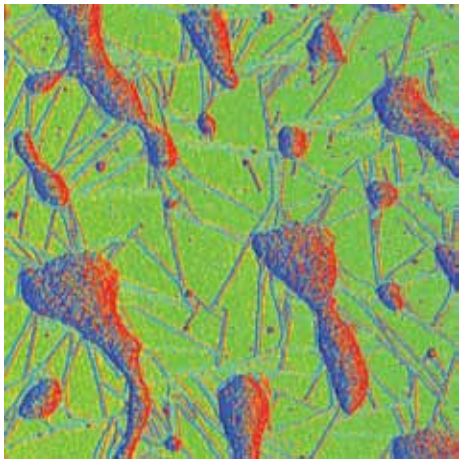

Figure 7: Green fluorescent proteins connected by MoSI nanowires.

Electron dynamics in biological macromolecules

In 2009 we have completed the first stage in our study of the electronic properties of M-DNA – spectroscopic studies on bulk samples. The spectroscopic techniques which we used in our research were: electron spin resonance (ESR) and the cavity-perturbation technique – a contactless method for measuring microwave (MW) conductivity and X-ray Absorption Near Edge Structure (XANES). The results of the performed measurements have led us to the following conclusions: (i) it is possible, by replacing a proton from a hydrogen bond in the interior of the double helix with a divalent transition metal cation (Zn^{2+}, Co^{2+} or Ni^{2+}), to achieve an effective electron doping of DNA, (ii) added electrons are located on the nucleobases Lowest Unoccupied Molecular Orbital (LUMO) levels, (iii) their unpaired electron spins yield a strong, broad and asymmetric ESR signal, (iv) spin susceptibility and MW conductivity of the M-DNA complex are almost temperature independent in a broad temperature interval reflecting a delocalization and a strong correlation of doped electrons and (v) spin-spin correlations between unpaired spins have a ferromagnetic character and they start to prevail at temperatures below 100 K were the electrons start to localize. With those experiments we have proven that it is possible to chemically dope DNA and thus greatly improve its conductivity, which was for a long time the main obstacle for realistic DNA applications in molecular nanoelectronics. The realization of a high electron density in the conduction band of the DNA by electron doping in the metal-DNA complex is not only important for any future application of M-DNA, but also introduces the physics of strongly correlated systems into the field of DNA conductivity.

Soft Matter

Liquid-crystal elastomers fascinate scientists because of their thermo-mechanical and symmetry-related properties. Our measurements have shown that if stretched beyond the elastic instability, a transition from solid-like to liquid-like behaviour is observed.

In cooperation with the Faculty of Physics at the University of Vienna we continued investigations of holographic polymer-dispersed liquid crystals (HPDLC) for use in diffraction elements for the manipulation of cold neutron beams. A series of diffraction 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 the decreasing grating periodicity. We also investigated the diffraction of cold neutrons on composite periodic structures fabricated from polymers and nanoparticles. The modulation of the coherent scattering-length density in these media is of a similar magnitude to that in HPDLCs, but their advantage is the possibility to fabricate elements with a larger thickness, which is important for the fabrication of mirrors and beams splitters. The results of these investigations are reported in the paper: J. Opt. A: Pure Appl. Opt. 11, 024019 (2009).

We also continued with investigations of 2D composite photonic structures from polymers and liquid crystals. With the use of the interference patterns of 4 and 3 coherent laser beams that were mixed on the sample with the help of a glass pyramid, we fabricated 2D photonic crystals with a quadratic lattice. The role of the Nematic-Isotropic phase transition and the effect of the external electric field on the structural and diffraction properties of the lattice were investigated. The results of this work are reported in the paper: J. Opt. A: Pure Appl. Opt. 11, 024020 (2009).

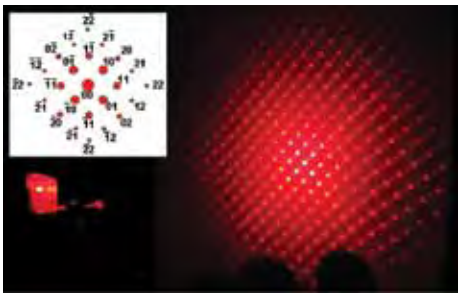

Figure 8: Diffraction of laser beam on 2D photonic crystal.

In cooperation with the Department for Condensed Matter Physics at the Jožef Stefan Institute and the National Institute of Chemistry in Ljubljana we investigated the process of optical holographic patterning in light-sensitive liquid crystal elastomers (LCEs). We demonstrated the large range reversible tunability of the grating period of 1D transmission gratings made from this material by modification of the strain and temperature of the medium. These features have a large potential for applications in optical sensors and various optical diffractive devices. This research work is reported in the publications: Polymer 50, 4837 (2009) and Phys. Rev. E 80, 050701 (2009).

In addition, our measurements of nematic fluctuations in LCEs revealed how the elastic properties change with the applied strain. Our findings gave a strong experimental support to one of the fundamental theoretical concepts, i.e., the existence of soft fluctuation modes. These soft

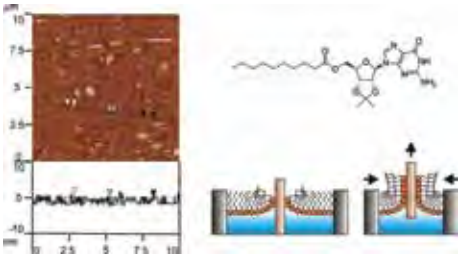

Figure 9: Atomic force microscope image of a lipophilic guanosine derivative on mica surface, deposited with Langmuir-Blodgett technique.

modes are responsible for the large strain-dependent dissipation of the acoustic waves, opening a whole new area of polarized acoustic technology. The experimental findings are reported in the paper: Phys. Rev. Lett., 103, 077801 (2009).

We continued our investigations of the self-assembling properties of guanosine derivatives in aqueous solutions and on various surfaces. A comparative study of the aggregation properties of lipophilic derivatives with one, two and three hydrocarbon tails was performed. We investigated the properties of the Langmuir films of these derivatives on water subphase and the properties of Langmuir Blodget (LB) films transferred to a mica surface. AFM imaging of the structure of the LB films showed that the surface adsorption features of the three derivatives are very different. This observation demonstrates that the self-assembling properties of guanosine molecules can be effectively manipulated by an appropriate chemical modification of the molecule. The results of these investigations are reported in the paper J. Phys. Chem. B 113, 7934 (2009) and in a manuscript accepted for publication in Applied Surface Science (2009). In cooperation with the group from Ulster University we started investigations of the self-assembling properties of guanosine-rich DNA oligonucleotides (6-30 bp) in solution and on surfaces.

Our cooperation with laser company Fotona d.d. from Ljubljana 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. The obtained results are reported in a manuscript accepted for publication in the IEEE Journal of Quantum Electronics.

We created an array of artificial cilia, which we can drive externally using magneto-optical tweezers. We have shown that their synchronised beating generates a fluid flow in a microfluidic chamber. This work was performed in collaboration with the Faculty of Mathematics and Physics.

We studied the thermal motion of polystyrene spheres in magnetic fluids using video microscopy. The measured micro-rheological properties, i.e., the viscosity and storage modulus of the magnetic fluid, strongly depend on the external magnetic field. The changes in the micro-rheological properties are the largest at an external field, at which the magnetic nanoparticles in magnetic fluid begin to chain. While the storage modulus perpendicular to the field is for a factor of two smaller than parallel to the field, the viscosity only slightly depends on the direction of the external field.

Nonlinear optics

In the Nonlinear Optics Laboratory we study new materials and their interaction with laser light. Integrated optics is a promising technology; however, better materials will increase its potential. In cooperation with the National Institute for Materials Science in Tsukuba, Japan, ($LiTaO_3$) and North Carolina State University in Raleigh, USA, (GaAlN) we study new concepts of compact light sources on the basis of the nonlinear optical conversion of existing lasers into the spectral regions where lasers are not yet available. 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 investigated pulsed photo-thermal radiometry (PPTR) for noncontact measurements of laser-induced temperature profiles in strongly scattering samples, and its potential for the characterization of vascular lesions in human skin. In systematic measurements involving agar- and collagen-based tissue models and detailed numerical simulations, we have determined the optimal spectral bands for PPTR signal acquisition. The spatial resolution of temperature profiling was significantly improved by the explicit consideration of the variation of the sample IR absorption coefficient within the acquisition spectral band. Comparison of the results with high-resolution magnetic resonance imaging demonstrated an unprecedented accuracy in the depth determination of the absorbing layers. Using such a PPTR system, we have measured temperature profiles during the therapy of vascular birthmarks (port-wine stains - PWS) with a prototype dual-wavelength lasers system. This enabled us to determine the role of the dynamic change of optical properties on the laser treatment of the PWS. (Performed in collaboration with Beckman Laser Institute and medical Clinic, University of California at Irvine.)

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

Biological systems

In collaboration with the Faculty of Mathematics and Physics, University of Ljubljana, we used combined magneto-optical tweezers to study biomimetic systems. Superparamagnetic spheres were assembled into long

chains that were attached to a glass surface on one end. This created an array of artificial cilia and we investigated the hydrodynamics around them. By using an external magnetic field, we rotated the cilia and the asymmetry of rotation resulted in a fluid flow. We measured the velocity profile of the flow as a function of height above the ciliated surface and studied its dependence on the rotation parameters (degree of asymmetry and rotational frequency). In collaboration with the Department of Condensed Matter Physics (F5), a theoretical model was proposed and an excellent agreement between the experimental data and the model was obtained. The paper was accepted for publication in the Proceedings of National Academy of Sciences (PNAS).

We also performed experiments that would finally prove the hypothesis that the metachronal waves on a cell surface appear as a result of hydrodynamic coupling between individual cilia. We created special non-magnetic cilia, which do not respond to the external magnetic field. Their motion is therefore determined by the motion of other cilia based on the hydrodynamic coupling. Experiments are still under way.

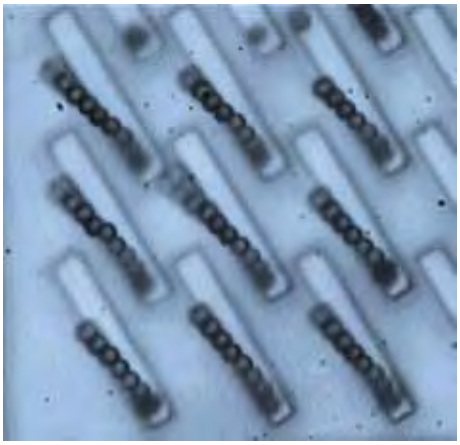

Figure 10: 3x3 array of biomimetic artificial cilia during pumping action. The cilia are self-assembled from 4.4-micrometer superparamagnetic beads using an external magnetic field; the field is also used for their asymmetric actuation that results in the generation of a fluid flow.

Some outstanding publications in the past three years

1. Jure Strle, Damjan Vengust, Dragan Mihailović. Inorganic molecular-scale MoSI nanowire-gold nanoparticle networks exhibit self-organized critical self-assembly. Nano lett. (Print), 2009, vol. 9, 1091-1095.
2. Verner K. Thorsmølle, Jure Demšar. Morphology effectively controls singlet-triplet exciton relaxation and charge transport in organic semiconductors. Phys. rev. lett., 2009, vol. 102, 017401-1-017401-4.
3. Tomaž Mertelj, Anderej Ošlak, Janez Dolinšek, I. R. Fisher, Viktor V. Kabanov, Dragan Mihailović. Fine structure in the electronic density of states near the Fermi energy of Al-Ni-Co decagonal quasicrystal from ultrafast time-resolved optical reflectivity. Phys. rev. lett., 2009, vol. 102, 086405-1-086405-4.
4. Tomaž Mertelj, Viktor V. Kabanov, Christoph Gadermaier, N. D. Zhigadlo, S. Katrych, J. Karpinski, Dragan Mihailović. Distinct pseudogap and quasiparticle relaxation dynamics in the superconducting state of nearly optimally doped $SmFeAsO_{0.8}F_{0.2}$ single crystals. Phys. rev. lett., 2009, vol. 102, 117002-1-117002-4.
5. Andrej Petelin, Martin Čopič. Observation of a soft mode of elastic instability in liquid crystal elastomers. Phys. rev. lett., 2009, vol. 103, 077801-1-077801-4.
6. Natan Osterman, Igor Poberaj, Jure Dobnikar, Daan Frenkel, Primož Ziherl, Dušan Babič. Field-induced self-assembly of suspended colloidal membranes. Phys. rev. lett., 2009, vol. 103, 228301-1-228301-4.
7. Dragan Mihailović. Inorganic molecular wires: physical and functional properties of transition metal chalcohalide polymers. Prog. Mater. Sci.. [Print ed.], 2009, vol. 54, 309-350.
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12. M. Avsec, I. Drevenšek Olenik, A. Mertelj, S. P. Gorkhali, G.P. Crawford, M. Čopič, Band structure of orientational modes in quasiperiodic mesoscale liquid-crystal-polymer dispersion, Phys. Rev. Lett. Vol. 98, 2007, 173901-1-173901-4.

Organization of conferences, congress and meetings

1. Conference European Science Foundation (ESF) Research Conference: »Self-assembly of Guanosine Derivatives: from Biological Systems to Nanotechnological Applications«, coorganizers, Ötz Valley, Austria, 20 – 25 June 2009.
2. SLONANO 2009, Ljubljana, Slovenia, coorganizers, 19 - 21 October 2009.
3. ECO-NET project, Meeting, 01 December 2009, Institut "Jožef Stefan", Ljubljana, Slovenia.

INTERNATIONAL PROJECTS

1. Electronic Response of Single Inorganic Nanowires
   ERESIN
   7. FP, 230975, PERG03-GA-2008-230975
   EC
   Prof. Dragan Mihailović
2. Composites of Inorganic Nanotubes and Polymers
   COINAPO
   COST MP0902
   EC; COST Office, Brussels, Belgium
   Prof. Dragan Mihailović
3. 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
4. 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
5. Light-Sensitive Nanocomposite Media for Tunable Photonic Devices
   BI-CN/09-11-016
   Prof. Xinzheng Zhang, Teda Applied Physics School, Nankai University, Tianjin, China
   Prof. Irena Olenik Drevenšek
6. 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
7. 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
8. 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
9. Ultrafast Electronic and Structural Dynamics in thin Films of Charge Density Wave Compounds
   BI-RO/08-09-017
   Dr. (PhD) Mihailescu Ion, National Institute for Lasers, Plasma and Radiation Physics, NILPRP, Magurele, IIfov, Romania
   Asst. Prof. Jure Demšar
10. Ultrafast Pump-probe Spectroscopy of Complex Matter
    e-GAP
    Royal Society International Joint Projects 2009/R2
    Prof. Sasha Alexandrov, Loughborough University, Physics Department, Loughborough, Great Britain
    Prof. Dragan Mihailović
11. Laser Therapy of Cutaneous Vascular Lesions using Repetitive Irradiation and Intermittent Cryogen Cooling
    BI-US/09-12-044
    Dr. John Stuart Nelson, Beckman Laser Institute and Medical Clinic, University of California at Irvine, Irvine, CA, USA
    Asst. Prof. Boris Majaron
12. 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
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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 metals
   Dr. Aleš Mrzel
3. Molecular elecronics with MoSI nanowires
   Prof. Dragan Dragoljub Mihailović
4. Biomimetic systems in microfluidics
   Dr. Mojca Vilfan
5. Ultrafast electron dynamics in metals and determination of electron-phonon coupling constant in metals and superconductors
   Asst. Prof. Viktor Kabanov

RESEARCH PROGRAMS

1. Dynamics of complex nanosystems
   Prof. Dragan Dragoljub Mihailović
2. Light and matter
   Prof. Martin Čopič

VISITORS FROM ABROAD

1. Li Jun, TEDA Applied Physics School, Nankai University, China, 18 January – 18 February 2009.
2. Dr. Elena Ouskova, Institute of Physics, National Academy of Sciences of Ukraine (NASU), Kiev, Ukraine, 05 – 19 April 2009.
3. Prof. Xin Yao, Shanghai Jiao University, Shanghai, China, 30 April – 13 May 2009.
4. Dr. Katica Biljaković, dr. Damir Starešinić, Damir Dominko, Institut za fiziku, Zagreb, Croatia, 07 May 2009.
5. Dr. Andras Kis, Laboratory of nanoscale Electronics and Structures, School of Engineering, EPFL, Lausanne, Switzerland, 06 May – 08 May 2009.
6. Prof. dr. Giulio Cerullo, dr. Christian Manzoni, Politecnico di Milano University, Milano, Italia, 10 – 15 May 2009.
7. Prof. Hans Kuzmany, University of Vienna, Faculty for Physics, Vienna, Austria, 11 – 15 May 2009.
8. Nason James Ma'ani-Hessari, School of Biomedical Sciences, University of Ulster, Belfast, United Kingdom, 11 – 22 May 2009.
9. Dr. Mykhailo Pevnyi, Physics Faculty, National Taras Shevchenko University, Kiev, Ukraine, 08 July – 08 August 2009.
10. Prof. dr. Sergey Zaytsev-Zotov, Kotel'nikov Institute of Radio Engineering and Electronics of RAS, Moscow, Russia, 02 – 07 July 2009.
11. Dr. Roman Yusupov, General Physics Chair Kazan State University, Kazan, Russia, 20 July – 20 August 2009.
12. Dr. Patrick Huber, Physics and Mechatronics Engineering, Saarland University, Germany, 07 – 11 September 2009.
13. Prof. Martin Fally, University of Vienna, Vienna, Austria, 26 – 30 October 2009.
14. Prof. dr. Giuglielmo Lanzani, Politecnico di Milano University, Milano, Italy, 23 – 24 November 2009.
15. Dr. J. Emilio Lorenzo, Institut Néel, Grenoble, Francija, 30 November – 02 December 2009.
16. Dr. Katica Biljaković, dr. Damir Sterešinić, Damir Dominko, Institut za fiziku, Zagreb, Croatia, 01 December 2009.
17. prof. dr. Hasna Samić- Sahinpašić, Faculty of Electrotechnics, University of Sarajevo, Sarajevo, Bosnia in Herzegovina, 01 December 2009.
18. Maja Đekić, Prirodno-matematički fakultet, Sarajevo, Bosnia and Herzegovina, 01 December 2009.

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Note:
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BIBLIOGRAPHY

Original Articles

1. Jure Demšar, Viktor V. Kabanov, A. S. Alexandrov, H. J. Lee, E. D. Bauer, John L. Sarrao, A. J. Taylor, "Hot electron relaxation in the heavy-fermion $Yb_{1-x}Lu_xAl_3$ compound using femtosecond optical pump-probe spectroscopy", *Phys. rev., B, Condens. matter mater. phys.*, vol. 80, no. 8, pp. 085121-1-085121-6, 2009.
2. Miha Devetak, Jerneja Milavec, R. A. Rupp, B. Yao, Irena Drevenšek Olenik, "Two-dimensional photonic lattices in polymer-dispersed liquid crystal composites", *J. opt. A, Pure appl. opt. (Print)*, vol. 11, pp. 024020-1-02420-8, 2009.
3. Miha Devetak, Blaž Zupančič, Andrija Lebar, Polona Umek, Boštjan Zalar, Valentina Domenici, Gabriela Ambrožič, Majda Žigon, Martin Čopič, Irena Drevenšek Olenik, "Micropatterning of light-sensitive liquid-crystal elastomers", *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, vol. 80, pp. 050701-1-050701-4, 2009.
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9. Blaž Kavčič, Dušan Babič, Natan Osterman, Boštjan Podobnik, Igor Poberaj, "Magnetically actuated microrotors with individual pumping speed and direction control", *Appl. phys. lett.*, vol. 95, pp. 023504-1-023504-3, 2009.
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14. Paolo Mariani, Francesco Spinozzi, Francesco Federiconi, Heinz Amenitisch, Lea Spindler, Irena Drevenšek Olenik, "Small angle x-ray scattering analysis of deoxyguanosine 5'-monophosphate self-assembing in solution: nucleation and growth of G-quadruplexes", *J. phys. chem., B Condens. mater. surf. interfaces biophys.*, issue 22, vol. 113, pp. 7934-7944, 2009.
15. Alenka Mertelj, Luka Cmok, Martin Čopič, "Anomalous diffusion in ferrofluids", *Phys. rev., E Stat. nonlinear soft matter phys. (Print)*, vol. 79, no. 4, pp. 041402-1-041402-8, 2009.
16. Tomaž Mertelj, Viktor V. Kabanov, Christoph Gadermaier, N. D. Zhigadlo, S. Katrych, Z. Bukowski, J. Karpinski, Dragan Mihailović, "Photoinduced quasiparticle relaxation dynamics in near-optimally doped $SmFeAsO_{0.8}F_{0.2}$ single crystals", In: *Proceedings of the International Conference on FeAs High Tc Superconducting Multilayers and Related Phenomena (Superstripes2008), Rome, Italy, December 9-13, 2008*, (Journal of superconductivity and novel magnetism, vol. 22, no. 6, 2009), Antonio Bianconi, ed., Nicola Poccia, ed., Allesandro Ricci, ed., New York, Springer, vol. 22, no. 6, pp. 575-578, 2009.
17. Tomaž Mertelj, Viktor V. Kabanov, Christoph Gadermaier, N. D. Zhigadlo, S. Katrych, J. Karpinski, Dragan Mihailović, "Distinct pseudogap and quasiparticle relaxation dynamics in the superconducting state of nearly optimally doped $SmFeAsO_{0.8}F_{0.2}$ single crystals", *Phys. rev. lett.*, vol. 102, no. 11, pp. 117002-1-117002-4, 2009.
18. Tomaž Mertelj, Andrej Ošlak, Janez Dolinšek, I. R. Fisher, Viktor V. Kabanov, Dragan Mihailović, "Fine structure in the electronic density of states near the Fermi energy of Al-Ni-Co decagonal quasicrystal from ultrafast time-resolved optical reflectivity", *Phys. rev. lett.*, vol. 102, no. 8, pp. 086405-1-086405-4, 2009.
19. Tomaž Mertelj, Roman V. Yusupov, Anton Gradišek, Marco Filippi, W. Prellier, Dragan Mihailović, "Temperature and fluence dependence of ultrafast phase-separation dynamics in $Pr_{0.6}Ca_{0.4}MnO_3$ thin films", *Phys. rev., B, Condens. matter mater. phys.*, vol. 80, no. 22, pp. 224411-1-224411-6, 2009.
20. Tomaž Mertelj, Roman V. Yusupov, Anton Gradišek, Marco Filippi, W. Prellier, Dragan Mihailović, "Ultrafast photoinduced phase separation dynamics in $Pr_{0.6}Ca_{0.4}MnO_3$ thin films", *Europhys. lett.*, vol. 86, no. 5, pp. 57003-1-57003-6, 2009.
21. Dragan Mihailović, "Inorganic molecular wires: physical and functional properties of transition metal chalco-halide polymers", *Prog. Mater. Sci.*, vol. 54, no. 3, pp. 309-350, 2009.
22. Matija Milanič, Vojko Jazbinšek, D. F. Wang, J. Sinstra, R. S. MacLeod, Dana H. Brooks, Rok Hren, "Evaluation of approaches to solving

electrocardiographic imaging problem", *Comput. cardiol.*, vol. 36, pp. 177-180, 2009.
23. Matija Milanič, Boris Majaron, "Spectral filtering in pulsed photothermal temperature profiling of collagen tissue phantoms", *J. biomed. opt.*, vol. 14, no. 6, pp. 064024-1-064024-8, 2009.
24. Matija Milanič, Igor Serša, Boris Majaron, "A spectrally composite reconstruction approach for improved resolution of pulsed photothermal temperature profiling in water-based samples", *Phys. Med. Biol.*, vol. 54, no. 9, pp. 2829-2844, 2009.
25. Natan Osterman, Igor Poberaj, Jure Dobnikar, Daan Frenkel, Primož Ziherl, Dušan Babič, "Field-induced self-assembly of suspended colloidal membranes", *Phys. rev. lett.*, vol. 103, pp. 228301-1-228301-4, 2009.
26. Tadej Perhavec, Matjaž Lukač, Janez Diaci, Marko Marinček, "Heat deposition of erbium lasers in hard dental tissues", *J. oral laser appl.*, vol. 9, no. 4, pp. 205-212, 2009.
27. Andrej Petelin, Martin Čopič, "Observation of a soft mode of elastic instability in liquid crystal elastomers", *Phys. rev. lett.*, vol. 103, no. 7, pp. 077801-1-077801-4, 2009.
28. Maja Remškar, Marko Viršek, Aleš Mrzel, "The MoS_2 nanotube hybrids", *Appl. phys. lett.*, vol. 95, no. 13, pp. 133122-1-133122-3, 2009.
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31. Verner K. Thorsmølle, Jure Demšar, (10 authors), "Morphology effectively controls singlet-triplet exciton relaxation and charge transport in organic semiconductors", *Phys. rev. lett.*, vol. 102, no. 1, pp. 017401-1-017401-4, 2009.
32. Jelena M. Todorović, Dejan M. Đokić, Zorana D. Dohčević-Mitrović, Dragan Mihailović, Zoran V. Popović, "Investigation of thermostability of $Mo_6S_3I_6$ nanowires using Raman spectroscopy", In: *Zbornik Sedme konferencije mladih istraživača nauka i inženjerstvo novih materijala, Beograd, 22-24. decembar 2008*, (Hemijska industrija, vol. 63, no. 3, 2009), Beograd, Savez hemičara i tehnologa Jugoslavije, 2009, vol. 63, no. 3, pp. 217-220, 2009.
33. Andrej Tomeljak, Blaž Kavčič, H, Schäfer, Viktor V. Kabanov, Dragan Mihailović, D. Starešinić, K. Biljaković, Jure Demšar, "Femtosecond nonequilibrium dynamics in quasi-1D CDW systems $K_{0.3}MoO_3$ and $RB_{0.3}MoO_3$", In: *Proceedings of the International Workshop on Electronic Crystals on Strongly Correlated Electron Systems, 24-30 August 2008, Cargèse, France*, (Physica, B, Condensed matter, vol. 404, no. 3/4, 2009), Serguei Brazovskii, ed., Natacha Kirova, ed., Pierre Monceau, ed., Amsterdam, North-Holland, 2009, vol. 404, no. 3/4, pp. 548-551, 2009.
34. Andrej Tomeljak, H, Schäfer, D. Städter, M. Beyer, K. Biljaković, Jure Demšar, "Dynamics of photoinduced charge-density-wave to metal phase transition in $K_{0.3}MoO_3$", *Phys. rev. lett.*, vol. 102, no. 6, pp. 066404-1-066404-4, 2009.
35. Marko Uplaznik, Boštjan Berčič, Maja Remškar, Dragan Mihailović, "Quantum charge transport in $Mo_6S_3I_6$ molecular wire circuits", *Phys. rev., B, Condens. matter mater. phys.*, vol. 80, no. 8, pp. 085402-1-085402-6, 2009.

Published Conference Papers

Invited Papers

1. Viktor V. Kabanov, "Kinetics of hot electrons in metals and superconductors: theory and experiments", In: *Nanofizika i nanoeletronika. Tom 1*, XIII Meždunarodn'ij Simpozium, 16-20 marta 2009 g., Novgorod, Rossija, Nižnij Novgorod, Institut fiziki mikrostruktur ran, 2009, pp. 68-69.
2. Alessandro Lukan, Aleksander Zidanšek, "The possibilities to influence the global climate change", In: *CD proceedings*, 5th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, September 29 - October 3, 2009, Dubrovnik, Croatia, Zvonimir Guzović, ed., Neven Duić, ed., Marko Ban, ed., [S. l., s. n.], 2009, 14 pp.

Regular papers

1. Matija Milanič, Vojko Jazbinšek, Rok Hren, "Assessment of regularization techniques used in solving the ill-posed inverse problem of electrocardiography", In: *Zbornik Osemnajste mednarodne elektrotehniške in računalniške konference - ERK 2009, 21-23. september 2009, Portorož, Slovenija*, Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2009, pp. B: 347-350.
2. Matija Milanič, Boris Majaron, "Comparison of binning approaches for pulsed photothermal temperature profiling", In: *Novel optical instrumentation for biomedical applications IV: 14 June 2009, Munich, Germany*, (Proceedigs of SPIE, vol. 7371), Christian D. Depeursinge, ed., Bellingham, SPIE, 2009, pp. 737100-1-737100-8.

Textbooks and Lecture Notes

1. Martin Čopič, *Fizika II*, Ljubljana, Fakulteta za matematiko in fiziko, Oddelek za fiziko, 2007-.
2. Boris Majaron, J. Stuart Nelson, *Laser treatment of port wine stains*, Ljubljana, [samozal.], 2009.

Theses

Ph. D. Theses

1. Klemen Kunstelj, *Structural analysis of surface layers with non-linear optical techniques: doctoral thesis*, Ljubljana, [K. Kunstelj], 2009.
2. Natan Osterman, *Study of viscoelastic properties, interparticle potentials and self-ordering in soft matter with magneto-optical tweezers: doctoral thesis*, Ljubljana, [N. Osterman], 2009.
3. Andrej Tomeljak, *Nonequilibrium dynamics of charge and collective modes in charge density wave compounds: doctoral dissertation*, Ljubljana, [A. Tomeljak], 2009.

Patent

1. Aleš Mrzel, Maja Remškar, Marko Viršek, Adolf Jesih, *Postopek za sintezo kvazi enodimenzionalnih struktur dihalkogenidov in oksidov prehodnih kovin: patent SI22623*, Ljubljana, Urad RS za intelektualno lastnino, 30. apr. 2009.

Patent Application

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: patent application EP2132142 (A2)*, 16. 12. 2009.

DEPARTMENT OF REACTOR PHYSICS
F-8

During the past year we have been working mainly on:

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

Head:
Prof. Bogdan Glumac

Our research in **reactor physics** has been oriented mostly into 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 for the evaluation of older critical 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 the transport calculations, and on advanced nodal methods aimed at 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. 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. SiC specimens were studied together with the JSI's 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.

In the field of **plasma** physics the research was directed into several areas. We continued our 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 a 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 a fluid model. A kinetic model of a plasma diode in 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 a measurement of the electron temperature. Modelling of the entire current voltage characteristics of the emissive probe, taking into account also 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. In addition to R&D programme coordination within the Slovenian Fusion Association we have also organized two meetings of collaborators from the whole European fusion programme. In May, the public information officers from all the associations, EFDA and Commission met at the JSI. In the autumn we hosted the regular annual meeting of experts from the field of plasma-wall interaction research. In Ljubljana we set up a successful exposition on fusion energy development and gave several interviews for newspapers and radio. In a special, popular TV show we presented national and European endeavours to realize fusion energy production.

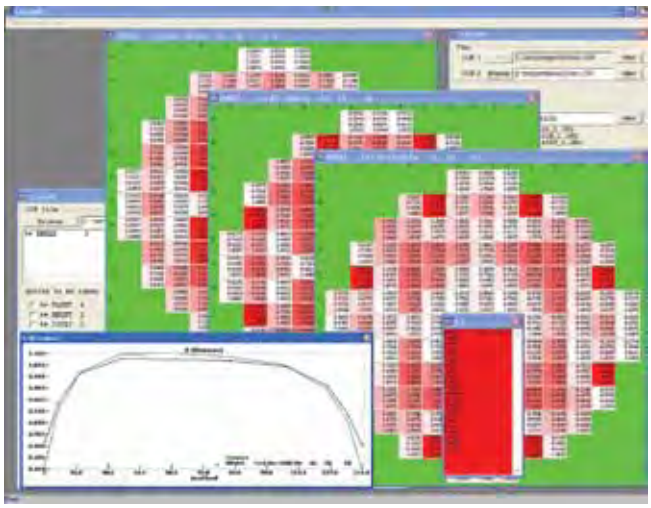

Figure 1: Comparison of two CORD-2 calculations for the Nuclear power plant Krško with the JSI program CORDSPW.

In the field of **neutron transport calculations** the collaboration with JET – Joint European Torus, the largest fusion reactor in the world, was continued. The work included estimation of effects, connected to the planned exchange of the first wall material with Beryllium and the divertor material with Tungsten. The focus was the influence of the mentioned changes on the neutron field inside the tokamak and on detector system response. During the last year special attention was given to the γ-ray and neutron camera, the KN-3, used for plasma profile monitoring during pulses. The Monte Carlo method was used for the calculations. In the case of the KN-3, the method has to be specially adjusted since the detectors are shielded by a concrete block with a thickness in excess of one meter. The result is a very low neutron flux, what makes the use of special, custom adjusted Monte Carlo technique, a necessity. These variance reduction techniques include source biasing, source generation and neutron weight adjustments. The work on the dependence of detectors on torus changes continued, as well. Sensitivity analyses of the response proved to be largely independent on changes in the torus. This includes also the change of some components in the vicinity of the detectors; neutrons were found to be subject to a larger number of scattering reactions prior to their detection. In parallel to the flux calculations the activation of the first wall was addressed and the most problematic nuclides defined. The calculations were compared to the irradiations on the TRIGA reactor, which resemble the conditions in the fusion reactor employing a DD plasma to a good degree.

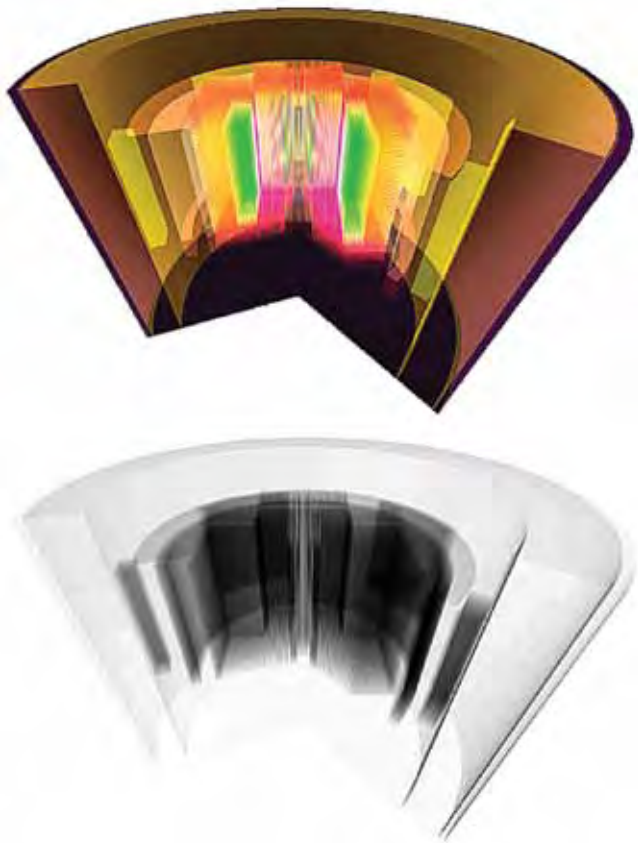

Figure 2: A three-dimensional cross-section of a detailed Monte Carlo computational model of the VENUS 2 MOX Core, represented in a quasi-transparent manner.

In the domain of **semiconductor physics** the short circuit current of a single-layer organic semiconductor solar cell has been interpreted on the basis of the observation that the exponentially decreasing light intensity within the organic semiconductor is uniquely related to the concentration of excitons within it. According to this view, the charge recombination within the organic is spatially non-uniform, leading to the spatial dependent trap density within it. The short circuit current represents the uncompensated charges, separated by the built-in potential, at most one exciton diffusion length away from the electrode. The model is applied to the hole-only single-layer poly(para-phenilene thienylene) organic solar cell ITO/LPPPT(59 nm)/Al published current-voltage data for which the spatial dependence of the internal potential, the resulting internal electric field, and the trap charge density were calculated. The closed solution for the drift-diffusion equation for unipolar charge carriers within the single layer organic semiconductor structure characterized by the bulk shallow single trap-charge energy level has been derived. The internal electric field and the total charge density are calculated for two examples of electric field boundary conditions using the measured current density-voltage data of the electron conducting aluminium/tris(8-hydroxyquinoline aluminium/calcium structure (W. Brütting, et al., Synthetic Metals 122, 99 (2001)) for which $j_{exp} \propto V_a^{3.4,}$ within the interval of bias $0.4\ V \leq V_a \leq 7$. It is found that the minimum value of the apparent electron mobility turns out to be proportional to the square root of the applied electric field, resulting in the bias independence of the spatial distribution of the organic bulk electric field as well as the total charge density. Depending on the suitable choice of boundary conditions, the spatial dependence of the total electron density may typically be represented by the U shape, which may, depending upon the parameters, peak at both or at either Alq3 boundary. The strong but finite accumulation of electrons close to the anode representing the inverted space charge limited current, SCLC, effect is consequently predicted for the first time.

Our research in the field of **medical physics** has been focused in three main areas: cancer treatment assessment with biomedical imaging, radiobiological studies on zebrafish and computer simulations of cancer growth and 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 tumours prior to and during antineoplastic therapies. We are performing experiments in small animals (mice) and large animals (dogs with spontaneous tumours). In addition, we are involved in several human clinical trials in patients with brain, head and neck, lung, oesophagus, and prostate tumours, 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 an accelerated start to a human clinical trial. In patients receiving radiotherapy, chemoradiotherapy and molecular targeted therapies we have observed a large heterogeneity and variability of pre-treatment biological substructures as well as the complex dynamics of the response. For radiobiological 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 radiobiological studies of localized irradiation, similar to the conditions met in external beam radiotherapy. In preliminary studies, comparing the total and partial body irradiation, following up apoptosis and inflammatory response, we observed that while the apoptosis is high in both cases, the inflammatory response is significant only during partial irradiation.

Some outstanding publications in 2009

1. S. Bowen, R. T. Flynn, S. Bentzen, Robert Jeraj, "On the sensitivity of IMRT dose optimization to the mathematical form of a biologcal imaging-based prescription function", Phys. Med. Biol., no. 6, vol. 54, str. 1483-1501, 2009.
2. Bruno Cvikl, "Single layer organic semiconductor solar cells", Journal of energy technology, str. 13-20, 2009.
3. U. Fischer, P. Batistoni, A. Klix, Ivan Aleksander Kodeli, R.L. Perel, "Neutronics R&D efforts in support of the european breeder blanket development programme", Nucl. fus., no. 6, vol. 49, str. 065009-1-065009-7, 2009.
4. Tomaž Gyergyek, Borut Jurčič-Zlobec, Milan Čerček, Jernej Kovačič, "Sheath structure in front of an electron emitting electrode immersed in a two-electron temperature plasma : a fluid model and numerical solutions of the Poisson equation", Plasma sources sci. technol., vol. 18, no. 3, str. 035001-1-035001-18, 2009.
5. Ivan Aleksander Kodeli, Andrej Trkov, R. Capote, Y. Nagaya, Vladimir Maslov, "Evaluation and use of the prompt fission neutron sprectrum and spectra covariance matrices in criticality and shielding", Nucl. instrum, methods phys res., Sect. A, Accel., issue 2, vol.610, str. 540-552, 2009.
6. Jernej Kovačič, Tomaž Gyergyek, Milan Čerček, "Pre-sheath formation in an oblique magnetic field : fluid model and PIC simulation", The European physical journal. D, Atomic, molecular and optical physics, vol. 54, no. 2, str. 383-389, Aug. 2009.

Awards and appointments

1. prof. Bogdan Glumac: Gold emblem of the Nova Gorica University, Zemono Castle, Vipava, received on October 22, 2009 for an important contribution of an archive of scientific literature for Nova Gorica University Library.
2. dr. Luka Snoj: Best poster award, Saratoga Springs, NY, USA, May 2009, Program committee of the "International Conference on Mathematics, Computational Methods and Reactor Physics (M&C 2009)", poster "MCNP and Visualization of Neutron Flux and Power Distributions"

Organization of conferences, congress and meetings

1. Joint Annual Meeting of the Special Expert Groups (SEWG): "SEWG High-Z" and "SEWG Transient Heat Loads", organized by Slovenian Fusion Association, Nuclear Training Centre Milan Čopič, Brinje, Dol near Ljubljana, Slovenia, 1. 10. – 2. 10. 2009 (23 participants)

INTERNATIONAL PROJECTS

1. Accurate Nuclear Data for Nuclear Energy Sustainability
   7. FP – EURATOM
   249671
   EC; Dr. Enrique Miguel Gonzalez Romero, Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas-CIEMAT, Madrid, Spain
   Asst. Prof. Andrej Trkov
2. Upgrade of Gamma-Ray Cameras: Neutron Attenuators - J1/b - 2.2.1. FU
   EURATOM – MHEST
   7. FP, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065, JW6-TA-EP2-GRC-02, JW8-NEP-MHST-02, JW9-NEP-MHST-02
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Igor Lengar
3. Development of Composites with Advanced/Alternative Manufacturing Concepts - 4.1.1.2 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
   Prof. Matjaž Ravnik, Asst. Prof. Saša Novak Krmpotič
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
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Andrej Trkov
5. 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
   Asst. Prof. Igor Lengar
6. 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
   Prof. Milan Čerček, Dr. Iztok Čadež
7. 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
8. 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
Asst. Prof. Igor Lengar, Melita Lenošek, B. Sc., Sabina Markelj, B. Sc., Asst. Prof. Saša Novak Krmpotič, Štefan Kolenko
9. F4E - Nuclear Data, Studies/Experiments in Support of TBM Activities (NUDATA_Exper), Task 5
F4E-2008-GRT-014-02 (ES-AC)
Fusion for Energy, The European Joint Undertaking for ITER and the Development of Fusion Energy, Barcelona, Spain; Paola Bastioni, Enter per le Nuove Technologie, l´Energia e l´Ambiente - ENEA, Rome, Italy
Dr. Ivan Aleksander Kodeli
10. F4E - Improvement of Nuclear Data, Development of Tools and Experiments/Validation in Support of ITER Activities (NUDATA_Files) - A1/T7 - 1.1. FU
F4E-2008-GRT-014-01 (ES-AC)
Fusion for Energy, The European Joint Undertaking for ITER and the Development of Fusion Energy, Barcelona, Spain; Dr. Jean-Christophe Sublet, United Kingdom Atomic Energy Authority (UKAEA), Oxfordshire, Great Britain
Asst. Prof. Andrej Trkov
11. Evaluation and Validation of Promt Fission Neutron Spectra and the Corresponding Covariance Matrices
15794/R0
Teresa Ann Benson, IAEA - International Atomic Energy Agency, Vienna, Austria
Dr. Ivan Aleksander Kodeli
12. Improvement of Evaluated Nuclear Data Files with Emphasis on Activation and Dosimetry Reactions
14914/R0, R1
Teresa Ann Benson, IAEA - International Atomic Energy Agency, Vienna, Austria
Asst. Prof. Andrej Trkov
13. Investigation of Boundary Plasmas and Development of Diagnostic Methods with Emissive Probes Reactions
BI-AT/09-10-013
Dr. Cordina Ioniță-Schrittwieser, Institute for Ion Physics and Applied Physics, Leopold-Franzens-University of Innsbruck, Innsbruck, Austria
Prof. Milan Čerček

R & D GRANTS AND CONTRACTS

1. PET with a novel photon detector
Prof. Peter Križan, Asst. Prof. Robert Jeraj
2. Concrete construction properties and water seeping through concrete structures
Asst. Prof. Andrej Trkov, Asst. Prof. Igor Lengar
3. Development of diagnostics for certain parameters of the edge plasma in fusion devices
Asst. Prof. Andrej Trkov, Prof. Milan Čerček
4. A study of plasma parameters for conditioning of the inner surfaces of a fusion reactor
Asst. Prof. Miran Mozetič, Prof. Milan Čerček

RESEARCH PROGRAM

1. Reactor physics
Asst. Prof. Andrej Trkov, Prof. Matjaž Ravnik

NEW CONTRACTS

1. NEK spent fuel container loading scheme optimization regarding maximum permissible power
Arao
Prof. Matjaž Ravnik, Prof. Bogdan Glumac
2. Reload operational care analysis, post refueling nuclear design check tests, PIS and KFSS cycle specific data for future fuel cycles
Krško Nuclear Power Plant
Prof. Matjaž Ravnik, dr. Marjan Kromar

VISITORS FROM ABROAD

1. Dr. Codrina Ionita Schrittwieser and prof. Roman Schrittwieser, Institute for Ion Physics, University of Innsbruck, Austria, 8. 2. – 21. 2. 2009
2. Members of the YGN (Young Generation Network) SNUS (Slovenská nukleárna spoločnosť), 12. 3. – 14. 3. 2009
3. Dr. Christophe Destouche, Project Coordinator, CEA, Cadarache, France, 8. 5. 2009
4. Dr. Jérôme Paméla, EFDA Leader, Garching / Munich, Germany, 14. 9. – 17. 9. 2009
5. Lori Scott, Idaho National Laboratory, OECD and DOE, Idaho, USA, 12. 10. – 14. 10. 2009
6. Dr. Codrina Ionita Schrittwieser and prof. Roman Schrittwieser, Institute for Ion Physics, University of Innsbruck, Austria, 29. 10. – 7. 11. 2009

STAFF

Researchers
1. Prof. Bruno Cvikl*
2. Prof. Milan Čerček
3. **Prof. Bogdan Glumac, Head**
4. Asst. Prof. Tomaž Gyergyek*
5. Asst. Prof. Robert Jeraj
6. Dr. Ivan Aleksander Kodeli
7. Dr. Marjan Kromar
8. Dr. Igor Lengar
9. *Prof. Matjaž Ravnik, died 08.10.09*
10. Asst. Prof. Andrej Trkov
11. Asst. Prof. Tomaž Žagar*

Postdoctoral associates
12. Dr. Luka Snoj

Postgraduates
13. Vladimir Radulović, B. Sc.
14. *Petra Rogan, B. Sc., left 01.11.09*
15. Urban Simončič, B. Sc.
16. Gašper Žerovnik, B. Sc.

Technical officers
17. Alberto Milocco, M. Sc.

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18. Dušan Rudman
19. Slavko Slavič, B. Sc.
20. Darinka Stich
21. Uršula Turšič, B. Sc.
22. Bojan Žefran

Note:
* part-time JSI member

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B. Sc. Thesis

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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 and at KEK in Tsukuba. The department is also engaged in developing and applying the technologically advanced particle detectors that are demanded by such measurements. Astroparticle physics is an emerging field, applying the experimental techniques of particle physics to solve astrophysical problems. Slovenian researchers are participating in measurements of ultra-high-energy cosmic rays with the Pierre Auger observatory spread over a surface of 3000 km² near Malargue in Argentina.

Head:
Prof. Marko Mikuž

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

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

- ATLAS at the Large Hadron Collider (LHC) at CERN (2900 researchers, 172 institutions from 37 countries),
- Belle at the asymmetric electron-positron collider (KEK-B) at KEK (409 researchers, 62 institutions from 15 countries)

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

A more detailed report on 2009's activities follows, focused on the contributions of our researchers:

ATLAS experiment

The year 2009 was the turning point for the ATLAS collaboration, as the LHC accelerator began its successful operation. The LHC circulated its first beams on 10 September 2008, but suffered a serious malfunction nine days later. A failure in an electrical connection led to serious damage, and CERN spent over a year repairing and consolidating the machine to ensure that such an incident cannot happen again. Re-commissioning the LHC began in the summer of 2009, and successive milestones have been regularly passed since then. Particles were injected on 23 October, but not circulated. On Monday 23 November, two beams circulated together for the first time, and the four big LHC detectors recorded their first collision data. Both LHC beams were accelerated to 1.18 TeV on 30 November. This is the highest energy ever achieved in accelerators. We are confident of achieving proton energies of 3.5 TeV in 2010, with good prospects of boosting them to 5 TeV.

In the period before the start of the accelerator we commissioned the ATLAS spectrometer. The work of our group was concentrated on the Beam Conditions Monitor (BCM), designed and built to warn of a possible beam loss and to prevent damage to the detector. Diamond detectors record the passage of charged particles with a time resolution a few nanoseconds, which enables the separation of events due to collisions of individual bunches and

Figure 1: Researchers in the ATLAS control room expecting the first collisions detected with the ATLAS spectrometer.

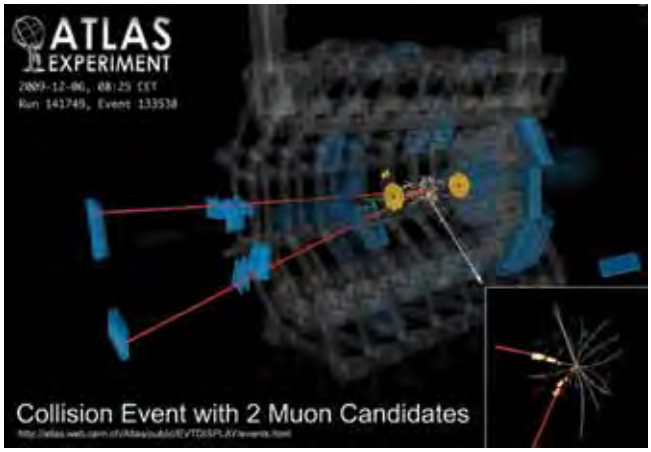

Figure 2: The display of an event with two reconstructed muons in the forward region. The proton energy in the collisions was 450 GeV.

- **The first collisions of protons in the LHC collider were observed in the ATLAS spectrometer on 23 November 2009. By the end of the year, the energy of protons was raised to 1.18 TeV. This is the highest energy achived in the accelators.**
- **Slovenia applied for full CERN membership in 2009 and will soon join the 20 CERN member states. Cern was established in 1954.**

the unwanted background. We completed the logic circuit (FPGA), which indicates the danger of a beam loss and records the luminosity of individual, colliding bunches of protons. The performance was first tested with cosmic rays in July. During the accelerator's operation in November and December, the BCM was finally commissioned and proved to be able to detect the potentially dangerous beam losses in the detector and abort the LHC beam. The other parts of the ATLAS spectrometer have also been successfully tested, which ensures that we will measure interesting physics events in 2010.

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. It will be impossible to store and process the data within a single computing centre. The network infrastructure is, as a result, an additional bottleneck. One cannot expect such a quantity of data to be sent over the internet more than once: from CERN, where the experiment will take place, to 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 the ATLAS collaboration. The use of Grid technology is the only solution, facilitating a rapid 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 the processing it is mandatory to also use Grid technologies for the data processing, since none of the research centres has enough storage and computing capacity.

Tier-2 SiGNET is a member of the EGEE-III and Nordugrid international grid projects. The cluster of 600 cores and 300TB of storage will double the capacity at the beginning of 2010. SiGNET was participating in the production and reconstruction of the data taken with the ATLAS detector at the LHC, making a significant contribution to the production among the 200 computing centres. We have actively participated in the development, testing and deployment of the ARC middleware. In collaboration with Arnes, the Slovenian NGI joined the computing centres within the European EGI initiative.

Belle experiment

One of the important unsolved questions of contemporary science is why we live in a universe in which matter (particles) completely dominates over antimatter (antiparticles). A necessary condition for this is the violation of CP symmetry, which can be measured in the world of subatomic particles. It corresponds to a small difference between the decays of particles and their anti-particles. The main purpose of the Belle detector operating at the electron-positron collider KEKB in Tsukuba, Japan, is to measure the CP violation in the system of B mesons, particles composed of heavy beauty quarks. After more than a decade of data acquisition the scientists in the Belle collaboration have experimentally confirmed the difference in the behaviour of particles and antiparticles with an unprecedented precision. The extent of the CP violation in the subatomic world, however, is not large enough to explain the large matter-antimatter asymmetry of the Universe. There must exist yet unobserved particles and processes, not included in the current theoretical explanation, that are responsible for the asymmetry. While no definite measurement of such processes exists so far, there are some measured hints of discrepancies with predictions of theoretical models. One of such hints emerged in 2009, when Belle scientists measured the angular distribution of the electron and positron in the decay of a B meson into a kaon, electron and positron. The measured data seems to be more in agreement with predictions incorporating yet unobserved supersymmetric particles than with the predictions of the Standard model of interactions among elementary particles (Fig. 3). In order to verify this and other hints of so far unknown physics processes, scientists from the Jožef Stefan Institute collaborate in the upgrade of the Belle detector, Belle II, using cutting-edge technologies to further improve the performance of the detector and the precision of the measurements. The Belle II detector is scheduled to start operating in 2013.

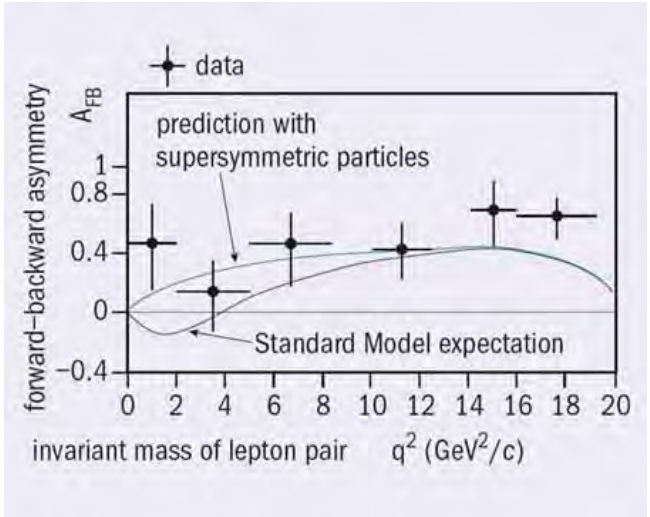

Figure 3: Measured asymmetry in the angular distribution of the electrons and positrons emerging in the decay of a B meson into a kaon, electron and a positron. The agreement with the Standard Model prediction is not good, but data from the future Belle II detector will enable significantly more precise measurements. Adopted from J.-T. Wei et al. (Belle), Phys. Rev. Lett. 103, 171801 (2009).

Pierre Auger observatory

The Pierre Auger collaboration has constructed a huge high-energy cosmic-ray observatory in Argentina covering more than 3000 km^2. The Auger Observatory is a "hybrid detector", employing two independent methods to detect high-energy cosmic rays. One technique detects high-energy particles through their interaction with water in more than 1600 Čerenkov detectors placed in a so-called Ground array. The other tracks the development of air shower s by detecting the ultraviolet light emitted high in Earth´s atmosphere. The observatory, originally sensitive to cosmic rays with energies above 10^{19} eV, was recently upgraded with the HEAT (High Elevation Auger Telescope), which extends the sensitivity to lower energies. The main physics results in 2009 are a confirmation of the correlation of the highest-energy cosmic rays with nearby active galactic nuclei and the suppression of the flux of cosmic rays above 10^{19} eV. An analysis of the cosmic-ray photon fraction and the diffuse flux of ultra-high-energy tau neutrinos was also published in 2009. Our group is involved in data analysis, the LIDAR system operation, the development of an offline data analysis package and the detectors' simulation and calibration.

Figure 4: Čerenkov detectors placed in the so-called Ground array. More than 1600 such detectors measure high-energy particles through their interaction with water

Detector development

In collaboration with CERN, University of Valencia, University of Michigan, Ann Arbor and Ohio State University we have continued 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 was continued in the framework of "MADEIRA", a 7th FP EU project. We developed the technology for the production of multilayer flexible circuits with a small spacing between the lines (100 microns) in cooperation with the company ELGOLINE Podskrajnik. This will allow a more compact layout of the detectors, thereby improving the spatial resolution.

Based on a successful measurement with the silicon photomultiplier detector module, we created a new type of apparatus for positron tomography (PET) and measured its energy and time resolution. Such a counter is an extremely interesting candidate for dual-modality medical imaging, where a PET apparatus is embedded in a MRI imager, and the light sensors have to operate in magnetic fields exceeding 2 T. This research is a part of a FP7 research project aimed at the development of novel detection methods for particle physics and medical imaging. In preparation for the next generation of measurements of rare phenomena in B meson decays with the Belle II spectrometer, we continued the study of sensors for two ring imaging Cherenkov detectors. In collaboration with leading producers in this area, Hamamatsu (Japan) and Photonis (France), we studied the characteristics of photomultiplier tubes with micro-channel plates and hybrid photon detectors with avalanche photodiodes as the photoelectron detectors.

We continued with the development of silicon detectors operating in high radiation fields. We irradiated the detectors at the Reactor Centre Podgorica to high neutron doses (10^{16} cm^{-2}), and measured the multiplication of free charge carriers near the electrodes. This phenomenon will allow the successful use of Si detectors in the upgrade of ATLAS spectrometer.

- **In more than a decade of data acquisition the scientists in the Belle collaboration have experimentally confirmed the difference in the behaviour of particles and antiparticles with an unprecedented precision.**
- **The Pierre Auger Observatory confirmed the correlation of the highest-energy cosmic rays with nerby active galactic nuclei and the suppresion of the flux of cosmic rays above 10^{19} eV**
- **Multiplication of the free charge carriers near the electrodes discovered after irradiations with neutrons will allow the successful use of Si detectors in the upgrade of the ATLAS spectrometer.**

Figure 5: Assembly of the detector module using BGA (Ball Grid Array) technology

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. Ilija Bizjak: Golden Emblen of Jozef Stefan for 2009, Ljubljana, Jožef Stefan Institute, Award for excellence of the doctoral thesis in the field of science: "Measurement of /Vub / Using Inclusive Semileptonic Decays on a Sample of Reconstructed B mesons with the Belle Detector".

Organization of conferences, congress and meetings

1. Workshop 7. OP MADEIRA, Jožef Stefan Institute, meeting room F-9, 5. 5. – 6. 5. 2009

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, Geneve, 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, Geneve, 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
   Prof. Marko Mikuž, Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc.
7. 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
   Prof. Marko Mikuž, Asst. Prof. Dunja Mladenič, Marko Grobelnik, Mitja Jermol, M. Sc.
8. Safe Production and Use of Nanomaterials
   NANOSAFE2
   6. FP, NMP2-CT-2005-515843
   EC; Commissariat a l` Energie Atomique, Grenoble, France
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13. Collaboration CERN RD-42
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14. Collaboration CERN RD-50
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    Prof. Marko Mikuž
15. Collaborations Belle in Belle II
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    Prof. Peter Križan
16. Collaboration CIMA
    Cameras for Imaging in Medical Applications
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17. Study of Top Events produced at the LHC for the Commissioning of the ATLAS Detector
    BI-IT/05-08-003
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    Asst. Prof. Borut Paul Kerševan
18. Development of New Detectors for PET Imaging
    BI-US/09-12-042
    Prof. Neal Clinthorne, University of Michigan, Dept. of Radiology, Ann Arbor, MI, USA
    Prof. Marko Mikuž

R &D GRANTS AND CONTRACTS

1. Construction of test beam telescope
   Dr. Andrej Gorišek
2. Research of mixing and symmetry braking in D^0 mesons
   Prof. Marko Starič
3. A combined method for particle detification
   Prof. Samo Korpar
4. Gridification of data analysis in particle physics: pilot project of Slovenian Grid Initiative
   Prof. Marko Mikuž
5. Development of high-resolution PET probe
   Dr. Dejan Žontar
6. Development and implementation of tools for the physics research with the ATLAS detector in the grid environment
   Prof. Borut Paul Kerševan
7. Verification of radioactive sources positioning during brachytherapy
   Dr. Gregor Kramberger
8. Optimizing of direct drive system for electric two-wheel vehicles
   Andrej Detela
9. Unknown manuscripts of Slovenian literature of the 17th and 18th century: IT supported register, original research presentations and analysis
   Jan Jona Javoršek
10. Slovene terminology web portal
    Jan Jona Javoršek
11. Positron emission tomography with a novel photodetector
    Prof. Peter Križan

RESEARCH PROGRAMS

1. Astroparticle physics
   Asst. Prof. Marko Zavrtanik
2. Experimetnal particle physics
   Prof. Marko Mikuž

NEW CONTRACTS

1. Co-financing L2-9212-0106-06: Verification of radioactive sources positioning during brachytherapy
   Elgoline, d. o. o.
   Dr. Gregor Kramberger
2. Development of an innovative numerical simulation environment by incorporating hybrid parallelization processes based on discontinuous Galerkin methods
   Arctur, d. o. o.
   Prof. Andrej Filipčič

VISITORS FROM ABROAD

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2. dr. Vladimir Khomenkov, University of Hamburg, Germany, 2. 2. – 14. 2. 2009
3. dr. Luciano Bosisio, INFN, Trieste, Italy, 3. 9. 2009

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Original Articles

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2. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (601 authors), "Evidence for a narrow near-threshold structure in the $J/\psi\phi$ mass spectrum in $B^+ \to J/\psi\phi K^+$ decays", *Phys. rev. lett.*, vol. 102, no. 24, pp. 242002-1-242002-7, 2009.
3. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (599 authors), "First direct bound on the total width of the top quark in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 102, no. 4, pp. 042001-1-042001-7, 2009.
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31. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (598 authors), "Search for charged higgs bosons in decays of top quarks in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV", *Phys. rev. lett.*, vol. 103, no. 10, pp. 101803-1-101803-7, 2009.
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39. The CDF Collaboration: T. Aaltonen, Ilija Bizjak, (622 authors), "Search for maximal flavor violating scalars in same-charge lepton pairs in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV", *Phys. rev. lett.*, vol. 102, no. 4, pp. 041801-1-04180-7, 2009.
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45. Dejan Žontar, Vojko Kanič, Dimitrij Kuhelj, Damijan Škrk, Urban Zdešar, "Patient exposure from interventional cardiology procedures in Slovenia", In: *World Congress on Medical Physics and Biomedical Engineering, 7-12 September, 2009, Munich, Germany*, (IFMBE proceedings, vol. 25), Heidelberg, Springer, 2009, pp. 386-389.

TEXTBOOKS AND LECTURE NOTES

1. Aleš Stanovnik, *Fizika I, Zapiski predavanj*, 5. izd., Ljubljana, Založba FE in FRI, 2009.

THESES

Ph. D. Thesis

1. Anže Zupanc, *Measurement of D^0 mixing in $D^0 \to \psi K^0_S$ decays: doctoral thesis*, Ljubljana, [A. Zupanc], 2009.

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 the synthesis of new inorganic compounds containing fluorine. The main research fields are: the synthesis of new coordination compounds with different ligands, the chemistry of noble gases, the chemistry of elements of the main groups and the synthesis of new, inorganic materials with special properties. A great deal of the activity of the group has been devoted to technological and ecological problems in Slovenia. For more than thirty years the group has been closely cooperating with Slovenian industry. The group is also active in the field of education 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 $[Cd(XeF_2)(HF)_2](TaF_6)_2$ should be mentioned. It represents the first example of a compound in which the metal centre is simultaneously coordinated with XeF_2 and HF molecules as ligands. This is especially interesting because the HF molecule is a much weaker ligand than XeF_2. The coordination sphere around the Cd^{2+} cation consists of eight fluorine atoms, five from two crystallographically distinct TaF_6^- anions, two from the HF ligands and one from the XeF_2 ligand. In the structure there are two types of hydrogen bonds involving the coordinated HF ligands. One HF ligand bridges a Cd^{2+} cation on one chain and a TaF_6^- anion on another chain; the other HF ligand bridges the Cd^{2+} cation and XeF_2 ligand on a third chain. This represents the first example of an H-bond between HF and XeF_2. A coordinated XeF_2 molecule is normally distorted, with the terminal Xe-F bond shorter than the coordinated one. In this case, however, both Xe-F bonds are the same length due to the strong Xe-F····H-F H-bond with a F····F distance of 2.54(1) Å.

The compound $[Cd(XeF_2)(HF)_2](TaF_6)_2$ represents the first example in which the metal centre is simultaneously coordinated by HF and XeF_2 molecules. For the first time, hydrogen bonding between XeF_2 and HF was crystallographically observed.

The research into 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 the magnesium atoms (by *cis* and *trans* F bridges), forming the layers along the *b* axis. The efforts to synthesize the coordination compound with only XeF_4 as a ligand were not successful up to now. XeF_2 is a much better ligand than XeF_4, which means that it will always replace XeF_4, even in the cases when it is present only in traces. Therefore, it would be wise to continue research in the direction to prepare the coordination compound that would contain only pure XeF_4 as a ligand. This work was published in Angew. Chem. Int. Ed.

The compounds where HF is acting as a ligand or where HF forms with F^- anion (poly)-hydrogen-fluoride anions of the type $H_xF_{x+1}^-$ should also be mentioned here. In 2009 a review paper dealing with these compounds was published in the Journal of Fluorine Chemistry.

Last year the first known compounds with mixed anions (BF_4^-, PF_6^- and AsF_6^-) were synthesized and their structures determined: $Ba(BF_4)(PF_6)$ and $Ba_2(AsF_6)(BF_4)_2(H_3F_4)$. This type of compounds is interesting because a whole series of different AF_6^- anions (A = Sb, Bi, Nb, Ta, Ru, Au etc.) could be applied. This year the research was continued. The whole series of compounds of the type $Ba(BF_4)(AF_6)$, where A=V, Ru, Sb, Nb, Ta, Bi, was isolated and structurally characterized. All the mentioned compounds crystallize in the orthorombic

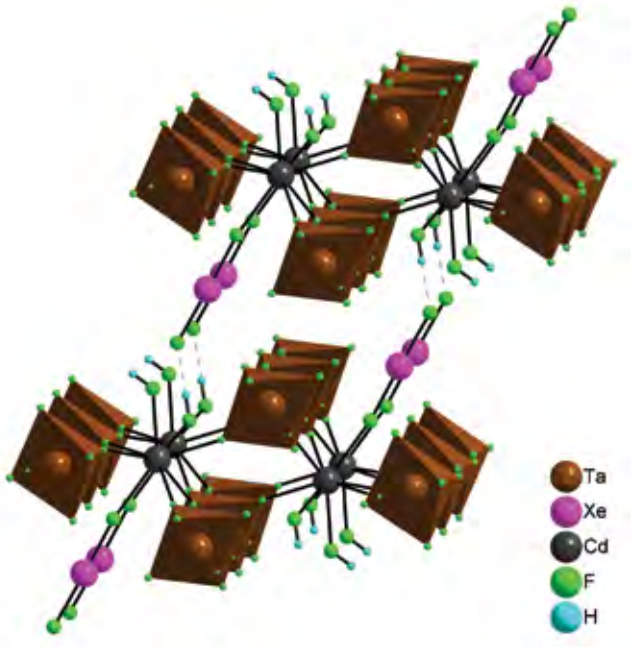

Figure 1: Double chains in the crystal structure of the $[Cd(HF)_2(XeF_2)](TaF_6)_2$ are held together for the first time by crystallographically observed XeF_2···HF hydrogen bonds.

We have demonstrated that aluminium fluoride with a very high surface area contains an amorphous phase and nanocrystalline phases of α-AlF_3 and β-AlF_3.

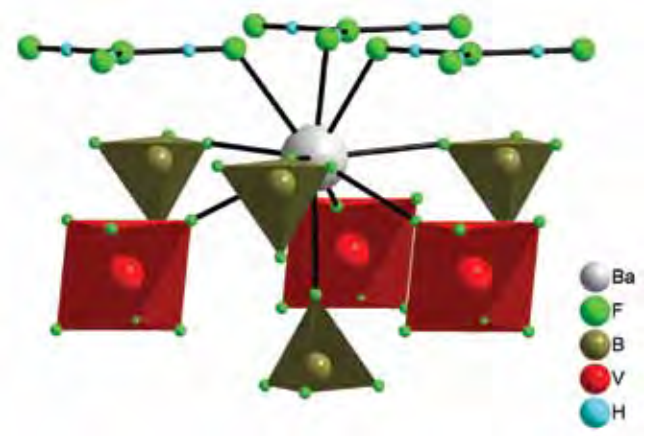

Figure 2: The coordination sphere of barium in the $Ba_2(BF_4)_2(VF_6)(H_3F_4)$ consists of three fluorine atoms from $H_3F_4^-$ and VF_6^- each and four fluorine atoms from BF_4^-.

space group and have a structure similar to the structure of the compound $Ba(BF_4)(AsF_6)$. The AF_6^- anion is bound to five barium atoms in V and Ru derivatives, whereas in the Sb, Nb, Ta, Bi analogues the AF_6 moiety is connected to six metal centres. The compound $Ba_2(BF_4)_2(VF_6)(H_3F_4)$ is isostructural with the compound $Ba_2(BF_4)_2(AsF_6)(H_3F_4)$. The increasing of the ionic radius of A precludes the formation of other $Ba_2(BF_4)_2(AF_6)(H_3F_4)$ analogues.

The possibility of the preparation of the so far unknown $[Ti_2F_9]^-$ anion has been investigated. In, this case two Ti atoms would be connected *via* three bridging fluorine atoms and the coordination of each Ti completed by three terminal fluorine atoms. In this way the C.N. of each Ti in the $[Ti_2F_9]^-$ anion would be equal to six. In the scope of this research, we checked whether the increase in the size of monocations (A^+) really favour the formation of $[Ti_2F_9]^-$ over $[Ti_4F_{18}]^{2-}$ salts, as proposed in the literature. The crystal-structure determination of the $[Me_4N]^+$ and $[Ph_4P]^+$ salts showed that both compounds are $[Ti_4F_{18}]^{2-}$ salts, i.e., $[Me_4N]_2[Ti_4F_{18}]$ and $[Ph_4P]_2[Ti_4F_{18}]$ were obtained instead of $[Me_4N][Ti_2F_9]$ and $[Ph_4P][Ti_2F_9]$. The product of the reaction of CsF with $2TiF_4$ could be formulated as $CsTi_2F_9$, however, instead of isolated $[Ti_2F_9]^-$ anions, infinite $([Ti_2F_9]^-)n$ double chains are present. In the case of $H_3OTi_2F_9$ a similar result was obtained.

In 2009 we performed some experiments in order to get copper(I) π-complexes built up as three-dimensional networks. The first known copper(I) hydrosulfate π-complex has been obtained. Within these investigations, an interesting in-situ izomerization of 1-allylbenzotriazole to 2- allylbenzotriazole has been observed.

Together with foreign researchers we, studied the surface fluorination of $Li_{4/3}Ti_{5/3}O_4$ (Aichi Institute of Technology, Nagoya, Japan), the preparation and characterization of ternary Ag(II) fluorides (University of Warsaw) and the selective fluorination of fullerenes (Colorado State University).

In cooperation with the Department O-2, a promising technology is under development for the removal of Hg^0 in wet FGD installations. Previously, it was anticipated that FGD installations were not capable of oxidising Hg^0 to soluble species by means of the air, but only with the use of costly chemicals that are non-selectively consumed for SO_2 conversion to sulphate.

In cooperation with the Department of Solid State Physics (F-5) the research of ferroelectric and ferromagnetic ternary metal fluorides was continued. This year the research was extended to the systems CuF_2-FeF_3-KF, CrF_3-FeF_2-KF and NiF_2-FeF_3-KF. The contribution of our department was mainly during the preparation and structural characterization of these new compounds. This research is very promising and we will continue with it.

In cooperation with the Electronic Ceramics Department (K-5) the structures of aluminium and chromium fluorides with unusually high specific surface areas were investigated with HRTEM. For aluminium fluoride it was determined that the compound consists of an amorphous phase and nanocrystalline AlF_3 phases, among them the α-AlF_3 in β-AlF_3 nanostructures with dimensions of 3-10 nm were identified. In contrast to aluminium fluoride, chromium fluoride with very high surface area is completely amorphous and very unstable. However, due to the rapid beam-induced crystallization a more detailed investigation of this material was not possible.

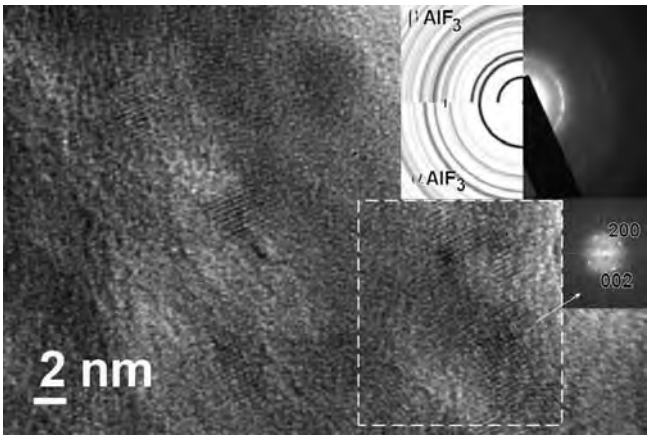

Figure 3: HRTEM of aluminium fluoride obtained by oxidative decomposition of hydrazinium fluoroaluminate with fluorine. Within the amorphous phase 3-nm crystallites of α-AlF_3 in β-AlF_3 can be observed.

By the reaction of gaseous fluorocarbons and hydrogen gas in a low-temperature radio-frequency plasma the plasma polymers in the shape of thin films 20–1000 nm thick were synthesized. The polymer films were hydrophobic, and the contact angle varied according to the composition of the plasma gases from 98 to 105 degrees.

In the past year the heat capacities and standard entropies of the corresponding potassium and ammonium ion species were investigated. Next to the relative packing efficiency in hydrates, also the influence of the power of *z* (charge of the species) on the estimation of the entropies of the formation of aqueous anions using simple parameters was studied.

Research into the possible sources that may significantly contribute to the intake of fluorine into the human organism was begun.

The majority of the partners from the first period of operation of the Center of Excellence (CE) for Environmental Technologies have been preparing the programme outline for the next period. International expertise in environmental sciences (Department O-2) and the technological expertise of our group in the purification of waste gases have been connected to develop

an understanding the speciation and the emission of mercury from power plants; the aim of the work was to propose measures for the reduction of emissions. The proposal for a new call for a CE was submitted, but the outcome was unsuccessful.

Contacts have been made with the research group of US EPA (Triangle Research Park, N.C.) in the field of the development of the technology for mercury removal from flue gases under conditions of the wet FGD process, by means of air oxidation. Applied research projects started in the field of biomass transformation into pure fuels and the optimisation of the management of PCB polluted soil storage.

In cooperation with the engineering firm Esotech d.d. the work on the technological development for the FGD installation on the planned block VI (600 MW power) of the Šoštanj thermal power plant continued, including the development of the technology for the production of boiler feed water using membrane techniques.

In the field of environmental and social impact assessments two co-workers from the department joined the EU FP7 project Civitas Elan in the roll of evaluators of five (of a total of sixteen) measures under implementation in Ljubljana (and in the partner cities of Gent, Porto, Brno and Zagreb). The aim of the measures is to improve the quality and safety of public and private users' mobility. A special emphasis is given to a cost–benefit analysis of the measures, which is carried out thoroughly with regard to three of the five measures.

Related to the fields of process safety (industrial risks) and the reliability of processes/equipments we have been engaged in consultations with local industry and the competent national authorities. For Geoplin plinovodi d.o.o., we elaborated a reliability analysis of the pressure regulation installation for the natural-gas transmission network. With Nafta Petrochem d.o.o. we prepared an assessment of damage distances for major accidents for the planned formaldehyde industrial production plant to be used in a formal licensing procedure. With Istrabenz plini d.o.o. we continued consultation services related to the implementation and performance of a safety management system (in the context of the EU directive 96/82/EC, or Seveso II). In addition, we were engaged by the Ministry for the Environment and Spatial Planning of the Republic of Slovenia in a further update of the expert review of process safety aspects for the project documentation for two planned LNG terminals in the Gulf of Trieste, Italy. In the EU FP7 project "Integ-Risk" we started our work on key performance indicators for a mutual consideration of the process safety-risk assessment and the spatial planning process.

Figure 4: Laboratory device for waste-gases desulphurization. The reconstructed device will allow the optimisation of the desulphurization process. It will also be used for the laboratory research of mercury removal from waste gases.

We continued with the activities of the School of Experimental Chemistry, both in the school laboratory as well as by visits to schools and kindergartens. Experimental work is complemented by visits to several departments of the JSI, which contribute to the broader promotion of scientific activities taking place at the institute. Among the additional school activities we should mention co-mentoring of the pupils that take part in competitions organized by the Association for Technical Culture of Slovenia (ZOTKS). One participant received a Silver Award and the other participant received a Gold Award. We are also included in the EU FP7 project "KidsINNscience), which is closely related to education and represents a continuation of a previous project "Form-it". The main objective of the "KidsINNscience" project is the development and field testing of innovative practices for teaching science in schools.

We participated at the 15th Slovenian Science Festival in Ljubljana, organized by the Slovenian Science Foundation and at the 2nd Science Festival organized by the Center for Youth Culture. We were again invited to the 2009 International Science Festival in Genova, Italy.

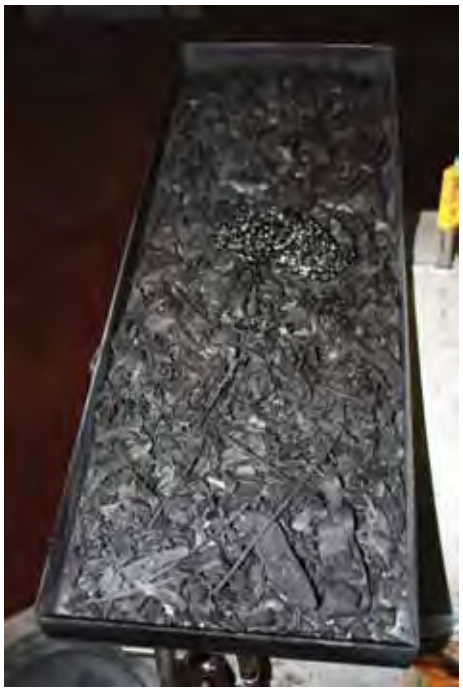

Figure 5: The picture shows the carbon-rich residue after wooden biomass pyrolysis, which enables the production of pure fuels for different purposes, including applications in fuel cells.

Some outstanding publications in 2009

1. Tavčar G., Žemva B., XeF_4 as a ligand for a metal ion, Angew. Chem., 48 (2009), 1432-1434.
2. Mazej Z., Goreshnik E. A., Poly[perfluorotitanate(IV)] salts of $[H_3O]^+$, Cs^+, $[Me_4N]^+$, and $[Ph_4P]^+$ and about the existence of an isolated $[Ti_2F_9]^-$ anion in the solid state, Inorg. Chem., 48 (2009), 6918-6923.
3. Mazej Z., Goreshnik E. A., Jagličić Z., $KAgF_3$, K_2AgF_4 and $K_3Ag_2F_7$: important steps towards a layered antiferromagnetic fluoroargentate(II), Cryst. Eng. Comm., 11 (2009), 1702-1710.
4. Blinc R., Tavčar G., Žemva B., Goreshnik E. A., Hanžel D., Cevc P., Potočnik A., Laguta V. V., Trontelj Z., Jagličić Z., Scott J. F., Electron paramagnetic resonance and Mössbauer study of antiferromagnetic $K_3Cu_3Fe_2F_{15}$, J. Appl. Phys., 106 (2009), 023924-1-023924-4.
5. Lozinšek M., Bunič T., Goreshnik E. A., Meden A., Tramšek M., Tavčar G., Žemva B., Syntheses, crystal structures and Raman spectra of $Ba(BF_4)(PF_6)$, $Ba(BF_4)(AsF_6)$and $Ba_2(BF_4)_2(AsF_6)(H_3F_4)$: the first examples of metal salts containing simultaneously tetrahedral $(BF_4)^-$ and octahedral $(AF)^{6-}$ anions, J. Solid State Chem., 182 (2009), 1897-2903.

6. Kontić B., Gerbec M., The role of environmental accidental risk assessment in the process of granting development consent, Risk Anal., 29 (2009), 1601-1614.
7. Chapter in book: Ponikvar-Svet M., Liebman J. F., Use of oximes, hydroxamic acids and related species as reagents in inorganic analytical chemistry. V: Rappoport, Z. (Ed.), Liebman J. F. (Ed.). The chemistry of hydroxylamines, oximes and hydroxamic acids, (Patai series). Chichester: Wiley, 2009, Band 2, 515-551.

Patent granted

1. Process for synthesising quasi-one-dimensional structures of dichalcogenides and oxides of transition metals
   Aleš Mrzel, Maja Remškar, Marko Viršek, Adolf Jesih
   Patent no. 22623

INTERNATIONAL PROJECTS

1. Innovation in Science Education - Turning Kids on to Science
   KidsINNscience
   7. FP, 244265
   EC; Nadia Prauhart, Markus Meissner, Austrian Institute of Ecology, Vienna, Austria
   Tomaž Ogrin, M. Sc., Dr. Špela Stres
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. Marko Gerbec, Asst. Prof. Branko Kontić
3. 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., Asst. Prof. Sonja Lojen
4. 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
5. 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
   Prof. Trajče Stafilov, Institute of Chemistry, Faculty of Natural Sciences and Mathematics, University "St. Cyril and Methodius", Skopje, Macedonia
   Dr. Tomaž Skapin
6. Synthesis and Thermal Stability Investigation of Transition and Rare-earth Metals Fluorides
   BI-RU/08-09-006
   Dr. Sci. Norbert Chiligarov, Moscow State University, Chemistry Department of Lomonosov, Moscow, Russia
   Dr. Zoran Mazej
7. Copper(I) ϖ-Complexes as Potentional Compounds with Three-Dimensional Frameworks
   BI-UA/09-10-015
   Dr. Marian Mys´kiv, Chemical Department, Ivan Franko National University, L´viv, Ukraine
   Dr. Zoran Mazej
8. 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

1. Optimisation of the remediation of the deposit of material, contaminated with polychlorinated biphenyls (PCB)
   Dr. Andrej Stergaršek
2. Faith and speciation of pollutants in the transformation of contaminated biomass into synthetic fuels and pure hydrogen
   Dr. Andrej Stergaršek
3. Control of Hg and other toxic elements emissions from TPP, cement works and other high-temperature industrial processes
   Prof. Milena Horvat, Dr. Andrej Stergaršek

RESEARCH PROGRAM

1. Inorganic Chemistry and Technology
   Prof. Boris Žemva

NEW CONTRACTS

1. Development of a technological process for the enhancement of the efficiency of removal of sulphur dioxide and mercury from fuel gases
   Esotech, d. d.
   Dr. Andrej Stergaršek
2. Co-financing L2-9023-0106-06: Control of Hg and other toxic element emissions from TPP, cement works and other high-temperature industrial processes
   Esotech, d. d.
   Dr. Andrej Stergaršek, Prof. Milena Horvat
3. Reliability analysis of natural gas transmission system
   Geoplin Pipelines, d. o. o.
   Dr. Marko Gerbec
4. Expert review of cross boundary effects of LNG terminal projects in the Gulf of Trieste
   Ministry of Environment and Spatial Planning
   Dr. Marko Gerbec

VISITORS FROM ABROAD

1. Prof. dr. Steven Strauss in dr. Olga Boltalina, Colorado State University, U.S.A., 15. – 22. 3. 2009
2. Dr. Wojciech Grochala, University of Warsaw, Poland, 1. – 7. 6. 2009
3. Igor M. Shlyapnikov, Lomonosov Moscow State University, Russia, 10. 6. – 10. 7. 2009 and 22. 11. – 5. 12. 2009
4. Gleb S. Veryasov, Lomonosov Moscow State University, Russia, 10. 6. – 10. 8. 2009
5. Sebastian A. Baer, Technische Universität München, Germany, 26. 10. – 6. 1. 2009

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BIBLIOGRAPHY

Original Articles

1. Robert Blinc, Gašper Tavčar, Boris Žemva, Evgeny A. Goreshnik, Darko Hanžel, Pavel Cevc, Anton Potočnik, Valentin V. Laguta, Zvonko Trontelj, Zvonko Jagličić, James Floyd Scott, "Electron paramagnetic resonance and Mössbauer study of antiferromagnetic $K_3Cu_3Fe_2F_{15}$", *J. appl. phys.*, vol. 106, no. 2, pp. 023924-1-023924-4, 2009.
2. Robert Blinc, Boštjan Zalar, Pavel Cevc, Alan Gregorovič, Boris Žemva, Gašper Tavčar, Valentin V. Laguta, James Floyd Scott, Naresh S. Dalal, "^{39}K NMR and EPR study of multiferroic $K_3Fe_5F_{15}$", *J. phys., Condens. matter*, vol. 21, no. 4, pp. 045902-1-045902-4, 2009.
3. H. Donald Brooke Jenkins, Maja Ponikvar-Svet, Joel F. Liebman, "Relative packing efficiency in hydrates", *J. chem. eng. data*, vol. 54, no. 9, pp. 2722-2728, 2009.
4. Marko Gerbec, Branko Kontić, "Implementation of the Seveso II directive in Slovenia: survey of implementation and opinions of operators regarding its safety benefits", *Saf. sci.*, vol. 47, no. 4, pp. 561-568, 2009.
5. Rajendra S. Ghadwal, Sakya S. Sen, Herbert W. Roesky, Gašper Tavčar, Sebastian Merkel, Dietmar Stalke, "Neutral penta- and hexacoordinate N-heterocyclic carbene complexes derived from SiX_4 (X = F, Br)", *Organometallics*, vol. 28, no. 21, pp. 6374-6377, 2009.
6. H. Donald Brooke Jenkins, Joel F. Liebman, Maja Ponikvar-Svet, Steve Scheiner, "The heat capacities and standard entropies of corresponding potassium and ammonium ion species: is there a constant difference?", *Struct. chem.*, vol. 20, no. 1, pp. 31-35, 2009.
7. Branko Kontić, Marko Gerbec, "The role of environmental accidental risk assessment in the process of granting development consent", *Risk anal.*, vol. 29, no. 11, pp. 1601-1614, 2009.
8. Adrijan Levstik, Cene Filipič, Vid Bobnar, Evgeny A. Goreshnik, Boris Žemva, Zvonko Trontelj, Zvonko Jagličić, "Polarons in magnetoelectric $K_3F^{II}_3Cr^{III}_2F_{15}$", *J. appl. phys.*, vol. 106, no. 7, pp. 073720-1-073720-7, 2009.
9. Matic Lozinšek, Tina Bunič, Evgeny A. Goreshnik, Anton Meden, Melita Tramšek, Gašper Tavčar, Boris Žemva, "Syntheses, crystal structures and Raman spectra of $Ba(BF_4)(PF_6)$, $Ba(BF)_4)(AsF_6)$ and $Ba_2(BF_4)_2(AsF_6)(H_3F_4)$: the first examples of metal salts containing simultaneously tetrahedral BF_4^- and octahedral AF_6^- anions", *J. solid state chem.*, vol. 182, no. 10, pp. 2897-2903, 2009.
10. Zoran Mazej, Evgeny A. Goreshnik, "Poly[perfluorotitanate(IV)] salts of $[H_3O]^+$, Cs^+, $[Me_4N]^+$, and $[Ph_4P]^+$ and about the existence of an isolated $[Ti_2F_9]^-$ anion in the solid state", *Inorg. chem.*, vol. 48, no. 14, pp. 6918-6923, 2009.
11. Zoran Mazej, Evgeny A. Goreshnik, "Syntheses and characterization of $ANi(AsF_6)_3$ ($A = H_3O^+, O_2^+, NO+, NH^{4+}, K^+, Rb^+$, and Cs^+) compounds", *J. fluorine chem.*, vol. 130, no. 4, pp. 399-405, 2009.
12. Zoran Mazej, Evgeny A. Goreshnik, "Synthesis and characteristion of $[XeF_5]_3[Ti_4F_{19}]$ containing a discrete $[Ti_4F_{19}]_{3-}$ anion", *European Journal of Inorganic Chemistry*, vol. 2009, no. 29/30, pp. 4503-4506, 2009.
13. Zoran Mazej, Evgeny A. Goreshnik, Kohei Hironaka, Yasushi Katayama, Rika Hagiwara, "Synthesis and characterization of $LnF(HF)(BF_4)_2$ (Ln = La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, and Dy), and crystal structures of $LnF(HF)(BF_4)_2$ (Ln = Pr, Nd) and La(BF[subynthesis and characterization of $LnF(HF)(BF]4)_3$", *Z. anorg. allg. Chem. (1950)*, vol. 635, no. 13/14, pp. 2309-2315, 2009.
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15. Zoran Mazej, Maja Ponikvar-Svet, Joel F. Liebman, Jack Passmore, H. Donald Brooke Jenkins, "Nitrosyl and dioxygenyl cations and their salts-similar but further investigation needed", In: *ACS Award Issue "For Creative Work in Fluoringe Chemistry" Henry Selig: March 24, 2009, Salt Lake City, Utah: special issue*, (Journal of fluorine chemistry, vol. 130, no. 9, 2009), Rozen Shlomo, ed., William R. Dolbier, ed., Lausanne, Elsevier, 2009, vol. 130, no. 9, pp. 788-791, 2009.
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17. Tomaž Skapin, Gašper Tavčar, Andreja Benčan, Zoran Mazej, "Recent developments in the preparation of high surface area metal fluorides", In: *Proceedings of the International Conference on Fluorine chemistry '09, Kyoto, May 20 - 22, 2009, Kyoto, Terrsa, Japan*, (Journal of fluorine chemistry, vol. 130, no. 12), Rika Hagiwara, ed., Lausanne, Elsevier, 2009, vol. 130, no. 12, pp. 1086-1092, 2009.
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1. Thomas Breznik, Marko Gerbec, Borut Smodiš, "Survey and evaluation of the safety measures applicable to the radioactive dangerous goods transportation in Slovenia", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 8 pp.
2. Marija Fabjan, Yves Niels, Jože Rojc, Gašper Tavčar, Koen Lenie, Matjaž Stepišnik, "Improvement of the management of institutional radioactive waste in Slovenia", In: *ICEM'09/DECOM9*, 12th International Conference on Environmental Remediation and Radioactive Waste Management, 11-15 October 2009, Liverpool, UK, [S. l., s. n.], 2009, 5 pp.
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4. Marko Gerbec, Branko Kontić, "Types and sources of uncertainties in environmental accidental risk assessment: a case for a chemical factory in the Alpine region of Slovenia", In: *Safety, reliability and risk analysis: theory, methods and applications: proceedings of the European Safety and Reliability Conference, ESREL 2008, and 17th SRA-Europe, Valencia, Spain, September 22-25, 2008*, Sebastián Martorell, ed., C. Guedes Soares, ed., Julie Barnett, ed., Boca Raton ... [etc.], CRC Press, 2009, zv. 3, pp. 2157-2165.

Thesis

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1. Tine Oblak, *Application of novel procedures for the preparation of gallium(III) fluoride with specific properties: master's thesis*, Nova Gorica, [T. Oblak], 2009.

Patent

1. Aleš Mrzel, Maja Remškar, Marko Viršek, Adolf Jesih, *Postopek za sintezo kvazi enodimenzionalnih struktur dihalkogenidov in oksidov prehodnih kovin: patent SI22623*, Ljubljana, Urad RS za intelektualno lastnino, 30. apr. 2009.

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: patent application EP2132142 (A2)*, 16. 12. 2009.
2. Maja Remškar, Marko Viršek, Miha Kocmur, Adolf Jesih, *Procedure for synthesis of threadlike tungsten oxide W_5O_{14}: patent application EP2114827 (A2)*, 11. 11. 2009.

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 halogenated, in particular fluorinated, organic molecules.

Head:
Prof. Ingrid Milošev

Experimental research in the field of electrochemistry continues for the materials that are important in biomedical and technological applications. In the field of corrosion protection we are interested in various ways of protecting – from corrosion inhibitors to surface layers. Due to their passivity, stainless steels are highly corrosion resistant in a large variety of environments. However, when exposed to chloride-rich media, the stability of the passive film is impaired. The effect of polyethyleneimine (PEI) as a corrosion inhibitor for AISI 420 stainless steel in 3% aqueous NaCl solution was investigated. Electrochemical measurements and stationary and dynamic weigh-loss tests were used to evaluate the inhibition effectiveness (IE). The effect of the mean molar mass (from 1300 to 750.000 g/mol) of the PEI on its inhibition effectiveness was also investigated. For a constant mean molar mass the IE increases with increasing inhibitor concentration, and for a constant concentration it increases with increasing mean molar mass. The PEI with a molar mass of 2000 g/mol achieved an IE of 91% and 93% effectiveness under stationary and dynamic conditions, respectively. The initiation of the localized corrosion is the slowest in the case of the PEI with a molar mass of 750.000 g/mol. Pit or crevice corrosion damage can be best prevented using 2000 g/mol. Based on X-ray photoelectron spectroscopy (XPS) measurements we can conclude that the reason for the high efficiency of the PEI could be the numerous active binding centres in the polymer molecule (amino groups). The polymer probably lies on the metal surface and thus acts as a diffusion barrier for the ionic species travelling from the metal to the electrolyte and also prevents any chloride attack from the solution.

Polyethyleneimine was applied as an effective corrosion inhibitor for AISI 420 stainless steel in a chloride medium and the mechanism of the inhibiton was elucidated.

Molecular modeling was used to evaluate the structural, electronic and reactivity parameters of 1,2,4-triazoles and its amino derivatives in relation to their effectiveness as corrosion inhibitors. 3-amino derivative with preferred corrosion inhibition performance possesses two electrophilic and two nucleophilic attack centers, implying multicenter adsorption of the molecule on a metal surface. Its interaction with the Cu atom is dominated by the electron donation from the Cu atom to the ring-carbon atom and the back-donation from the amino nitrogen atom.

Our theoretical investigations of atmospherically relevant radical reactions were based on quantum chemical methods and were focused on the examination of the mechanism of the reaction between the halogenated methylperoxy radicals CHX_2O_2 (X = F, Cl) and NO. The increased attractive character of the potential energy surface found upon halogenation combined with the increased exothermocity of the $CHX_2O_2 + NO \rightarrow CHX_2O + NO_2$ reaction are suggested to be the important factors contributing to the enhanced reactivity of the halogenated reactions relative to $CH_3O_2 + NO \rightarrow CHX_2O + NO_2$. The calculated values for the heat of formation indicate the great stability of the fluorinated derivatives. Our calculated electronic spectra of XOONO (X = Cl, Br) provide information for the identification of these species using UV-Vis spectroscopic approaches and reveal that BrOONO comprises more low-lying exited states available for solar radiation where significant actinic flux exists through the lower stratosphere.

In the context of chemistry at noble-metal surfaces, we investigated the adsorption of chlorine on a Cu(111) surface by means of extensive density functional theory calculations. Due to the good mechanical properties and the excellent electrical and thermal conductivity, copper is one of the most

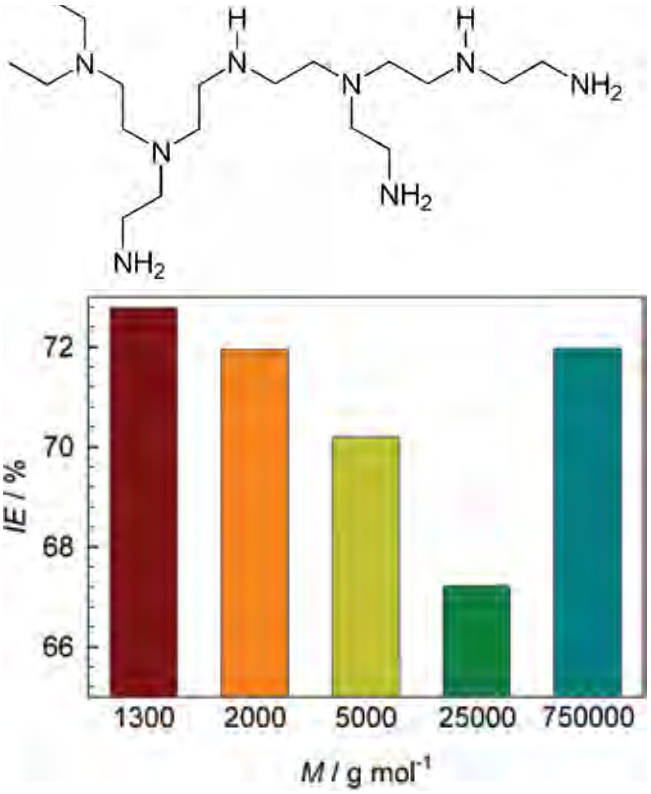

Figure 1: The structure of branched polyethyleneimine and the inhibition effectiveness of different sized PEI (1000 ppm) in a 3% NaCl solution after 90 days of immersion.

The multicenter adsorption of the 3-amino-1,2,4-triazole molecule on a copper surface was proposed by the molecular modelling of inhibitory and reactivity properties.

Figure 2: The changes at a metal's surface caused by a corrosion attack are often analysed using an optical microscope.

The first example of the non-enzymatic aerobic oxidative halogenation of organic compounds in aqueous media was introduced.

Figure 3: Density-of-states analysis showing the bonding and antibonding states between the Cl adatom and the Cu(111) surface.

We published in *Angevandte Chemie* a review paper on green methods for the oxidative halogenation of organic compounds using the molecular oxygen of aqueous hydrogen peroxide.

useful materials. However, copperware is frequently exposed to various harsh environments, with chloride media representing one of the most frequent. The adsorption of chlorine on copper surfaces therefore represents a key issue when it comes to understanding the basic surface processes connected with corrosion. According to the calculations the chemisorption energy is almost independent of the coverage up to a coverage of a 1/3 monolayer due to the good screening of the metal electrons, and upon a further increase of coverage, its magnitude then decreases. The analysis of the adsorption free energy reveals that the on-surface $(\sqrt{3}\times\sqrt{3})R30°$ adsorption phase is thermodynamically the most stable over a very broad range of Cl chemical potentials. Our results provide some insight into the initial stages of the copper-chloride formation, as they reveal that for CuCl(s) to form a *critical* coverage of Cl adatoms has to build up locally on the surface.

In the framework of Laboratory for Organic and Bioorganic Chemistry we continued the investigation of the application of the principles of green chemistry to the transformations of organic compounds, stressing the selective introduction of halogen atoms into organic compounds. We developed a selective and effective method for the direct fluorination of ketones in aqueous media using the reagent Selectfluor™ F-TEDA-BF_4 in the presence of an anionic surfactant, sodium dodecylsulfate, in amounts over its critical micelle concentration. We have further investigated the transformation of organic compounds with Selectfluor™ F-TEDA-BF_4 in ionic liquids as reaction media. We have prepared a variety of florous and nonfluorous aryl and alkyl iodine(III) diclhorides, investigated their characteristics and reactivities and on this basis developed a method for the chlorination of organic compounds, which includes a protocol for a regeneration of the reagent as fluorous iodides, its re-chlorination with Cl_2 and its further use in the chlorination process. We have developed an environmentally friendly method for the electrophilic and radical bromination of organic compounds in aqueous media using the HBr/H_2O_2 reaction system or N–bromosuccinimide and comparing their efficiency. The first reaction system was found to be more efficient for the bromination of ketones and the derivatisation of the benzylic position, while NBS was more efficient for the bromination of activated aromatics. The aerobic oxidative dibromination of alkenes was developed using 45% aqueous HBr and $NaNO_2$ as the catalyst. We have investigated a benzylic bromination of alkylaromatics with NBS under the solvent-free reaction conditions and established that this transformation was promoted by 40W visible light irradiation. We have introduced the first example of the non-enzymatic aerobic oxidative halogenation of an organic compound in an aqueous medium. Ketones were selectively and efficiently iodinated in aqueous media using elemental iodine, air oxygen as the terminal oxidant, $NaNO_2$ as the catalyst, and sulfuric acid as the activator of the overall catalytic system. The total iodine atom economy was accomplished, while the process was established to be more efficient and faster in the presence of the anionic surfactant sodium dodecylsulfate in amounts over its critical micelle concentration. On the basis of invitations we prepared review articles and chapters in books reviewing the halogenation of organic compounds in ionic liquids, the halogenation of organic compounds under solvent-free reaction conditions, the method for a green oxidative halogenation of organic compounds using oxygen or hydrogen peroxide, green methods for benzylic bromination, and antibacterial organic peroxides. In collaboration with the pharmaceutical company Krka, we have developed an independent protocol for the synthesis of precursors for quinolone-type antibiotics.

Some outstanding publications in the past three years

1. M. Finšgar, S. Fassbender, F. Nicolini, I. Milošev, Polyethyleneimine as a corrosion inhibitor for ASTM 420 stainless steel in near-neutral saline media, Corrosion Science, 51 (2009) 525-533
2. M. Finšgar, A. Lesar, A. Kokalj and I. Milošev, A comparative electrochemical and quantum chemical calculation study of BTAH and BT-AOH as copper corrosion inhibitors in near neutral chloride solution, Electrochim. Acta 53 (2008) 8287-8297

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4. S. Peljhan and A. Kokalj, Adsorption of chlorine on Cu(111): a density-functional theory study, J. Phys. Chem. C 113 (2009) 14363-14376
5. A. Podgoršek, M. Zupan and J. Iskra, Oxidative halogenation with "green" oxidants: oxygen and hydrogen peroxide; Angew. Chem. (Int. ed., Print) 48 (2009) 8424-8450

Awards and appointments

1. Jernej Iskra and Stojan Stavber: Silver Acknowledgement for the Inovation; Chamber of Commerce of Dolenjska and Bela Krajina; for the patent application: Process for preparing 2-sulfinyl-1H-benzimidazoles
2. Jasminka Pavlinac: Krka Award, Novo mesto, Krka d.d., PhD thesis
3. Ajda Podgoršek: Krka Award, Novo mesto, Krka d.d., PhD thesis

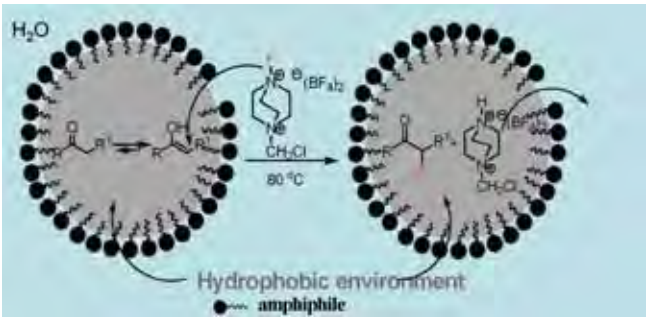

Figure 4: Fluorination of organic compounds in aqueous micelles of anionic surfactant sodium dodecylsulfate

Figure 5: Green methods for the oxidative halogenation of organic compounds

INTERNATIONAL PROJECTS

1. A Swedish-Slovenian Nanobattery Network
   SVEN-SLO-BATT
   Micro-Nano-Technology MNT ERA NET
   Uppsala University, Uppsala, Sweden
   Dr. Anton Kokalj
2. 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
3. Chemistry at Silver Surfaces: Understanding Ethylene Epoxidation and Other Pepuliar Reactions on Silver based Catalysts
   BI-IT/05-08-004
   Prof. Mario Rocca, Department of Physics, University of Genova, Genova, Italy
   Dr. Anton Kokalj
4. MSA Corrosiveness Characterization on Stainless Steels Grades Agreement
   BASF SE, Ludwigshafen/Rhein, Germany
   Dr. Ingrid Milošev

R & D GRANTS AND CONTRACTS

1. Role of molecular structure of inhibitors and their self-assembling in corrosion protection of metal surfaces
   Dr. Anton Kokalj
2. The effect of bio-environment on the stability of biomedical metallic materials
   Prof. Ingrid Milošev
3. The influence of electronic structure of corrosion inhibitors on their efficiency
   Dr. Anton Kokalj
4. Survivorship of total hip replacements as a function of type of bearing surfaces
   Prof. Ingrid Milošev
5. PVD hard coatings as an alterative for corrosion protection of Fe and Al alloys
   Dr. Darinka Kek Merl, Dr. Ingrid Milošev

RESEARCH PROGRAMS

1. Bioanorganic and bioorganic chemistry
   Dr. Stojan Stavber
2. Multiphase nanoarchitectures: development, physical and chemical characterization and simulation of processes
   Prof. Ingrid Milošev

NEW CONTRACT

1. Development of new synthesis of quinolone type antibiotic
   Krka, d.d.
   Dr. Jernej Iskra

STAFF

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

Postdoctoral associates
6. *Dr. Jasminka Pavlinac, left 20.08.09*
7. Dr. Ajda Podgoršek

Postgraduates
8. Matjaž Finšgar, B. Sc.
9. Nataša Kovačević, B. Sc.
10. Sebastijan Peljhan, B. Sc.
11. Dejan Vražič, B. Sc.

Technical officers
12. Barbara Kapun, B. Sc.
13. Emanuela Žunkovič, B. Sc.

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1. Matjaž Finšgar, Stefan Fassbender, Sabine Hirth, Ingrid Milošev, "Electrochemical and XPS study of polyethyleneimines of different molecular sizes as corrosion inhibitors for AISI 430 stainless steel in near-neutral chloride media", *Mater. chem. phys.*, vol. 116, no. 1, pp. 198-206, 2009.
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19. Gaj Stavber, Jernej Iskra, Marko Zupan, Stojan Stavber, "Aerobic oxidative iodination of ketones catalysed by sodium nitrite on water or in a micelle-based aqueous system", *Green chem. (Print)*, vol. 11, no. 8, pp. 1262-1267, 2009.
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1. Matjaž Finšgar, Ingrid Milošev, "Inhibicijska učinkovitost benzotriazola in 1-hidroksi-benzotriazola proti koroziji bakra", *Vakuumist*, vol. 29, no. 4, pp. 4-8, 2009.
2. Jernej Iskra, "Antimalarial peroxides: from artemisinin to synthetic peroxides", In: *New developments in medicinal chemistry*, Marta P. Ortega, ed., Irene C. Gil, ed., New York, Nova Science Publishers, cop. 2009, pp. 131-170.
3. Anton Kokalj, "Computer-aided design of the reaction site in heterogeneous catalysis", In: *Encyclopedia of complexity and systems science*, Robert A. Meyers, ed., New York, Springer, cop. 2009, zv. 2, pp. 1307-1335.
4. Ingrid Milošev, "Znanstveno raziskovalno delo", In: *Ortopedska bolnišnica Valdoltra: 1909-2009: od obmorskega okrevališča do moderne ortopedske bolnišnice = dall'ospizio marino al moderno ospedale ortopedico = from littoral sanatorium to modern orthopaedic hospital*, Vlasta Beltram, ed., Valdoltra, Ortopedska bolnišnica, 2009, pp. 132-136.
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Regular papers

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Theses

Ph. D. Theses

1. Jasminka Pavlinac, *Research on the reaction conditions for the iodo- and fluorotransformation of organic molecules : doctoral dissertation*, Ljubljana, [J. Pavlinac], 2009.
2. Ajda Podgoršek, *Chlorination studies of organic molecules in water and fluorinated solvents: doctoral dissertation*, Ljubljana, [A. Podgoršek], 2009.

B. Sc. Theses

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ELECTRONIC CERAMICS DEPARTMENT

K-5

The Electronic Ceramics Department is active in the research of the synthesis, properties and applications of materials for electronics and energetics, mainly complex multifunctional materials and structures. 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 synthesis and structure on the nano-, micro- and macro-levels. The group also works on the principles of basic technologies of ceramic pressure sensors, ceramic MEMS and flexible electronics.

Head:
Prof. Marija Kosec

Lead-free piezoceramics based on the $K_xNa_{1-x}NbO_3$ solid solution represent the most studied and environment-friendly alternative to lead-based piezoelectrics; however, not much data is available on its basic properties, such as the crystal structure or phase composition.

Following an X-ray diffraction study of the **phase transitions of the piezoelectric perovskite** $K_{0.5}Na_{0.5}NbO_3$ the structural changes of the material were studied using Extended X-ray Absorption Fine Structure analysis in collaboration with the Universities of Ljubljana and Nova Gorica. Within the entire temperature range the Nb atom is displaced from the centre of the octahedron of its immediate oxygen neighbours, as witnessed by the splitting of the Nb–O distance. As a general result, the phase transitions are found as an effect of the long-range order, while the placement of the atoms in the immediate vicinity remains largely unaffected.

We continued research on the ferroelectric, piezoelectric and electrostrictive properties of $K_{0.5}Na_{0.5}NbO_3$ **single crystals** prepared by solid-state crystal growth (SSCG). The dielectric constant (ε), dielectric losses (tg δ), remanent polarization (Pr) and coercive field (Ec) for the KNN single crystal in the $[1\bar{3}1]$ direction at room temperature are 1015, 1%, 17 μC/cm² and 24 kV/cm, respectively. The discovery of a high electrostrictive coefficient (M_{33}=2.59 • 10^{-14} m²/V²) is especially interesting. The main contribution to the high electrostrictive strain, which is significantly higher than the values reported in the open literature, arises from the contribution of 180° domain walls. (Figure 1)

Dr. Martina Oberžan, M.Sc. Marjan Buh and Ivan Lavrač from the ETI Elektroelement company, and Dr. Janez Holc and Prof. Dr. Marija Kosec from the Electronic Ceramics Department, Jožef Stefan Institute, received the Puh Award 2009 for inventions, development achievements and the use of scientific results in planning and introducing the production of high alumina porcelain with improved mechanical and thermal properties.

Within the collaboration with the Swiss Federal Institute of Technology in Lausanne, Switzerland, we studied $BiFeO_3$, which is presently the most popular material among **multiferroic oxides**. The goal of the research was to gain an insight into the basic functional properties of $BiFeO_3$ ceramics, for which poor data exist, mainly due to the problem related to the high conductivity of this material. The ferroelectricity of $BiFeO_3$ ceramics is characterized by a strong domain-wall pinning effect caused by the presence of charged defects. Preventing the migration of these defects into their stable configuration, which can be achieved by freezing the disordered defect state above the Curie temperature, was found to increase considerably the domain-wall mobility and, therefore, the remanent polarization. Similarly, the formation of defects associated with Bi_2O_3 loss during annealing at high temperatures leads to depinning of the domain walls. To the best of our knowledge, the measured piezoelectric d_{33} coefficient of 44 pC/N is presently the highest reported in the literature.

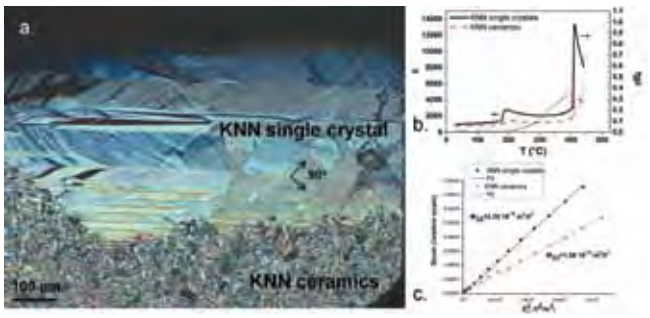

Figure 1: Domain structure of $K_{0.5}Na_{0.5}NbO_3$ single crystal (KNN s.c.) embedded into KNN polycrystalline ceramics in polarized transmission light under an optical microscope. The KNN single crystal is composed of large 90° domains, which consist of smaller 180° domains (a). A comparison of the dielectric constant ε and the dielectric losses tg δ vs. temperature for the KNN s.c. and KNN ceramics measured at 100 kHz (b). Relative strain vs. square of the amplitude of the electric field of KNN s.c. and KNN ceramics at 2 Hz (c).

Within the activities on multiferroics, the synthesis and characterization of $0.8Pb(Fe_{0.5}Nb_{0.5})O_3$–$0.2Pb(Mg_{0.5}W_{0.5})O_3$ thin films has to be mentioned due to their magnetoelectric relaxor behaviour. The research was done in collaboration with the research group of Prof. M. Karkut from Université de Picardie Jules Verne, Amiens, France within the EU 6FP project "MULTICERAL".

High-energy milling method: we carried on a detailed study of the mechanisms of mechanochemical reactions, which are triggered by high-energy impacts between milling balls and powder particles. The results of systematic studies on Na_2CO_3–X_2O_5 (X = V, Nb, Ta) reaction systems revealed that the formation of a carbonato complex, as an intermediate phase dur-

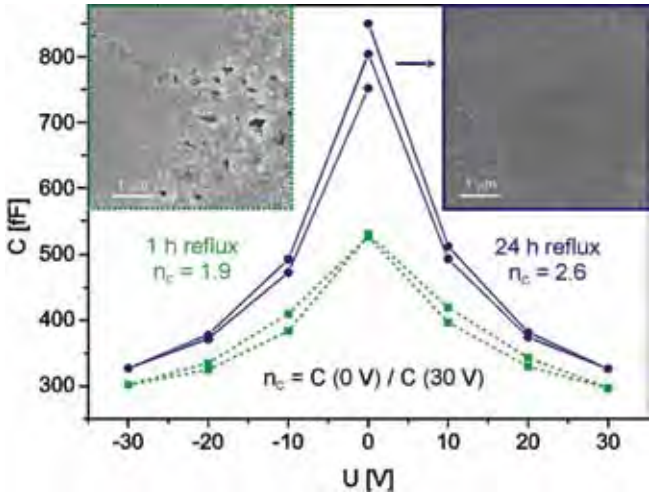

Figure 2: Microstructure and voltage dependence of the capacitance for the $KTa_{0.6}Nb_{0.4}O_3$ planar thin-film capacitors on alumina substrates prepared by chemical solution deposition. By increasing the reflux time of the heterometallic sol synthesis from 1 hour to 24 hours, the films crystallized after heating at 900 °C as single-phase perovskite and exhibited a homogeneous microstructure. The films from the 1h-refluxed sols also contained secondary phases and revealed a non-homogeneous microstructure. The capacitance tunability (n_c) of the 24 h-refluxed capacitors, as the functional property of tunable thin film components, is strongly enhanced in comparison to the value obtained for the 1h-refluxed samples.

In a $K_{0.5}Na_{0.5}NbO_3$ single crystal a high electrostrictive coefficient (M_{33} = 2.59·10^{-14} m^2/V^2 at 2 Hz) was obtained. Such a high value is due to the specific domain structure of the crystal.

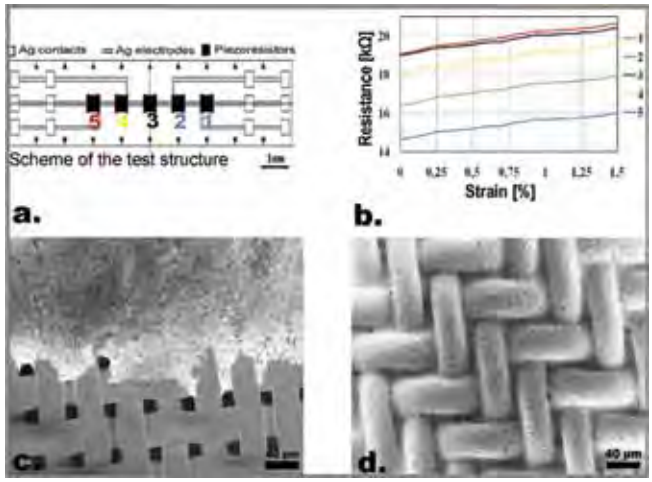

Figure 3: Strain sensor on a fabric produced by thick-film technology. The scheme of the test structure; the strain sensors are marked by the numbers from 1 to 5 (a). Electrical resistance of the sensors vs. strain (b). SEM micrograph of the carbon layer on top of the fabric. A piezoresistive sensor layer covered the fabric as well as the open areas between the threads (c). SEM micrograph of the silver (Ag) contact and the fabric interface. The silver electrode is fine grained and randomly distributed around the filaments (d).

ing the synthesis of the oxides, is closely related to the acidity of the metal cation, which increases in the order $V^{5+} > Ta^{5+} > Nb^{5+}$. The higher the acidity, the faster the formation of the complex and also its further milling-induced decomposition. The amount of carbonate in the "quasi" equilibrium, which is reached by prolonged milling, also decreases with the increasing acid-base potential between the metal cation and the carbonate ions. In comparison with the Na_2CO_3–Nb_2O_5 system the cumulative kinetic energy for the crystallization is much larger (factor of 500) in the case of the K_2CO_3–Nb_2O_5 system.

The research of **the Chemical Solution Deposition (CSD) of ferroelectric thin films** was focused mainly on alkaline, alkaline earth, and lead-based complex perovskites.

Dielectric measurements of $KTa_{0.6}Nb_{0.4}O_3$ thin films on alumina substrates, prepared by CSD from acetate-alkoxide-based sols with a 24-h reflux were performed in the radio-frequency range by patterning planar capacitors on the film surface and in the microwave-frequency range by the split-post dielectric resonator method. The relaxorlike behaviour of the dielectric properties, which has not been determined in (K,Ta) NbO_3 thin films previously, was unambiguously confirmed by the fit to the Vogel–Fulcher law. The room-temperature values of the permittivity and the dielectric losses, measured at 10 kHz, are 2430 and 0.08, respectively. The corresponding values measured at 14.5 GHz are 590 and 0.52. (Figure 2)

In the frame of the EU 6FP project "CAMELIA" we studied thin films with high permittivity for microelectronics. The research of $CaCu_3Ti_4O_{12}$ thin films on platinized silicon substrates prepared by CSD from nitrate-alkoxide-based precursors continued. The about 250-nm-thick $CaCu_3Ti_4O_{12}$ films prepared on a nucleation layer (NL) crystallize in the predominantly (222) oriented perovskite phase after heating at 750°C with a trace amount of rutile phase and consist of columnar grains. The films without the NL crystallize in the perovskite phase with a random orientation and the microstructure consists of nm-sized equiaxed grains. The permittivity of the films with the NL is about 70 in a wide frequency range from 100 K to RT, while the permittivity of the films without the NL is between 600 and 1000 at RT in the kHz-MHz range. With colleagues from 3D-plus, France, we studied the conditions of the laser activation of amorphous $CaCu_3Ti_4O_{12}$ and $Pb(Zr_{0.30}Ti_{0.70})O_3$ films which would enable the crystallization of the film without heating the substrate. By adjusting the parameters of the Nd:YAG laser we succeeded in preparing $Pb(Zr_{0.30}Ti_{0.70})O_3$ films with the room-temperature value of the dielectric permittivity of about 1000; however, with rather high losses. The work is in progress.

In collaboration with colleagues from CSIC, Spain, we studied the thermal decomposition of the as-dried diol-based precursors for $Pb(Mg_{0.33}Nb_{0.67})O_3$–$PbTiO_3$ (PMN-PT) thin films. We systematically compared the thermal decompositions of the PMN, PT and PMN–PT precursors, prepared from a lead acetate or acetylacetonate-based reagent. We concluded that the thermal decompositions were affected by the choice of the lead-compound and the chemical composition of the sample. The results present a good starting point for the design of the optimum heating profile for the PMN-PT thin films.

We studied the processing and properties of multicomponent ceramics as a possible dielectric in transparent **thin-film transistors** (TFTs). We combined two oxides that represent the trade-off between dielectric constant and breakdown voltage that are related to the band gap. The ceramics based on the Ta_2O_5-Al_2O_3 and HfO_2-SiO_2 systems were prepared by mechanochemical activation of the constituent oxides followed by sintering. We obtained ceramics with a high density, a homogeneous microstructure, and the desired phase composition.

The transparent TFTs were processed at University Nova, Lizbon, Portugal within the EU 6 FP project "MULTIFLEXIOXIDES" at temperature of 150°C on glass substrates using ceramic targets prepared at the JSI, namely

In-Zn-O as the gate, source and drain electrodes, Ga-In-Zn-O as the channel layer and Ta-Al-O as the dielectric. The field-effect mobility above 30 cm^2/Vs and On/Off ratio higher than 10^7 have been achieved.

The processing of **thick films** using screen printing and the electrophoretic deposition process (EPD) was studied.

We investigated the properties of suspensions for the processing of lead-based thick films by the **electrophoretic deposition process**. The zeta-potential, the viscosity and the electrical conductivity were measured to identify the conditions for the preparation of a stable suspension suitable for the EPD. The applied voltage, the deposition time, the chemical composition of the suspension and the concentration of the powder were investigated in order to obtain a high-quality deposit. The highest functional response was obtained for a homogeneous, dense, crack-free PMN-PT thick film prepared from a PMN-PT suspension with excess PbO. The film was deposited on a Pt/Al_2O_3 substrate at a constant voltage, followed by sintering at 1100°C. The film's properties were as follows: a dielectric permittivity ε of 20,000 at a T_{max} of 172°C, a remanent polarization of 17 $\mu C/cm^2$ and a coercive field of 5 kV/cm.

We explained the mechanism of the synthesis of $Pb(Mg_{1/3}Nb_{2/3})O_3$ by high-energy milling, which occurs via the nucleation and growth of the perovskite phase from the amorphous matrix. In contrast, the nuclei of the unstable pyrochlore phase do not grow.

The structural and microstructural properties of PMN-PT thick films screen-printed on different substrates, i.e., alumina, Pt, PMN-PT and AlN, were studied. The microstructures, phase compositions (tetragonal to monoclinic phase ratio) and electric properties strongly depend on the choice of the substrate material, mainly due to the different temperature expansion coefficients of the films and substrates. Due to the compressive stresses, dense PMN-PT thick films on the Al_2O_3 and Pt substrates crystallize in a tetragonal phase.

Within the EU 7 FP project "MICROFLEX" a **strain sensor on fabric** was produced by thick-film technology. The sensor consists of polymer-carbon-based piezoresistive layers terminated with polymer-silver conducting lines. The gauge factor of 5 was measured on the sensor at room temperature. (Figure 3)

In cooperation with our colleagues from the University of Warsaw, Poland, the materials for **lead-free thick-film resistors** were investigated. Thick-film materials are currently an exemption from the RoHS directive (RoHS - restriction of the use of certain hazardous substances) which requires the elimination of lead based materials. However, there is a trend towards the development of suitable materials. The characteristics of thick-film resistors based on either RuO_2 or $CaRuO_3$ as conductive phases were studied. The experimental results indicated that acceptable electrical characteristics (sheet resistivity, current noise and temperature coefficients of resistivity) could be obtained. Nevertheless, the composition of the resistors ought to be optimized to obtain the values typical for commercial thick-film resistors based on lead-oxide-containing glasses.

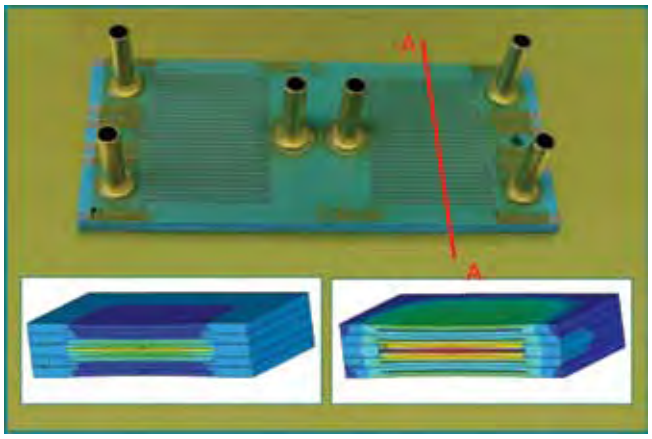

Figure 4: Prototype of the ceramic micro-reactor (top) and the results of numerical simulations presenting the temperature distribution and the stress intensity in the structure of the cross-section AA (bottom). Collaboration JSI – HIPOT-RR.

The investigations of **phase equilibria** in the RuO_2–CaO–V_2O_5 system are closely related to the lead-free thick-film resistors. Literature data indicate that the electrically conducting perovskite $CaRuO_3$ is often used as the conductive phase in lead-free resistors. V_2O_5 is added to prevent the crystallization of the glass phase during firing. Preliminary results (tie lines in the system) indicate that the $CaRuO_3$ is not compatible with the V_2O_5.

The work on **LTCC materials** (Low Temperature Co-fired Ceramics) that are used for multilayer hybrid electronic circuits and 3D structures (MEMS – Micro Electro-Mechanical Systems) with buried channels and cavities continued. These materials are based on mixtures of low-temperature melting crystallizing glasses and ceramic fillers, mainly alumina particles. LTCC materials were heated at different temperatures. The development of the structure and the microstructure was studied by X-ray powder diffraction analysis and scanning electron microscopy. Upon heating, the alumina dissolves in the glass and the anorthite phase crystallizes from the glass. Both reactions contribute to the increased viscosity of the glass phase.

To obtain buried channels or cavities within the LTCCs without delamination and/or sagging during the lamination and firing processes, so-called sacrificial and temporary materials are often used. In cooperation with our partner HIPOT-RR d.o.o. these materials were investigated. The investigated sacrificial materials were carbon based, namely, the carbon burns out during heating, while the temporary materials were pastes based on $SrCoO_3$, which is leached-out from the sintered structures. For the former, the correct heating profile is very important, while for the latter, preliminary investigations revealed cracking and delamination of the LTCC structures.

The article 'Modelling and characterization of thin film planar capacitors: inherent errors and limits of applicability of partial capacitance methods ' (authors: M. Vukadinović, B. Malič, M. Kosec and D. Križaj, Meas. Sci. Technol. 2009, 20 [11]) has been selected by the Journal Editors to feature in iopselect (http://www.iop.org/Select/) for its novelty, significance and potential impact on future research.

The article 'A novel approach to prepare large-displacement 0.65Pb($Mg_{1/3}Nb_{2/3}$)O_3–0.35$PbTiO_3$/Pt actuators prepared by screen printing' (authors: H. Uršič, M. Hrovat, J. Holc, M. Santo-Zarnik, S. Drnovšek, S. Maček, M. Kosec, Sensors and Actuators, 2008, 133) has been selected by the Editors to feature in the newspaper Vertical News with the title: "Reports from H. Ursic and colleagues advance knowledge in sensors and actuators" due to its significance. The displacement of the actuator is around five times higher than the highest values reported in the open literature.

Based on the above described investigations and within the collaboration with the partner HIPOT-RR d.o.o., several prototypes of the **ceramic micro-reactor** for the reforming of liquid fuels and water into hydrogen for use in low-temperature fuel-cells were designed and realized. The micro-reactor consists of the evaporator for water and fuel, buried channels with a catalyst for fuel reforming, platinum-based heaters and temperature sensors. Numerical analyses of the temperature distribution and the stress intensity in the 3D LTCC structures assisted in the evaluation of the realized structures and were helpful for the further work. (Figure 4)

We collaborated in the development and technology transfer of the **ceramic pressure sensors** based on the LTCC technology with our partners HIPOT-RR d.o.o and HYB d.o.o. The capacitive pressure sensor for lower pressure ranges was designed and developed. The novel design of the sensor required a demanding construction, but it enabled low-energy consumption, suitable for applications in wireless-sensor networks, increased sensitivity, minimized parasitic effects, as well as an efficient protection from the electromagnetic interference.

Some outstanding publications in 2009

1. 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., 2009, 11, 320–324.
2. Andreja Benčan, Elena Tchernychova, Matjaž Godec, John Gerard Fisher, Marija Kosec, Compositional and structural study of a $K_{0.5}Na_{0.5}NbO_3$ single crystal prepared by solid state crystal growth. Microsc. Microanal. 2009, 15 (5), 435-440.
3. Danjela Kuščer, Elena Tchernychova, Janez Kovač, Marija Kosec, Characterization of the amorphous phase and the nanosized crystallites in high-energy-milled lead-magnesium-niobate powder. J. Am. Ceram. Soc., 2009, 92 (6), 1224-1229.
4. Mišo Vukadinović, Barbara Malič, Marija Kosec, Dejan Križaj, Modelling and characterization of thin film planar capacitors : inherent errors and limits of applicability of partial capacitance methods, Meas. Sci. Technol. 2009, 20 (11), 115106-115106-11.
5. Marina Santo-Zarnik, Darko Belavič, Srečo Maček, Janez Holc, Feasibility study of a thick-film PZT resonant pressure sensor made on a prefired 3D LTCC structure, International Journal of Applied Ceramic Technology, 2009, 6 (1), 9-17.

Awards and appointments

1. Dr. Martina Oberžan, Dr. Janez Holc, Ivan Lavrač, Marjan Buh, M. Sc. , Prof. Marija Kosec: Puh award for inventions, research achievements and the application of the scientific research at development of high alumina porcelain with improved mechanical and thermal properties, Ministry for Higher Education, Science and Technology, Ljubljana, 23 November 2009
2. Dr. Marina Santo Zarnik, Acknowledgement "Excellent poster Award" for the poster and the contribution of the referate "FE analyses and prototype testing of a piezoresistive LTCC-based low pressure sensor", Steering Committee of International Symposium for Design and Technology o Electronics packages SIITME, Gyula, Hungary, 20 September 2009

Organization of conferences, congress and meetings

1. The 17th European Microelectronics and Packaging Conference & Exhibition (EMPS 2009), Rimini, Italy, April 15-18 2009
2. 31st International Spring Seminar on Electronics Technology (ISEE 2009), Brno, Czech Republic, May 13-17 2009
3. E-MRS 2009 Spring Meeting, EMRS Symposium G: Fundamentals and Technology of Multifunctional Oxide Thin Films, Strassbourg, France, 8-12 June 2009 (co-chair)
4. 10th International Balkan Workshop on Applied Physics, Constanta, Romania, 5-8 July 2009
5. 12th International Meeting on Ferroelectricity (IMF-12) & 18th IEEE International Symposium on the Applications of Ferroelectrics (ISAF-18), Xi´an, China, 23-27 August 2009

6. 45th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Photovoltaic Devices and Technologies (MIDEM), Postojna, Slovenia, 9-11 September 2009
7. 15th International Symposium for Design and Technology of Electronics Packages (SIITME 2009), Gyula, Hungary, 17-20 September 2009
8. 33rd International IMAPS-IEEE CPMT, Pszczyna, Poland, 21-24 September 2009
9. Slovenski kemijski dnevi 2009, Maribor, Slovenia, 24-25 September 2009
10. Electroceramics for End Users IV (PIEZO 2009), Zakopane, Poland, 1-5 March 2009 (co-chair)
11. Posvet o naprednih materialih, TC SEMTO, Ljubljana, Slovenia, 16-17 November 2009

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
   Prof. Marija Kosec, Dr. Janez Holc
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, Kvistgård, Denmark
   Prof. Marija Kosec, Asst. Prof. 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; Dr. Richard Winfield, Tyndall National Institute, Lee Maltings, Cork; University College Cork, National University of Ireland, 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 Desenvolivimento de Novas Technologias, Monte de Caparica, Portugal
   Asst. Prof. Danjela Kuščer Hrovatin
6. 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
7. Electroceramics from Nanopowders produced by Innovative Methods
   ELENA, COST 539
   EC
   Asst. Prof. Barbara Malič
8. New Generation of 3D Integrated Passive Components and Microsystems in LTCC Technology
   IPCTECH
   EUREKA
   Asst. Prof. Marko Hrovat
9. Nanostructures of Perovskite-Type Ferroelectrics for Electronic Applications
   BI-FI/09-003
   Dr. Marina Tjunina, University of Oulu, Microelectronics and Materials Physics Laboratories, Oulun Yliopisto, Finland
   Asst. Prof. Barbara Malič
10. Studies on Structure-Properties Relationship of Novel Electronic Ceramics
    BI-CN/09-11-001
    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
11. Processing, Structure and Properties of Advanced Electronic 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, Wydzial Elektroniki Mikrosystemów i Fotoniki, Wroclaw, Poland
    Asst. Prof. Marko Hrovat

R & D GRANTS AND CONTRACTS

1. Ceramic materials for 3D structures and study of functional properties
   Dr. Janez Holc
2. Functional properties of thin films based on environment-friendly complex perovskite materials: dependence on microstructure and chemical homogeneity
   Asst. Prof. Barbara Malič
3. Materials and processes for shaping miniature thick film ceramic 2D and 3D structures
   Asst. Prof. Marko Hrovat
4. Energy-saving ceramic pressure sensors with digital output
   Asst. Prof. Marko Hrovat
5. Processing of ceramic microelectromechanical systems (MEMS) by novel technologies
   Dr. Janez Holc
6. Miniaturized ceramic low pressure sensors
   Asst. Prof. Marko Hrovat
7. 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. Capacitive ceramic pressure sensor
   Hipot - RR, d. o. o.
   Prof. Marija Kosec
2. Project KeraPro – ceramic processor for fuel reforming and cleaning of obtained gasses
   Ministry of Defence
   Asst. Prof. Marko Hrovat

VISITORS FROM ABROAD

1. Prof. Angus Kingon, Brown University, Rhode Island, USA, 7 – 11 January 2009
2. Dr. Oana Catalina Mocioiu, Institute of Physical Chemistry Ilie Murgulescu, Bucharest, Romania, 11 January – 1 February 2009
3. Dr. Luca Gregoratti, Sincrotrone Trieste SCpA, Trieste, Italy, 27 January 2009
4. Mrs. Francesca Bortolani, Cranfield University, Cranfield, Great Britain, 30 March – 9 April 2009
5. Prof. Mamoru Senna, Keio University, Yokohama, Japan, 8 -11 April 2009
6. Mr. Viktor Lukač, Institute of Chemical Technology, Prague, Czech Republic, 4 – 15 May 2009
7. Mr. Pawel Durczynski, Polytechnica Wroclawska, Wroclaw, Poland, 24 – 30 May 2009
8. Prof. Hisao Suzuki, Graduate School of Science and Technology, Shizuoka University, Shizuoka, Japan, 14 – 17 June 2009
9. Prof. Tomoaki Yamada, Department of Innovative and Engineered Materials, Tokyo Institute of Technology, Tokio, Japan 17 – 21 June 2009
10. Mr. Shintaro Yasui, Department of Innovative and Engineered Materials, Tokyo Institute of Technology, Tokio, Japan, 17 – 21 June 2009

11. Dr. Oana Catalina Mocioiu, Institue of Physical Chemistry Ilie Murgulescu, Bucharest, Romania, 3 May – 31 July, 2009
12. Prof. Andrzej Dziedzic, Wroclaw University of Technology, Wroclaw, Poland, 8 – 11 September 2009
13. Dr. Piotr Markowski, Wroclaw University of Technology, Wroclaw, Poland, 8 -11 September 2009
14. Prof. Jerzy Krupka, Institute of Microelectronics and Optoelectronics, Warsaw University of Technology, Warsaw, Poland, 8 – 11 September 2009
15. Dr. Ciprian Ionescu, Politechnica University of Bucharest, Center of Electronics Technology and Interconnection Technologies-CETTI, Bucharest, Romania, 19 – 23 October 2009
16. Prof. dr. Marina Tjunina, University of Oulu, Microelectronics and Materials Physics Laboratories, Oulu, Finland, 15 -23 October 2009
17. Mr. Janne Narkilahti, University of Oulu, Microelectronics and Materials Physics laboratories, Oulu, Finland, 25 November – 7 December 2009

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9. Dr. Tadej Rojac
10. Dr. Gaj Stavber
11. Dr. Jenny Julie Angeline Tellier
12. *Dr. Mišo Vukadinović, left 01.03.09*

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Technical and administrative staff
28. Srečko Maček
29. Tina Ručigaj, B. Sc.

Note:
* part-time JSI member
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*** researcher financed by industry

BIBLIOGRAPHY

Original Articles

1. Harvey Amorín, Isabel Santacruz, Mai Pham Thi, Marija Kosec, Rodrigo Moreno, Miguel Algueró, "Tape-casting performance of ethanol slurries for the processing of textured PMN-PT ceramics from nanocrystalline powder", *J. Am. Ceram. Soc.*, vol 92, no. 5, pp. 996-1001, 2009.
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Patent Application

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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 covers 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

In 2009 we continued our research on the hydrolysis of aluminum nitride (AlN) powder in diluted aqueous slurries. The kinetic regimes for AlN powder hydrolysis were studied with the use of the un-reacted core model, in the temperature range between 22°C to 90°C. On the basis of the obtained experimental data the activation energy for the reaction of AlN and water was calculated and a mechanistic model of AlN powder degradation in water was proposed. The hydrolysis was then exploited for the synthesis of nanostructured boehmite coatings with a high specific surface area. After a subsequent heat treatment the boehmite coating transformed into one of the transitional aluminas, depending on the temperature of the heat treatment. However, after the heat treatment the morphology of the nanostructured alumina coating was preserved. Subsequently, the coatings were modified by various carboxylic acids, differing in length, or by (heptadecafluoro-1,1,2,2 tetrahydrodecyl) trimethoxy-silane. The influence of the heat treatment of the boehmite coating and of the length and the structure of the organic precursors used for the coating modification on the degree of the hydrophobicity of the coatings was studied. The results indicate that when using the right hydrophobic agent the superhydrophobic surface can be prepared with a contact angle of 155° (Figure 1).

- **Superhydrophobic surfaces can be prepared by applying organic precursors to nanostructured alumina coatings.**
- **Compressive strength of sintered ceramic foams with 20% relative density exceeds 70 MPa, which is a remarkably high strength for such a porous material.**
- **The process for applying alumina adhesion coatings for the improved bonding of dental luting agents to the sintered Y-TZP ceramic as a strucrural material for full-ceramic dental restoration was developed and patented.**

The research on the Hydrolysis Assisted Solidification process for the shaping of ceramic green bodies was also continued. During the investigation it was found that the thin boehmite layer present on the alumina particles enables the preparation of porous alumina ceramics with a 60–70% relative density, which exhibit a twice as large flexural strength when compared with ordinary alumina ceramics sintered to an equivalent density. This increase in strength was attributed to the thin boehmite layer that hinders the sintering of the alumina matrix in the initial phase due to the transformation of boehmite to α-alumina. In the second stage of the sintering the α-alumina nanoparticles accelerate the formation of necks between the matrix particles, resulting in an increased strength of the material.

The rheological properties of paraffin wax suspensions with high solid loadings were investigated. The dependence of the size and volume fractions of particles and the length of the surface-active additives on the yield stress of the suspension were determined. It was discovered that the particles in the suspension can be ordered into a denser stack than is their nominal part in the suspension using the appropriate shear forces. If the round particles with a uniform particle size are used, they can be assembled into a close-packed arrangement. (Figure 2)

In the frame of the research on the processing of ceramic materials, alumina ceramic foams were produced. For the preparation of these materials, aqueous suspensions of alumina-containing carboxylic acids with short non-polar tails were used. During the intensive mixing air is incorporated into the suspension and stable air bubbles are formed and the volume of the suspension is increased. This makes possible the preparation of ceramic materials with a very high porosity. Sintered ceramic foams with 20% of theoretical density and an average pore size of 10 μm were produced using this method. Despite the low sintered density these ceramic foams do not exhibit an open porosity. The compressive strength of the samples exceeds 70 MPa, which is a remarkably high strength for a material that is so porous (Figure 3).

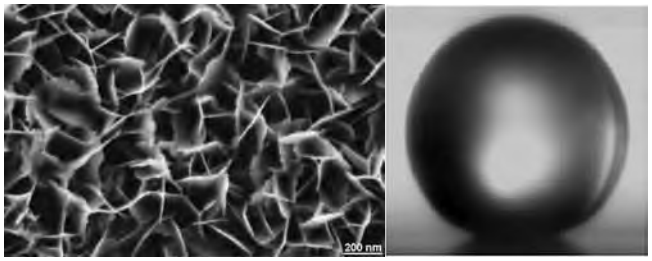

Figure 1: A nanostructured alumina coating and a droplet of water (2 µl) on a polished ceramic surface covered with a nanostructured alumina coating modified by the FAS organic precursor. The contact angle is 155°.

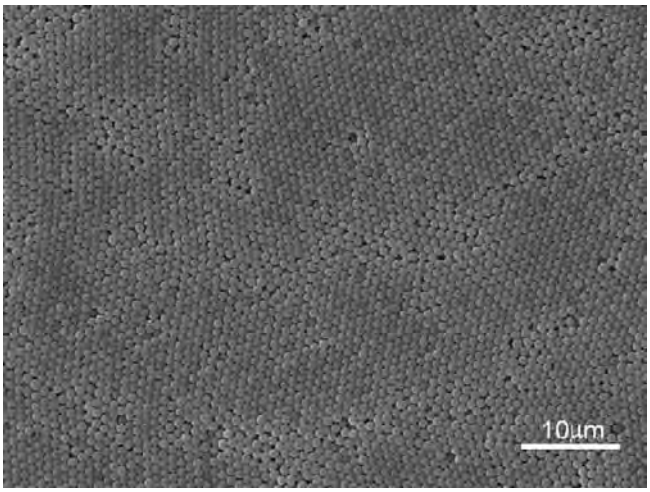

Figure 2: SiO_2 globules dispersed in paraffin wax assembled into a close-packed arrangement using the appropriate shear forces.

In the research on the development of electrically conductive composites, the preparation and properties of ceramic composites based on silicon nitride with dispersed conductive particles (TiN in ZrN) was continued in 2009. The conductive particles were formed by the gel-precipitation of hydroxides on the silicon nitride powder surface and a subsequent thermal treatment. After a calcination at 600°C in air both metallic hydroxides were transformed to crystalline TiO_2 and ZrO_2. At an elevated temperature in a nitrogen atmosphere they react with Si_3N_4 to form TiN (at 1250°C) and ZrN (at 1600°C). To fabricate an electrically conductive Si_3N_4/TiN and Si_3N_4/ZrN composite the Si_3N_4 powder coated with nanosized TiN or ZrN particles was sintered together with an appropriate amount of oxide additives (Y_2O_3 and Al_2O_3) at 1850°C for 2 h in a nitrogen atmosphere. The sintered composites exhibited a high density and flexural strength. The results of the electrical conductivity showed that the composites are electrically conductive, but the composites with 20 vol. % of conductive particles attained the appropriate electrical conductivity for the production of heating elements. The prototype for a ceramic heater was developed with the use of these materials (Figure 4).

In the field of the R&D of dental ceramics based in tetragonal zirconia (Y-TZP) ZrO_2 we continued our investigation of the phase instability of conventionally sintered dental 3Y-TZP ceramics in simulated clinical conditions. The sintered samples in the shape of discs were surface treated with standard dental grinding and sandblasting techniques and subsequently exposed to cyclic thermal and mechanical loading (fatigue testing) in the artificial saliva. The phase transformation from the tetragonal to monoclinic singony was monitored. The influence of the material and processing variables on the transformation rate was determined and the effect of the mechanical surface treatment and accelerated ageing on the survival rate was investigated. To estimate the expected lifetime of dental restorations made from Y-TZP ceramics, in-vivo experiments of the ageing of materials were designed in cooperation with dentists from the Medical Faculty: two pairs of sintered ceramic discs were mounted into the lingual part of the removable denture and the relative amount of transformed monoclinic zirconia was determined every six months and compared with the results of in-vitro tests of the accelerated ageing in artificial saliva. At the moment, four patients are included in this study and the results after the first six months indicate that the kinetics of ageing of the dental Y-TZP ceramics in the mouth cavity is substantially different than the kinetics of accelerated ageing under isothermal conditions.

We also continued the research on the adhesion of dental luting agents to the Y-TZP ceramic surface of full-ceramic dental restorations. Our findings that with the application of an alumina adhesion layer to the ceramic surface the strength of the bond is up to five times higher and that the strength is not diminished, even after long-term thermo-cycling, were used in the development of the process for applying such adhesion coatings that can be used in a dental technician's lab. The process was also patented.

The development of porous yttria-stabilized tetragonal zirconia (Y-TZP) ceramics was continued as a part of a PhD programme. The basic approach is based on the core-shell concept, which is in our case a consequence of the aggregation between the micron-sized core and the nano-sized shell particles of the same material. The concept exploits homo-aggregation, which results in a homogeneous distribution of nanosized particles attached to the surface of submicron-sized particles. The samples were shaped by slip casting and when completely dried, sintered in air to reach a fixed relative density. The above approach results in an approximately two-times higher bi-axial flexural strength at 30% of porosity, compared to the samples prepared only from micron-sized core material.

Figure 3: Fracture surface of the alumina ceramic foam.

In 2009 we cooperated with many other research institutions and industrial partners.

The research on the applicative research programme "The influence of fillers on the mechanical properties of fibre-cement composites" was completed. In the frame of this project the possibilities of substituting amorphous silica with metakaolin, fly-ash or organic additives was investigated. We applied various methods for the preparation of fibre-cement (FC) composites as well as various conditions. The finding from previous years that the substitution mentioned above does not degrade the mechanical properties was confirmed. The rheological measurements of cement pastes were performed in order to determine the conditions under which the rheological properties of the wet composites that enable plastic deformation from flat board to wavy can be estimated. Despite the fact that in such a complicated

system, where the viscosity changes with time due to the cement's hydration, it is very hard to ensure the repeatability of the measurement, we discovered, that the substitution of amorphous silica with metakaolin or fly-ash does not deteriorate the rheological properties and that shaping of wavy FC boards is still possible. In 2009 the industrial tests were performed in ESAL, where the amorphous silica was substituted with fly-ash and the results indicate that fly-ash could serve as a good substitute for relatively expensive amorphous silica.

- **Fly-ash proved to be a good substitute for amorphous silica in the production of fibre-cement composites.**
- **Using a new model, describing the thermal debinding of green parts produced by low-pressure injection moudling, the binder-removal step could be shortened by 80%.**

The Engineering Ceramics Department cooperates with the Interdent company from Celje in the applicative research project "Ageing of dental zirconia (Y-TZP) ceramics under simulated clinical conditions". In the investigation two commercially available granulates of zirconia powder with same chemical composition, differing in the average size of the primary crystallites and the specific surface area were used. The processing variables were the pressure of the uniaxial dry pressing and the time and temperature of the pre-sintering, which influenced the strength and workability of the semi-manufactured product and the shrinkage during sintering to the final density.

In the frame of the EU 7FP project "Development of wear resistant coatings based on complex metallic alloys for functional applications (AppliCMA)", in which the JSI is one of the partners, our department is responsible for the synthesis of the super-hard $AlMgB_{14}$ compound, sintering of the powders and microscopic analysis of the products. In 2009, which is the first year of the project, we synthesised the above-mentioned compound and prepared a solid sample for the analysis. The analyses of boron in the samples of other project partners using EELS were also begun.

During our research work in the area of the shaping of ceramic products using low-pressure injection moulding (LPIM) the cooperation with Hidria AET company continued also in 2009. This company uses the LPIM process for the shaping of alumina ceramic products. We focused mainly on the investigation of the thermal debinding of green parts in a highly porous powder bed. It was discovered that in this process the removal of the binder follows two main mechanisms. At the temperatures from the binder melting point (60°C) to 180°C the binder is removed by thermal expansion and the capillary suction of binder into a highly porous powder bed. At temperatures above 180°C the main mechanism of binder removal is oxidation and binder degradation into gaseous products. On the basis of this research, a new theoretical model of binder removal up to 180°C was proposed that considers all the major mechanisms. The model was thoroughly experimentally verified and good agreement with the experimental data was confirmed.

Figure 4: The ceramic heater prepared from a silicon-nitride-based composite with dispersed conductive particles

As part of our bilateral cooperation with Chubu University near Nagoya in Japan the research on improving the wear resistance of titanium alloys, which can be used as bone implants, was continued. After direct nitration in ammonia at elevated temperatures, on the surface of the alloy, a layer composed of titanium nitride is formed. The formation of this layer resulted in a significantly increased surface hardness. The "Scratch" test was used to verify the adhesion between the titanium nitride and the alloy. It was found that by optimizing the temperature and time of direct nitration in ammonia, the adhesion between the titanium nitride and the alloy can exceed the adhesion between the alloy and the titanium nitride layer, deposited on the same alloy using the PVD method.

Some outstanding publications in the past three years

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2. Aleš Dakskobler, Tomaž Kosmač. Rheological properties of re-melted paraffin-wax suspensions used for LPIM. J. Eur. Ceram. Soc., 2009, vol. 29, no. 10, str. 1831-1836.
3. Kristoffer Krnel, Aljoša Maglica, Tomaž Kosmač. β-SiAlON/TiN nanocomposites prepared from TiO_2-coated Si_3N_4 powder. J. Eur. Ceram. Soc., 2008, vol. 28, no. 5, str. 953-957.
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INTERNATIONAL PROJECTS

1. Novel Technology for High-PERformance Piezoelectric Actuators
   HIPER-Act, 7. FP
   CP-IP 212394, FP7-NMP-2007-LARGE-1
   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, Cork; University College Cork, National University of Ireland, 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, 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 Titanium-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, Kasugai, Aichi, Japan
   Prof. Tomaž Kosmač

R & D GRANTS AND CONTRACTS

1. Patterns, structural self-assembling and magnetoelectrics in mixtures of nanoparticles 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. Ceramic materials for 3D structures and study of functional properties
   Dr. Janez Holc, Prof. Tomaž Kosmač
4. Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
   Asist. Prof. Darko Makovec, Tomaž Pustotnik
5. Influence of fillers on mechanical properties of fibre cement composites
   Dr. Kristoffer Krnel
6. Phase-boundary investigations between biomimetically prepared calcium phosphate and Al_2O_3 or ZrO_2 ceramics
   Dr. Irena Pribošič

RESEARCH PROGRAMS

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

NEW CONTRACTS

1. Research and development work of the CarCIM project
   Hidria AET, d. o. o.
   Dr. Aleš Dakskobler, Prof. Tomaž Kosmač
2. Co-financing L2-1238-0106-08: Ageing of dental zirconia (Y-TZP) ceramics under simulated clinical conditions
   Interdent, d. o. o.
   Prof. Tomaž Kosmač

VISITOR FROM ABROAD

1. Prof. Dr. Tomihara Matsushita, Prof. Dr. Hiroaki Takatama, Dr. Takashi Kizuki, Chubu University, College of Life and Health Sciences, Department of Biomedical Sciences, Kasugai, Japan, August 21. – 24, 2009

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8. Aljoša Maglica, B. Sc.
9. Sebastjan Perko, B. Sc.
10. Martin Štefanič, B. Sc.
11. Lovro Gorjan**, B. Sc.

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

Note:
** young researcher financed by industry

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PUBLISHED CONFERENCE PAPERS

Invited Paper

1. Aleš Dakskobler, Tomaž Kosmač, "The effect of interparticle interactions on the rheological properties of paraffin-wax suspensions", In: *Proceedings of the 33rd International Conference and Exposition on Advanced Ceramics and Composites, January 18-23, 2009, Daytona Beach, Florida, USA*, Dileep Singh, ed., Jonathan A. Salem, ed., [S. l.], The American Ceramic Society, 2009, 8 pp.

Regular papers

1. Milan Ambrožič, Maja Martinšek, Dimitrij Najdovski, Aleksander Zidanšek, "Detection of the underground object by a triangular radar system", In: *CD proceedings*, 5th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, September 29 - October 3, 2009, Dubrovnik, Croatia, Zvonimir Guzović, ed., Neven Duić, ed., Marko Ban, ed., [S. l., s. n.], 2009, 8 pp.
2. Matej Cvetko, Milan Ambrožič, Samo Kralj, "Memory effects in randomly perturbed systems exhibiting long range orientational ordering", In: *Proceedings of the 2009 SEM Annual Conference & Exposition on Experimental & Applied Mechanics, June 1-4, 2009, Albuquerque, New Mexico USA*, Stoughton, The Printing House, cop. 2009, 174, pp. 1-7.
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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.

THESIS

B. Sc. Thesis

1. Martin Štefanič, *Biocompatibility and bioactivity of zirconium dioxide ceramics with calcium phosphate coatings: undergraduate thesis*, Ljubljana, [M. Štefanič], 2009.

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 experimental and theoretical investigations of structures, analyses of chemical compositions at the atomic level, and measurements and calculations of physical properties, all of which help us to improve the properties of micro- and nanostructured materials.

Head:
Prof. Spomenka Kobe

One-dimensional and two-dimensional **Fe-Pd-based nanostructures** were prepared on conductive substrates and via template-assisted electrodeposition into high-aspect-ratio polycarbonate membranes. The deposition process was found to be kinetically controlled, and therefore the targeted composition of $Fe_{50}Pd_{50}$ was adjusted using the applied potential. The annealing was performed in forming gas in order to transform the cubic Fe-Pd into tetragonal Fe-Pd, which has a high magnetocrystalline anisotropy. The coercivity of 80 kA/m in the out-of-plane direction was achieved with a modest heat treatment at 400°C for 1h, where the other reactions like grain growth, sintering and interdiffusion were sluggish. Tubular, Fe-Pd nanostructures were obtained directly, without any pore-wall functionalization, as was previously reported in the literature. The mechanism of direct tube formation was attributed to the appropriate relative rates of the deposition and the diffusion of the Fe^{2+} and Pd^{2+} ions into partially Au-covered pores. It was found that diffusion is the rate-determining step of the electrodeposition process; therefore, the composition and the related properties can be controlled via the electrolyte composition. The highest obtained coercivity for Fe-Pd nanotubes was 150 kA/m, which makes these materials interesting for **advanced electronic and magnetic devices**, as media for **high-density magnetic recording**. Another composition of $Fe_{70}Pd_{30}$ was also investigated due to its magnetic-shape-memory effect, where strains up to 10% can be achieved in modest fields. Thin films as well as nanotubes with an appropriate composition were synthesized and the work proceeds with the functionalization of the $Fe_{70}Pd_{30}$ nanotubes towards their **use as a drug-delivery agent**.

High-resolution scanning electron microscopy (FEGSEM) combined with complementary atomic force microscopy (AFM) and with electron-probe microanalytical methods, i.e., energy-dispersive and wavelength-dispersive X-ray spectroscopies (EDXS, WDXS), were applied to study different materials on the micro- and nanoscale. Among others we have studied the morphology, distribution and the size of nanoparticles and have determined the chemical composition of submicrometer thin films of the ferromagnetic alloys Co-Pt and Fe-Pd, which were obtained by electrodeposition. In this case the microanalytical approach using the EDXS and the WDXS was improved and adjusted for nanometre-scale analysis, taking into account specific anomalies related to the spectroscopy of the Co-L and Fe-L spectral lines. As a result we have implemented an optimized, reliable approach for accurate quantitative elemental analysis of the Co-Pt and Fe-Pd thin films. The obtained results allowed us to define the influence of process parameters of electrodeposition on the thickness and the composition of Co-Pt and Fe-Pd films as well as to correlate the composition with magnetic properties of these materials.

The magnetic response of individual Co-Pt, Fe-Pd nanospheres and nanotubes was measured and quantified for the first time in this system by applying Electron Holography (EH) in a Cs-corrected Tecnai F20 operated in magnetic-field-free Lorentz mode. EH is the only method that can visualize and quantify the magnetic properties inside and outside individual nanostructures with nanometre sensitivity.

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: $Ti_{40}Zr_{40}Ni_{20}$, $Ti_{45}Zr_{38-x}Ni_{17}Cu_x$ (x=3.5), $Ti_{53}Zr_{27-x}Ni_{20}Cu_x$ (x=3.5) and $Ti_{58}Zr_{24-x}Ni_{18}Cu_x$ (x=3.5). We were mainly interested in the formation of the icosahedral quasicrystalline phase (i-phase). 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 over a relatively wide range of compositions. With a higher titanium-to-zirconium ratio the quasicrystalline lattice constant a_q was found to linearly decrease. Using mass-spectrometry of the desorbed hydrogen we discovered that the **bonding energy of hydrogen** depends only on the structure of material, and not on the composition nor on the content of the bonded hydrogen. Decreasing the saturation magnetization and the susceptibility by about 30 % was determined for hydrided Ti-Zr-Ni quenched rods of diameters 3, 2 and 1.5 mm. The most important discovery was a selective hydrogenation of crystalline Ti-Zr-Ni samples within a narrow range of compositions. At the edge of this area we found that if we added 1 at.% more Ti the hydrogen content drops from 2 mass% to below 0.1 mass% H. This phenomenon was not observed for quasicrystalline samples, which indicates their better oxidation resist-

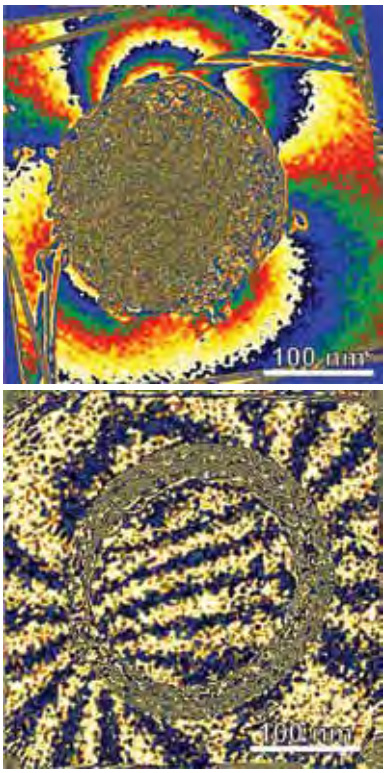

Figure 1: Magnetic field of CoPt nanosphere visualized by electron holography (above). Magnetic field of FePd nanotube visualized by electron holography (below).

ance. With XPS analysis we found a 5-times thicker oxide layer on non-absorbing samples after hydrogen treatment. We believe that the reason for such performance is the different structure in the density of states at the Fermi level, which we are going to prove by measurements of the Pauli susceptibility using PPMS device, by resistivity measurements, and by XAS analysis.

In the frame of the EU's MNT ERA-Net project "**Hydrogen-impermeable nanomaterial coatings for steels** (Hy-nano-IM)" we are investigating the possibility of producing **hydrogen-impermeable coatings** for steels for the long-term storage and transport of gaseous and liquid hydrogen. We have recently achieved outstanding success with a newly developed TiAlN-based coating, which when applied as a 5-μm-thick layer to the steel is able to reduce the permeation of hydrogen through the material by as much as 17,000 times. Transmission electron microscopy studies have revealed that close to the steel substrate the TiAlN forms in nanometre-sized grains, with columnar grains extending towards the surface of the coating.

We started with a new PhD-studies project looking at the effects of heavy-rare-earth substitutions on the coercivities of **Nd–Fe–B-based magnets**. In collaboration with Shinetsu, Japan, we are looking quantitatively at the extent of the Tb diffusion along the magnet's grain boundaries. Also related to Nd–Fe–B magnets, we have conducted a successful high-resolution SEM study to determine the origin of the **anisotropic hydrogen decrepitation** effect observed in aligned, sintered magnets. Using carefully prepared, partially hydrided samples, we were able to observe the presence of aligned, parallel cracks within the individual $Nd_2Fe_{14}B$ grains. These results will be published in J. Appl. Phys. in May of 2010.

In the field of intermetallic alloys with **magnetocaloric properties** we continued our research in the frame of European Network of Excellence **NoE CMA** (Complex Metallic Alloys) by studying the influence of the iron substitutions in the Gd-Si-Ge matrix phase. We observed very significant differences in terms of the macrostructures, microstructures and magnetic properties. The large magnetocaloric effect is a consequence of the structural transition, which occurs at the same time as the magnetic transition. Additions of iron suppress this transition. The research was performed on the Gd-Si-Ge system with a low temperature X-Ray diffractometer. We were interested on the effect of Fe on the structural suppression. The results showed that when substituting Si, the magnetic measurements showed a second-order transition with no structural change, but the X-ray showed that a structural transition still takes place. Research has also been done on a new system: Gd-based metallic glasses show interesting mechanical, electrical and magnetic properties. The magnetocaloric effect is comparable with pure Gd, but with the peak at lower temperatures. It is interesting that the Curie temperature shifts to lower temperatures with higher fields and can change by as much as 20 degrees.

As part of our investigations of Gd–Ge–Si-based magnetocaloric materials we have looked at the role of surfactants in producing high-aspect-ratio flakes for improved packing densities in **magnetocaloric elements**. By adding small amounts of oleic acid we were able to produce Gd–Ge–Si flakes, while retaining the material's crystal structure, during high-energy milling.

Sm-Fe-Ta-N-based **magnetic core-shell nanospheres**, showing a crystalline core and an amorphous shell structure were investigated by employing state-of-the-art techniques of TEM. A detailed analysis procedure was developed to extract the structure and the composition of the core and the shell separately. The obtained, combined structural and compositional information is essential for explaining the fundamental thermodynamics, which dominates the formation of intermetallic core-shell droplets, and the associated magnetic interactions at the nanoscale.

Figure 2: Nano meadow: TiO_2-Al_2O_3 crystals grown from the Ti6Al4V alloy during thermal treatment in Ar 99.99

The magnetic response of individual **Co-Pt**, **Fe-Pd nanospheres and nanotubes** was measured and quantified for the first time in this system by applying **Electron Holography (EH)** in a Cs-corrected Tecnai F20 operated in a magnetic-field-free Lorentz mode. EH is the only method that can visualize and quantify the magnetic properties inside and outside individual nanostructures with nanometre sensitivity. The phenomenon of charge-density wave (CDW) formation was studied by high-resolution transmission electron microscopy and electron diffraction performed on pure Nb_3Te_4 at room- and liquid-nitrogen temperatures. The study revealed both the basic structure and the low-temperature charge-density waves (CDWs) modulation.

Technologically interesting properties of materials were studied within the framework of the density-functional theory. We were focused on the **calculations of transport properties** in the approximants of quasicrystals and the alloys that exhibit a magnetocaloric effect by applying the semi-classical Boltzman theory and the relaxation-time approximation. We started with investigations in the field of nanotribology, where we will model a DLC surface in the presence of various lubricants.

The investigations in the frame of the FP6 project "Meddelcoat" have been focused on the development of new, bioactive coatings on metallic body implants with a highly porous surface layer. We studied the effect of process parameters in a hydrothermal treatment of the Ti6Al4V alloy on the structure and properties of the TiO_2 coating and as a result we prepared a coating with biocompatible, bioactive, photocatalytic and after UV irradiation hydrophilic properties. We also developed a sol-gel synthesis technique for the production of nanosized bioactive glass powder. Based on analyses of their electrokinetic properties we prepared a stable suspension that enables the preparation of a thin coating with suitable properties.

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In accordance with the direction of EFDA, the development of ceramic matrix composites SiC_f/SiC (FP7-Euratom/Fusion) has been reoriented in increasing the thermal conductivity of the composite. With this aim we performed a feasibility study of the incorporation of carbon nanotubes or tungsten. Using electrophoretic deposition we applied a thin coating (<100 nm) of CNTs on a SiC fibre mat that was further infiltrated in an electric field with a SiC-based suspension. As alternative densification technique we also verified an adapted technique of infiltration with pre-ceramic polymer.

We started with preliminary investigations of self-assembly of titania particles in anatase crystal form. We studied the influence of various parameters (temperature, time, pH, added dopants, etc.) of the hydrothermal synthesis on the size and morphology of particles. Using specific dopants we tried to induce the formation of twins, which would eventually lead to the fractal growth of the crystals. Synthesized particles were thoroughly investigated using electron microscopy and microanalytical methods, and the crystal planes where the preferential crystal growth took place were determined.

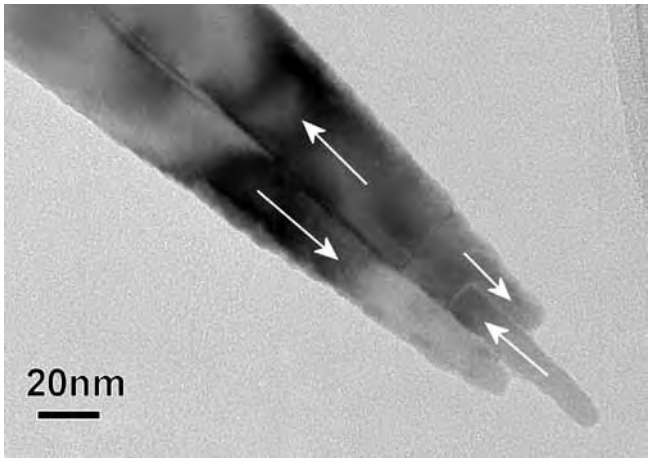

Figure 3: Terminal pair of ZnO bipods where the prismatic and basal inversion domain boundaries (IDBs) are clearly seen. Arrows indicate the polar axes [0001](+c direction).

We continued with our study of the nucleation and crystallization of various nanomaterials. We explained the formation of ZnO bipods where very small amount of silicon was present on inversion-domain boundary, which is positioned at the middle of crystal. Although this morphology has been known for years we were the first to publish the explanations of its origin. We investigated the self-assembly of Ge quantum dots in an amorphous silica matrix and the crystallization of TiO_2–CeO_2 during in-situ heating experiments inside the transmission electron microscope. Together with the industrial partner Cinkarna Celje we studied the processing parameters for the synthesis of **TiO_2 nanoparticle**s with rutile and anatase structures and 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.

The synthesis of ZnO nanopowders from water solutions of ZnO-nitrates by precipitation and hydrothermal methods was studied. The influence of the Zn^{2+} concentration in solution, pH, type, quantity and concentration of the added precipitation agent on the solution equilibrium and consequently the type, morphology and crystallinity of the precipitation product was analyzed. The processing parameters resulting either in the formation of square-shaped $Zn(OH)_2$ platelets with nanometre thickness or ZnO powders with a particle size of about 100 nm were determined. The influence of the type and morphology of the powder obtained by precipitation and used for hydrothermal synthesis, concentration of suspension, pH, temperature and time on the growth, morphology and crystallinity of the ZnO obtained by hydrothermal synthesis was investigated. The parameters that enable the reproducible preparation of ZnO powders with a morphology of either whiskers or plates, with a size in the range from 100 nm to 10 mm, were determined.

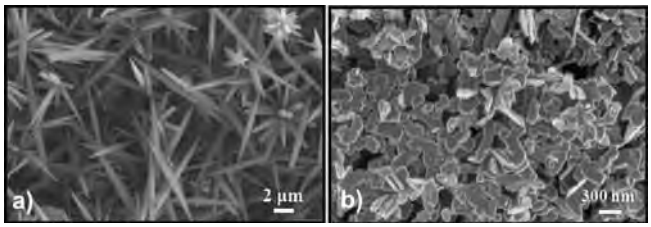

Figure 4: ZnO powders prepared by hydrothermal synthesis at 100°C from a) suspension of $Zn(OH)_2$ and b) ZnO.

We continued with the studies of the microstructure development in ZnO-based ceramics for very low additions of Bi_2O_3 and Sb_2O_3, under the influence of inversion boundaries (IBs). The amount of Bi_2O_3 liquid phase at the grain boundaries crucially affects the grain growth under the influence of inversion boundaries (IBs), which are triggered by the addition of Sb_2O_3. Based on the findings we were able to prepare homogeneous, coarse-grained varistor ceramics with an average ZnO grain size of about 40 mm, a low threshold voltage below 70 V/mm and a coefficient of nonlinearity above 40. These studies enabled us to reproducibly prepare low-doped varistor ceramics with the addition of only about 3 wt.% of varistor dopants (typical addition about 10 wt.%) with an excellent current-voltage nonlinearity – threshold voltage in the range from 60 to 350V/mm, coefficient of nonlinearity from 30 to 50 and leakage current below 1 mA.

We successfully finished the development of low-capacity varistor ceramics for applications in telecommunications systems. The main microstructural parameters (ZnO grain size, amount of secondary phases at the grain boundaries, nature of the grain boundaries) that can be influenced by processing parameters (starting composition and amount of varistor dopants added to ZnO, temperature and time of sintering), which influence the capacity of varistor ceramics and can be tailored to reduce it at a given thickness of ceramic and electrode surface, were determined. Based on the findings varistor ceramics with several times lower capacity were developed.

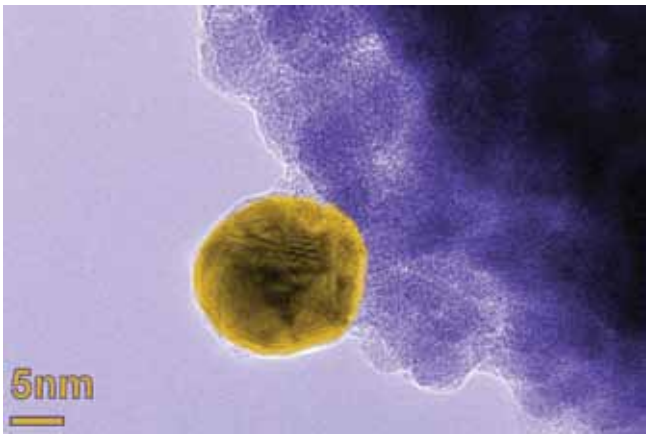

Figure 5: Crystalized Au nanoparticle on amorphous TiO_2.

Perovskite $BaTiO_3$, $(Ba,Sr)TiO_3$ and TiO_2 **nanorods** and $SrTiO_3$ **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 electrodeposition were 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 $BaTiO_3$ nanorods consist of all three polymorph structures (cubic, tetragonal and hexagonal). Electrical conductivity measurements on a single $BaTiO_3$ nanorod as a function of temperature showed that the $BaTiO_3$ nanorods exhibited the NTC effect. The $SrTiO_3$ nanotubes were composed of ordered cubic nanocrystals exhibiting a texture, which was proven by 3D electron tomography and electron diffraction.

One of important research areas of the group is the **implementation** and **development** of various **electron microscopy analytical technique***s* within the existing EU project "ESTEEM", such as electron energy-loss spectroscopy (EELS), high-resolution scanning transmission electron microscopy (STEM, HAADF-STEM) electron holography, 3D electron tomography and mechanical preparation of the TEM samples. In atomically resolved HAADF-STEM we were among the first to show, on model ceramic materials $CaTiO_3$, $SrTiO_3$ and $BaTiO_3$, that the local lattice distortions, apart from chemical composition, significantly influence the experimentally determined intensities of single atom columns. In this sense, the quantitative structural and compositional analysis of Ruddlesden-Popper faults was performed using combined high-resolution transmission electron microscopy (HRTEM) and high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) analyses. In this study we demonstrated that local planar structural defects can be fully reconstructed and quantified, meaning that the type and position of the atoms inside the investigated structure can be precisely determined.

The quantitative structural and compositional analysis of Ruddlesden-Popper faults was performed by combined high-resolution transmission electron microscopy (HRTEM) and high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM) analyses. We demonstrated that local planar structural defects can be fully reconstructed and quantified, meaning that the type and the position of the atoms inside the investigated structure can be precisely determined.

Another new analytical method was developed, called concentric electron probe. CEP is a new spectroscopic method for measuring extremely low amounts of dopants on grain boundaries and 2D defects in crystals on the subnanometer scale. The method is dedicated to determining the fine structural elements at the initial stage of the phase transformations by providing up to two orders of magnitude more accurate results compared to the existing analytical TEM methods. The technique was originally developed on the inversion boundaries in ZnO, and nowadays it is widely used in solving the defect structures in various natural and synthetic materials.

The research group is additionally strongly involved in managing of the **Center for Electron Microscopy** within the frame of national infrastructure Center for Microstructural and Surface Analysis. The implementation of various electron microscopy analytical techniques and the possibility for researchers to access research infrastructure for electron microscopy is of utmost importance for numerous research institutions, industrial partners, as well as for graduate and post-graduate education.

Some outstanding publications in 2009

1. Paul J. McGuiness, Andraž Kocjan, Spomenka Kobe. Permanent magnets based on nanostructured intermetallic alloys. V: Cristian I. Contescu (ed.), Karol Putyera (ed.), James A. Schwarz. *Dekker encyclopedia of nanoscience and nanotechnology*. 2nd ed. Boca Raton: CRC Press: imprint of the Taylor & Francis Group, cop. 2009, pp. 3328-3335.
2. Benjamin Podmiljšak, Paul J. McGuiness, Blaž Miklavič, Kristina Žužek Rožman, Spomenka Kobe. Magnetocaloric properties and nanoscale structure of Fe-doped $Gd_5Ge_2Si_2$ alloys. *J. Appl. Phys.*, 2009, vol. 105, no. 7, pp. 07A941-1-07A941-3.

3. Saša Novak, Uroš Maver, Špela Peternel, Peter Venturini, Marjan Bele, Miran Gaberšček. Electrophoretic deposition as a tool for separation of protein inclusion bodies from host bacteria in suspension. *Colloids surf., A Physicochem. eng. Asp.*, 2009, vol. 340, no. 1/3, pp. 155-160.
4. Sašo Šturm, Miran Čeh. Atomic-scale structural and compositional analyses of Ruddlesden-Popper planar faults in AO-excess $SrTiO_3$ (A = $Sr^{(2+)}$, $Ca^{(2+)}$, $Ba^{(2+)}$) ceramics. *J. mater. res.*, 2009, vol. 24, no. 8, pp. 2596-2604.
5. Maja Buljan, Goran Dražić. Formation of long-range ordered quantum dots arrays in amorphous matrix by ion beam irradiation. *Appl. phys. lett.*, 2009, vol. 95, no. 6, pp. 063104-1-063104-3.

Patent applications

1. P-200900340, Anatase nanoparticles and procedure for synthesis of anatase nanoparticles: patent application, Dejan Verhovšek, Tatjana Rožman, Miran Čeh, Pavel Blagotinšek, Sašo Šturm, Kristina Žagar, Slovenian Intellectual Property Office, Ljubljana, Slovenia, 14 November 2009
2. P-200900340, Rutile nanoparticles and procedure for synthesis of rutile nanoparticles: patent application, Dejan Verhovšek, Tatjana Rožman, Miran Čeh, Pavel Blagotinšek, Sašo Šturm, Kristina Žagar, Slovenian Intellectual Property Office, Ljubljana, Slovenia, 14 November 2009

Awards and appointments

1. Alenka Lenart: "Structural analysis of twins in quartz"; Winning poster contribution at the International School of Crystallization "La Factoria", Granada, Spain, 25–29 May 2009; International Union of Crystallography, Ministerio de Ciencia e Innovación Superior de Investigaciones Cientificas.
2. Darja Pečko: "Electrodeposition and characterization of Fe-Pd magnetic thin films". Winning contribution of young scientists at the 17th Conference on Materials and Technologies in the field "Nanomaterials and Nanotechnology", Portorož, Slovenia, 16–18 November 2009.

Organization of conferences, congress and meetings

1. Fusion EXPO, Fuzija, energija prihodnosti, Galerija Kresija, 10–20 March 2009 (co-organisation)
2. AdSTEM2009, Workshop on Quantitative HAADF-STEM imaging and EELS, Piran, Slovenia, 11–14 October 2009
3. 17th Conference on Materials and Technology, 16–18 November 2009 (co-organisation)
4. European School in Materials Science: Mechanical Properties of Complex Metallic Alloys, Ljubljana, Slovenia, 25–30 May 2009 (co-organisation)
5. 9 Multinational Conference on Microscopy – MC2009, Graz, Austria, 30 August – 4 September 2009 (members of International Advisory Board)
6. 2009 EFDA Public Information Group Meeting, Ljubljana, 14–15 May 2009
7. Project Meeting FP6 RII3 ESTEEM: "Enabling Science and Technology for European Electron Microscopy", Ljubljana, 14 September 2009

INTERNATIONAL PROJECTS

1. Nanoscale of Tribological Interfaces for Clean and Energy-Efficient Diesel and Gasoline Power Trains
   2020 Interface, EU FP7
   234324, SCP8-GA-2009-234324
   EC; Jackie Kidd, PA - Support Officer to Director of Research, Institute of Engineering Thermofluids, Surfaces and Interfaces, School of Mechanical Engineering, The University of Leeds, Leeds, Great Britain
   Asst. Prof. Matej Komelj
2. Merging Atomistic and Continuum Analysis of Nanometer Length-scale Metal-oxide Systems for Energy and Catalysis Applications
   MACAN, EU FP7
   233484, NMP3-CA-2009-233484
   EC; Prof. Wayne Kaplan, Technion - Israel Institute of Technology, Haifa, Israel
   Dr. Aleksander Rečnik
3. Improving the Gender Diversity Management in Materials Research Institutions
   DIVERSITY, EU FP7
   230253
   EC; Leibniz-Institut fuer Festkoerper- und Werkstoffforschung, Dresden, Germany
   Prof. Spomenka Kobe
4. Cooperation of Space NCPs as a Means to Optimise Services
   COSMOS, EU FP7, 218813
   EC; Dr. Adrien Klein, Deutsches Zentrum für Luft und Raumfahrt e.v., (DLR), Köln, Germany
   Prof. Spomenka Kobe, Dr. Boris Pukl, Dr. Špela Stres
5. Property Requirements for SiC/SiC Composites as Structural Materials, 4.1.1.1.-FU
   EURATOM – MHEST
   EU FP7, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Goran Dražič, Asst. Prof. Saša Novak Krmpotič
6. Development of Composites with Advanced/Alternative Manufacturing Concepts, 4.1.1.2 FU
   EURATOM – MHEST
   EU FP7, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Asst. Prof. Goran Dražič
7. SiC/SiC Composite for Structural Application in Fusion Reactor, A-2 FU
   WP08-09-MAT-SiSiC
   EURATOM – MHEST
   EU FP7, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Goran Dražič

8. Public Information; Research Unit - Administration and Services - RU-FU
   EURATOM – MHEST
   EU FP7, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Prof. Milan Čerček
9. Fusion Expo Activities under an EFDA
   WP08-PIN-FUSEX
   EURATOM – MHEST
   EU FP7, EURATOM, Slovenian Fusion Association – SFA
   3211-08-000102, FU07-CT-2007-00065
   EC; RS, Ministry of Higher Education and Technology, Ljubljana, Slovenia
   Asst. Prof. Saša Novak Krmpotič, Melita Lenošek, B. Sc.
10. Multifunctional Bioresorbable Biocompatible Coatings with Biofilm Inhibition and Optimal Implant Fixation
    EU FP6, MEDDELCOAT
    NMP3-CT-2006-026501
    EC; Prof. Jozef Vleugels, Katholieke Universiteit Leuven, Research & Development, Leuven, Belgium
    Asst. Prof. Saša Novak Krmpotič
11. Enabling Science and Technology through European Electron Microscopy
    ESTEEM, EU FP6, 026019
    EC; Prof. Gustaaf Van Tendeloo, Universiteit Antwerpen, Antwerpen, Belgium
    Asst. Prof. Miran Čeh, Dr. Sašo Šturm
12. Complex Metallic Alloys
    CMA, EU FP6
    NMP3-CT-2005-500140
    EC; Centre National de la Recherche Scientifique, Paris, France
    Prof. Spomenka Kobe, Prof. Janez Dolinšek, Dr. Peter Panjan
13. Hydrogen Impermeable Nano-material Coatings for Steels
    Hy - Nano – IM, MNT ERA NET
    Asst. Prof. Paul McGuiness
14. Advanced Methods and Technologies for Processing of a New Generation of ZnO-based Varistor Ceramics
    BI-CN/09-11-017
    Dr. Zheng Liaoying, The Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China
    Dr. Slavko Bernik
15. Novel Magnetocaloric Materials for Ecological Refrigeration
    BI-CN/09-11-009
    Dr. Yan Gaolin, School of Physics and Technology, Wuhan University, Wuhan, China
    Asst. Prof. Paul McGuiness
16. 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
17. Enviromental Hydrogen-based Recycling of Nd-Fe-B Magnets
    BI-CN/05-07/008
    Dr. Gaolin Yan, Harbin Institute of Technology, ShenZhen Graduate School, XiLi, ShenZhen, China
    Asst. Prof. Paul McGuiness
18. Nanostructural Studies of Phase Transformations and Defect Structures in Iron Oxides and Sulphides
    BI-HU/09-10-007
    Prof. Mihály Pósfai, University of Pannonia, Department of Earth and Environmental Sciences, Veszprém, Hungary
    Dr. Aleksander Rečnik
19. Synthesis and Characterization of Nanostructured Catalytic Materials
    Sintese e Caracterizacao de Materiais Cataliticos Nanoestructurados
    BI-PT/08-09-003
    Dr. Adrian M.T. Silva, Faculdade de Engenharia da Universidade do Porto, Departamento de Engenharia Quimica, Laboratorio de Caralise e Materiais (Associado); Associated Laboratory LSRE/LCM, FEUP-University of Porto (Portugal), Porto, Portugal
    Asst. Prof. Goran Dražić
20. ZnO-Nanostructures for Novel Applications
    ZnO nanostrukturni materiali za nove primene
    BI-RS/08-09-015
    Dr. Zorica Branković, Institut za multidisciplinarne študije, Belgrade, Serbia
    Dr. Slavko Bernik

R & D GRANTS AND CONTRACTS

1. The influence of magnetic structure of materials on the magnetocaloric effect
   Asst. Prof. Matej Andrej Komelj
2. Ecotechnological 1D nanomaterials: synthesis and characterisation of 1D titanate nanomaterials doped with transition metal ions
   Dr. Polona Umek, Asst. Prof. Miran Čeh
3. Exploration and preservation of mineralogical heritage
   Dr. Aleksander Rečnik
4. Physics and chemistry of interfaces of nanostructured metallic materials
   Prof. Monika Jenko, Asst. Prof. Miran Čeh
5. Low-doped ZnO-based ceramics for energy varistors
   Dr. Slavko Bernik

RESEARCH PROGRAM

1. Nanostructured materials
   Prof. Spomenka Kobe

NEW CONTRACTS

1. VIZIPIN: A safe infrastructure for command and control
   Varsi, d. o. o.
   Dr. Slavko Bernik
2. WISEVAR: Varistors for protection of renewable energy systems
   Varsi, d. o. o.
   Dr. Slavko Bernik
3. Low-doped ZnO-based ceramics for energy varistors
   Iskra Protections, d. o. o.
   Dr. Slavko Bernik
4. Low-doped ZnO-based ceramics for energy varistors
   Varsi, d. o. o.
   Dr. Slavko Bernik
5. Exploration and preservation of mineralogical heritage
   Litija Municipality
   Dr. Aleksander Rečnik
6. Development of polymer varistors
   Varsi, d. o. o.
   Dr. Slavko Bernik

VISITORS FROM ABROAD

1. Prof. Hui Gu, Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China, 10–18 February 2009
2. Gao Xiang, Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, Kitajska, Shanghai, China, 10 February – 14 March 2009
3. Prof. Mihály Pósfai, Ilona Nyiro Kósa in Dorottya Sára Csákberényi Nagy, University of Pannonia, Veszprém, Hungary, 16–22 March 2009
4. Dr. Goran Branković, Institute for Multidisciplinary Studies, Belgrade, Serbia, 22–29 March 2009
5. Dr. Davor Gracin, Institut Rudjer Bošković, Zagreb, Croatia, 10 March 2009
6. Dr. Mehmet Ali Gülgün, Salih Buyukkilic and Yeliz Ekinci, Sabanci University, Istanbul, Turkey, 19–27 April 2009
7. Elke Fuchs, Universität Bayreuth, Bayreuth, Germany, 14 April – 7 June 2009
8. Prof. A. C. Cefalas, National Helenic Research Foundation, Athens, Greece, 28–30 April 2009
9. Prof. Ajayan Pulickel, Mechanical Engineering & Materials Dept., Rice University, Houston, Texas, USA, 6 May 2009
10. Dr. Andreja Gajović, Dr. Davor Gracin, Institut Rudjer Bošković, Zagreb, Croatia, 15 May 2009
11. Dr. Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 25–31 May 2009
12. Dr. Alberto Bollero Real, Department of Energy, CIEMAT – Centro de Investigaciones Energéticos, Mediaoambientales y Tecnológicas, Madrid, Spain, 8–15 June 2009
13. Prof. Michael Coey, Trinity College, Dublin, Ireland; Prof. Jean Marie Dubois, Institut Jean Lamour, Nancy, France; Dr. Ester Belin - Ferré, Laboratoire de Chimie Physique Matière et Rayonnement – LCPMR-UMR, Paris, France, 29 May 2009
14. Geir Andreas Slotten, Norges Teknisk-Naturvitenskapelige Universitet, Trondheim, Norway, 30 June – 23 July 2009
15. Alexander Ford, Imperial College London, London, United Kingdom, 12 July – 2 October 2009
16. İsmail Özgür Özer, Anadolu University, Department for Materials Science and Engineering, Eskişehir, Turkey, 22 July – 1 August 2009
17. Dr. Goran Branković and Dr. Zorica Branković, Institut for Multidisciplinary Studies, Belgrade, Serbia, 7–19 August 2009
18. Milan Žunić, Institut for Multidisciplinary Studies, Belgrade, Serbia, 7–12 August 2009
19. Hahn Sven, Martin Luther Universität Halle/Wittenberg, Halle/Wittenberg, Germany, 3 August – 4 September 2009
20. Mrs. Marina Kutin and Prof. Milorad Davidović, Institut Goša, Belgrade, Serbia
21. Dr. Andreja Gajović, Dr. Davor Gracin, Institut Rudjer Bošković, Zagreb, Croatia, 18 September 2009
22. Dr. Andreja Gajović, Institut Rudjer Bošković, Zagreb, Croatia, 11–15 October 2009
23. Dr. Wolfgang Waldhauser, Dr. Jürgen Markus Lackner, Markus Kahn M.Sc., Mr. Harald Parizek, Joanneum Research Forschungsgesellschaft mbH Laserzentrum, Niklasdorf, Austria, 11 November 2009
24. Mrs. Marina Kutin and Prof. Milorad Davidović, Institut Goša, Belgrade, Serbia

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1. Dr. Slavko Bernik
2. Asst. Prof. Miran Čeh
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17. Katja König, B. Sc.
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20. Matejka Podlogar, B. Sc.
21. Benjamin Podmiljšak, B. Sc.
22. Mojca Presečnik, B. Sc.
23. Katarina Rade, B. Sc.
24. Marko Soderžnik, B. Sc.
25. Tea Toplišek, B. Sc.
26. Dejan Verhovšek**, B. Sc.
27. Kristina Žagar, B. Sc.

Technical officers
28. Sanja Fidler, B. Sc.
29. Medeja Gec, B. Sc.

Note:
** employed in industry

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THESES

Ph. D. Thesis

1. Andraž Kocjan, *Hydrogen absorption in Ti-Zr-Ni alloys: doctoral dissertation*, Ljubljana, [A. Kocjan], 2009.

B. Sc. Thesis

1. Darja Pečko, *Electrochemical synthesis and characterization of iron-palladium magnetic thin films: undergraduate thesis*, Ljubljana, [D. Pečko], 2009.

PATENT APPLICATIONS

1. Dejan Verhovšek, Tomi Gominšek, Miran Čeh, Pavel Blagotinšek, Sašo Šturm, Kristina Žagar, *Nanodelci anatasa in postopek sinteze za pridobivanje nanodelcev anatasa: patent application P-200900341*, Ljubljana, Urad RS za intelektualno lastnino, 14 Nov. 2009.
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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.

Head:
Prof. Darko Makovec

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

The research on magnetic nanoparticles has mainly been focused on bonding different biologically active molecules to the surfaces of functionalized, superparamagnetic iron oxide maghemite nanoparticles. The nanoparticles were functionalized by bonding different organosilane molecules to their surfaces, usually through a thin surface layer of silica. The functionalization molecules provide specific functional groups for the further bonding of biologically active molecules to the nanoparticles' surfaces. At the same time, the functionalization layer allows the nanoparticles' compatibility with physiological fluids and prevents their agglomeration. The biologically active molecules are usually bonded to the functionalization molecules using a linker molecule. In cooperation with the Faculty of Pharmacy, Ljubljana, we studied the nanoparticles' targeting into cancer cells using the bonding of monoclonal antibodies. The antibodies were bonded to the surfaces of the amino-functionalized nanoparticles using different linker molecules, in the first instance different derivates of ethylene glycol. In cooperation with the Nanotesla Institute, Ljubljana, and a company Lek, the bonding of a therapeutic agent celecoxib to the nanoparticles was also studied.

The bonding of different biologically active molecules (monoclonal antibodies, therapeutic agents) onto the surfaces of functionalized magnetic nanoparticles has been studied.

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 managed to be the first in the world to synthesize superparamagnetic nanoparticles of Ba-hexaferrite ($BaFe_{12}O_{19}$) using the hydrothermal method. Normally, a high temperature is needed to form hexaferrite, resulting in relatively large particles. By understanding the mechanisms involved in the nanoparticles' formation, we managed to decrease the temperature of the hexaferrite formation during the hydrothermal synthesis. Besides the decreased formation temperature, the prevention of secondary re-crystallization (Ostwald ripening) during the synthesis is necessary if we wish to obtain the ultrafine, monodispersed superparamagnetic Ba-hexaferrite nanoparticles. The secondary re-crystallization was successfully suppressed by using the addition of a surfactant, oleic acid. As a result of the oleic acid bonded to the nanoparticles' surfaces, they were hydrophobic and could be dispersed in non-polar liquids to prepare relatively concentrated ferrofluids.

Ba hexaferrite is considered to be toxic and therefore not appropriate for biomedical applications. Superparamagnetic Sr-hexaferrite ($SrFe_{12}O_{19}$) nanoparticles were also successfully synthesised. It appeared that the thermodynamics and kinetics of Sr-hexaferrite synthesis are significantly different to those found for Ba hexaferrite.

Synthesized superparamagnetic nanoparticles were dispersed in polymer matrixes to prepare superparamagnetic nanocomposites. Here, it is of crucial importance to disperse a high content of the nanoparticles to ensure high magnetizations, without their agglomeration, which would influence their superparamagnetic properties. The superparamagnetic nanocomposite was prepared by dispersing the superparamagnetic nanoparticles in a methyl methacrylate monomer, followed by its polymerization. To prepare

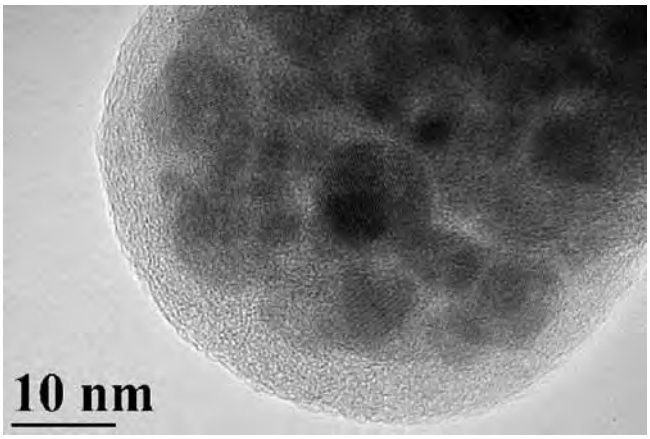

Figure 1: Nanocomposite superparamagnetic bead prepared by the polymerization of a suspension of maghemite nanoparticles in methyl methacrylate. The polymerization was performed in a mini-emulsion.

Magnetic fluids based on superparamagnetic nanoparticles of Ba hexaferritn and Sr hexaferrite were prepared

A procedure for the preparation of superparamagnetic nanocomposite beads (25-50 nm in size) based on the dispersion of ricinoleic-acid-coated maghemite nanoparticles in a methyl methacrylate monomer and its subsequent polymerization in a mini-emulsion was developed.

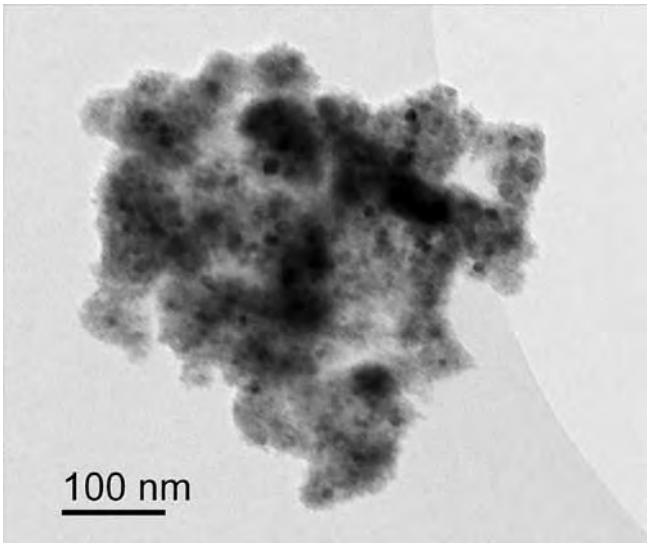

Figure 2: Nanocomposite particle composed of a photocatalytic anatase coating on an agglomerate of superparamagnetic nanoparticles. The nanocomposite particles were developed for the purification of water.

A method for the preparation of superparamagnetic, photocatalytic nanocomposite particles for an application in water purification based on coating nanocrystalline anatase onto agglomerates of superparamagnetic nanoparticles was developed.

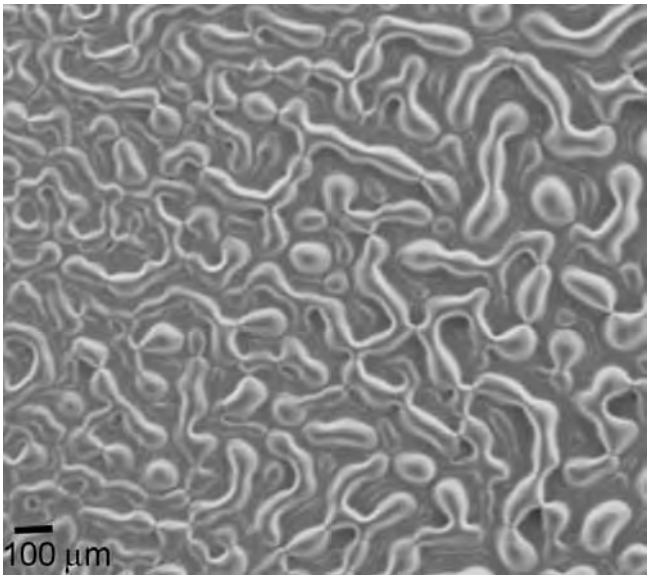

Figure 3: Assembly of $BaFe_{12}O_{19}$ nanoparticles under the influence of an external magnetic field.

a stable suspension of nanoparticles in the monomer, the nanoparticles have to be coated with an appropriate surfactant. Due to the OH group in its aliphatic chain, ricinoleic acid displays partial polarity, which enables the preparation of relatively concentrated methyl methacrylate suspensions. It is beneficial to prepare the nanocomposite in the form of particles of defined morphology. This can be achieved by using polymerization in a mini-emulsion system, made up of water, the surfactant sodium dodecyl sulphate (SDS), and the suspension of nanoparticles in the monomer, obtained by intensive ultrasonification. The polymerization resulted in the formation of nanocomposite polymer beads containing a large content of the magnetic phase. The presence of the SDS surfactant at their surfaces made possible their colloidal stability in water. The size of the beads can be tuned by changing the composition of the mini-emulsion system in the range between 25 and 50 nm. The advantage of the nanocomposite beads over individual superparamagnetic nanoparticles is in their larger volume and consequently the larger forces acting on them in a magnetic field.

We also studied the synthesis of nanocomposite particles used for the decomposition of organic pollutants in water. The nanocomposite particles were composed of photocatalytic anatase (TiO_2) nanoparticles coated onto agglomerates of the superparamagnetic maghemite (Fe_2O_3) nanoparticles. For photocatalytic purification, the particles are dispersed in polluted water. The surface anatase layer provides a 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 co-founder Cinkarna and researchers from Public Health Institute Maribor, the procedure for the preparation of magnetic agglomerates in aqueous suspensions of the functionalized superparamagnetic nanoparticles, and the procedure for the coating of the agglomerates with anatase were patented. The nanocrystalline anatase coatings are coated onto the surfaces of the magnetic agglomerates using the hydrolysis of titanil sulphate in the aqueous solution.

The studies in the field of magnetic materials for telecommunications were focused on the development of ceramic films for micro- and mm-wave applications. We studied thermal spraying technologies for the preparation of absorbing coatings in the frame of an international project, "Absolfilm". The K8 Department was involved in a study related to the mechanism of the crystallization of ferrite coatings using structural, phase and magnetic characterization. The classical spraying conditions induce partial or complete melting of a feedstock powder. However, the crystallization degree of the as-sprayed ferrite coatings is low due to a very rapid cooling rate during the spraying and a very slow crystallization rate of ferrite, especially hexaferrites. We found out that we need to minimize the processing temperature and the cooling rate together with the minimization of the melting degree of a feedstock powder in order to obtain crystalline as-sprayed ferrite coatings. In such a way, we managed to prepare ceramic and composite absorbing coatings based on Ni ferrite and various hexaferrites for frequencies of 1–10 GHz and 50–60 GHz.

Research in the field of microwave magnetic materials for nonreciprocal devices was conducted in the frame of an international applicative project "IMICIMO". The aim is to develop materials and technology for a low-temperature co-fired microwave (LTCC) module. The department was involved in the development of an LTCC hard-magnetic material based on Sr hexaferrite. We developed materials that sinter at 1000°C that are suitable for a planned microwave module with golden electrodes. We were also involved in the optimization of slurries from materials for tape casting. The optimization was based on the rheological measurements of slurries, the surface properties of particles and the microstructures of green and sintered tapes.

Magnetically oriented films based on Ba hexaferrite were prepared using electro- and magnetophoretic deposition for the first time.

Another study in the field of mm-wave materials was focused on the electro- and magnetophoretic deposition of $BaFe_{12}O_{19}$ particles. Our aim was to develop a simple method for the preparation of magnetically oriented thick hexaferrite films with low magnetic losses that are suitable for self-biased nonreciprocal devices operating in mm-waves. A profound theoretical study of the particles' stabilization in suspensions, supported with experimental evidence, showed that stabilization in polar solvents was only possible for particles with diameters up to 30 nm via an electrosteric mechanism. Slightly larger particles sedimented under an applied magnetic field. Consequently, magnetophoresis was suitable only for suspensions from the smallest particles, while less-stable suspensions of larger particles were successfully applied in electrophoresis. Magnetophoretically prepared films showed a 98% magnetic orientation. The optimization of suspensions with a combination of small and large particles resulted in nearly 100% dense films with a magnetic orientation of around 90%.

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 systems $SrNb_2O_6$–$BaNb_2O_6$ and $BaTiO_3$–$Na_{0.5}Bi_{0.5}TiO_3$ were investigated. In the latter systeme PTC resistors displaying a Curie temperature of 180°C and a low room temperature-specific resistivity were developed.

Some outstanding publications in 2009

1. Darja Lisjak, Mihael Drofenik. The dispersion of single-domain $BaFe_{12}O_{19}$ particles in water. J. appl. physi., 2009, vol. 105, no. 8, str. 084908-1-084908-8.
2. Simona Ovtar, Darja Lisjak, Mihael Drofenik. Barium hexaferrite suspensions for electrophoretic deposition. J. colloid interface sci., 2009, vol. 337, no. 2, str. 456-463.
3. Sašo Gyergyek, Darko Makovec, Alojz Kodre, Iztok Arčon, Marko Jagodič, Mihael Drofenik. Influence of synthesis method on structural and magnetic properties of cobalt ferrite nanoparticles. J. nanopart. res., [in press] 2009, 11 str., doi: 10.1007/s11051-009-9833-5.
4. Darinka Primc, Darko Makovec, Darja Lisjak, Mihael Drofenik. Hydrothermal synthesis of ultrafine barium hexaferrite nanoparticles and the preparation of their stable suspensions. Nanotechnology (Bristol), 2009, vol. 20, no. 31, str. 315605-1-315605-9.
5. 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, str. 2182-2186.

Organization of conferences, congress and meetings

1. Cooperation in organization of Slovenian Conference on Materials and Technologies for Sustainable Development, Ajdovščina, 11.-12. 5. 2009

INTERNATIONAL PROJECTS

1. Composites with Novel Functional and Structural Properties by Nanoscale Materials (Nano Composite Materials NCM)
   COST MP0701, EC
   Prof. Darko Makovec
2. New Generation Microwave Ferrite Thick Films for Absorbers
   ABSOFILM
   MATERA ERA-NET, 3211-07-000176
   VTT, Technical Research Centre of Finland, Finland
   Asst. Prof. Darja Lisjak
3. Integrated Miniature Circulators for Microwave Modules
   IMICIMO
   EUREKA
   Chelton Telecom & Microwave FRANCE, France
   Asst. Prof. Darja Lisjak
4. Preparation of Thick Ferrite Coatings with the Deposition in Magnetic Field
   BI-BG/09-10-004
   Dr. Tatyana Koutzarova, Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria
   Asst. Prof. Darja Lisjak
5. Hexaferrite-spinel Intergrowth Nanocomposites Paricles for Cancer Treatment using Magnetic Hyperthermia
   BI-CZ/09-10-001
   Dr. Pavel Veverka, Institute of Physics ASCR, v.v.i., Prague, Czech Republic
   Prof. Darko Makovec
6. Synthesis of Superparamagnetic Hexaferite Nanoparticles using Hydrothermal Methods PROTEUS
   BI-FR/09-10-PROTEUS-003
   Dr. Nadine Millot, ICB, UMR 5209, CNRS/Université de Bourgogne, Dijon, France
   Prof. Darko Makovec
7. Non Conductive Magnetic Materials for Microwave Absorbers
   BI-IT/05-08-007
   Dr. Enzo Ferrara, Instituto Elettrotecnico Nazionale Galileo Ferraris Torino, Torino, Italy
   Asst. Prof. Darja Lisjak
8. 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

R & D GRANTS AND CONTRACTS

1. Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
   Prof. Darko Makovec
2. Patterns, structural self-organisation and magneto-electrics in mixtures of nanoparticles and liquid crystals
   Prof. Samo Kralj, Prof. Mihael Drofenik
3. Development of photocatalytic superparamagnetic nanocomposites for application in diminishing emissions of harmful pollutants into the environment
   Prof. Darko Makovec

RESEARCH PROGRAM

1. Advanced anorganic magnetic and semiconducting materials
   Prof. Mihael Drofenik

NEW CONTRACTS

1. Co-financing L2-9151-0106-06: Synthesis of magnetic nanoparticles for the microwave absorbers and magnetic fluids
   Nanotesla Institute Ljubljana
   Prof. Darko Makovec
2. Co-financing L2-1156-0106-08: Development of photocatalytic superparamagnetic nanocomposites for application in diminishing emissions of harmful pollutants into the environment
   Cinkarna Celje, d. d.
   Prof. Darko Makovec
3. Cooperation in development of magnetic nanoparticles for magnetofection
   Nanotesla Institute Ljubljana
   Prof. Darko Makovec

VISITORS FROM ABROAD

1. Sándor Hosszú, Laszló Jakab, Tibor Berceli, Budapest University of Technology and Economics, Budapest, Hungary, 18.–19. 3.2009.
2. Patrick Queffelec, University of Brest, Brest, France, 18.–19. 3. 2009.
3. Gilles Martin, Chelton Telecom & Microwave, Goussainville, France, 18.–19. 3. 2009.
4. Jean Pierre Ganne in Richard Lebourgeois, Thales S.A., Palaiseau, France, 18.–19. 3. 2009.
5. Daniel Caban-Chastas, Thales Systems Aeroportes SA, Elancourt, France, 18.–19. 3. 2009.
6. Robert Szelenbaum, Dyderski Piotr, Ryszard Frender, Telecommunication Research Institute, Warsaw, Poland, 18.–19. 3. 2009.
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8. Anna Sztaniszlav, Daniel Sztaniszlav, Vince Botyánszki, TKI Ferrit, Budapest, Hungary, 18.–19. 3. 2009.
9. Svetoslav M. Kolev, IE-BAS, Sofia, Bulgaria, 1. 4.–10. 12. 2009.
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11. Pavel Veverka, Ondrej Kaman, Institute of Physics ASCR, Prague, Czech Republic, 14.–27. 9. 2009.
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13. Tatyana Koutzarova, IE-BAS, Sofia, Bulgaria, 26. 10.–2. 11. 2009.
14. Botyanszki Vince, TKI-Feriti, Material Synthesis by TKI–Ferrite, Budapest, Hungary, 27.10.2009.

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Original Articles

1. M. Bégard, Darja Lisjak, Sašo Gyergyek, (12 authors), "Thermal spraying of Co,Ti-substituted Ba-hexaferrite coatings for electromagnetic wave absorption applications", *Surf. coat. technol.*, vol. 203, no. 20/21, pp. 3312-3319, 2009.
2. D. Branković, Vukoman Jokanović, B. Babić-Stojić, Zvonko Jagličić, Darja Lisjak, D. Kojić, "Interference effect between superparamagnetic and spin glass correlated moments in a system of dispersed Co_3O_4 nanocrystallites", *J. phys., Condens. matter*, vol. 21, no. 9, pp. 095303-1-095303-11, 2009.
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5. Mirjana Küzma, Robert Dominko, Anton Meden, Darko Makovec, Marjan Bele, Janko Jamnik, Miran Gaberšček, "Electrochemical activity of Li_2FeTiO_4 and for Li ion batteries: A comparison with Li_2NiTiO_4", V: *Selected papers presented at the 14th international meeting on lithium batteries : Tianjin, China, 22 -28 June 2008 : IMLB-2008*, (Journal of power sources, Vol. 189, Issue 1, 2009), Lausanne, Elsevier, 2009, issue 1, vol. 189, str. 81-88, 2009. [COBISS.SI-ID 4119578]
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7. Darja Lisjak, Mihael Drofenik, (12 authors), "Preparation of barium hexaferrite coatings using atmospheric plasma spraying", *J. Eur. Ceram. Soc.*, vol. 29, no. 11, pp. 2333-2341, 2009.
8. Darja Lisjak, et al. (9 authors), "The preparation of barium hexaferrite coatings using HVOF", *J. Am. Ceram. Soc.*, vol. 92, no. 4, pp. 818-824, 2009.
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11. Simona Ovtar, Darja Lisjak, Mihael Drofenik, "Barium hexaferrite suspensions for electrophoretic deposition", *J. colloid interface sci.*, vol. 337, no. 2, pp. 456-463, 2009.
12. Darinka Primc, Darko Makovec, Darja Lisjak, Mihael Drofenik, "Hydrothermal synthesis of ultrafine barium hexaferrite nanoparticles and the preparation of their stable suspensions", *Nanotechnology (Bristol)*, vol. 20, no. 31, pp. 315605-1-315605-9, 2009.

PUBLISHED CONFERENCE PAPERS

Invited Paper

1. Darja Lisjak, "Mikrovalovni heksaferiti", In: *Slovenski kemijski dnevi 2009, Maribor, 24. in 25. september 2009*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, FKKT, [2009], 10 pp.

Regular papers

1. G. Bolelli, Darja Lisjak, (12 authors), "Thermally-sprayed $BaCoTiFe_{10}O_{19}$ layers as microwave absorber", In: *ITSC 2009: proceedings from the 2009 International Thermal Spray Conference, May 4-7, 2009, Las Vegas, Nevada*, Basil Richard Marple, ed., [S. L.], The Materials Information Society, 2009, pp. 628-633.
2. Brina Dojer, Matjaž Kristl, Mihael Drofenik, Amalija Golobič, Marta Kasunič, Zvonko Jagličić, "Sinteza in karakterizacija bishidroksilamonijevega tetrafluorokobaltata(II) in tetrafluorokuprata(II)", In: *Slovenski kemijski dnevi 2009, Maribor, 24. in 25. september 2009*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, FKKT, [2009], 9 pp.
3. Matjaž Kristl, Irena Ban, Anita Danč, Valerija Danč, Mihael Drofenik, "Sonokemijska metoda za sintezo CdS in CdSe: priprava nanodelcev za uporabo v fotocelicah", In: *Knjiga povzetkov, Zbornik*, Slovenska konferenca o materialih in tehnologijah za trajnostni razvoj, Ajdovščina, 11.-12. maj 2009, Matjaž Valant, ed., Urša Pirnat, ed., V Novi Gorici, Založba Univerze, 2009, pp. 42-51.
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5. Simona Ovtar, Mihael Drofenik, Massimo Pasquale, Darja Lisjak, "Electrophoretically prepared barium hexaferrite thick films for microwave absorbers", In: *Knjiga povzetkov, Zbornik*, Slovenska konferenca o materialih in tehnologijah za trajnostni razvoj, Ajdovščina, 11.-12. maj 2009, Matjaž Valant, ed., Urša Pirnat, ed., V Novi Gorici, Založba Univerze, 2009, pp. 84-88.

TEXTBOOKS AND LECTURE NOTES

1. Irena Ban, Matjaž Kristl, *Vaje iz splošne in anorganske kemije: navodila za vaje*, Maribor, Fakulteta za kemijo in kemijsko tehnologijo, 2009.

PATENT APPLICATION

1. Darko Makovec, Dejan Verhovšek, Marjan Sajko, *Fotokatalitski nanosi TiO2 na superparamagnetnih nosilcih ter postopek njihove izdelave: patent application P-200900337*, Ljubljana, Urad RS za intelektualno lastnino, 3. nov. 2009.

DEPARTMENT FOR ADVANCED MATERIALS K-9

The primary activities of the department are the development of new materials, and new processes for the preparation of such materials, in the form of nanostructures and nanocomposites. The main objective of the current projects is the synthesis of new, environmentally friendly materials with special electrical and optical properties, with the emphasis on tunable materials that exhibit a dependence of the electric polarization on external electric, mechanical or magnetic fields and, furthermore, the development of new dielectrics and semiconductors that can be exploited for their microwave and optical properties.

Head:
Prof. Danilo Suvorov

Development of tunable materials

We have investigated the structural and electrical characteristics of the $Na_{0.5}Bi_{0.5}TiO_3$-$SrTiO_3$ ceramic system. The end-members of the system have already been thoroughly investigated with respect to their various characteristics; however, their solid-solution has very seldom been the focus of research. $Na_{0.5}Bi_{0.5}TiO_3$ is a complex perovskite with relaxor characteristics, related to the compound's compositional disorder. Recently, it has been tested frequently for applications in electronic devices, mainly as an ecological alternative to lead-containing relaxors. $SrTiO_3$ is a well-known incipient ferroelectric and therefore enables a shift of the $Na_{0.5}Bi_{0.5}TiO_3$ phase transitions towards lower temperatures. In this way we were able to control the samples` polar order and the intensity of the dielectric relaxations at room temperature. We observed that samples with intermediate compositions have the most intense relaxation and thus exhibit a pronounced stress tunability. Moreover, samples with a higher $SrTiO_3$ concentration have smaller dielectric losses and still a marked DC-bias dependence of the dielectric constant. These samples are therefore attractive for voltage-tunable applications, such as varactors, phase shifters, etc.

In addition, we focused on perovskite ceramics in the form of the $(Na_{1-x}K_x)_{0.5}Bi_{0.5}TiO_3$ solid solution system (NBT-KBT). NBT crystallizes in the rhombohedral R3c polar structure, whereas KBT exhibits the tetragonal P4mm polar structure. At a concentration of 80 mol% of NBT in the NBT-KBT solid solution the samples consist of coexisting tetragonal and rhombohedral crystal structures, which are both thermodynamically stable and form a morphotropic phase boundary. We performed transmission electron microscopy and electron diffraction experiments of the local structure of pure KBT and found that the grains consist of typical differently oriented transformation domains separated by <100> and <110> twin boundaries.

We found that during the synthesis of $K_{0.5}Bi_{0.5}TiO_3$ the volatilization of the potassium and bismuth components occurs, followed by a thermal decomposition of the matrix phase during annealing at temperatures higher than 1000°C This leads to the formation of potassium polytitanate and bismuth-rich phase $K_{0.5}Bi_{4.5}Ti_4O_{15}$ with an Aurivillius-type crystal structure. In contrast, some papers report single-phase ceramic samples, sintered from powders prepared by different methods. Therefore, we started with investigations of materials prepared by the hydrothermal and molten salt methods.

Measurements of the uniaxial stress dependence of permittivity in lead-free $Na_{0.5}Bi_{0.5}TiO_3$-based materials showed the most favorable results for relaxor compositions. These materials exhibit the highest change in the permittivity. Moreover, the change of permittivity was reversible above the temperature of the permittivity maximum. Thereafter, relaxor compositions from the $Na_{0.5}Bi_{0.5}TiO_3$– $SrTiO_3$ system with an even higher dielectric constant were investigated. Measurements of the stress dependence of the permittivity for compositions with 50 and 70 mol% of $SrTiO_3$ showed a decrease in the relative permittivity of 400 and 900, respectively, at an applied pressure of 200 MPa and a measuring frequency of 1 kHz. The change of the permittivity was reversible, which gives potential applications of these materials in pressure sensing

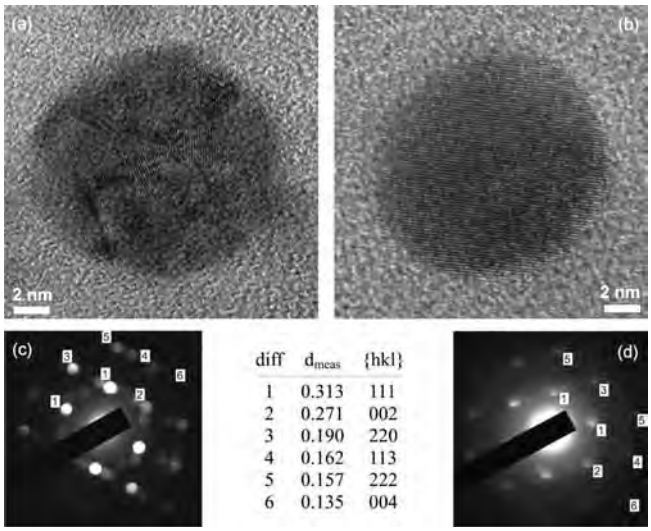

Figure 1: TEM images of (a) a ZnS nanocluster and (b) a ZnS nanoparticle after subsequent recrystallisation, formed in a (PAH/PAA)$_{7.5}$ polyion matrix assembled at pH=3.0 with the corresponding micro-diffraction patterns(c,d)

Development of microwave dielectrics

In the scope of further research on coherent intergrowths between the ordered cubic perovskite $Ba_3CoNb_2O_9$ and polytypes of hexagonal perovskite

In collaboration with Epcos OHG we developed LTCC-technology-compatible ceramic materials with a thermal expansion coefficient that can be tailored in the range 4-12 ppm/K. Regarding the dielectric properties, these materials are superior to those available commercially.

with cation vacancies we investigated the formation of intergrowth phases within the $Ba_3CoNb_2O_9$ – $Ba_5Nb_4O_{14}$ (BCN-5L) system. We found that the intergrown phase forms during the first stage of reaction among the cubic BCN and five-layered hexagonal 5L perovskite. In the second stage the Co diffuses from the cubic into the hexagonal part and in the third phase the Co orders to occupy every eighth (111)c plane. Coherently intergrown phases can thus be understood as a transient phenomenon during ordering into the thermodynamically stable 1:8 ordered hexagonal polytypic phase.

We continued with investigations of the glass-ceramic $MgO\text{-}B_2O_3\text{-}SiO_2$ system and studies of the binary compound $Mg_3B_2O_6$, which crystallizes from the aforementioned ternary system. Nucleating agents (TiO_2 and ZrO_2) were added to the initial oxides from the $MgO\text{-}B_2O_3\text{-}SiO_2$ system with the intention to increase the crystallization rate and to influence the dielectric properties. In both cases the temperature of the peak maximum increases with the amount of added nucleating agent and, furthermore, the Qxf values also increase with the amount of nucleating agent. We assume that the higher Qxf values are the result of a higher degree of crystallization. The highest Qxf values above 160,00GHz were measured for the sample with 7% of added TiO_2.

During the synthesis of the single-phase $Mg_3B_2O_6$ ceramics sintered at 1310°C we observed exaggerated grain growth, which is attributed to the presence of a liquid phase. This could be due to: 1) the melting of the glassy phase, which is often present in systems containing B_2O_3 or 2) the presence of a small amount of $Mg_2B_2O_5$, which according to the reported phase diagram incongruently melts at the temperature close to the sintering temperature of $Mg_3B_2O_6$. The Qxf values increase with the increase in the grain size and the maximum measured values of $Mg_3B_2O_6$, ceramics with or without the addition of $Mg_2B_2O_5$ exceed 220,000GHz. With the use of electron back-scatter diffraction we determined (011) twin boundaries within the exaggeratedly grown grains.

In the scope of the applied project with EPCOS OHG, Deutschlandsberg, Austria, several low-permittivity LTCC materials with temperature expansion coefficients (TCEs) of 4, 6-8, 10-12 ppm/K have been developed. Simultaneous co-firing of materials in the LTCC modules requires their matching in the TCE. The majority of applications requires a low-permittivity substrate with TCE 6-8 ppm/K; however, higher TCE materials are more appropriate in some cases. In contrast to the commercially used glass-based substrates, we managed to sinter the ceramics at the LTCC conditions with small additions of borates. Regarding the dielectric properties, the developed materials exceed those values of the commercially used materials.

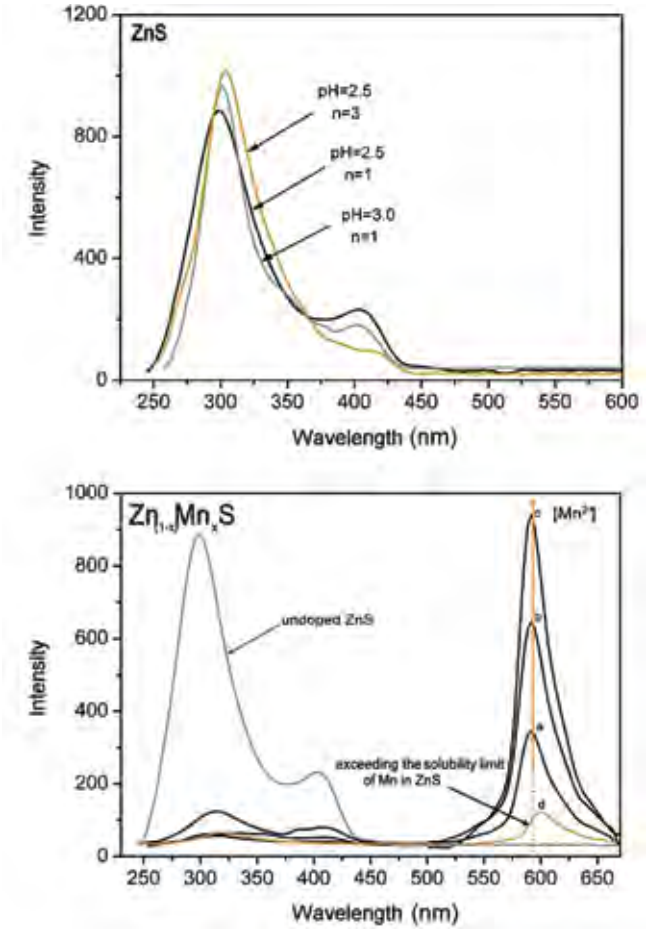

Figure 2: Photoluminiscence (PL) spectra of ZnS nanoparticles synthesized with n=1 and n=3 reaction cycles in $(PAH/PAA)_{2.5}$ polyelectrolyte multilayers assembled at a pH value of 2.5 and at a pH of 3.0 and the PL spectra of undoped and Mn-doped ZnS nanoparticles in a polyion matrix assembled at a pH value of 2.5, n=1, exposed to the various concentrations of Mn solution (a) 0.001M, (b) 0.0015M, (c) 0.002 and (d) 0.003M.

Research of nanostructured materials and nanocomposites

Research of nanomaterials has been focused on investigations of low-dimensional titanate nanostructures, the synthesis of nanopowders of the relaxor perovskite $Na_{0.5}Bi_{0.5}TiO_3$ and high-surface-area nanopowders of TiO_2.

Hydrothermally synthesized layered titanate-based nanotubes (din = 4–5 nm, dout = 8–10 nm, L = 100 nm – several 100 nm) were introduced in further hydrothermal reactions as a template material for the preparation of nanotubes with modified properties (i.e., photocatlytic activity) and as a precursor for the synthesis of the nanostructured perovskite $CaTiO_3$. The hydrothermal intercalation of calcium into the structure of the precursor at 100°C for 5 days led to the formation of nanotubes with the maximum amount of incorporated calcium. The Ca^{2+}-exchanged nanotubes inherited the dimensions of the precursor and exhibited improved photocatalytic activity as compared to the template nanotubes. The hydrothermal treatment of the precursor in the presence of a source of calcium at 150°C yielded the formation of clusters of nanosized crystals of orthorhombic $CaTiO_3$. The crystals were 100–300 nm wide and 500–800 nm long. The crystals grow in the [010] direction and have edges curled perpendicular to the growth direction, which suggests the influence of the precursor's morphology on the formation of nanosized $CaTiO_3$ crystals.

The hydrothermal method was employed for the preparation of nanosized $Na_{0.5}Bi_{0.5}TiO_3$ (NBT) particles, suitable for further thin-film fabrication. Under the hydrothermal conditions of the selected precursors several different solid phases can form, besides NBT, 1-D sodium titanate and bismuth titanate phases of various stoichiometry. Therefore, the focus of our study was the correlation between the chemical-thermodynamic parameters applied in the synthesis and the phase composition and morphology of the obtained powders. Furthermore, we introduced organic surface-active agents and polymers into the hydrothermal reactions, in order to control the particle size. Polymers and surfactants can be used to facilitate the dispersion of inorganic particles in a given solvent; in addition, they may also control the process of nucleation and inhibit the crystal growth through adsorption on the growing facets. Best results were obtained by the employment of an SDS surfactant (sodium dodecyl sulfate) combined with polymer PVP (polyvinyl pyrrolidone). With this surfactant/polymer-assisted synthesis we obtained NBT particles of small size (~50 nm) and a narrow size distribution.

We developed a synthesis process that enables control of the size and consequently the optical properties of semiconducting ZnS nanoparticles within a polyelectrolyte matrix.

With the combination of sol-gel and solvothermal synthesis we prepared anatase powders with a high crystallinity and a high specific surface area (up to 335 m^2/g). We established the influence of triblock copolymere P123 as a TiO_2 framework template and phosphorous as a framework stabilizer on crystallinity and the specific surface area of un-annealed and annealed (500–1000°C) anatase powders. We can conclude that by the use of triblock copolymer P123 and phosphorous it is possible to prepare anatase powders with a high crystallinity and a high specific surface area (296 m^2/g) that remains high even after annealing at higher temperatures (500°C, 176 m^2/g). By analyzing samples prepared with and without phosphorous we can presume that the incorporation of the phosphorous into the TiO_2 framework increases the thermal stability of the anatase.

We also synthesized Ca and Ca-Mg carbonate particles in different polyols, where carbonate particles with various morphologies and different crystal structures were formed, depending on the reaction parameters.

It seems that the aragonite particles synthesized in ethylene glycol grow in accordance with an aggregation mechanism and they appear in a sheaf-like shape. However, the calcite particles synthesized in di- and tetraethylene glycol appear in a cube-like and a scalenoeder-like shape.

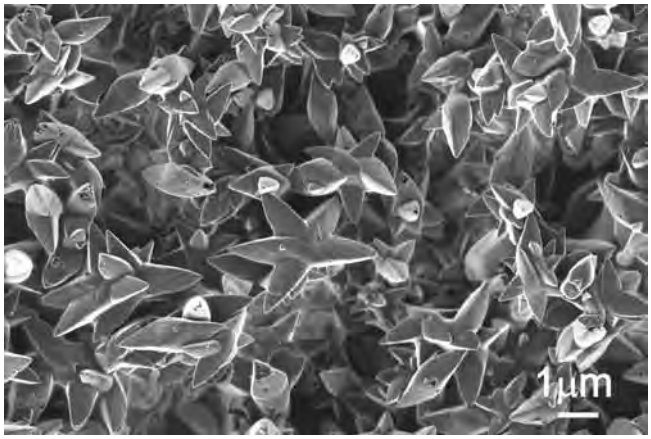

Figure 3: Scalenoeder-shaped calcite particles precipitated from a $CaCl_2$ solution in tetraethylene glycol at 140 °C

In the scope of the research on nanocomposites we synthesized inorganic-organic nanocomposite thin films of ZnS and Mn-doped ZnS. The organic matrix in the form of polyelectrolyte multilayers (PEMs) was fabricated using the layer-by-layer (LbL) self-assembly of weak polyion of polyacryllic acid (PAA) and polyallylamine (PAH) due to the electrostatic interactions between appositively charged polyion chains. The conformational arrangement of the polyion chains induced by a variation in the assembly pH is the key parameter that affects the structural and morphological characteristics of ZnS nanocrystallites. The morphology of the ZnS nanoparticles suggests that the as-formed ZnS clusters are constructed of more primary building particles of different orientations. In order to reduce the high surface energy the primary particles, which are 2–3 nm in diameter, tend to assemble into larger clusters by a random-aggregation mechanism. Within the clusters, primary ZnS particles aggregated in a random manner underwent a subsequent recrystallisation process, resulting in single-crystalline particles. By cycling the absorption-precipitation reaction process, further growth of the initially formed particles by the Ostwald ripening mechanism resulted in an increase in the volume density of ZnS nanoparticles within the polyion matrix. With the ability to obtain control over the size, the size distribution and the density of the surface states on the ZnS nanoparticles, attributed to the surface passivation of the ZnS nanoparticles by the polyion matrix, the tunability of the optical absorption and emission properties of the inorganic/organic nanostructured composite films can be obtained. The surface passivation of the ZnS nanocrystallites within the polyion matrix enables the enhanced radiative emission of ZnS composite films in the UV range, whereas by doping the ZnS nanocrystallites show emission characteristics of the manganese ions in the visible region.

Some outstanding publications in 2009

1. Jana Bezjak, Aleksander Rečnik, Boštjan Jančar, Philippe Boullay, Ivana Radosavljević Evans, Danilo Suvorov, "High-temperature transmission electron microscopy and X-ray powder diffraction studies of polymorphic phase transitions in $Ba_4Nb_2O_9$", J. Am. Ceram. Soc., Vol. 92, No. 8, pp. 1806-1812, 2009.
2. Jakob König, Matjaž Spreitzer, Boštjan Jančar, Danilo Suvorov, Zoran Samardžija, Arkadije Popović, "The thermal decomposition of $K_{(0.5)}Bi_{(0.5)}TiO_3$ ceramics", J. Eur. Ceram. Soc., Vol. 29, No. 9, pp. 1695-1701, 2009.

3. Špela Kunej, Srečo D. Škapin, Danilo Suvorov, "Phase relations in the pyrochlore-rich part of the Bi_2O_3-TiO_2-Nd_2O_3 system", J. Am. Ceram. Soc., Vol. 92, No. 10, pp. 2373-2377, 2009.
4. Manca Logar, Boštjan Jančar, Aleksander Rečnik, Danilo Suvorov, "Controlled synthesis of pure and doped ZnS nanoparticles in weak polyion assemblies : growth characteristics and fluorescence properties", Nanotechnology (Bristol), Vol. 20, No. 27, pp. 275601-1-275601-11, 2009.
5. Ni Qin, Marjeta Maček, Anton Meden, Danilo Suvorov, "Structural investigation of $K_xBa_{(1-x)}Ga_{(2-x)}Ge_{(2+x)}O_8$ solid solutions using the X-ray Rietveld method", J. Solid State Chem., Vol. 182, No. 7, pp. 1666-1672, 2009.

Awards and appointments

1. Ines Bračko, Urban Došler, Mojca Otoničar, Tina Šetinc, Asja Veber, Vojka Žunič: Award for efficient presentation of research achievements, Ljubljana, Jožef Stefan International Postgraduate School, Presentation of young researchers of Advanced Materials Department

Organization of conferences, congress and meetings

1. 3rd Slovenia- Korea Workshop on Advanced Materials, Ljubljana, Slovenia, 11–14 May 2009.
2. Materials Science & Technology 2009 Conference and Exhibition, International Symposium on Dielectric Materials and Electronic Devices, Pittsburgh, USA, 25– 29 October 2009 (co-organizers).

INTERNATIONAL PROJECTS

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
   Dr. Srečo D. Škapin, Dr. Miha Čekada, Prof. Janez Dolinšek, Dr. Kristoffer Krnel
2. 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
3. Functional Nanostructured Ceramic Materials
   BI-AR/09-11-001
   Prof. Noemí Elisabeth Walsöe de Reca, CINSO (Centro de Investigaciones en Sólidos), CITEFA-CONICET, Buenos Aires, Argentine
   Prof. Danilo Suvorov
4. High K Dielectrics for Mobile Phone Base Stations
   Agreement IJS/EPCOS
   Dr. Christian Hoffmann, Pavol Dudesek, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
   Prof. Danilo Suvorov
5. LTCC Materials for High Frequency Applications
   Agreement IJS/EPCOS
   Pavol Dudesek, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
   Prof. Danilo Suvorov
6. Relaxor-based Tunable Materials
   T080038
   Dr. Christian Hoffmann, Dr. Andrea Testino, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
   Prof. Danilo Suvorov, Dr. Boštjan Jančar
7. LTCC Materials for High Frequency Applications
   T080033
   Pavol Dudesek, EPCOS OHG Ceramic Components Division, Deutschlandsberg, Austria
   Prof. Danilo Suvorov, Dr. Marjeta Maček Kržmanc
8. Biomimetic Preparation of Inorganic Nanomaterials
   BI-HR/09-10-037
   Dr. Ivan Sondi, Ruđer Bošković Institute, Zavod za raziskovanje morja in okolja, Zagreb, Croatia
   Dr. Srečo Davor Škapin
9. Ultra-low Dielectric Constant LTCC Material
   BI-CN/09-11-013
   Dr. Xing Hu, South China University of Technology, Guangzhou, China
   Dr. Srečo Davor Skapin
10. Synthesis of Piezoelectric Thin Films and Magnetoelectic Composites by a Layer-by-layer Self Assembly
    BI-KR/09-11-001
    Dr. Jae-Ho Jeon, Korea Institute of Materials Science, Changwon, Korea
    Prof. Danilo Suvorov
11. Designing of Functional Materials on Molecular and Nano Level
    Dizajniranje funkcionalnih materiala na molekularnom i nano nivou
    BI-RS/08-09-027
    Prof. Dragan Uskoković, Institut tehničkih nauka Srpske akademije nauka i umetnosti, Belgrade, Serbia
    Prof. Danilo Suvorov
12. Electric-field Tunable Ferroelectric Materials Based on $Na_{0,5}Bi_{0,5}TiO_3$
    BI-UA/09-10-007
    Prof. Anatolii Belous, SPE "Oxid" of V.I. Vernadskii Institute of General & Inorganic Chemistry NAS of Ukraine - Solid State Chemistry Department, Kiev, Ukraine
    Prof. Danilo Suvorov
13. Materials World Network: Improved Lanthanide-based Filters for Mobile Telekommunications
    BI-US/08-10-005
    Prof. Rick Ubic, Boise State University, Boise, Idaho, USA
    Prof. Danilo Suvorov

R & D GRANTS AND CONTRACTS

1. Self-cleaning antibacterial fotocatalitic coatings in whitewear production
   Prof. Danilo Suvorov
2. Functionalization of the surface of organic pigments for durable, efficient and colour-stable paints
   Dr. Srečo Davor Škapin
3. Physics and chemistry of porous aluminium for Al panels, capable of highly efficient energy absorbtion
   Prof. Danilo Suvorov
4. Multifunctional composites based on Al-Mg-Ti intermetallic compounds, reinforced with ceramic particles
   Dr. Srečo Davor Škapin

RESEARCH PROGRAM

1. Contemporary inorganic materials and nanotechnologies
   Prof. Danilo Suvorov

NEW CONTRACT

1. Co-financing L2-2185: Self-cleaning antibacterial fotocatalitic coatings in whitewear production
   Gorenje Household Appliances, d. d.
   Prof. Danilo Suvorov

VISITORS FROM ABROAD

1. Prof. Taras Kolodiazhnyi, National Institute for Materials Science, Tskukuba, Japan, 17 February 2009.
2. Dr. Ivan Sondi, Ruđer Bošković Institute, Zagreb, Croatia, 19 February 2009
3. Prof. Dragan Uskoković, Institute of Technical Sciences of SASA, Belgrade, Serbia, 22-26 April 2009.
4. Dr. Christian Hoffmann, EPCOS OHG, Deutschlandsberg, Austria, 22 April 2009.
5. Prof. K. Byrappa, University of Mysore, Mysore, India, 30 May to 3 June 2009.
6. Dr. Noemi Elisabeth Walsöe de Recca, Centro de Investigaciones en Solidos, CITEFA-CONICET, Buenos Aires, Argentina, 30 June to 22 July 2009.
7. Prof. Masahiro Yoshimura, Tokyo Institute of Technology, Yokohama, Japan, 23-26 August 2009.
8. Aleksander Babak B. Sc., NPP "Tomilinsky elektronny zavod", Tomilin, Russia, 21 August 2009.
9. Anton Konda B. Sc., Keko oprema, Žužemberk, Slovenia, 21 August 2009.
10. Dr. Christian Hoffmann, EPCOS OHG, Deutschlandsberg, Austria, 4 September 2009.
11. Dr. Pavol Dudešek, EPCOS OHG, Deutschlandsberg, Austria, 4 September 2009.
12. Dr. Hyo-Tae Kim, Korea Institute of Ceramic Engineering and Technology, Seoul, Korea, 22-24 October 2009.
13. Dr. Kyung Hoe Kim, Korea Institute of Ceramic Engineering and Technology, Seoul, Korea, 22-24 October 2009.
14. Dr. Yukio Sakabe, Murata, Kyoto, Japan, 11-18 October 2009.
15. Silva Gabriella Nobre Meneah, University of Sao Paolo, Sao Paolo, Brazil, 18-25 November 2009.
16. Monyse Nobre Meneah, University of Sao Paolo, Sao Paolo, Brazil, 18-25 November 2009.
17. Prof. Anatolii Belous, V. I. Vernadsky Institute of General and Inorganic Chemistry, Kiev, Ukraine, 10-15 November 2009.
18. Dr. Oleg Ovchar, V. I. Vernadsky Institute of General and Inorganic Chemistry, Kiev, Ukraine, 10- 29 November 2009.

Visiting researchers:

1. Marija Vukomanović, M.Sc., Institute of Technical Sciences of SASA, Belgrade, Serbia, 4 May 2009 to 31 December 2009.
2. Dr. Jyoti Prosad Guha, University of Rolla, Rolla, USA, 27 May to 31 August 2009.
3. Dr. Smilja Marković, Institute of Technical Sciences of SASA, Belgrade, Serbia, 2 November to 18 December 2009.

STAFF

Researchers
1. Asst. Prof. Boštjan Jančar
2. Dr. Marjeta Maček Kržmanc
3. **Prof. Danilo Suvorov, Head**
4. Dr. Srečo Davor Škapin

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6. Dr. Uroš Kunaver*
7. Dr. Špela Kunej
8. Dr. Manca Logar
9. Dr. Matjaž Spreitzer
10. Dr. Marko Udovič*

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11. Ines Bračko, B. Sc.
12. Urban Došler, B. Sc.
13. Mojca Otoničar, B. Sc.
14. Tina Šetinc, B. Sc.
15. Asja Veber, B. Sc.
16. Vojka Žunič, B. Sc.
17. Dr. Jana Bezjak**

Technical and administrative staff
18. Maja Šimaga Saje, M. Sc.
19. Silvo Zupančič

Note:
* part-time JSI member
** young researcher financed by industry

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Anatolii Belous, Boštjan Jančar, Matjaž Spreitzer, (7 authors), "The effect of chemical composition on the structure and dielectric properties of the columbites $A^{2+}Nb_2O_6$", *J. Electrochem. Soc.*, vol. 156, no. 12, pp. G206-G212, 2009.
2. Anatolii Belous, et al. (10 authors), "Low-loss perovskite niobates $Ba(M^{2+}_{1/3}Nb_{2/3})O_3$: composition, structure, and microwave dielectric properties", In: *MMA 2008, The 5th International Conference on Microwave Materials and Their Applications, November 1-4, 2008, Hangzhou, China*, (Ferroelectrics, vol. 376, no. 1, 2009), New York, Gordon and Breach, 2009, vol. 387, no. 1, pp. 36-45, 2009.
3. Jana Bezjak, Boštjan Jančar, Philippe Boullay, Aleksander Rečnik, Danilo Suvorov, "Hexagonal perovskite-type phases in the BaO-rich part of the BaO – WO_3 – Nb_2O_5 system", *J. Am. Ceram. Soc.*, issue 12, vol. 92, pp. 3022-3032, 2009.
4. Jana Bezjak, Aleksander Rečnik, Boštjan Jančar, Philippe Boullay, Ivana Radosavljević Evans, Danilo Suvorov, "High-temperature transmission electron microscopy and X-ray powder diffraction studies of polymorphic phase transitions in $Ba_4Nb_2O_9$", *J. Am. Ceram. Soc.*, vol. 92, no. 8, pp. 1806-1812, 2009.
5. Xing Hu, Srečo D. Škapin, Danilo Suvorov, "Subsolidus phase relations in the $Bi_4Ti_3O_{12}$ – Ag/Ag_2O – TiO_2 system", *J. Ceram. Soc. Jpn. (Print)*, vol. 117, no. 1364, pp. 494-498, 2009.
6. Marta Kasunič, Anton Meden, Srečo D. Škapin, Danilo Suvorov, Amalija Golobič, "Order-disorder of oxygen anions and vacancies in solid solutions of La_2TiO_5 and $La_4Ga_2O_9$", *Acta crystallogr., B Struct. sci.*, vol. B65, no. 5, pp. 558-566, 2009.
7. Varužan Kevorkijan, Srečo D. Škapin, "Fabrication and characterisation of Mg-B_4C composites", *Metalurgija*, vol. 15, br. 1, pp. 3-18, 2009.
8. Varužan Kevorkijan, Srečo D. Škapin, "Fabrication and characterization of TiAl/Ti_3Al-based intermetallic composites (IMCS) reinforced with ceramic particles", *Metalurgija*, vol. 15, br. 2, pp. 75-89, 2009.
9. Varužan Kevorkijan, Srečo D. Škapin, "Mg/B_4C composites with a high volume fraction of fine ceramic reinforcement", *Mater. manuf. process.*, vol. 24, iss. 12, pp. 1337-1340, Dec. 2009.
10. Varužan Kevorkijan, Srečo D. Škapin, "Preparation and testing of prototype Mg_2Si – Mg – TiC and Mg_2Si – TiC/TiB_2 composites", *Mater. tehnol.*, vol. 43, no. 6, pp. 309-313, 2009.
11. Varužan Kevorkijan, Srečo D. Škapin, "Pressureless reactive sintering of TiAl-TiC and Ti3Al-TiC composites", *Mater. tehnol.*, vol. 43, no. 5, pp. 239-244, 2009.
12. Varužan Kevorkijan, Srečo D. Škapin, "Pressureless sintering and characterization of B_4C, TiC and TiB_2-particle-reinforced $TiAl_3$ matrix composites_", *Mater. tehnol.*, vol. 43, no. 3, pp. 123-128, 2009.
13. Jakob Koenig, Matjaž Spreitzer, Boštjan Jančar, Danilo Suvorov, Zoran Samardžija, Arkadije Popović, "The thermal decomposition of $K_{0.5}Bi_{0.5}TiO_3$ ceramics", *J. Eur. Ceram. Soc.*, pp. 1695-1701, 2009.
14. T. Kolodiazhny, Giuseppe Annino, Matjaž Spreitzer, T. Taniguchi, Robert Freer, F. Azough, A. Panariello, W. Fitzpatrick, "Development of Al_2O_3 – TiO_2 composite ceramics for high-power millimeter-wave applications", *Acta mater.*, vol. 57, no. 11, pp. 3402-3409, 2009.
15. Špela Kunej, Danilo Suvorov, "Dielectric properties of the $Bi_{(1.6-0.8x)}Y_xTi_2O_{(6.4+0.3x)}$ ($0.03 < x < 2$) pyrochlore solid solution", *J. Am. Ceram. Soc.*, vol. 92, no. 4, pp. 959-961, 2009.
16. Špela Kunej, Srečo D. Škapin, Danilo Suvorov, "Phase relations in the pyrochlore-rich part of the Bi_2O_3 – TiO_2 – Nd_2O_3 system", *J. Am. Ceram. Soc.*, vol. 92, no. 10, pp. 2373-2377, 2009.
17. Manca Logar, Boštjan Jančar, Aleksander Rečnik, Danilo Suvorov, "Controlled synthesis of pure and doped ZnS nanoparticles in weak polyion assemblies: growth characteristics and fluorescence

properties", *Nanotechnology (Bristol)*, vol. 20, no. 27, pp. 275601-1-275601-11, 2009.
18. Oleg V. Ovchar, et al. (10 authors), "The effect of impurity phases on the structure and properties of microwave dielectrics based on complex perovskites $Ba(Co^{2+}_{1/3}Nb_{2/3})O_3$", In: *MMA 2008, The 5th International Conference on Microwave Materials and Their Applications, November 1-4, 2008, Hangzhou, China*, (Ferroelectrics, vol. 376, no. 1, 2009), New York, Gordon and Breach, 2009, vol. 387, no. 1, pp. 189-196, 2009.
19. Ni Qin, Marjeta Maček, Anton Meden, Danilo Suvorov, "Structural investigation of $K_xBa_{1-x}Ga_{2-x}Ge_{2+x}O_8$ solid solutions using the X-ray rietveld method", *J. solid state chem.*, vol. 182, no. 7, pp. 1666-1672, 2009.
20. Raluca Savu, Boštjan Jančar, (10 authors), "The effect of cooling rate during hydrothermal synthesis of ZnO nanorods", *J. cryst. growth*, vol. 311, no. 16, pp. 4102-4108, 2009.
21. Ivan Sondi, Jasenka Biščan, Neda Vdović, Srečo D. Škapin, "The electrokinetic properties of carbonates in aqueous media revisited", *Colloids surf., A Physicochem. eng. asp.*, vol. 342, no. 1/3, pp. 84-91, 2009.
22. Matjaž Spreitzer, Boštjan Jančar, Danilo Suvorov, "Phase relations in the $Na_{0.5}Bi_{0.5}TiO_3 - Li_{3x}La_{(2/3)-x}\square_{(1/3)-2x}TiO_3$ system", *International journal of applied ceramic technology*, issue 2, vol. 6, pp. 302-311, 2009.
23. Marko Udovič, (8 authors), "Formation domain and characterization of new glasses within the $Tl_2O - TiO_2 - TeO_2$ system", *Mater. res. bull.*, vol. 44, no. 2, pp. 248-253, 2009.
24. Marko Udovič, Anton Meden, Danilo Suvorov, "Pyrochlore formation and its dielectric properties within $Bi_2O_3 - TiO_2 - WO_3$ ternary system", *Mater. sci. technol.*, vol. 25, no. 11, pp. 1325-1328, 2009.

Published Conference Papers

Invited Papers

1. Jakob Koenig, Matjaž Spreitzer, Boštjan Jančar, Danilo Suvorov, "Structural and dielectric properties of the $Na_{0.5}Bi_{0.5}TiO_3 - NaTaO_3$ ceramic system", In: *Advances in electroceramic materials: a collection of papers presented at the 2008 Materials Sceince and Technology Conference (MS&T08), October 5-9, 2008, Pittsburgh, Pennsylvania*, (Ceramic transactinos, vol. 204), K. M. Nair, ed., Danilo Suvorov, ed., R. W. Schwartz, ed., Ruyan Guo, ed., Hoboken, Wiley, Danvers, The American Ceramic Society, 2009, pp. 121-127.

Regular papers

1. Varužan Kevorkijan, Srečo D. Škapin, "Priprava in karakterizacija Mg_2Si-Mg-TiB_2 in Mg_2Si-TiC kompozitov", In: *Slovenski kemijski dnevi 2009, Maribor, 24. in 25. september 2009*, Peter Glavič, ed., Darinka Brodnjak-Vončina, ed., Maribor, FKKT, [2009], 11 pp.
2. Andrijana Sever Škapin, Luka Škrlep, Srečo D. Škapin, "Characterization of undoped and doped anatase for self-cleaning surfaces", In: *Conference proceedings*, 2nd International Conference on Advanced Plasma Technologies (iCAPT-II) & 1st International Plasma Nanoscience Symposium (iPlasmaNanoSym-I), September29th - October 2nd 2009, Piran, Slovenia, Uroš Cvelbar, ed., Miran Mozetič, ed., Ljubljana, Slovenian Society for Vacuum Technique, = DVTS - Društvo za vakuumsko tehniko Slovenije, 2009, pp. 181-184.

Theses

Ph. D. Theses

1. Jana Bezjak, *The synthesis and characterization of BaO-rich phases within the BaO-Nb_2O_5 and BaO-WO_3-NB_2O_5 system: doctoral dissertation*, Ljubljana, [J. Bezjak], 2009.
2. Jakob Koenig, *$Na_{(0.5)}Bi_{(0.5)}TiO_3$-based materials with mechanical-stress-dependent dielectric properties: doctoral dissertation*, Ljubljana, [J. König], 2009.
3. Manca Logar, *Polyelectrolyte multilayer template assisted in-situ synthesis of inorganic nanostructures: doctoral dissertation*, Ljubljana, [M. Logar], 2009.

DEPARTMENT OF BIOCHEMISTRY, MOLECULAR AND STRUCTURAL BIOLOGY B-1

The research activities of the members of the department are largely focused on studies of the physiological role of proteases in normal and pathological conditions, the mechanism of their action and regulation, as well as their properties and structure.

Head:
Prof. Boris Turk

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 in this regulation can lead to pathologies such as autoimmune, neurological and cardiovascular disorders, cancer and osteoporosis.

Proteases, including the caspases and the cathepsins, are critical mediators of apoptosis, the essential mechanism of an organism to remove damaged or superfluous cells. We have studied the role of cathepsins in apoptosis, induced by the tumour necrosis factor-alpha (TNF-alpha). TNF-alpha is a cytokine known to be an important mediator of apoptosis and inflammation and implicated in the pathogenesis of a number of diseases, including cancer and rheumatoid arthritis. Based on the use of pharmacological caspase inhibitors, TNF-alpha induced caspase-dependent apoptotic cell death, which was accompanied by lysosomal destabilization and the release of cathepsins in the cytosol. However, blocking cysteine cathepsins with cathepsin inhibitors had no effect on the progression of the apoptosis, suggesting that the TNF-alpha apoptosis is not critically dependent on the cathepsins in the cellular models used.

We have also continued our studies on the mechanisms of regulation of cysteine proteases. They are synthesized as zymogens, which are processed to their mature forms autocatalytically or by other proteases. Autocatalytic processing was suggested to be a bimolecular process, whereas initiation of the processing has not yet been clarified. Procathepsin B was shown by zymography to hydrolyze a synthetic substrate, suggesting that procathepsin B is catalytically active. The activity-based probe DCG-04, which is an E-64-type inhibitor, was found to label both mature cathepsin B and its zymogen, confirming the zymography data. Mutation analyses in the linker region between the propeptide and the mature part revealed that the autocatalytic processing of procathepsin B is largely unaffected by mutations in this region, including mutations to prolines. On the basis of these results, a model for the autocatalytic activation of cysteine cathepsins is proposed, involving propeptide dissociation from the active-site cleft as the first step during zymogen activation. This unimolecular conformational change is followed by a bimolecular proteolytic removal of the propeptide, which can be accomplished in one or more steps. Such activation, which can also be facilitated by glycosaminoglycans or by binding to negatively charged surfaces, may have important physiological consequences because cathepsin zymogens were often found to be secreted in various pathological states.

We have also continued with our work on protease inhibitors. The cystatin superfamily is composed of cysteine protease inhibitors that play key regulatory roles in protein-degradation processes. Although they have been the subject of many studies, little is known about their genesis, evolution and functional diversification. Our aim has been to obtain a comprehensive insight into their origin, distribution, diversity, evolution and classification in Eukaryota, Bacteria and Archaea. We have identified in silico the full complement of the cystatin superfamily in more than 2100 prokaryotic and eukaryotic genomes. The analysis of numerous eukaryotic genomes has provided strong evidence for the emergence of this superfamily in the ancestor of eukaryotes. The progenitor of this superfamily was most probably intracellular and lacked a signal peptide and disulfide bridges, much like the extant Giardia cystatin. A primordial gene duplication produced two ancestral eukaryotic lineages, cystatins and stefins. While stefins remain encoded by a single or a small number of genes throughout the eukaryotes, the cystatins have undergone a more complex and dynamic evolution through numerous gene and domain duplications. In the cystatin superfamily we discovered 20 vertebrate-specific and 3 angiosperm-specific orthologous families, indicating that functional diversification has occurred only in multicellular eukaryotes. In vertebrate orthologous families, the prevailing trends were a loss of the ancestral inhibitory activity and the acquisition of novel functions in innate immunity. Bacterial cystatins and stefins may be emergency inhibitors that enable the survival of bacteria in the host, defending them from the host's proteolytic activity. The findings thus provide guides for future structural and evolutionary studies of the cystatin superfamily as well as of other protease inhibitors and proteases.

Our studies on stefin formation of amyloid fibers extended our knowledge of their structure and cellular toxicity. We have also investigated the putative role of cystatins in Alzheimer's disease and in neuroprotection in general, and studied the interaction between human stefin B (cystatin B) and amyloid- beta(1-40) peptide (Abeta). Using surface

plasmon resonance and mass spectrometry we were able to show a direct interaction between the two proteins. As an interesting new fact, we show that stefin B binding to Abeta is oligomer-specific. The dimers and tetramers of stefin B, which bind Abeta, are domain-swapped, as judged from structural studies. Consistent with the binding results, the same oligomers of stefin B inhibited Abeta-fibril formation. When expressed in cultured cells, stefin B co-localised with Abeta intracellular inclusions. It also co-immunoprecipitated with the APP fragment containing the Abeta epitope. Thus, stefin B is another APP/Abeta-binding protein *in vitro* and likely in cells.

In the group of structural biology they have, in addition, solved the structures of several new proteins and/or protein complexes. They focused on the plant cysteine protease inhibitors mycocypins, clitocypins and macrocypins, isolated from the mushrooms *Clitocybe nebularis* and *Macrolepiota procera*. The crystal structures of the complex of clitocypin with the papain-like cysteine protease cathepsin V and of macrocypin and clitocypin alone have revealed yet another motif of binding to papain like-cysteine proteases, which in a yet unrevealed way occludes the catalytic residue. The binding is associated with a peptide-bond flip of glycine that occurs before or concurrently with the inhibitor docking. Mycocypins possess a beta-trefoil fold, the hallmark of Kunitz-type inhibitors. The two loops that bind to cysteine cathepsins belong to the lower layer of the crown loops, whereas a single loop from the crown region can inhibit trypsin or asparaginyl endopeptidase, as demonstrated by site-directed mutagenesis. These loops present a versatile surface with the potential to bind to additional classes of proteases. When appropriately engineered, they could provide the basis for possible exploitation in crop protection.

We participate in two FP7 projects, being the coordinators of one of them, "LIVIMODE", which started at the end of 2009. In addition, there are many other international collaborations with many high-quality research teams from different countries, including Belgium, Germany, UK, 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 2009

1. Dušan Kordiš, Vito Turk. Phylogenomic analysis of the cystatin superfamily in eukaryotes and prokaryotes. BMC Evol Biol, 2009, 9, 266.
2. Jun Zhang, Marko Fonović, Kaye Suyama, Matthew Bogyo, Matthew P. Scott. Rab35 controls actin bundling by recruiting fascin as an effector protein. Science (Washington D.C.), 2009, 325, 1250-1254.
3. Eva Žerovnik. The emerging role of cystatins in Alzheimer's disease. BioEssays, 2009, 31, 597-599.
4. Boris Turk, Vito Turk. Lysosomes as 'suicide bags' in cell death: myth or reality?. J Biol Chem, 2009, 284, 21783-21787

Organization of conferences and meetings

1. 26th Winter School on Proteinases and their Inhibitors, Recent Developments, Tiers, Italia, 25 Feb. to 3 Mar. 2009 (co-organisers)

INTERNATIONAL PROJECTS

1. Light-based Functional in Vivo Monitoring of Diseases Related Enzymes
   LIVIMODE
   7. FP, 241919
   EC
   Prof. Boris Turk
2. Understanding and Fighting Metastasis by Modulating the Tumour Microenvironment through Interference with the Protease Network
   MICROENVIMENT
   7. FP, 201279
   EC; Universite de Liege, Liege, Belgium
   Dr. Olga Vasiljeva, Prof. Boris Turk
3. Chemical Genomics by Activity Monitoring of Proteases
   CAMP
   6. FP, LSHG-CT-2006-018830
   EC; Prof. Francesco X. Aviles, Universitat Autonoma de Barcelona, Institut de Biotechnologia i de Biomedicina (IBB), Campus Universitari de Bellaterra, Bellaterra (Cerdanyola del Vallès), Spain
   Prof. Boris Turk
4. Safe Production and Use of Nanomaterials
   NANOSAFE2
   6. FP, NMP2-CT-2005-515843
   EC; Commissariat a l"Energie 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
   HFSP - International Human Frontier Science Program, Strasbourg, France
   Prof. Boris Turk
6. FEBS Fellowship for Dr. Zoran Štefanić
   FEBS - Federation of European Biochemical Societies; prof. dr. Maciej Nalecz, UNESCO, SB/BES, Paris, France
   Prof. Dušan Turk
7. Supply of DPPI Enzyme and the Non-exclusive License Rights
   PROZYMEX A/S, Horsholm, Denmark
   Prof. Dušan Turk
8. Development of New Algorithms for the Analysis of Protein Active Sites
   Razvoj novih alogoritama za analizu aktivnih mjesta proteina
   BI-HR/09-10-040
   Dr. Zoran Štefanić, Ruđer Bošković Institute, Zagreb, Croatia
   Prof. Dušan Turk
9. Function of Proteases in TRAIL/DR5-induced Apoptosis Pathway
   BI-CN/09-11-006
   Dr. Juan Shi, National Laboratory of Medical Molecular Biology, Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China
   Prof. Boris Turk
10. The Role of Cysteine Proteinases and Their Inhibitors in Endotoxin Tolerance and Cancer
    BI-CN/09-11-024
    Dr. Tao Sun, Liaoning Cancer Hospital & Institute, Shenyang, China
    Dr. Nataša Kopitar Jerala

11. Interactions between Tuberculosis causing Mycrobacteria and Dendritic Cells
    Interaccoes 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

R & D GRANTS AND CONTRACTS

1. Proteomic identification of extracellular substrates of cysteine proteases
   Asst. Prof. 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. Cathepsin E: characterisation and biological role
   Prof. Vito Turk
5. The effect of citrulination of extracellular matrix proteins on degradation by cysteine and metalloproteases in arthritic joints
   Prof. Boris Turk
6. Cathepsin F: new cysteine proteinase involved in neuronal ceroid lipofuscinosis
   Asst. Prof. Veronika Stoka
7. The role of nuclear cystatins in the regulation of interleukin-10 synthesis during endotoxin tolerance
   Asst. Prof. Nataša Kopitar - Jerala
8. The role of cysteine cathepsins and caspases in neurodegeneration
   Asst. Prof. Veronika Stoka
9. The role of cysteine proteinases and their inhibitors in endotoxin tolerance
   Asst. Prof. Nataša Kopitar - Jerala
10. Use of phage display for new medicinal substances of biotechnological source
    Prof. Borut Štrukelj, Polonca Pirš Kovačič

RESEARCH PROGRAMS

1. Structural biology
   Prof. Dušan Turk
2. Proteolysis and its regulation
   Prof. Boris Turk

VISITORS FROM ABROAD

1. Dušana Majera, Bački Petrovac, Serbia, 1 Jan. to 31 Dec. 2009, (Scholarship IJS)
2. Zoran Štefanić, Ruđer Bošković Institute, Physical Chemistry - Laboratory for Chemical and Biological Crystallization, Zagreb, Croatia, 1-6 Jun. 2009, 26 -31 Oct 2009, 14 -18. Dec. 2009
3. Georgy Mikhaylov, Siberian State Medical University, Tomsk, Siberia, Russia, 1 Jan. to 31 Dec. 2009 (Scholarship IJS)
4. Prof. William J. Lennarz, Dept. Of Biochemistry and Cell Biology, Stony Brook University, USA , 11-14 May 2009
5. Prof. Walter Keller, Institute of Molecular Biosciences – Structural Biology, Karl-Franzens-University Graz , Austria , 15 May 2009
6. Dr. Alla Gutschina, Staff Scientist, , Macromolecular Crystallography Laboratory NCI-Frederick, USA, 22 Jun 2009
7. Dr. Alexander Wlodawer, Chief, Macromolecular Crystallography Laboratory NCI-Frederick, USA, 22 Jun. 2009
8. Dr. Andrew Ramsay,Oviedo University, Spain , 15 Oct. 2009
9. Prof. Kazuo Umezawa, Keio University, Yokohama, Japan, 9–11 Nov. 2009
10. Prof. Eriko Suzuki, Keio University, Yokohama, Japan, 9–11 Nov. 2009

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25. *Martina Klarić, B. Sc., left 01.09.09*
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44. Dejan Pelko
45. Polonca Pirš Kovačič
46. Zvonka Vadnjal
47. Barbara Vrtačnik

Note:
* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Simone A. Beckham, Boris Turk, (16 authors), "A major cathepsin B protease from the liver fluke Fasciola hepatica has atypical active site features and a potential role in the digestive tract of newly excysted juvenile parasites", *Int J Biochem Cell Biol*, vol. 41, no. 7, pp. 1601-1612, 2009.
2. Dejan Caglič, Gregor Kosec, Lea Bojič, Thomas Reinheckel, Vito Turk, Boris Turk, "Murine and human cathepsin B exhibit similar properties: possible implications for drug discovery", *Biol Chem*, vol. 390, no. 2, pp. 175-179, 2009.
3. Dora Cavallo-Medved, Deborah Rudy, Galia Blum, Matthew Bogyo, Dejan Caglič, Bonnie F. Sloane, "Live-cell imaging demonstrates extracellular matrix degradation in association with active cathepsin B

in caveolae of endothelial cells during tube formation", *Exp. cell res.*, vol. 315, no. 7, pp. 1234-1246, 2009.
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5. Mohammed Abul Kashem, Huyghues Des Etages, Nataša Kopitar-Jerala, Iain S. McGregor, Izuru Matsumoto, "Differential protein expression in the corpus callosum (body) of human alcoholic brain", *J. neurochem.*, issue 2, vol. 10, pp. 486-495, 2009.
6. Martina Klarić, Sun Tao, Veronika Stoka, Boris Turk, Vito Turk, "Cysteine cathepsins are not critical for TNF-α-induced cell death in T98G and U937 cells", *Biochimica et biophysica acta, Proteins and proteomics*, vol. 1794, no. 9, pp. 1372-1377, 2009.
7. Boštjan Kobe, Gregor Gunčar, Robin Buchholz, Thomas Huber, B. Maco, "The many faces of platelet glycoprotein *Ib*α- thrombin interaction", *Current protein and peptide science*, vol. 10, no. 6, pp. 551-558, 2009.
8. Dušan Kordiš, Vito Turk, "Phylogenomic analysis of the cystatin superfamily in eukaryotes and prokaryotes", *BMC Evol Biol*, vol. 9, pp. 266-1-266-22, 2009.
9. Matvey S. Korovin, V. V. Novitsky, Olga Vasiljeva, "Rolj lizosomaljnih cisteinovih proteinaz v opuholevoj progressii", *Bull. sib. med. (Print)*, no. 2, pp. 85-91, 2009.
10. Jun Nojima, Yoko Oma, Eugene Futai, Noboru Sasagawa, Reiko Kuroda, Boris Turk, Shoichi Ishiura, "Biochemical analysis of oligomerization of expanded polyalanine repeat proteins", *J. neurosci. res.*, issue 10, vol. 87, pp. 2290-2296, 2009.
11. Jure Pražnikar, Pavel Afonine, Gregor Gunčar, Paul D. Adams, Dušan Turk, "Averaged kick maps: less noise, more signal . . . and probably less bias", *Acta crystallogr., D, Biol. crystallogr.*, issue 9, vol. 65, pp. 921-931, 2009.
12. Jerica Rozman Pungerčar, Dejan Caglič, Mohammed Sajid, Marko Dolinar, Olga Vasiljeva, Urška Požgan, Dušan Turk, Matthew Bogyo, Vito Turk, Boris Turk, "Autocatalytic processing of procathepsin B is triggered by proenzyme activity", *FEBS journal*, vol. 276, no. 3, pp. 660-668, 2009.
13. Jerica Sabotič, Tatjana Popovič, Vida Puizdar, Jože Brzin, "Macrocypins, a family of cysteine protease inhibitors from the basidiomycete Macrolepiota procera", *FEBS journal*, vol. 276, no. 16, pp. 4334-4345, 2009.
14. Aida Smajlović, Selma Berbić, Cordelia Schiene-Fischer, Magda Tušek-Žnidarič, Ajda Taler-Verčič, Saša Jenko-Kokalj, Dušan Turk, Eva Žerovnik, "Essential role of Pro 74 in stefin B amyloid-fibril formation: dual action of cyclophilin A on the process", *FEBS lett.*, vol. 583, no. 7, pp. 1114-1120, 2009.
15. Katja Škerget, Andrej Vilfan, Maruša Pompe Novak, Vito Turk, Jonathan P. Waltho, Dušan Turk, Eva Žerovnik, "The mechanism of amyloid-fibril formation by stefin B: temperature and protein concentration dependence of the rates", *Proteins*, vol. 74, no. 2, pp. 425-436, 2009.
16. Kazuya Toriumi, Yoko Oma, Ai Mimoto, Eugene Futai, Noboru Sasagawa, Boris Turk, Shoichi Ishiura, "Polyalanine tracts directly induce the release of cytochrome c, independently of the mitochondrial permeability transition pore, leading to apoptosis", *Genes cells (Print)*, vol. 14, no. 6, pp. 751-757, 2009.
17. Olga Vasiljeva, "Kompleksnoe uchastie cisteinovih katepsinov v rakovoj progressii", *Issled. Ross.*, vol. 12, pp. 677-685, 2009.
18. Jun Zhang, Marko Fonović, Kaye Suyama, Matthew Bogyo, Matthew P. Scott, "Rab35 controls actin bundling by recruiting fascin as an effector protein", *Science (Wash. D.C.)*, vol. 325, no. 5945, pp. 1250-1254, 2009.
19. Eva Žerovnik, "The emerging role of cystatins in Alzheimer's disease", *BioEssays*, vol. 31, no. 6, pp. 597-599, 2009.

Review Articles and Chapters in Books

1. Boris Turk, Vito Turk, "Lysosomes as 'suicide bags' in cell death: myth or reality?", *J Biol Chem*, vol. 284, no. 33, pp. 21783-21787, 2009.
2. Olga Vasiljeva, "Rolj katepsina B v rakovoj progressii na primere transgennih modelej raka moločnoj i podželudochnoj željoz", *Issled. Ross.*, vol. 098, pp. 1234-1242, 2009.
3. Eva Žerovnik, "Understanding molecular background of Alzheimer's disease: in search for a cure", In: *Philosophical insights about modern science*, (Scientific revolutions series), Eva Žerovnik, ed., Olga Markič, ed., Andrej Ule, ed., New York, Nova Science Publishers, cop. 2009, pp. 53-72.

Theses

Ph. D. Theses

1. Miha Andrejašič, *PURY: a topology and geometry parameter library for small molecules: doctoral dissertation*, Ljubljana, [M. Andrejašič], 2009.
2. Ana Petelin, *Role and significance of cysteine cathepsins in different models of apoptosis: doctoral dissertation*, Ljubljana, [A. Petelin], 2009.

B. Sc. Thesis

1. Matej Vizovišek, *Preparation of recombinant cathepsin V and potential role of cathepsins in degradation of inhibitors of apoptosis: undergraduate thesis*, Ljubljana, [M. Vizovišek], 2009.

DEPARTMENT OF MOLECULAR AND BIOMEDICAL SCIENCES B-2

The research program of the Department of Molecular and Biomedical Sciences is focused mainly on basic research in protein biochemistry, molecular and cellular biology, and genetics. The primary goal of our investigations is the acquisition of a new understanding of mammalian pathophysiology, with the aim of improving human and animal health.

Head:
Prof. Igor Križaj

Secreted phospholipases A_2 ($sPLA_2$s)

The major research topic of the department is the secreted phospholipases A_2 ($sPLA_2$s) originating from animal toxins as well as those found in humans. We are studying molecular mechanisms of the action of toxic $sPLA_2$s, particularly those endowed with presynaptic neurotoxicity, and the role of endogenous $sPLA_2$s in pathological and physiological processes in mammals.

Within the scope of our research on the molecular mechanism of action of the presynaptically neurotoxic snake venom $sPLA_2$s, we became the first group in the world to successfully confirm the internalization of a presynaptically neurotoxic $sPLA_2$, ammodytoxin (Atx), from the venom of the long-nosed viper *Vipera ammodytes ammodytes*, in the motor nerve terminal *in vivo* (U. Logonder et al., **Experimental neurology**, 219 (2009), 591–596). In this study, we labelled a recombinant mutant of AtxA, AtxA(N79C), by covalently attaching nanogold particles and inoculating the conjugate into the limb of laboratory mice. Several hours after inoculation of the labelled toxin the soleus muscle was isolated, fixed in glutaraldehyde, exposed to a silver-enhancing medium and ultra-thin sections were prepared for transmission electron microscopy. The results showed extensive mitochondrial damage and depletion of the synaptic vesicles in most of the terminal boutons, which are typical indicators of neurotoxicity following exposure to neurotoxic $sPLA_2$s. Silver-enhanced particles were found concentrated in the perisynaptic area (particularly within the synaptic gutter, Schwann cell lamellae and mastocytes) and were taken up into the cytoplasm of the terminal boutons of the motor axon, where they were localized in mitochondrial and vesicle structures as well as in the cytosol (Figure 1).

New substances and molecular tools to improve human and animal health.

Detailed analyses of the influence of calmodulin (CaM), a cytosolic protein with a high affinity for AtxA, on the enzymatic activity of AtxA showed that CaM completely stabilized the enzyme/toxin in the reducing cytosol-like conditions and substantially increased its enzymatic activity in such conditions as well as in the non-reducing environment (L. Kovačič et al., **Biochemistry**, 48 (2009), 11319–11328). We concluded that CaM augmented the phospholipase activity of the $sPLA_2$ as a nonessential activator and suggested a model of structural-mechanistic relationships for the CaM-Atx interactions (Figure 2). In the same way, the CaM also activated the mammalian group V and X $sPLA_2$s. Our results provide a further insight into the neurotoxic action of Atx and the mechanisms involved in the regulation of $sPLA_2$ activity within the cytosol.

Employing our *in vitro* model of mouse motoneuronal cells, we have observed that the neurotoxic AtxA causes a rapid dissipation of mitochondrial membrane potential (Figure 3) leading to cell death. The cellular changes accompanying the process, including the activation of caspase 3 and structural changes in the plasma membrane, led us to conclude that the observed cell death is apoptotic (Z. Jenko Pražnikar et al., **Annals of the New York academy of sciences**, 1152 (2009), 215–224). Our subsequent experiments on motoneuronal cells in culture showed that the apoptotic cell death triggered by AtxA is most probably a consequence of the cellular damage caused by the accumulation of intracellular free arachidonic acid, released through the enzymatic action of the neurotoxic $sPLA_2$ (Z. Jenko Pražnikar, **Doctoral thesis**, 2009).

In our search for new compounds with potential inhibitory activity against AtxC, a natural isoform of AtxA, and pancreatic $sPLA_2$, we screened two phage-displayed random peptide libraries and found several short

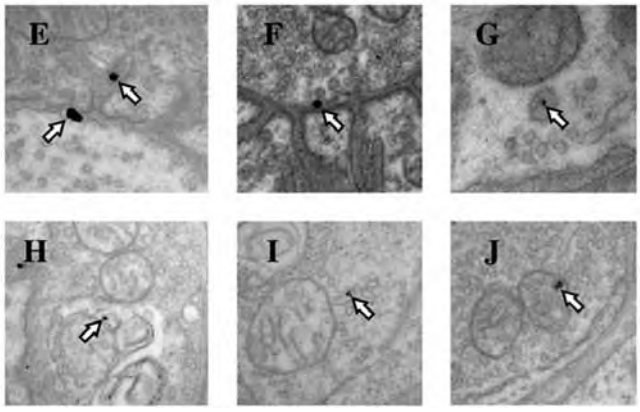

Figure 1. Electron micrographs of a terminal bouton from muscle fibres exposed to a mutant form of AtxA conjugated to nanogold particles and silver enhanced. High-resolution images show the localization of particles to the plasma membrane of the terminal bouton (E and F) and internalized into the terminal bouton. Internalized particles are visible within vesicular structures (G and H), in the cytosol and mitochondria (I and J). The figure is reproduced from U. Logonder et al., Experimental neurology, 219 (2009), 591–596.

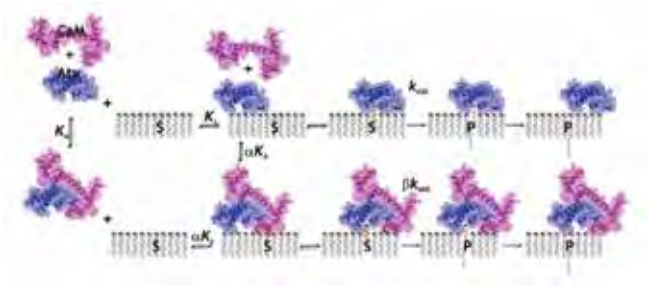

Figure 2. Structural-mechanistic relationships of the interaction between CaM and Atx. On binding to Atx, CaM modulates the association of Atx with the lipid membrane and its catalytic step. The figure is reproduced from L. Kovačič et al., Biochemistry, 48 (2009), 11319–11328.

peptides expressing a binding affinity for both $sPLA_2$s, of groups IB and IIA. None of these peptides was, however, able to inhibit the enzymatic activity of the $sPLA_2$s efficiently *in vitro* (D. Gaser et al., **Acta chimica Slovenica**, 56 (2009), 712–717).

In collaboration with colleagues from the Pasteur Institute in Paris, the crystal structures of AtxA and AtxC were determined (F.A. Saul et al., **Journal of structural biology**, 2009, doi:10.1016/j.jsb.2009.10.010). The two natural isoforms differ in only two amino acid residues in their C-terminal parts: while AtxA has Phe and Lys in positions 124 and 128, respectively, AtxC has Ile and Glu. However, in spite of the minimal differences in their primary structures these two $sPLA_2$s differ substantially in their enzymatic activity, neurotoxicity and anticoagulant activity. The tridimensional structures of AtxA and AtxC revealed that the amino acid variation in position 128 causes significant local structural alterations between the two proteins. The result is a weaker interaction of the AtxC with the blood-coagulation factor X than that of AtxA and consequently a lower anticoagulant activity of AtxC compared to AtxA. In contrast, the amino acid residue variation in position 124 does not induce evident conformational change. AtxA is thus more toxic than AtxC because of the specific nature of Phe that it has in this position (Figure 4).

In 2009, we also continued with our research project on the role of $sPLA_2$s in the development and progression of breast cancer, which is a topic that receives increasing attention in the scientific community. Recent studies have indicated the involvement of $sPLA_2$s in the pathology of colorectal, gastric and prostate cancers. The role of $sPLA_2$s in breast cancer has not been investigated to a significant extent yet, but there are several older studies showing increased levels of expression of the group IIA $sPLA_2$ in invasive areas of the breast-cancer tissue. In the past year, we have concluded our analysis of the expression of the full set of human $sPLA_2$s in immortalized mammary epithelial cells and cancer cell lines with different tumourigenic properties by quantitative PCR. The differential expression patterns of groups IIA, IIF, III, V and X $sPLA_2$s suggest a potential role for these enzymes in breast cancer and indicate that different $sPLA_2$s may have distinct roles at different levels of progression of the disease. For our follow-up experiments, we have selected the group X $sPLA_2$ ($sPLA_2$-X) for an in-depth analysis of its potential involvement in breast cancer. The cDNA for $sPLA_2$-X was therefore cloned in a mammalian expression vector and stably transfected in a highly invasive and tumourigenic breast-cancer cell line. By performing a clonal selection we successfully isolated several clonal cell lines expressing different levels of $sPLA_2$-X. We are currently performing experiments in order to determine the possible connection between the expression of $sPLA_2$-X and the proliferation, invasiveness and tumourigenic potential of breast-cancer cells.

Within our studies of the role of endogenous $sPLA_2$s in the (peripheral) nervous system, which is a specific target for the snake neurotoxic $sPLA_2$s, we addressed the issue of cellular effects of exogenously added mammalian group V and X $sPLA_2$s. We have shown previously that these two $sPLA_2$s are expressed in two established cellular models suitable for studying $sPLA_2$ presynaptic neurotoxicity – a mouse motoneuronal and a rat neuronal-like cell line. By using a bacterial expression system we prepared recombinant human $sPLA_2$-V and -X enzymes, which are also the most enzymaticly active isoforms among the ten known mammalian $sPLA_2$s. The recombinant $sPLA_2$s were then exogenously added to mammalian motoneuronal cells in culture and their cytotoxic action was followed over time and depending on the differentiation status of the cells. Both $sPLA_2$s were cytotoxic to motoneuronal cells and the effect was already significant after several hours of treatment. The effects were similar to those observed with the previously studied snake neurotoxic $sPLA_2$s, but the human enzymes were approximately 10-fold less toxic.

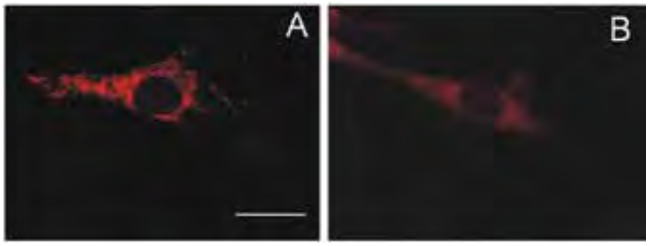

Figure 3. Fluorescence microscopy analysis of mitochondrial integrity in motoneuron-like cells without exposure to AtxA (A) and following the AtxA treatment (B). Weakening of the red fluorescence, characteristic for the healthy mitochondria, in the presence of AtxA indicates a fall in the mitochondrial membrane potential. The scale bar represents 20 μm. The figure is reproduced from Z. Jenko Pražnikar et al., Annals of the New York academy of sciences, 1152 (2009), 215–224.

Other pharmacologically active components from natural toxins

As one of the 20 partners in the EU 6FP Integrated Project "Conco" we have been involved in the analysis of the genome, transcriptome and venom proteome of the piscivorous marine snail *Conus consors* and related snails. In 2009 we started the work on the preparation of a recombinant new type of conotoxin that possesses more disulfides than all the characterized conotoxins. Its activity and biological roles are not known so far. We continued our analysis of the venom proteome, focusing on the components with molecular masses higher than 10 kDa and identified several new molecules. With structural analyses we participated in the description of the two novel conopeptides of the αD superfamily. They selectively inhibit some subtypes of neuronal nicotinic acetylcholine receptor (S. Kauferstein et al., **Toxicon**,

54 (2009), 295–301). Based on the structure of RNA acquired from different *Conus* species, we performed a phylogenomic analysis.

Together with colleagues from the Biotechnical Faculty of the University of Ljubljana we characterized a new cytolysin from the venom of the sea anemone *Urticina crassicornis*. This toxin binds selectively to membranes enriched in cholesterol and sphingomyelin (A. Razpotnik et al., **Toxicon**, 53 (2009), 762–769).

High-throughput genetics and functional genomics in yeast Saccharomyces cerevisiae

Functional genomics is a field of molecular biology focused on describing the function of genes in the genome and their interactions. One of the areas of functional genomics that develops the fastest is imaging-based phenotyping for the analysis of gene function. In collaboration with a research group from the University of Graz, Austria, we have developed a method and published a paper in which we describe a novel approach for linking high-resolution imaging data with a genome-wide approach to understanding the biogenesis of peroxisomes – organelles with an important role in the energy metabolism of cells – in the yeast *Saccharomyces cerevisiae* (H. Wolinski et al., **Journal of proteome research**, 8 (2009), 20–27) (Figure 5). In the future, such experimental approaches will enable much more detailed analyses of the molecular mechanisms of the action of drugs and also different cellular perturbers of mammalian cells.

Peroxisomes are organelles whose communication with other cell constituents is not well understood. The Pex11 protein is involved in peroxisome proliferation, both in yeast and mammalian cells, but its molecular mechanism of action is not known. Using DNA microarrays for a transcriptome study, and high-throughput genetics and chemogenomics methods for genetic interactome study, we proposed a model for the role of Pex11 in the regulation of energy metabolism, as a function of the availability of sugars or fats as the cellular energy source. This result has a potentially important influence in the development of new drugs and prophylaxis regimens for type-2 diabetes and other metabolic syndrome-related diseases.

In drug design and development, one of the main challenges is the early identification of side-effects, which can significantly decrease the costs of research and development in the pharmaceutical industry. The development of chemogenomics methods enables the use of simple model organisms, such as yeast *S. cerevisiae*, as relevant *in vivo* systems for predicting the molecular mechanism of action of drugs/chemicals globally. We have developed a new algorithm for combining chemogenomic and gene-interaction data that is based on local profile similarity and whose accuracy of target prediction for drugs or chemicals is superior to already available methods.

In collaboration with a research group from the Faculty of Computer and Information Sciences of the University of Ljubljana, we also developed an original computing method to study the structure of promoter regions in genes. We demonstrated the utility of the method in the analysis of gene expression data on budding yeast *S. cerevisiae* where cells were induced to proliferate peroxisomes (T. Curk et al., **Methods of information in medicine**, 48 (2009), 229–235).

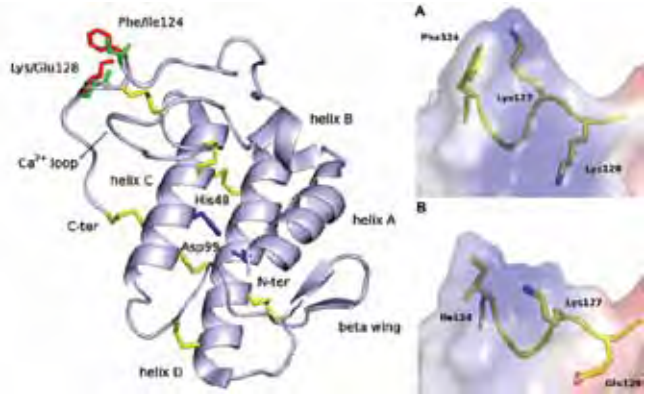

Figure 4. Superposition of tridimensional structures of AtxA and AtxC (left). AtxA and AtxC differ in their primary structures only at positions 124 and 128. The amino acid residues on these positions in the AtxA are shown in red (Phe124 and Lys128) and in AtxC in green (Ile124 and Glu128). Figures A and B display structural details in which both molecules differ from each other and the different charge distribution in this area (blue: positive, red: negative). Figures are reproduced from F.A. Saul et al., Journal of structural biology, 2009, doi:10.1016/j.jsb.2009.10.010.

Evolutionary genomics of transposable elements and functional studies of retrotransposons

The cystatin superfamily is composed of cysteine protease inhibitors that play key regulatory roles in protein degradation processes. Although they have been the subject of many studies, little is known about their genesis, evolution and functional diversification. A comprehensive survey of the cystatin superfamily, using the extensive genomic, proteomic and transcriptomic data for Archaea, Bacteria and Eukaryota, has provided new insights into their origin, evolution and classification. We have identified *in silico* the full complement of the cystatin superfamily in more than 2100 prokaryotic and eukaryotic genomes. The analysis of numerous eukaryotic genomes has provided strong evidence for the emergence of this superfamily in the ancestor of eukaryotes. Only two ancestral lineages, the stefins and the cystatins, exist in bacterial and eukaryotic genomes. In addition, 20 vertebrate-specific and three angiosperm-specific orthologous families have been discovered. In vertebrate orthologous families, the prevailing trends were a loss of the ancestral inhibitory activity and the acquisition of novel functions in innate immunity. Our analysis suggests that bacterial cystatins and stefins originated by horizontal transfer from the eukaryotic hosts, constituting a rare case of horizontal transfer from eukaryotes to bacteria. Bacterial cystatins and stefins may be emergency inhibitors that enable survival of the bacteria in the host, defending them from the host's proteolytic activity. This study challenges the current view on the classification, origin and evolution of the

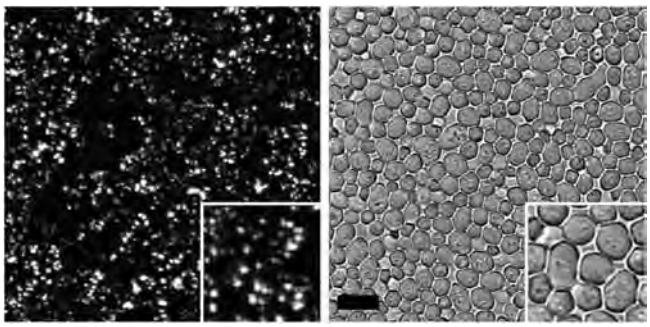

Figure 5. Yeast S. cerevisiae peroxisomes marked by a fluorescent marker (left) and the corresponding cells imaged with transmission imaging (right). The image represents the phenotype of one of the 4740 strains that have been analyzed in the study; imaging of all strains required merely 3 days. The scale bar represents 10 μm. The figure is reproduced from H. Wolinski et al., Journal of proteome research, 8 (2009), 20–27.

cystatin superfamily and provides valuable insights into their functional diversification. The findings of this comprehensive study provide guides for future structural and evolutionary studies of the cystatin superfamily as well as of other protease inhibitors and proteases (D. Kordiš and V. Turk, **BMC evolutionary biology**, 9 (2009), 266).

The large amount of recently accumulated genome-wide data on transposable elements (TEs) in diverse lineages of sauropsids has provided a timely opportunity to review the current knowledge about transposable elements of sauropsids in their genomic context. TEs have profound effects on the structure, function and evolution of their host genomes. Our knowledge about these agents of genomic change in sauropsids, a sister group of mammals that includes all extant reptiles and birds, is still very limited. Invaluable information concerning the diversity, activity and repetitive landscapes in sauropsids has recently emerged from analyses of the draft genomes of chicken *Gallus* and lizard *Anolis* and other preliminary reptilian genome-sequencing projects. Avian and reptilian genomes differ significantly in the classes of TEs present, their fractional representation in the genome and by the level of TE activity. While lepidosaurian genomes contain many young, active TE families, the extant avian genomes have very few active TE lineages. Most reptilian genomes possess quite rich TE repertoires that differ considerably from those of birds and mammals, being more similar in diversity to that of lower vertebrates (D. Kordiš, **Cytogenetics genome research**, in press).

By using phylogenomic analysis (combining phylogenetic tree construction, the integration of experimental data and the differentiation of orthologs and paralogs) we obtained and characterized retroelement-derived neogenes from all currently available mammalian genomes and their progenitors from the genomes of the key tetrapod genomes (amphibians and reptiles). With the analysis of genomes from monotremes, marsupials and four placental superoders and by the analysis of novel neogene families, an in-depth insight into the origins, evolution, regulatory and functional diversification of diverse retroelement-derived neogenes in mammals has been obtained. We explained where and when the domestication of retroelements occurred and how similar to the modern neogenes were the first mammalian retroelement-derived neogenes. Novel data that we obtained from the genomes of monotremes, marsupials and basal placental superoders has greatly improved and finally resolved the evolutionary relationships of diverse neogenes.

Human APOBEC3G (hA3G), a member of the AID/APOBEC family of deaminases, is a restriction factor for human immunodeficiency virus (HIV). In the absence of the viral Vif protein hA3G is packaged into virions and during reverse transcription in a recipient cell it deaminates cytosines, leading to G to A hypermutation and the inactivation of the viral DNA. Unlike humans, who carry seven APOBEC3 genes, mice only carry one, mA3. Thus the role of mA3 in the restriction of retroviral infection could be studied in mA3 -/- knockout mice, where the gene is inactivated. M-MuLV-infected mA3 -/- mice showed substantially higher levels of infection at very early times compared to wild-type mice (ca. 2 logs at 0-10 days), particularly in the bone marrow and spleen. The restriction of the M-MuLV infection was studied *ex vivo* in primary bone-marrow-derived dendritic cells (BMDCs) that express or lack mA3, using an M-MuLV-based retroviral vector expressing enhanced jellyfish green fluorescent protein (EGFP). The results indicated that mA3 within the virions as well as mA3 in the recipient cell contribute to the resistance to infection in BMDCs. Finally, M-MuLV-infected mA3 +/+ mice developed leukemia more slowly compared to animals lacking one or both copies of mA3, although the resulting disease was similar (T-lymphoma). These studies indicate that mA3 restricts the replication and pathogenesis of M-MuLV *in vivo* (A. Low et al., **Virology**, 385 (2009), 455–463).

Members of the apolipoprotein B mRNA editing complex polypeptide 1-like (APOBEC) family of enzymes exhibit inhibitory activity against a variety of exogenous and endogenous retroviruses including retrotransposons, such as the long interspersed element 1 (LINE-1). Indeed, human APOBEC3A, APOBEC3B, and APOBEC3F inhibit retrotransposition of the human LINE-1, mouse IAP and MusD retrotransposons. In our study, we examined whether the inhibitory effect of APOBEC3 proteins correlates with APOBEC3's ability to bind the LINE-1 ORF1 protein. We examined the interactions between the LINE-1 ORF1 protein and the most potent LINE-1 retrotransposon inhibitors, human APOBEC3A and APOBEC3B, by immunofluorescence and immunoprecipitation. Although human APOBEC3A shows the highest inhibitory potency against LINE-1 retrotransposon, no direct interactions were identified, either by immunofluorescence or by co-immunoprecipitation. APOBEC3B binds to the LINE-1 ORF1 protein, yet no co-localization was detected. We concluded that APOBEC3 proteins interfere indirectly with the LINE-1 retrotransposition pathway, probably through interference with RNA targeting (N. Lovšin and B.M. Peterlin, **Annals of the New York academy of sciences**, 1178 (2009), 268–275).

Other subjects

In 2009 we also collaborated in several projects out of the thematic scope of our department or the program group "Toxins and biomembranes".

We performed structural analysis of trypsin-specific inhibitors isolated from the basidiomycete *Clitocybe nebularis* at the Department of Biotechnology at the Jožef Stefan Institute. They have regulatory and defensive functions in this fungus (P. Avanzo et al., **Microbiology** (2009), doi: 10.1099/mic.0.032805-0).

From an analysis of the DNA and RNA samples of patients with unipolar depression we participated in a pharmacogenetic study of an alternative antidepressant response of these people (R. Uher et al., **American journal of psychiatry**, in press).

In the quantification study of the coenzyme Q10 and cholesterol in fractionated chicken-breast tissue we were preparing a homogenous mitochondrial fraction from the cells (P. Jazbec et al., **Journal of planar chromatography**, 22 (2009), 395–398).

Some outstanding publications in 2009

1. Logonder, U., Jenko-Pražnikar, Z., Scott-Davey, T., Pungerčar, J., Križaj, I. and Harris, J. B. (2009): Ultrastructural evidence for the uptake of a neurotoxic snake venom phospholipase A_2 into mammalian motor nerve terminals. Exp. Neurol. 219, 591–594.
2. Kovačič, L., Novinec, M., Petan, T., Baici, A. and Križaj, I. (2009): Calmodulin is a non-essential activator of secretory phospholipase A_2. Biochemistry 48, 11319–11328.
3. Saul, F.A., Prijatelj, P., Vuilliez-le Normand, B., Villette, B., Raynal, B., Pungerčar, J., Križaj, I. and Faure, G. (2009): Comparative structural studies of two natural isoforms of ammodytoxin, phospholipases A_2 from *Vipera ammodytes ammodytes* which differ in neurotoxicity and anticoagulant activity. J. Struct. Biol., doi:10.1016/j.jsb.2009.10.010.
4. Kordiš, D. and Turk, V. (2009): Phylogenomic analysis of the cystatin superfamily in eukaryotes and prokaryotes. BMC Evol. Biol. 9, 266.
5. Wolinski, H., Petrovič, U., Mattiazzi, M., Petschnigg, J., Heise, B., Natter, K. and Kohlwein, S.D. (2009): Imaging-based live cell yeast screen identifies novel factors involved in peroxisome assembly. J. Proteome Res. 8, 20–27.

Awards and appointments

1. Igor Križaj - Toxicon (Elsevier): Top Reviewer in 2009.

INTERNATIONAL PROJECTS

1. Applied Venomics of the Cone Snail Species Conus Consors for the Accelerated, Cheaper, Safe and More Ethnical Produdction of Innovative Biomedical Drugs
   CONCO
   6. FP EC, Integrated Project
   037592, LSHB-CT-2007-03792
   EC; Dr. Reto Stöcklin, Atheris Laboratories, Plan-les-Quates, Geneve, Switzerland
   Prof. Igor Križaj
2. Identification of Essential Proteins Involved in Peroxisome and Lipid Droplet Biogenesis in Yeast
   BI-AT/09-10-019
   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 Disfunction
   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. Photostability of selected industrial chemicals and their influence on the environment
   Assist. Prof. Uroš Petrovič
2. Regulatory genomics: origin and evolution of the complex transcriptional regulatory network in vertebrates
   Assist. Prof. Dušan Kordiš
3. Use of yeast for determination of toxicity of selected neonicotinoids on the genome level
   Assist. Prof. Uroš Petrovič
4. Data and knowledge integration methods for network systems biology
   Assist. Prof. Uroš Petrovič
5. Computational genomics
   Assist. Prof. Uroš Petrovič
6. The role of secretory phospholipases A2 in breast cancer
   Prof. Jože Pungerčar
7. Proteins of the long-nosed viper venom acting on haemostasis - development of innovative biomedical antitrombotics
   Prof. Igor Križaj
8. Antiretroviral APOBEC3 proteins and their role in retroelement defense
   Dr. Marija Nika Lovšin
9. Knowledge technology approaches in drug discovery: analysis and experiment planning in high-throughput genetics
   Assist. Prof. Uroš Petrovič

RESEARCH PROGRAM

1. Toxins and biomembranes
   Prof. Igor Križaj

VISITORS FROM ABROAD

1. Prof. dr. Jürgen Brosius, University of Münster, Germany, 20–23 September 2009
2. Prof. dr. Charles Boone, University of Toronto, Canada, 20–23 September 2009
3. Prof. dr. Sepp D. Kohlwein, University of Graz, Austria, 2–3 October 2009

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2. **Prof. Igor Križaj, Head**
3. Asst. Prof. Uroš Petrovič
4. Prof. Jože Pungerčar

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6. Dr. Toni Petan
7. Dr. Jernej Šribar

Postgraduates
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10. Janez Kokošar, B. Sc.
11. Adrijana Leonardi, B. Sc.
12. Mojca Mattiazzi, B. Sc.
13. Anja Pucer, B. Sc.
14. Tamara Sajevic, B. Sc.

Technical officer
15. Petra Kaferle, B. Sc.

Technical and administrative staff
16. Igor Koprivec
17. Darja Žunič Kotar

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Original Articles

1. Petra Avanzo, Jerica Sabotič, Sabina Anžlovar, Tatjana Popovič, Adrijana Leonardi, Roger H. Pain, Janko Kos, Jože Brzin, "Trypsin-specific inhibitors from basidiomycete Clitocybe nebularis with regulatory and defensive functions", *Microbiol (Soc. Gen. Microbiol.)*, vol. 155, no. 12, pp. 3971-3981, 2009.
2. Tomaž Curk, Uroš Petrovič, Gad Shaulsky, Blaž Zupan, "Rule-based clustering for gene promoter structure discovery", *Methods inf. med.*, vol. 48, no. 3, pp. 229-235, 2009.
3. Dominik Gaser, Borut Štrukelj, Tomaž Bratkovič, Samo Kreft, Jože Pungerčar, Mojca Lunder, "Cross-affinity of peptide ligands selected from phage display library against pancreatic phospholipase A2 and ammodytoxin C", *Acta chim. slov.*, vol. 56, no. 3, pp. 712-717, 2009.
4. Petra Jazbec, Andrej Šmidovnik, Mateja Puklavec, Mitja Križman, Jernej Šribar, Luka Milivojević, Mirko Prošek, "HPTLC and HPLC-MS quantification of coenzyme Q10 and cholesterol in fractionated chicken-breast tissue", *JPC, J. planar chromatogr. mod. TLC*, vol. 22, pp. 395-398, 2009.
5. Zala Jenko Pražnikar, Toni Petan, Jože Pungerčar, "A neurotoxic secretory phospholipase A_2 induces apoptosis in motoneuron-like cells", In: *Mechanisms of exocytosis*, (Annals of the New York academy of science, vol. 1152), Robert Zorec, ed., Malden, MA, Wiley-Blackwell, 2009, vol. 1152, pp. 215-224, 2009.
6. S. Kauferstein, Y. Kendel, A. Nicke, F. I. V. Coronas, L. D. Possani, P. Favreau, Igor Križaj, C. Wunder, G. Kauert, D. Mebs, "New conopeptides of the D-superfamily selectively inhibiting neuronal nicotinic acetylcholine receptors", *Toxicon (Oxford)*, vol. 54, no. 3, pp. 295-301, 2009.
7. Dušan Kordiš, Vito Turk, "Phylogenomic analysis of the cystatin superfamily in eukaryotes and prokaryotes", *BMC Evol Biol*, vol. 9, pp. 266-1-266-22, 2009.
8. Lidija Kovačič, Marko Novinec, Toni Petan, Antonio Baici, Igor Križaj, "Calmodulin is a non-essential activator of secretory phospholipase A_2", *Biochemistry (Easton)*, vol. 48, no. 47, pp. 11319-11328, 2009.
9. Uroš Logonder, Zala Jenko Pražnikar, T. Scott-Davey, Jože Pungerčar, Igor Križaj, J. B. Harris, "Ultrastructural evidence for the uptake of a neurotoxic snake venom phospholipase A_2 into mammalian motor nerve terminals", *Exp. neurol.*, issue 2, vol. 219, pp. 591-594, 2009.
10. Andrej Razpotnik, Igor Križaj, William R. Kem, Peter Maček, Tom Turk, "A new cytolytic protein from the sea anemone Urticina crassicornis that binds to cholesterol- and sphingomyelin-rich membranes", *Toxicon (Oxford)*, vol. 53, no. 7/8, pp. 762-769, 2009.
11. Heimo Wolinski, Uroš Petrovič, Mojca Mattiazzi, Julia Petschnigg, Bettina Heise, Klaus Natter, Sepp D. Kohlwein, "Imaging-based live cell yeast screen identifies novel factors involved in peroxisome assembly", *Journal of proteome research*, vol. 8, no. 1, pp. 20-27, 2009.

Published Conference Papers

Regular papers

1. Petra Jazbec, Andrej Šmidovnik, Mateja Puklavec, Mitja Križman, Jernej Šribar, Luka Milivojević, Mirko Prošek, "Accumulation and distribution of coenzyme $Q_{(10)}$ in chicken under prolonged feeding with an estrogeneous source", In: *[Book of abstracts]*, Mini conference on CoQ10 applications in food, human and veterinary medicine, October 16 - 18, 2009, Ljubljana, Petra Jazbec, ed., Andrej Šmidovnik, ed., Mirko Prošek, ed., Ljubljana, National Institute on Chemistry, 2009, pp. 86-96.
2. Lan Umek, Petra Kaferle, Mojca Mattiazzi, Aleš Erjavec, Črtomir Gorup, Tomaž Curk, Uroš Petrovič, Blaž Zupan, "A subgroup discovery approach for relating chemical structure and phenotype data in chemical genomics", In: *Machine learning in systems biology: proceedings of the Third International Workshop, September 5-6, 2009, Ljubljana, Slovenia*, (Julkaisusarja - Helsingin yliopisto. Tietojenkäsittelytieteen laitos, report B-2009-1), Sašo Džeroski, ed., Pierre Geurts, ed., Juho Rousu, ed., Helsinki, Department of Computer Science, University, 2009, pp. 125-132.

Textbooks and Lecture Notes

1. Zala Jenko Pražnikar, *Biokemija: Prehransko svetovanje-dietetika*, Izola, Visoka šola za zdravstvo, 2009.
2. Zala Jenko Pražnikar, *Biokemija: Zdravstvena nega*, Izola, Visoka šola za zdravstvo, 2009.

Theses

Ph. D. Theses

1. Zala Jenko Pražnikar, *Development and use of a cell model for studying the molecular mechanisms of snake venom phospholipases A_2 neurotoxicity: doctoral dissertation*, Ljubljana, [Z. Jenko Pražnikar], 2009.
2. Lidija Kovačič, *Characterization of ammodytoxin interaction to its binding proteins to explain their role in the process of neurotoxicity: doctoral dissertation*, Ljubljana, [L. Kovačič], 2009.

DEPARTMENT OF BIOTECHNOLOGY B-3

At the Department of Biotechnology we investigate the biological molecules of microbiological, fungal, plant and animal origin using modern biotechnological methods. We would like to apply them for diagnostic and therapeutic purposes in human and veterinary medicine, for plant protection, the preparation of quality and safe food and for the protection of the environment, contributing to an improvement in peoples' health and of the environment in which we live. Our research work is focused on the processes of cancer progression and immune response, the biology of fungi, plant stress response and in the search for sweet proteins and natural pesticides.

Head:
Prof. Janko Kos

- **Determinantion of the 3D structure of clitocypin, microcypin and lectin CNL**
- **Defined role of cathepsin X in cell nanotube formation and the regulation of neurothropic activity of enolase**
- **Lectins from the mushrom Clitocybe nebularis were determined as activators of dendritic cells**
- **Mutaton in FUS, RNA processing protein, causes familial amyotrophic lateral sclerosis type 6**
- **40 scientific papers were published in journals with an impact factor**

In the field of research on fungal protease inhibitors we have continued with the characterization of mycocypins, cysteine protease inhibitors from clouded agaric (*Clitocybe nebularis*) and parasol mushroom (*Macrolepiota procera*). We have determined the reactive sites of mycocypins responsible for the inhibition of three different protease families including papain-like cysteine proteases, cysteine protease legumain and serine protease trypsin. Research of the serine protease inhibitors from mushrooms continued with the characterization of natural serine protease inhibitors from clouded agaric. For one of these inhibitors, named cnispin, an analysis was concluded at the genetic and biochemical levels by means of the recombinant protein heterologously expressed in *Escherichia coli*. The expression profile in different parts of the mushroom was examined and its regulatory and defensive biological role was suggested. In addition, we have expressed in *E. coli* a similar serine protease inhibitor from the model basidiomycete, the inky cap mushroom (*Coprinopsis cinerea*). Kinetic measurements confirmed its similarity to cnispin as they share very similar inhibitory profiles. For the inky cap mushroom serine protease inhibitor the crystal structure has been determined in collaboration with the Department of Biochemistry and Molecular and Structural Biology (B1). Trials of protease inhibitors from mushrooms in different animal test systems (Colorado potato beetle, slugs, caterpillars) as well as their influence on the growth of pathogenic molds are in progress.

From the mushroom clouded agaric (*Clitocybe nebularis*) the lectins were isolated, exhibiting interesting biological effects. Their immunomodulatory effects on human bone-marrow-derived dendritic cells and the activity against various pests, like Colorado potato beetle (*Leptinotarsa decemlineata*), nematodes (*Caenorhabditis elegans*) and slugs (*Arion* sp.), were studied. The lectins appeared as potent activators of the dendritic cells, which are the most important antigen-presenting cells. On the other hand, the ricin B-like lectin, designated *Clitocybe nebularis* lectin (CNL), was shown to exhibit an inhibitory effect on leukemic T-cells. The recombinant CNL was characterized and its crystal structure in a complex with lactose and *N,N'*-diacetyllactosediamine (GalNAcβ1–4GlcNAcβ) at a 1.1 Å resolution was determined. The sugar N,N'-diacetyllactosediamine has been demonstrated by the glycan microarray analysis to have a high affinity for the lectin, and it has been proposed that the sugar is expressed in tumour but not in normal cells. CNL is a homodimeric protein, composed of two identical domains that adopt a β-trefoil fold typical of ricin B lectin domains

An important part of our research in 2009 was focused on the role of proteases and protease inhibitors in immune and neurodegenerative processes. In dendritic cells we continued our studies on the role of endogenous protease inhibitors during the cell maturation. We also studied further the role of cysteine proteases in the activation of integrin receptors and proved that the increased activity of cathepsin X causes changes in the cell signalling, adhesion and migration as a result of the gradual cleavage of the C terminal tail of beta-2 chain of integrin receptors. This activity causes the remodulation of the cytoskeleton and the formation of cell extensions, the uropods, which at additional cathepsin X activity form nanotubes. The nanotubes, formed by certain cells, and discovered only recently, enable cells to have a new mechanism of signalling via the transfer of cytoplasmic

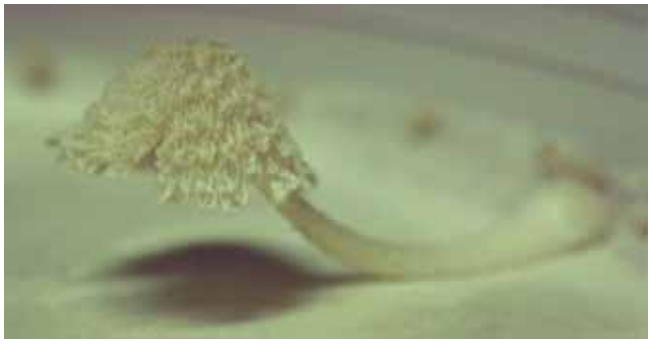

Figure 1. Model inky-cap mushroom (Coprinopsis cinerea)

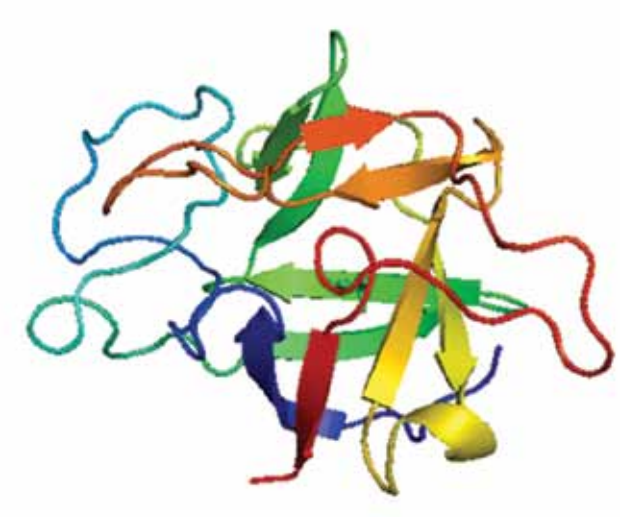

Figure 2. 3D structure of serine protease inhibitor from the inky-cap mushroom (Coprinopsis cinerea)

vesicles. We also discovered a new molecular target for cathepsin X activity, i.e., gamma enolase. Cathepsin X cleaves the C terminal part of the enolase, which possesses a regulatory motif for neurothropic activity. The inhibitors of cathepsin X increase the neurothropic activity in neuronal cells and enhance neuritogenesis, which could be very important in the treatment of patients with neurodegenerative disorders. In this field, important results were also obtained by our researchers in collaboration with UK partners. They established the association of mutation in FUS, RNA processing protein, with the cause of familial amyotrophic lateral sclerosis type 6.

Last year we prepared a system for the display of heterologous proteins on the surface of lactic acid bacterium *Lactococcus lactis*. We have displayed on the surface a domain of protein A, which has served as a model protein and is capable of binding the Fc region of an antibody. The surface localization was confirmed by microscopy and flow cytometry.

We have determined an array of surface proteins (surface proteome) of the lactic acid bacterium *Lactococcus lactis* NZ9000 using mass spectrometry. We have confirmed the presence of predicted surface proteins and determined the presence of proteins with an unknown function. Selected identified proteins will be used as the carriers for surface display.

The sweet-tasting protein brazzein was expressed in different lactic acid bacteria of the genus *Lactobacillus*, which are often used as probiotic and are therefore appropriate for the use in food. The expression level of brazzein will be optimized in the future.

We were also interested in the interaction of bacteria of the genus *Lactobacillus* with different drugs. This is especially important in the concomitant consuming of drugs and probiotic supplements. We have incubated bacteria with several drugs *in vitro* and determined the quantity of the remaining drug and its metabolites using LC-MS/MS. We have observed an increased adsorption of drugs to the bacteria in several cases.

We continued to study the response of plants to water stress. Several serine endopeptidases and aminopeptidases were identified and shown to be involved in the response to drought in the leaves of a number of plants: *Ramonda serbica*, which is able to survive complete desiccation of its vegetative tissues, *Saintpaulia ionantha* from the same family but without such capability, and several cultivars of common bean (*Phaseolus vulgaris*), which is important for the human diet. Among them is an aminopeptidase from bean leaves, with a molecular mass of about 37 kDa, an isoelectric point 5.85 and an optimal activity at pH 8.5, which is different from those described till now and is one of the rare serine aminopeptidases. It has also been shown that a water deficit affects the activity of a subtilisin-like serine endopeptidase (its molecular mass is ~ 60 kDa and isoelectric point ~ 4.8) which, on the basis of amino acid sequence, can be classified as a member of the S8 family. Water deficit is also shown to affect the expression of the gene coding for a similar protease. The level of response of some of the identified proteases depends on the degree of drought tolerance of the plant species or cultivar, a characteristic that could be used in plant breeding.

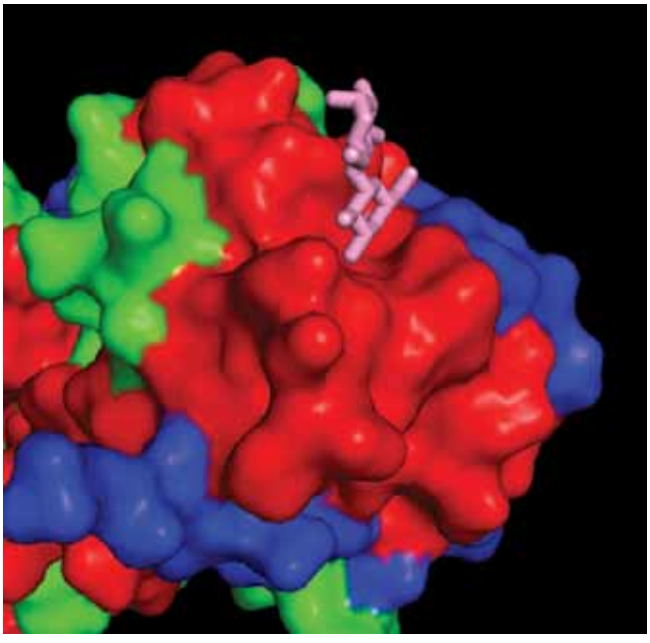

Figure 3. The binding pocket for lactose or N,N'-diacetyllactosediamine on lectin CNL domain

The results of the research work at the Department of Biotechnology in 2009 were published in 40 scientific papers in journals with an impact factor, in two chapters in books and presented at scientific conferences as lectures and posters. Four 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 and doctoral thesis at the University of Ljubljana, University of Maribor and the Jožef Stefan Postgraduate School. The following awards were given to members of the department in 2009: Krka and L'Oreal award for the best doctoral thesis, Lapanje award for research work, Mlinarik award and the award for the best supervisor in the year 2009.

Some outstanding publications in the past three years

1. Caroline Vance, Boris Rogelj. Mutations in FUS, an RNA processing protein, cause familial amyotrophic lateral sclerosis Type 6. Science (Wash. D.C.), 2009, vol. 323, no. 5918, p. 1208-1211. JCR IF (2008): 28.103
2. Zala Jevnikar, Nataša Obermajer, Matthew Bogyo, Janko Kos. The role of cathepsin X in the migration and invasiveness of T lymphocytes. J Cell Sci, 2008, 121, . 2652-2661. JCR IF: 6.247.

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5. Nataša Obermajer, Bojan Doljak, Janko Kos. Cytokeratin 8 ectoplasmic domain binds urokinase-type plasminogen activator to breast tumor cells and modulates their adhesion, growth and invasiveness. Mol Cancer, 2009, 8, 88, JCR IF (2008): 5.362,
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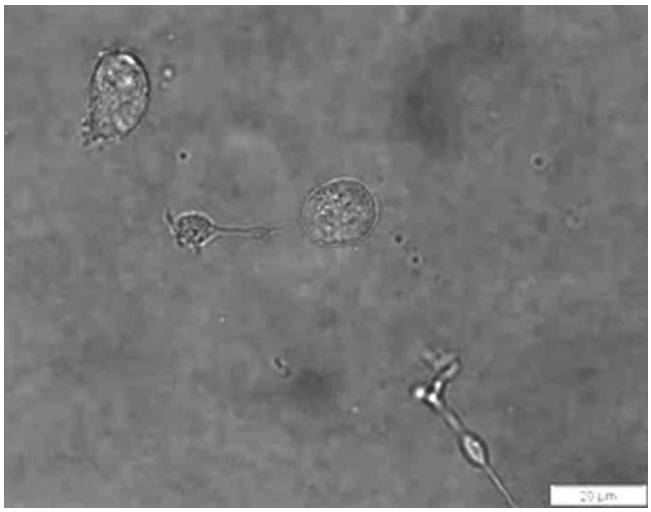

Figure 4. Nanotubes formed by T cells expressing increased levels of cathepsin X

Awards and appointments

1. Prof. Janko Kos: Slovenian young investigator society, Award mentor of the year 2009
2. Prof. Janko Kos: Slovenian biochemical society, Lapajne award for research work 2009
3. Prof. Borut Štrukelj: Slovenian pharmaceutical Society, Mlinarik award 2009
4. Dr. Nataša Obermajer: L'Oreal Award for Ph. D. thesis
5. Dr. Nataša Obermajer: Krka award for Ph. D. thesis

Organization of conferences, congress and meetings

1. Organisation of Annual meeting of the Programme group "Pharmaceutical Biotechnology: Knowledge for Health" Department of Biotehnology, Jožef Stefan Institute and Faculty of Pharmacy, University of Ljubljana, Ljubljana, 13 November 2009

R & D GRANTS AND CONTRACTS

1. Expression and function of uncoded RNA in Parkinson disease
   Dr. Boris Rogelj, Dr. Nada Lavrič
2. Functional analysis of proteins resistant to drought and insects
   Dr. Jerica Sabotič
3. Lectins as modulators of anti-tumor immunoresponse
   Prof. Janko Kos
4. Evaluation of genotypes of bean (Phaseolus vulgaris L.) with help of candidate genes for drought resistance
   Prof. Janko Kos
5. Development of new biological drugs with phage display technology
   Prof. Borut Štrukelj

RESEARCH PROGRAM

1. Pharmaceutical biotechnology: knowledge for health
   Prof. Janko Kos

VISITOR FROM ABROAD

1. Prof. Jae Seong-So, College of Engineering, Inha University, South Korea, 16–30 November 2009

STAFF

Researchers
1. Asst. Prof. Kristina Gruden*
2. **Prof. Janko Kos*, Head**
3. Dr. Boris Rogelj
4. Prof. Borut Štrukelj*

Postdoctorial associates
5. Dr. Aleš Berlec
6. Nataša Obermajer, B. Sc.
7. Dr. Jure Pohleven
8. Dr. Jerica Sabotič

Postgraduates
9. Petra Avanzo, B. Sc.
10. Špela Magister, B. Sc.

Technical and administrative staff
11. Darja Žunič Kotar

Note:
* part-time JSI member

BIBLIOGRAPHY

ORIGINAL ARTICLES

1. Petra Avanzo, Jerica Sabotič, Sabina Anžlovar, Tatjana Popovič, Adrijana Leonardi, Roger H. Pain, Janko Kos, Jože Brzin, "Trypsin-specific inhibitors from basidiomycete Clitocybe nebularis with regulatory and defensive functions", *Microbiol (Soc. Gen. Microbiol.)*, vol. 155, no. 12, pp. 3971-3981, 2009.
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4. Hugh Barker, Kara D. McGeachy, Nataša Toplak, Kristina Gruden, Jana Žel, Isla Browning, "Comparison of genome sequence of PVY isolates with biological properties", *American journal of potato research*, issue 3, vol. 86, pp. 227-238, 2009.
5. Aleš Berlec, Borut Štrukelj, "Large increase in brazzein expression achieved by changing the plasmid /strain combination of the NICE system in Lactococcus lactis", *Lett. appl. microbiol.*, vol. 48, no. 6, pp. 750-755, 2009.
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7. Karin Bunakova, Nataša Obermajer, Jaromir Kotzya, Milos Pesek, Janko Kos, "Levels of cathepsins S and H in pleural fluids of inflammatory and neoplastic origin", *Int. j. biol. markers*, vol. 24, no. 1, pp. 47-51, 2009.
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15. Rade Injac, Martina Perše, Manica Černe, Nejka Potočnik, Nataša Radić, Biljana Govedarica, Aleksandar Djordjević, Anton Cerar, Borut Štrukelj, "Protective effects of fullerenol C60(OH)24 against doxorubicin-induced cardiotoxicity and hepatotoxicity in rats with colorectal cancer", *Biomaterials*, vol. 30, no. 6, pp. 1184-1196, 2009.
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Review Articles and Chapters in Books

1. Aleš Berlec, Borut Štrukelj, "Novel applications of recombinant lactic acid bacteria in therapy and in metabolic engineering", *Recent Patents on Biotechnology*, vol. 3, no. 2, pp. 77-87, 2009.
2. Rade Injac, Nataša Radić, Biljana Govedarica, Aleksandar Đorđević, Borut Štrukelj, "Upotreba fulerenola C60(OH)24 kao organo-protektora u akutnoj toksičnosti izazvanoj doksorubicinom", *Pharmaca Serbica*, vol. 1, no. 1-2, pp. 19-26, 2009.
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4. Janko Kos, "Biološka zdravila pri raku", *Farm. vestn.*, vol. 60, no. 2, pp. 61-66, 2009.
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Published Conference Papers

Invited Paper

1. Borut Štrukelj, "Dileme sodobnih pristopov k obvladovanju in zagotavljanju kakovosti", In: *BIA in biotehnologija na slovenski biotehnološki poti*, (Pomen biotehnologije in mikrobiologije za prihodnost, 07), Posvetovanje Pomen biotehnologije in mikrobiologije za prihodnost, 2. in 3. december 2009, Ljubljana, Peter Raspor, ed., Ljubljana, Biotehniška fakulteta, Oddelek za živilstvo, Katedra za biotehnologijo, mikrobiologijo in varnost živil, BIA, 2009, pp. 23-32.

Regular papers

1. Nada Lavrač, Petra Kralj Novak, Igor Mozetič, Vid Podpečan, Helena Motaln, Marko Petek, Kristina Gruden, "Semantic subgroup discovery: using ontologies in microarray data analysis", In: *Engineering the future of biomedicine: proceedings of the 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2-6 September, 2009, Minneapolis, Minnesota*, [New York], Institute of Electrical and Electronics Engineers, cop. 2009, pp. 5613-5616.
2. Nada Lavrač, Igor Mozetič, Vid Podpečan, Petra Kralj Novak, Helena Motaln, Marko Petek, Kristina Gruden, "Gene analytics: discovery and contextualization of enriched gene sets", In: *Workshop on Explorative Analytics of Information Networks at ECML PKDD 2009, September 11, 2009, Bled, Slovenia*, Andreas Nüernberger, ed., [S. l., s. n.], 2009, pp. 39-49.
3. Irma Virant-Klun, Andrej Vogler, Jasna Šinkovec, Matjaž Hren, Kristina Gruden, Elvira Maličev, Helena Meden-Vrtovec, "Ovarijska neplodnost, matične celice in oogeneza in vitro", In: *4. Kongres ginekologov in porodničarjev Slovenije z mednarodno udeležbo, Portorož, 11. do 13. november 2009*, (Zdravniški Vestnik, vol. 78, Suppl 1), Ljubljana, Slovensko zdravniško društvo, 2009, pp. I-57 - I-61.

Theses

Ph. D. Thesis

1. Jure Pohleven, *Biochemical properites of lectin from higher fungus clouded agaric (Clitocybe necularis) and its biological activity: doctoral dissertation*, Ljubljana, [J. Pohleven], 2009.

Patent Applications

1. Mojca Lunder, Tomaž Bratkovič, Uroš Urleb, Samo Kreft, Borut Štrukelj, Petra Ekar, *Ultrasound elution of biological ligands: Pub. No. WO/2009/007463*, München, Isenbruck Bösl Hörschler Wichmann Huhn LLP; Prinzregentenstrasse 68, 15.01.2009.
2. Borut Štrukelj, Samo Kreft, Andrej Umek, Damjan Janeš, *Antioksidativni izvleček iz skorje jelke in smreke: patentna prijava P-20080029/UL20080787004*, Ljubljana, Urad Republike Slovenije za intelektualno lastnino, 5.1.2009.

DEPARTMENT OF ENVIRONMENTAL SCIENCES O-2

The basic characteristic of the Department of Environmental Sciences is multidisciplinarity, as our researches comprehend different 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 binding the scientific excellence of our research work by 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 geochemical cycles of elements, nutrition and the health of humans, animals and plants, waste management, mathematical and GIS modelling of environmental processes as well as risk and environmental impact assessments.

Head:
Prof. Milena Horvat

Environmental analytical chemistry

Pioneer research work on the use of liquid chromatography based on monolithic supports for elemental chemical speciation was continued by the use of Convective-interaction media (CIM®) columns and disks for the speciation of Al, Cr and Zn. The speciation of Al in human serum at normal concentration levels was performed on a weak anion-exchange CIM® diethylamine (DEAE) monolithic column and followed by UV detection at 278 nm. Separated Al species were detected online by ICP-MS. It was experimentally proven that 91 ± 7 % of Al in human serum was eluted under the transferrin peak. Transferrin was identified on the basis of the retention volume and by UPLC-ESI-MS. This is the first report in the world on the quantitative and reliable speciation of Al in human serum at physiological concentration levels.

A new analytical method for the speciation of organotin compounds (OTC) was developed for the determination of methy- butyl-, phenyl- and octyltin compounds that can be simultaneously determined also in water samples with complex matrices, for example, in leachates from landfills. Butyltin compounds were also determined by the isotope dilution GC-ICPMS technique. For this purpose the stable isotope (^{119}Sn) enriched butyltin species was used. Chromium stable isotopes (^{51}Cr and ^{53}Cr) were used as tracers in order to check the potential oxidation–reduction processes of chromium during analytical procedures.

In the field of organic analytical chemistry we have devoted most of our research to studying the fate of pharmaceutical residues and endocrine-disrupting compounds in the environment. We introduced a series of analytical procedures in order to determine new compounds like carbamazepine, diazepame, citaloprame and estrone, 17β-estradiol, 17α-ethnylestradiol and estriol in various matrixes such as surface and waste water.

The research exclusivity of the Center for Mass Spectrometry (CMS) can be shown in three main approaches: ESI studies of weakly bounded non-covalent and inclusion complexes, upLC-MS analyses of target endogenous opiopeptides in urine samples as potential biomarkers of autistic disorders and the identification of drug biodegradated products and ESI studies of proteins and inclusion complexes of cyclodextrins and isomeric coumaric acids. Currently, the Center for Mass Spectrometry supports about 30 national and international research programs and projects from various scientific areas, such as chemistry, biochemistry, pharmacy, medicinal chemistry and biology and some technological applications of the pharmaceutical industry and produces about 4500 analyses per year.

The improvements of the methods based on instrumental neutron activation analysis (INAA) for the determination macro, micro and trace elements in environmental samples continued. The neutron flux was re-measured in

Outstanding achievements:

- **pioneer research work on the use of liquid chromatography based on monolithic supports for the elemental chemical speciation of Al, Cr and Zn**
- **upLC-MS analyses of target endogenous opiopeptides in urine samples as potential biomarkers of autistic disorders**
- **characterisation and identification of pharmaceutical transformation products formed during waste-water treatment and in the environment**
- **accreditation of the seven laboratory methods**

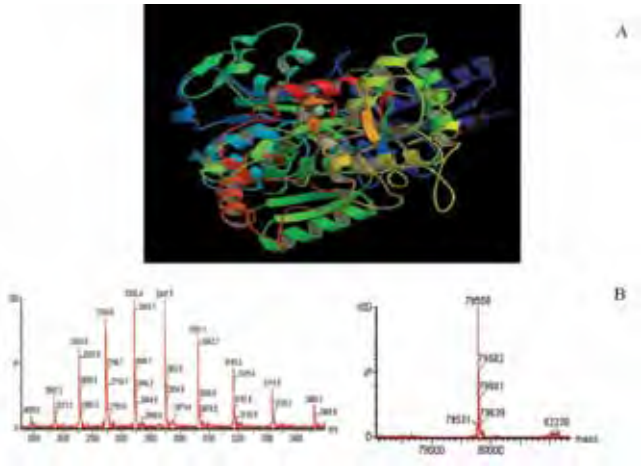

Figure 1: Transferrin in human serum (A) molecule of transferrin and (B) identification of transferrin in human serum by UPLC-ESI-MS (ESI mass spectrum).

typical irradiation channels of the TRIGA reactor and validated MATSSF software (developed at JSI) for the calculation of self-shielding factors (thermal and epithermal). In addition, the k0-method has been optimized to work with samples contenting Fe as a matrix element. The accuracy and reliability of the method were checked by the analyses of reference materials from Japan (JSS). We studied radiation defects in semiconductors induced by fast neutrons using the reactor TRIGA. Irradiated and relaxed samples were subsequently studied by electrical measurements, particularly by the capacitive spectroscopy of deep levels (DLTS) and high-resolution DLTS (L-DLTS) developed at the "Ruđer Bošković" Institute, Zagreb.

In the framework of the EU Marie Curie fellowship of dr. S. Ribeiro Guevara, further refinement and optimization of the use of radiotracer 197-Hg prepared from enriched 196-Hg were implemented, particularly in the area of understanding the behaviour of mercury in aqueous solutions.

Metrology in Chemistry: We participated in the certification process of five new reference materials: three produced by the IRMM (Belgium) and two produced by BAM (Germany). In addition, we participated in a proficiency test for IAEA-452, WEPAL and FAPAS®.

In 2009, Slovenian accreditation imparted the accreditation certificate LP-090 (http://www.sa.gov.si/teksti-1/doc/test/LP090.pdf) to the Department O-2 and with this the accreditation process for seven chemical and radiochemical testing methods was finished. In addition, the quality management system of the Department O-2 was successfully presented and defended at meeting of the Technical Committee – Quality (TC-Q) of EURAMET (European Association of National Metrology Institutes) in Thessaloniki, Greece.

Environment, Nutrition and Health

In the field of new research for cancer therapy, the distribution and kinetic of metalodrugs that contain Ru or Pt in experimental animals and humans were investigated by applying analytical approaches of elemental chemical speciation, and the potential use of ferro-magnetic nanoparticles evaluated by measuring Fe in various samples from pre-clinical studies.

Together with partners from University Clinical Centre of Ljubljana, long-term research is being performed on arsenic metabolism in cancer patients treated with arsenic trioxide. In 2009 most of the work was dedicated to selenium as a possible indicator for complications (toxicity) during the therapy. Results indicate that the serum and urine selenium drop significantly during the therapy, which was especially dangerous for patients with very low selenium even before the therapy. Part of the study includes cell cultures of patients and commercial cell lines. Transformations of arsenite in the culture media solutions were studied and we found that some of the routinely used media are not suitable in arsenic studies due to the high degree of the oxidation of arsenite into arsenate. We also started with the validation and application of (q)RT-PCR (Reverse Transcription PCR) for the amplification, isolation and identification of cellular mRNA of metallothioneins (MT). MT can represent a part of the resistance mechanisms during arsenic therapy.

Although Se has not been confirmed as being an essential micronutrient in higher plants, it is known that they are capable of accumulating larger amounts of the element. These plants can be a key factor in achieving a satisfactory intake of Se in human and animal diets. However, not the total Se content, but its species present, parallels Se bioavailability. The method for determination of the volatile Se species (SPME-GC-MS) was optimised. Due to the fact that the volatilisation of Se species could occur during the plant growth we used the method developed to check whether buckwheat sprouts, the seeds of which were soaked in selenate solution (various concentrations) for 4 hours, are capable of converting inorganic Se, during the growth, into the volatile form. The buckwheat sprouts were found to be capable of accumulating higher amounts of Se. Volatile Se species, namely dimethyl selenide and dimethyl diselenide, were present in traces during the plant growth. Additionally, no volatilisation occurred during the sample preparation procedure used for a determination of the soluble Se species. Buckwheat sprouts were capable of transforming selenate to other Se species, while around 25% of the total Se remained unchanged. While plants are a good source of polyphenols we checked what their influence could be on a determination of water-soluble Se species. SeMet, SeMetSeCys, Se(VI) and $SeCys_2$ were found to be stable in plant extracts. On the other hand, tannin and rutin, present in a specific ratio, had the ability to transform Se(IV) to other species, which we were not able to detect with HPLC-ICP-MS. This indicates that we have to be extremely careful when giving the plant Se species content.

Research on ^{210}Po in marine and freshwater organisms was also continued with the emphasis on a determination of the dose for an average Slovenian due to the consumption of fishes, squids and mussels. The results of the work were presented at the conference on Nuclear Energy for New Europe 2009 held in Bled, where our work was awarded with the best poster award. The content of natural radionuclides in milk from the vicinity of a former uranium mine Žirovski vrh was determined and compared with the milk from the reference location, powdered milk from a Ljubljana shop and with human milk.

In cooperation with the University Medical Centre in Ljubljana many researches on the influence of mercury on the health of Idrija inhabitants and the wider Slovenian population, especially women of childbearing age and pregnancy, were continued within the project "PHIME".

Within the PHIME framework, research was conducted in which we assessed exposure to cadmium, lead and mercury in different areas of Slovenia on the population of women aged between 50 and 60 years. The analytical work was done at the "Jožef Stefan" Institute and the University Medical Centre Ljubljana.

Food analysis: 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. The potential natural abundance of nitrogen isotopes for the control of the biological production of lettuce and celery was evaluated under different fertilizer administration regimes. The regular analysis and speciation of mercury in food in contaminated areas of Idrija was also conducted.

Biological and geochemical cycles:

The content of ^{129}I in samples from the various environments of Slovenia was further investigated. From the marine environment, seawater, alga (*Fucus virsoides*), blue mussel (*Mytilus galloprovincialis*) and sediment samples were analyzed. The results found were in the range from 1.3 to $55.4 \cdot 10^{-9}$ μq g^{-1} for seawater, from 104 to $127 \cdot 10^{-9}$ μq g^{-1} for blue mussel, from 334 to $471 \cdot 10^{-9}$ μq g^{-1} for alga *Fucus virsoides* and from 72 to $256 \cdot 10^{-9}$ μq g^{-1} for marine sediment. We participated in the inter-laboratory comparison entitled "^{129}I in Mediterranean Sea water" organised by the IAEA.

In cooperation with the Marine Biology Station Piran we studied the metal contents in mucilage heteropolysaccharides from the northern part of the Adriatic sea. The pilot study was performed on polysccharides (DOM – dissolved organic matter) fractionation by ultrafiltration and chromatographic filtration. In the obtained fractions the presence of the metals was determined by HPLC-UV, HPLC-ICPMS.

Biogeochemical cycles of biogenic elements: The research performed in Lake Bled was focused on the processes affecting the distribution and cycling of carbon and nitrogen in the water column and sediment. The results suggest that in the autumn-winter period ammonium and not nitrate is the main assimilation species for particulate nitrogen, and fixation is not an important source either. Organic-matter degradation is a source of nitrate, which is actively consumed by denitrification at anoxic hypolimnium. The results also imply an autochtonic origin of the particulate organic matter, with phosphorus being the limiting factor of primary production. In anoxic sediment the composition and distribution of lipids suggested that the surface had been dominated by sterols and fatty acids, while deeper in sediments aliphatic alcohols and hydrocarbons, which are less degradable, prevailed. Lipids of bacterial origin constitute about 5% of the total lipids in the whole sediment column. Microbiological studies have shown that at the surface and at 10-12 cm, the methanogenic population accounted for 73 and 38% of arcaheal community, respectively.

Response of natural systems to environmental change: Stable isotopes of soil CO_2 were used to evaluate the abiotic contribution to soil respiration rate and the net exchange of carbon in the Karst grassland, which represents an important part for the national carbon-balance calculation. The first results of 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 CO_2 to the atmosphere. Uncertainties of tufas at the Dinaric carbonate platform as terrestrial palaeoenvironmental archives were evaluated based on the application of isotopic ($\delta^{18}O$) and geochemical (Mg/Ca) thermometry, and possible ways of reducing uncertainties were tested. The response of karstic cave systems to the environmental change was analysed in Pisani rov in the Postojna Cave. It was found that the continuous warming of the atmosphere is already reflected in the most isolated parts of the cave. An analysis of a high-resolution (> 0.5 μm) profile of the elemental and stable isotope compositions of two stalagmites showed the influence of the increased temperature, as well as land use and forest composition on the chemical and structural variations in slow-growing speleothems.

The research continued on the migration of natural radionuclides in the vicinity of a former uranium mine Žirovski vrh, with special emphasis on natural radionuclide fractionation in the soil and on natural radionuclides transfer into the grass.

In the Radon Center, the study of the influence of seismicity and tectonic activity on radon transport has been continued. It is based on a long-term continuous (once an hour) radon monitoring (i) in thermal springs at Bled


SLOVENSKA AKREDITACIJA

LP-090

akreditacijska listina
accreditation certificate

Institut Jožef Stefan

SIST EN ISO/IEC 17025:2005

Figure 2: The department obtained the Accreditation Certificate no. LP-090, granted by the Slovenian Accreditation body (SA). Seven methods were accredited: (1) determination of strontium by beta counting, (2) determination of tritium by liquid scintillation counting, (3) determination of C-14 in basis solution, (4) determining the elemental composition of environmental samples by k0-INAA, (5) determination of organotin compounds in water, (6) determination of metals in water by ICP MS, and (7) determination of the total mercury in water.

and Hotavlje in Slovenia, (ii) in soil gas in Friuli and Sicily in Italy, and in Sapporo in Japan, and (iii) in air at the tectonic faults in the Postojna and Kostanjevica caves (Slovenia). In addition to the statistical methods generally used in data evaluation, the machine-learning methods (decision trees and neuron networks) were introduced and have been used successfully to identify the anomalies in the time series of radon activity concentration, possibly caused by seismic activity, and not ascribed to the environmental parameters solely. These statistical tools are used in collaboration with the Department of Knowledge Technologies and the Department of Computer Systems. Since 2009 a study of radon and carbon dioxide in soil gas and some typical natural radionuclides in soil has been performed over different geological units. At Velenje, a more than a year long monitoring of radon in outdoor air as well as the hydrometeorological parameters has been carried out continuously (once an hour) at two points, one on the fly ash depository and the other as a reference on an undisturbed ground a few kilometres away. At this well-defined uniform radon source we intend to explore the influence of the hydrometeorological conditions on the radon transfer at the ash-atmosphere interface and the role of the local and global air mass movements on its dilution and dispersion in the atmosphere. Our long-term research of radon short-lived decay products (RnDP) in the air (a crucial parameter in radon dosimetry) was extended to the non-radioactive aerosols (10–1000 nm) to which RnDP was attached. For this purpose, their concentration and size distributions have been measured in the Postojna Cave, as well as in some karst caves and underground mines in Hungary (as part of our bilateral collaboration). In addition, all the data available on radon concentration in Slovenian homes were statistically elaborated and a database was created in the form required to include Slovenia in the European radon map.

Lichen samples collected from polluted sites in Portugal and the representative of high loadings, medium loadings and zero loadings for factors related to natural and anthropogenic emission sources, were analysed to determine the arsenic contents and its species extractability. The anionic arsenic compounds were extracted at most of the sites, varying between 0.5% and 6.6%, while no cationic arsenic compounds were found at any of the sites. The As(V) present as a pollutant was thus partially transformed into As(III), dimethylarsinic acid or methylarsonic acid, confirming our previous findings on arsenic speciation in lichen samples.

Environmental technologies and waste management

The potential for the use of electric arc furnace (EAF) dust for the manufacturing of cement composites to be used in civil engineering and for balances in washing machines was critically evaluated in investigations on the reuse of waste materials. To estimate the environmental impacts of new products, a leachability test based on diffusion was performed over a time period of 175 days in compact and ground cement composites and cement composites with the addition of EAF dust.

For pharmaceutical residues, our focus was on determining the pharmaceutical transformation products formed during waste-water treatment and in the environment. This is a novel and demanding field of research that only those groups equipped with state-of-the-art instrumentation and the necessary technical skills can tackle. We studied the elimination of selected pharmaceuticals in an optimised pilot waste-water treatment plant (PWWTP), where attention was given to contaminant-elimination mechanisms (degradation, biodegradation, photodegradation and adsorption), the application of different treatment technologies (ozonation, ClO_2, biological, UV and photocatalytic treatment) and stable-degradation product identification. We succeeded in identifying a number of pharmaceutical transformation products and degradation pathways. The excellence of our work is shown by the number and quality of journals in which we have published our findings (Environmental Science and Technology, Environmental Pollution, Journal of Hydrology, etc.). Our research has also focused on the toxicity of the identified transformation products, and the results so far have shown that the transformation products can have a greater toxicity than the parent compounds. In the area of steroid estrogens we have, based on developed and validated analytical procedures, estimated the extent of pollution in the Slovene environment and shown it to be comparable to that of other European countries. We have also begun researching the effects of steroid estrogens on biological systems, which will, in combination with chemical tests, provide a more accurate risk assessment of steroid estrogens in the environment. For such purposes we now have the capability to perform CALUX and YES, complementary biological tests, within our our laboratory.

In collaboration with the Department of Inorganic Chemistry and Technology a pilot-scale laboratory testing for the removal of elemental mercury from flue gases was investigated. The overall objective is to increase the capacity of a wet flue-gas desulphurisation system to oxidize elemental mercury and reduce emissions into the atmosphere. An international symposium "Mercury Emission from Coal", MEC-6, was also organized in Ljubljana, bringing together leading researcher from all over the world.

Risk and environmental impact assessments

Projects in 2009 were primarily associated with a strategic (spatial) environmental evaluation and environmental & health assessment. The project "Technical basis for the preparation of regional spatial development plan

for Ljubljana Urban Region" involved strategic environmental assessment (SEA); such an SEA has been prepared for the first time in Slovenia. Work on the project "iNTeg-Risk" involves the integration of strategic, sustainability and project level environmental evaluation with spatial planning for new emerging risk technologies. The work in the context of the "ArcRisk" project focuses on the process evaluation activities aimed at achieving harmonised work among working packages and assuring the ultimate project results according to a "fit-for-purpose" approach.

The reports on the environmental and health risks of mercury related to the planned installation of liquid gas terminals in the Gulf of Trieste were prepared at the request of the Ministry of the Environment and the Ministry of Health.

Figure 3: In June an international symposium MEC-6 (Mercury Emission from Coal), was organized in Ljubljana in cooperation with the International Energy Agency from the UK. Over 70 experts investigating the best technologies for the reduction of emissions of mercury to the atmosphere from all over the world attended the meeting.

Monitoring programmes

The human bio-monitoring programme continued and involves our department as well as the National Chemical Bureau of the Republic of Slovenia, University Medical Centre Ljubljana and Institutes of Public Health over 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 results obtained will be the basis for a determination of reference values and an estimation of human exposure to selected environmental pollutants. A new EU programme on Human Biomonitoring – COPHES was launched in December 2009.

In the framework of the EU project "HYDRONET", which aims at the development of remotely operated sensitized robots for water monitoring (i.e., intelligent monitoring systems), scenarios for the coastal lagoons and coastal environments were developed, including the basis for the development of databases.

Two types of bio-indicators, lichens and mosses, were compared for assessing the levels of natural (^{210}Pb) and artificial (^{137}Cs) radionuclides for environmental bio-monitoring purposes. ^{210}Pb deposition data obtained on the basis of a bio-monitoring survey was compared with the data on ambient air radon measurements on the entire area of Slovenia. It was found that both lichens and mosses reflect radionuclide deposition in a similar way and that the spatial distribution depends on the sources of particular radionuclides as well as environmental factors (e.g., precipitations, movement of air masses, etc.). We are actively participating in the standardisation of bio-monitoring methods with mosses and lichens by membership of the international committee CEN/TC264/WG31.

Lichen samples collected in polluted sites in Portugal and representative of high loadings, medium loadings and zero loadings for factors related to natural and anthropogenic emission sources were analysed to determine the arsenic contents and its species extractability. The anionic arsenic compounds were extracted at most of the sites varying between 0.5% and 6.6%, while no cationic arsenic compounds were found at any of the sites. As(V) present as a pollutant was thus partially transformed into As(III), dimethylarsinic acid or methylarsonic acid, confirming our previous findings on arsenic speciation in lichen samples.

In collaboration with the Environmental Agency of the Republic of Slovenia the monitoring of metals and organotin compounds in sea water and surface waters continued in 2009.

In collaboration with the Environmental Agency measurements of atmospheric mercury and mercury in deposition were launched at the EMEP station in Iskrba.

We participated in Off–Site Monitoring of Krško Nuclear power plant with determining the strontium in environmental samples. We determined the tritium and C-14 in gas effluents from Nuclear power plant Krško.

Databases: Maintenance of the EU database on the isotopic composition of Slovenian wine. 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 precipitation in Slovenia and Croatia.

Some outstanding publications in 2009

1. Andrej Osterc, Štefan Fujs, Peter Raspor, Vekoslava Stibilj. Saccharomyces cerevisiae : the effect of different forms and concentrations of iodine on uptake and yeast growth. FEMS yeast research., 2009, 1/9, 45-51.
2. Delphine Foucher, Nives Ogrinc, Holger Hintelmann. Tracing mercury contamination from the Idrija mining region (Slovenia) to the Gulf of Trieste using Hg isotope ratio measurements. Environ. sci. technol. 2009, 43, 33-39.
3. Sonja Lojen, Andrej Trkov, Janez Ščančar, Juan A. Vázquez-Navarro, Neven Cukrov. Continuous 60-year stable isotopic and earth-alkali element records in a modern laminated tufa (Jaruga, river Krka, Croatia) : implications for climate reconstruction. Chem. geol.. 2009, 3-4,258, 242-250.

4. Simona Murko, Radmila Milačič, Bogdan Kralj, Janez Ščančar. Convective interaction media monolithic chromatography with ICPMS and ultraperformance liquid chromatography-electrospray ionization MS detection: a powerful tool for speciation of aluminum in human serum at normal concentration levels. Anal. Chem. (Wash.)., 2009, vol. 81/12, 4929-4936.
5. Janez Ščančar, Radmila Milačič. Monolithic chromatography for elemental and speciation analysis. TrAC, Trends Anal. Chem.), 2009, vol. 28/ 9, 1048-1056,
6. Tina Kosjek, Henrik R. Andersen, Boris Kompare, Anna Ledin, Ester Heath. Fate of carbamazepine during water treatment. Environ. sci. technol.., 2009, 16, 43, 6256-6261.
7. Branko Kontić, Marko Gerbec. The Role of Environmental Accidental Risk Assessment in the Process of Granting Development Consent. Risk Analysis, 29 (11) 2009. doi: 10.1111/j.1539-6924.2009.01285.

Awards and appointments

1. Karmen Bizjak Bat: Bitenc Award for bachelor degree »Characterization of Slovenian and Cypriot fruit juices with different methods" (N. Ogrinc)
2. Dr. Radojko Jaćimović: CDTN/CNEN (Nuclear Technology Development Centre/Brazilian Commission for Nuclear Energy), Belo Horizonte, Brazil, honoured him for supporting the Neutron Activation Group to re-establish and improve the k0-standardization method of NAA at CDTN, September 2009
3. Tina Kosjek: Fellowship World Federation of Scientists (WFS) and The Slovenian Science Foundation (SZF)
4. Wagner S., Vreča P., Leis A. & Boechzelt H.: The 3th Poster Award "Carbon isotope ratio analysis of authentic and commercial essential oils of lavandin (lavandin hybrida)", at the Conference "TRACE 5th Annual Meeting and Conference, TRACE in practice - new methods and systems of confirming the origin of food", 1. 4.-3. 4. 2009, Freising, Germany.
5. Marko Štrok, Borut Smodiš: Best Poster Award "Assessment of Po-210 Ingestion Dose Due to Fish and Squid Consumption from Slovenian Market«. Presented at the International Conference "Nuclear Energy for New Europe 2009«, Bled, Slovenia
6. Simona Murko: Reward for outstanding research work of young researchers, Trešt, Czech Republic

Organization of conferences and meetings

1. Milena Horvat: Mercury Emission from Coal – MEC6, Ljubljana, 22. 4.-24. 4. 2009
2. Milena Horvat: Meeting HydroNet, Ljubljana, 1. 10.-2. 10. 2009

INTERNATIONAL PROJECTS

1. European Coordinaton Action on Human Biomonitoring
   COPHES
   7. FP, 244237
   EC; Dr. Alexandra Polcher, BiPRO GmbH, Beratungsgesellschaft für integrierte Problemlösungen, München, Germany
   Prof. Milena Horvat
2. Arctic Health Risks: Impacts on Health in the Arctic and Europe Owing to Climate-induced Changes in Contaminant Cycling
   ArcRisk
   7. FP, 226534
   EC; Arctic Monitoring and Assessment Programme, Secretariat, Oslo, Norway
   Prof. Milena Horvat, Prof. Branko Kontić
3. 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
4. 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
   Prof. Branko Kontić, Asst. Prof. Marko Gerbec
5. 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
6. Mobilising Citizens for Vital Cities Ljubljana-Gent-Zagreb-Brno-Porto
   CIVITAS-ELAN
   7. FP, 218954, TREN/FP7TR/218954
   EC; Zdenka Šimonovič, City of Ljubljana, Ljubljana, Slovenia
   Prof. Branko Kontič
7. 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
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
   Asst. Prof. Sonja Lojen, Andrej Gyergyek, B. Sc., Dr. Andrej Stergaršek
9. Stable Isotopes in Atmosphere-Biosphere-Earth System Research
   SIBAE, COST ES0806
   EC; COST Office, Brussels, Belgium
   Asst. Prof. Sonja Lojen
10. Xenobiotics in the Urban Water Cycle
    COST 636
    EC; COST Office, Brussels, Belgium
    Asst. Prof. Ester Heath
11. Global Study on Contaminated Sites
    UNEP
    Per Bakken, UNEP Chemicals Branch, Châtelaine, Geneve, Switzerland
    Prof. Milena Horvat
12. Conditioning of Drinking Water with Constructed Wetlands
    WETPUR, EUREKA
    Limnos Company for Applied Ecollogy Ltd., Great Britain
    Asst. Prof. Janez Ščančar

13. Eradication of Lung Cancer Caused by Radon Gas in Azerbaijan and Slovenia
SCOPES, CCR-067
Dr. Claudio Valsangiacomo, Marcus Hoffmann, Swiss University of Applied Sciences of Southern Switzerland, Scuola Universitaria Professionale della Svizzera Italiana - SUPSI, Radon Competence Centre, Trevano, Canobbio, Switzerland; SNSF- Swiss National Science Foundation, Bern, Switzerland
Dr. Chingiz Alyiev, Geology Institute of National Academy of Science, Baku, Azerbaijan
Asst. Prof. Janja Vaupotič
14. Stable Isotope Technique to Assess Human Milk Intake in Infants Living in Areas Contaminated with Mercury, Lead and Cadmium; Stable Isotope Technique to Assess Human Milk Intake in Infants Living in Contaminated Areas
15825/R0
IAEA, Vienna, Austria
Prof. Milena Horvat
15. Assessment of Potential Association of Exposure to Vehicular Lead with Nutritional Status in Women of Child-Bearing Age in Nigeria
15628/R0
IAEA, Vienna, Austria
Dr. Darja Mazej
16. 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
17. 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
18. Measurements and Calculations of the Neutron Spectrum in Different Irradiation Channels of the TRIGA Mark II Reactor, Slovenia
13279/R1, R2
IAEA, Vienna, Austria
Dr. Radojko Jaćimović
19. Fellowship for Mr Khalid Embarch
IAEA Fellow, MOR/09008, Pr. MOR/4/018
IAEA, Vienna, Austria
Dr. Radojko Jaćimović
20. Fellowship for Mr Dennis Kpakpo Adotey
IAEA Fellow, GHA/07017, Pr. GHA/0/010
IAEA, Vienna, Austria
Prof. Vekoslava Stibilj
21. Fellowship for Mr Tomislav Andjelić
IAEA Fellow, MNE/08013
IAEA, Vienna, Austria
Asst. Prof. Borut Smodiš
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. Training in Radioactivity Measurement for Practitioners from Countries Eligible under the JRC Enlargement & Integration Policy
54018
Ivan Celen, European Commission, Joint Research Center JRC, Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Asst. Prof. Ljudmila Benedik, Asst. Prof. Borut Smodiš
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. 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 Jaćimović
27. The Creation of Cypriot and Slovenian Analytical Databases for Authentic Fruit Juices
Dr. Rebecca Kokkinofa, Ministry of Health, State General Laboratory, Nicosia, Cyprus; Dr. Iztok Jože Košir, Slovenian Institute for Hop Research and Brewing, Žalec, Slovenia
Asst. Prof. Nives Ogrinc
28. Udvikling af innovative teknologier for kvantificering og fjernelse af miljofremmede stoffer fra spildevand
Development of Innovative Technologies for Determination and Treatment of Xenobiotic Organic Compounds in Eastewater
BI-DK/07-09-003
Prof. Anna Ledin, Institute of Environment & Resources, Technical University of Denmark, Kgs. Lyngby, Denmark
Asst. Prof. Ester Heath
29. Presence, Mobility and Persistence of Organotin Compounds in the Terrestrial Enivornment
BI-FR/09-10-PROTEUS-009, PROTEUS
Prof. Gaëtane Lespes, Laboratoire de Chimie Analytique Bioinorganique et Enivornnement (LCABIE), UMR CNRS IPREM-UPPA, France
Asst. Prof. Janez Ščančar
30. Study of Defects in Semiconductors Irradiated by Fast Neutrons
BI-HR/09-10-027
Dr. Sc. Branko Pivac, Ruđer Bošković Institute, Zagreb, Croatia
Dr. Radojko Jaćimović
31. Pollution of Croatian and Slovenian Northern Adriatic Coast with Organotin Compounds and Toxic Metals studied by Different Analytical Techniques
BI-HR/09-10-025
Dr. Nevenka Mikac, Ruđer Bošković Institute, Zagreb, Croatia
Dr. Janez Ščančar
32. Isotopic Composition of Precipitation in Croatia and Slovenia
BI-HR/09-10-032
Dr. Ines Krajcar Bronić, Ruđer Bošković Institute, Zagreb, Croatia
Dr. Polona Vreča
33. Mercury Interdisciplinary Research for Appropriate Clam Farming in Lagoon Environment MIRACLE
Agreement Disgam-IJS
Universita degli Studi di Trieste, Dipartimento di Scienze Geologiche, Ambientali e Marine, Comprensorio di S. Giovanni, Trieste, Italy
Prof. Milena Horvat
34. 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
35. Mercury Emission, its Influence and its Correlation to Radon in Mount Etna Area
BI-IT/05-08-026
Dr. Salvatore Giammanco, Instituto Nazionale di Geofisica e Vulcanologia, Sezione di Palermo, Palermo, Italy
Dr. Jože Kotnik
36. 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, Instituto Nazionale di Oceanografia e di Geofisica Sperimentale, Sgonico (Trieste), Italy
Asst. Prof. Janja Vaupotič
37. 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
38. 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
39. Biomarkers of Exposure and Effects in Sensitive Population Groups Living in Contaminated Sites
BI-CN/09-11-007
Prof. Chunying Chen, Key Lab for Nuclear Analytical Techniques, Insitute of High Energy Physics (IHEP), Chinese Academy of Sciences (CAS), Beijing, China
Prof. Milena Horvat
40. Environmental Impacts and Restoration after Closure of Wanshan Mercury Mine, Guizhou Province, China and the Comparison with Idrijca Mercury Mine, Slovenia
BI-CN/09-11-025
Dr. Feng Xinbin, State Key Laboratory of Environmental Geochemisty, Institute of Geochemistry, Chinese Academy of Science, Guiyang, China
Dr. Jože Kotnik
41. Modelling of Mercury and its Compounds in Polluted Freshwater Systems: Comparison between Reservoirs in the Guizhou Province and the Idrijca 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
42. 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

43. 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
44. Radon Potential on Different Geologic Basis-Continuation
BI-PL/08-09-017
Dr. Krzysztof Kozak, The Henryk Niewodniczanski, Institute of Nuclear Physics of the Polish Academy of Sciences, Laboratory of Radiometric Expertise, Krakóv, Poland
Asst. Prof. Janja Vaupotič
45. 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, Institut za nuklearne nauke "Vinča", Belgrade, Serbia
Asst. Prof. Nives Ogrinc
46. 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
47. Hydrogeochemistry of Carbonate Weathering Fluxes at the Terrestrial/Marine Interface of the Adriatic Sea: A Collaborative Field Study
BI-US/09-12-015
Prof. Walter Lynn M., University of Michigan, Geological Sciences, Ann Arbor, MI, USA
Asst. Prof. Nives Ogrinc
48. Exchange of Toxic Metals between Eater and Sediment in Polluted Freshwater Systems. The Idrijca 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. Development and evaluation of a toxicity test for engineered nanoparticles with terrestrial isopods
Asst. Prof. Maja Remškar, Dr. Ingrid Falnoga
2. Emission control of mercury and other toxic elements from thermal power plants, cement kilns and other high temperature industrial processes
Prof. Milena Horvat
3. Chemical and biological cycling of compounds with endocrine disrupting function in wastewater treatment
Asst. Prof. Janez Ščančar
4. Assessment of risk from metal contaminated soils and aerosols to human health through advanced and vitro gastrointestinal and respiratory bioaccessibility tests
Dr. Zdenka Šlejkovec
5. Physiochemical processes involved in formation of radioactive nanoaerosols
Asst. Prof. Janja Vaupotič
6. Interaction of organic matter with metals in coastal waters of the Gulf of Trieste
Prof. Milena Horvat
7. The use of isotope dilution inductively coupled plasma mass spectrometry technique in environmental studies
Asst. Prof. Radmila Milačič
8. CO_2 fixation in river carbonates: mass balance, hydrological, geochemical and biochemical controls
Asst. Prof. Sonja Lojen
9. Influence of arsenic trioxide metabolites on treatment of various cancer types
Dr. Zdenka Šlejkovec
10. Biochemical correlates of autism spectrum disorders
Dr. Bogdan Kralj
11. Deforested karst grasslands and their changes in sink activities for carbon
Asst. Prof. Nives Ogrinc
12. The impact of selenium on product and quality of growing plants
Prof. Vekoslava Stibilj
13. Functional foods with polyphenol antioxidants, plant proteins and trace elements.
Prof. Vekoslava Stibilj
14. The influence of UV-B radiation to antioxidant content and distribution in cultivated plants
Prof. Vekoslava Stibilj
15. Integrated methodologies for remediation of mercury contaminated sites
Prof. Milena Horvat
16. Natural hydrochemical backgrounds of groundwaters in Slovenia
Dr. Jasmina Kožar Logar , Asst. Prof. Sonja Lojen
17. Modelling, hydrodinamics, and transport of suspended matter and pollutants using SPH
Prof. Milena Horvat
18. Remediation of PCB contaminated waste deposit site
Dr. Stergaršek Andrej , Prof. Milena Horvat
19. Climate change and impacts of anthropogenic disturbances on primary production in forest soil
Asst. Prof. Nives Ogrinc
20. The impact of environmental changes to the growing responce of oak (Quercus robur L.) and larch (Larix decidua Mill.)
Asst. Prof. Nives Ogrinc
21. The impact of climate change on the sustainability, stability and biodiversity of beech and black pine stands in the Balkans
Asst. Prof. Nives Ogrinc
22. Establishment of ratio between 129-I and 127-I in marine and terrestial environment in Slovenia
Prof. Vekoslava Stibilj
23. Fate and speciation of pollutants during production of sinthetical fuel and pure hidrogen from polluted biomass
Dr. Andrej Stergaršek, Dr. Jože Kotnik
24. Quality and authenticity of honey on the Slovenian market
Dr. Marijan Nečemer, Asst. Prof. Nives Ogrinc
25. Comparison of two production forest systems in the light of climate change
Asst. Prof. Nives Ogrinc
26. Sequestration of CO_2 in geological media: criteria and approach for site selection in response to climate change
Dr. Tjaša Kanduč

RESEARCH PROGRAMS

1. Cycling of nutrients and contaminants in the environment, mass balances and modelling of environmental processes and risk analysis
Prof. Milena Horvat
2. Modelling and environmental impact assessment of processes and energy technologies
Asst. Prof. Borut Smodiš

NEW CONTRACTS

1. Background documents for the preparation of the regional spatial plan
Urban Planning Institute of Slovenia
Prof. Branko Kontić
2. Radioactivity monitoring RŽV 2009
Žirovski vrh Mine
Asst. Prof. Borut Smodiš
3. Analysis of selected metals, mercury and organotin compounds in water and analysis of cadmium and mercury in sediment of mussels
Ministry of Environment and Spatial Planning, Environmental Agency of Slovenia
Asst. Prof. Janez Ščančar

VISITORS FROM ABROAD

1. Dr. Sergio Ribeiro Guevarra, Centro Atomico Bariloche, Argentina, 1. 1.-1. 9. 2009
2. Dennis Kpakpo Adotey, Ghana Atomic Energy Commission, Accra, Ghana, 1. 1.-13. 5. 2009
3. Dr. Sergio Ribeiro Guevarra, Centro Atomico Bariloche, Argentina, 1. 1.-1. 9. 2009
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6. Dr. Nada Miljević, Institute of Nuclear Sciences, Physical Chemistry Department, Vinča, Belgrade, Serbia, 22. 2.-28. 2. 2009
7. Mag. Lylia Alghem Hamidatou from Research Nuclear Centre of Birine, Algeria, 1. 3.-14. 3. 2009
8. Prof. Dr. Nevenka Mikac, Martina Furtek, Rudjer Bošković Institute, Zagreb, Croatia, 14. 4.-17. 4. 2009
9. Dr. Norbert Kávási, Institute of Radiochemistry and Radioecology, University of Pannonia, Veszprém, Hungary, 13. 4.-9. 5. 2009
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11. Dr. David Dominguez Villar, Department of Geography, University of Birmingham, Great Britain, 10. 6.-14. 6. 2009
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18. Bharath Prasad Alevoor Srinivas, Manipal University, Manipal Life Sciences Centre, The Training in Metal Analysis of Biological Samples, 13. 8.-3. 9. 2009, Karnataka, India
19. Prof. Akihide Tada, Nagasaki University, Asst. Prof. Shin-ichirou Yano, Kyushu University, Prof. Takuji Tomiyasu, Kagoshima Univetsity, Akito Matsuyama; National Institute of Minamata Disease, Japan, 6. 9.-7. 9. 2009
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21. Dr. Tomislav Andjelić, Center for Ecotoxicological Researches of Montenegro, Radiation Protection and Monitoring Department, Podgorica, Montenegro, 28. 9.-10. 11. 2009
22. Dennis Kpakpo Adotey, Ghana Atomic Energy Commission, Accra, Ghana, 1. 10.-31. 12. 2009

23. Dr. Jadwiga Mazur, dr. Krzysztof Kozak, Laboratory of Radiometric Expertise at the Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences', Kraków, Poland, 4. 10.-8. 10. 2009
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27. Martina Furtek, Rudjer Bošković Institute, Zagreb, Croatia, 9. 11.-13. 11. 2009
28. Dr. Franco Baldi, University of Venice, Venice, Italy, 11. 11.-12. 11. 2009
29. Prof. Dr. Markus Meili, University of Stockholm, Sweden, 23. 11.-29. 11. 2009
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51. Silva Perko, B. Sc.
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54. Zdenka Trkov, B. Sc.
55. Stojan Žigon

Note:
** young researcher financed by industry

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Original Articles

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2. Ljudmila Benedik, M. Vasile, Y. Spasova, U. Wätjen, "Sequential determination of ^{210}Po and uranium radioisotopes in drinking water by α-particle spectrometry", In: *5th International conference on radionuclide metrology: low-level radioactivity measurement techniques ICRM-LLRMT'08: September 22 - 26, 2008, Braunschweig, Germany*, (Applied radiation and isotopes, Vol. 67, issue 5, 2009), Dirk Arnold, ed., Oxford, Pergamom, 2009, issue 5, vol. 67, pp. 770-775, 2009.
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4. Victoria Daskalou, Polona Vreča, Gregor Muri, Constantine Stalikas, "Recent environmental changes in the Shallow lake Pamvotis (NW Greece): evidence from sedimentary organic matter, hydrocarbons, and stable isotopes", *Arch. environ. contam. toxicol.*, vol. 57, no. 1, pp. 21-31, 2009.
5. José María Esbrí, David Kocman, Milena Horvat, (13 authors), "Especiación de mercurio en tres distritos mineros mediante XANES", *Macla*, vol. 11, pp. 79-80, 2009.
6. Jadran Faganeli, Nives Ogrinc, "Oxic-anoxic transition of benthic fluxes from the coastal marine environment (Gulf of Trieste, northern Adriatic Sea)", *Mar. freshwat. res.*, vol 60, pp. 700-711, 2009.
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12. Darija Gibičar, Milena Horvat, Martina Logar, Vesna Fajon, Ingrid Falnoga, Romano Ferrara, Enrica Lanzillotta, Claudia Ceccarini,

Barbara Mazzolai, Bruce Denby, Jozef M. Pacyna, "Human exposure to mercury in the vicinity of chlor-alkali plant", *Environ. res. (N.Y. N.Y.)*, issue 4, vol. 109, pp. 355-367, 2009.
13. Ester Heath, Janez Ščančar, Tea Zuliani, Radmila Milačič, "A complex investigation of the extent of pollution in sediments of the Sava River. Part 2, Persistent organic pollutant", *Environ. monit. assess.*, 17 pp.
14. Robert Hrastar, Marinka Gams Petrišič, Nives Ogrinc, Iztok Jože Košir, "Fatty acid and stable carbon isotope characterization of Camelina sativa oil: implications for authentication", *J. agric. food chem.*, issue 2, vol. 57, pp. 579-585, 2009.
15. Jasna Huremović, Milena Horvat, Esma Ruždić, Radojko Jaćimović, "Istraživanje radiokontaminacije grada Sarajeva i njegove okolice s obzirom na radionuklide", *Kem. ind.*, vol. 58, no. 4, pp. 165-170, 2009.
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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 aim is to make available advanced knowledge, as well as to develop and transfer systems and technologies to our customers in industry, medicine and sports.

Head:
Asst. Prof. Leon Žlajpah

The main directions of the research in the past year were humanoid robotics, learning strategies and the control of robot systems, studies of human physiology in extreme environments, the evaluation of protective equipment, the development of biomedical devices and methods, and the robotics and automation of industrial manufacturing.

The main focus of our current research in the field of humanoid robotics is the implementation of cognitive processes on 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 communicate and share these with humans and other artificial agents. Our main result in the past year was the development of new methods for the learning of robot actions on objects, which we based on the imitation learning paradigm. To be effective, the learning of actions that involve objects should not be limited to the direct replication of movements obtained during training, but must also enable the generation of actions in situations that a robot has never encountered before. We proposed a methodology that enables the generalization of the available motor knowledge. New actions are synthesized by applying statistical methods, where the goal and other characteristics of an action are utilized as queries to create an optimal control policy with respect to the current state of the world. Nonlinear dynamic systems are employed as an underlying motor representation. The proposed approach enables the generation of a wide range of policies without requiring an expert to modify the underlying representations to account for different task-specific features and perceptual feedback. We also demonstrated that the proposed methodology can be integrated with the active vision system of a humanoid robot. Three-dimensional vision data is used to provide query points for statistical generalization. While the 3-D vision on humanoid robots with complex oculomotor systems is often difficult due to the modelling uncertainties, we showed that these uncertainties can be accounted for by the proposed approach. The proposed methods have been partially implemented on our own humanoid robot, HOAP-3, and in collaboration with the ATR Computational Neuroscience Laboratories, Kyoto, Japan, and Karlsruhe Institute of Technology, Germany, which allowed us to test our approaches on full-size humanoid robots.

Besides supervised learning, cognitive humanoids must also be able to autonomously acquire new action knowledge. To this end, we studied how a robot can learn new manipulation knowledge by observing the outcomes of exploratory movements on objects.

Besides supervised learning, cognitive humanoids must also be able to autonomously acquire new action knowledge. To this end we studied how a robot can learn new manipulation knowledge by observing the outcomes of exploratory movements on objects. We developed a learning process based on neural networks that enables the robot to acquire the relationship between its own manipulation actions and the observed object motion after the application of these actions. In real-world experiments we successfully realized the learning of an object-pushing action, where we used low-resolution object images as the input to a neural network. The learning and execution processes were implemented on different humanoid and industrial robots. The proposed methodology is suitable for the acquisition of the manipulation knowledge that is applicable not only to objects that the robot acted upon during learning, but to whole classes of objects.

We applied the research on methods for the control of periodic motion to different devices, e.g., to a yo-yo, a gyroscopic toy called the Powerball and a pendulum. We showed that for all of the devices mentioned, our system for movement imitation, which is based on adaptive frequency oscillators and a statistical learning method, can be effectively used for the synchronization of the motion of the robot and the actuated device. In this way we improved

Figure 1: Grasping and obstacle avoidance using active vision and a library of movement primitives. This work has been carried out in collaboration with the ATR Computational Neuroscience Laboratories, Kyoto, Japan.

Figure 2: The humanoid robot is pushing an object in order to support grasping. The pushing action has been learned autonomously by exploration of the robot's environment without prior knowledge. This work has been done in collaboration with the Karlsruhe Institute of Technology, Germany.

the previously achieved results of robotic control for the devices mentioned. We also adapted the method to allow the performance of movements that cannot be achieved using simple modulation, but have to be attained using a generalization between different demonstrations.

Modern trends in robotics are also oriented towards new types of biologically inspired actuators. It is a common belief that these actuators should have a certain level of 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 electrically sensitive elastomers. Different artificial neural-network topologies and structures are being used in order to find the optimal control approach. A novel, more-performing activation strategy was proposed for electro-sensitive elastomers, which is based on a custom electronic driver derived from the flyback transformer topology. In addition, the actuator's mechanical design and the materials used are also a big issue and need to be addressed thoroughly. Research is being done in collaboration with the University of Bologna, Italy.

The detection and recognition of abnormal events (such as falls) or unexpected behaviours that may be related to a health problem in elderly people have 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 typical elderly-person pathologies. After the motion capture and tracking of 12 markers, the trajectories of the characteristic points of the human body were used as the input for the analyses, modelling and recognition.

We continued the development of a novel motion synthesis paradigm that exploits human visuo-motor learning capacity. We established a method of robot control that enables a human to obtain the desired target motion through practice.

We continued the development of a novel motion-synthesis paradigm that exploits the human visuo-motor learning capacity. We established a method of robot control that makes it possible for the human to obtain the desired target motion through practice. Such control can be used as the basis for designing robot controllers that operate autonomously. To demonstrate the effectiveness of our methodology, we developed and implemented an in-place stepping on a humanoid robot. The motion of the human demonstrator was captured using the contactless motion-capture system and fed to a humanoid robot in real time. The state of the stability of the humanoid robot was fed back to the human demonstrator through the inclining platform on which the human was standing. Therefore, the demonstrator was able to keep the humanoid robot stable, while carrying out the desired motion.

We carried out a biomechanical study where the proprioceptive control of posture was addressed. We determined the directional sensitivity of various muscle groups involved in balance corrections during the angular perturbations of the support surface. Furthermore, the relative contributions from the ankle, knee and hip proprioceptive inputs in triggering the automatic postural responses to the unexpected angular perturbations were determined. The subjects were required to stand on an inclined parallel platform on which a force plate was mounted. The inclined parallel platform perturbed the posture of the subjects by inclining the support surface randomly in one of 16 directions around the vertical axis. The ground forces were recorded, the EMG data were collected and the motion of the subjects was captured using the contactless motion capture system.

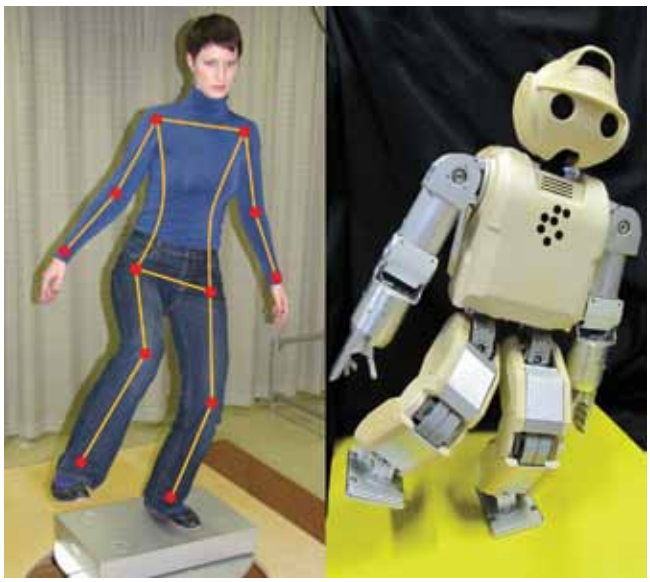

Figure 3: Humanoid robot motion synthesis through human visuo-motor learning

In this year we finished an applied research project, aimed at carrying out a major rearrangement and upgrade of a tea-production plant. The focus was on the supervisory and control system. We first analyzed the present state and the requirements. Basing on this we conceived and then implemented new control methods. The complete resulting system is implemented on a number of distributed computers. In addition to others, the supervisory and control system functionality includes an integrated, automatic data exchange with the company's manufacturing execution and enterprise resource planning levels, automatic control of all the plant's machines and devices, fast and flexible production configuration, error identification and alarming, and the collection of production data. The implementation and distribution of the overall system results in a minimal functionality loss during individual

equipment or subsystem malfunction situations. The final plant can carry out the production of various items simultaneously, while the number and utilization of special dedicated machines is optimized.

In this year we continued a cooperation with a glass-production company that we started at the end of the previous year. The goal of the project is the analysis, design, discovery of necessary solutions, development and implementation of an automatic production environment for a large number of glass products. The final solution will encompass all operations, from acquiring the melted glass from different glass furnaces to the final forming of the glass products. We carried out some feasibility study phases and identified the processes that are critical for the success of the overall automated production facility. We carried out a number of measurements, data analyses, the development of special analysis programs, experimental equipment and test procedures. Based on this, we designed possible solutions for a number of critical processes. We developed an experimental test setup, including the physical model of the production items and devices. We developed control methods and algorithms, carried out numerous tests, experiments and necessary modifications. Finally, we transferred the experimental setup to the factory environment and successfully replicated the designed automatic procedures in the target environment.

Figure 4: Measurement of cerebral and muscle oxygenation during normoxic and hypoxic exercise.

Having successfully completed a comprehensive evaluation of various hypoxic training protocols for athletes (an ARRS project co-financed by the Slovenian Olympic Committee) with regards to normoxic and hypoxic performance, our research has now focussed also on the effect of hypoxia on metabolism. With the assistance of a new ARRS grant (co-financed by the Dutch company b-CAT), we are now conducting a collaborative study with colleagues from the Royal Institute of Technology (Stockholm, Sweden) and the University of Nottingham (Nottingham, UK), investigating the effect of chronic hypoxia on nutrient absorption. One of the practical aims of the study is to assess the potential benefit of chronic hypoxia in weight-loss programmes.

The European Space Agency (ESA) sponsored a Technical Team Workshop at the Olympic Sport Centre in Planica on the theme of Lunar Habitat Simulations. ESA and NASA scientists concluded that the Olympic Sport Centre is an ideal research platform for evaluating the effects of lunar habitat environments on humans.

During the course of our hypoxic training studies, we also investigated the hypothesis that sleep-high, train-low hypoxic training (SH-TL), demonstrated to be the most efficient method of hypoxic training, might cause an improvement in cerebral and/or muscle oxygenation during normoxic and hypoxic exercise, which could potentially influence maximum performance. Our results suggest that the improved performance in normoxia after SH-TL could be attributed mainly to central adjustments that potentially reduce the exercise-induced impairments in cerebral oxygenation.

We presented our research programme to representatives of the European Space Agency, and suggested that the Planica facility would be ideal for the simulation of lunar habitat ambients. Namely, it is envisaged that astronauts will live in hypobaric hypoxic environments on the moon, to allow frequent EVAs (extra-vehicular activities) without the risk of decompression sickness. We have completed several 10-day hypoxia confinement studies, demonstrating the manner in which we could perform simulations of lunar habitats. Our FP7 proposal for a pilot study "Lunabitat" (Simularion of lunar habitats), which was ranked 14 among 138 submissions, although not among the 22 projects funded, sparked the interest of ESA and NASA. Indeed, ESA sponsored a Topical Team Workshop on the problem of lunar habitat simulations. The Workshop, organised by profs. Ola Eiken and Igor B. Mekjavic, was held at the Olympic Sports Centre in Planica.

The prevention of thermal injury continues to be one of the aims of our research. In particular, we are interested in the cold-induced vasoconstriction (CIVD) response, as it may have a significant cryoprotective role, minimising the risk of freezing and non-freezing cold injury of the digits of the hands and feet. Our studies have demonstrated that exercise and hypoxic training enhance the CIVD response, particularly in the exercising limbs. With colleagues from the University of Maribor Medical Faculty we hope to explore the mechanisms responsible for the CIVD response.

Figure 5: Manufacturing process for ceiling lamps: production phase analysis for automation

Our previous work in the evaluation and development of the Slovenian Armed Forces military garments for winter and summers conditions has expanded into a larger collaborative study with the Royal Institute of Technology to evaluate and provide recommendations for an improvement to the Swedish military desert ensemble.

Our thermal manikin R&D programme has focused on the development of a gripping sweating thermal hand manikin, for the evaluation of working gloves. Industrial partners from Scandinavia have identified the need to test the thermal and evaporative resistances of working gloves. A gripping hand manikin will evaluate the effect of handling tools on the thermal and evaporative resistances of gloves. The provision of the appropriate protective clothing in cold ambient conditions is of paramount importance for the prevention of cold injury.

In collaboration with the Swedish Defence Research Agency we investigated the efficacy of different pharmacological agents on motion illness. The focus of our research also covered which pharmacological agents also exert an influence on temperature regulation in cold environments. This study revealed which agents would be preferred in extreme environments.

Some outstanding publications in the past three years

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Awards and appointments

1. Bojan Nemec: Award for Entertainment Robotics and Systems, St. Louis, USA, New Technology Foundation, Japan, Award for most outstanding paper and presentation in IROS 2009, 11.-15. 10. 2009: title of the paper: Control and navigation of the skiing robot
2. Igor B. Mekjavić: The Award for the best article in the international scientific publication ISA (International Society for Automation) Transactions in 2008, granted by International Society for Automation, for the article, Matej Gašperin, Đani Juričić, Bojan Musizza, Igor B. Mekjavić: A model-based approach to the evaluation of flame-protective garments. ISA trans., 2008, vol. 47, no. 2, p. 198-210.

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. Perception, Action & Cognition through Learning of Object-Action Complex
   PACO-PLUS
   6. FP, 027657
   EC; Universität Karlsruhe (TH), Karlsruhe, Germany
   Dr. Aleš Ude
3. Human to Humanoid Robot Full Body Motion Transfer
   BI-JP/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
4. Co-financing of the Hypoxic and Hyperoxic Exercise
   Contract dated 16.4.2009
   Edwin Willemsen, b-Cat BV, Tiel, The Netherlands
   Prof. Igor Mekjavić

R & D GRANTS AND CONTRACTS

1. Robot motion synthesis through human visuo-motor learning
   Dr. Jan Babič
2. Goal-directed action synthesis using a library of example movements
   Asst. Prof. Aleš Ude
3. Guided explosion with an internal combustion engine
   Dr. Jan Babič
4. System for an automatic supervision and control of a production line for simultaneous production of different products
   Asst. Prof. Leon Žlajpah
5. Hypoxic and hyperoxic excercise
   Prof. Igor Mekjavić

RESEARCH PROGRAM

1. Automation, robotics and biocybernetics
   Prof. Jadran Lenarčič

NEW CONTRACTS

1. Additional production analysis and automation assessment for a class of glass components
   Dr. Anton Ružić
2. Adaptation of the supervisory and control system and transfer to a new location
   Dr. Anton Ružić

VISITORS FROM ABROAD

1. Dr. Erhan Oztop, ATR Computational Neuroscience Laboratories, Kyoto, Japan, 3.-12. 3. 2009
2. Prof. Minija Tamošiunaite, Department of Informatics, Vytautas Magnus University, Kaunas, Lithuania, 19.-21. 3. 2009
3. Dr. Siniša Vujić, Sports medicine associtation of Serbia, Belgrade, Serbia, 27. 3.-5. 4. 2009
4. Prof. Minija Tamošiunaite, Department of Informatics, Vytautas Magnus University, Kaunas, Lithuania, 22.-25. 11. 2009
5. dr. Jan Peters, Max Planck Institut for Bilogical Cybernetics, Tübingen, Germany, 8.-9. 9. 2009
6. prof. Antonio Pedotti, Politecnico di Milano, Italy, 12.-15. 11. 2009
7. prof. Andrea Aliverti, Politecnico di Milano, Italy, 12.-15. 11. 2009
8. Emre Ugur, ATR Computational Neuroscinece Laboratories, Kyoto, Japan, 16. 11. 2009.
9. Prof. Vincenzo Parenti Castelli with students, University of Bologna, Italy, 21. 12. 2009

STAFF

Researchers

1. Dr. Jan Babič
2. Dr. Ladislav Lenart
3. Prof. Igor Mekjavić
4. Asst. Prof. Bojan Nemec
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6. Asst. Prof. Aleš Ude
7. **Asst. Prof. Leon Žlajpah, Head**

Postdoctoral associates

8. Dr. Andrej Gams
9. Dr. Stylianos Kounalakis
10. Dr. Damir Omrčen
11. Dr. Martin Tomšič

Postgraduates

12. Mojca Amon, M. Sc.
13. Mitja Babič, B. Sc.
14. Tadej Debevec, B. Sc.
15. Denis Forte, B. Sc.
16. Blaž Hajdinjak, B. Sc.
17. Michail Keramidas, M. Sc.
18. Tadej Petrič, B. Sc.
19. Eva Stergaršek Kuzmič, B. Sc.

Technical officers

20. Andrej Kos, B. Sc.
21. Borut Lenart, B. Sc.
22. Bogomir Vrhovec, B. Sc.

Technical and administrative staff

23. Tanja Dragojević, B. Sc.
24. Dušan Filipič
25. Marija Kavčič, B. Sc.
26. Jožef Opeka
27. Janez Zalar

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Original Articles

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4. Andrej Gams, Auke Jan Ijspeert, Stefan Schaal, Jadran Lenarčič, "On-line learning and modulation of periodic movements with nonlinear dynamical systems", *Auton. robots*, vol. 27, no. 1, pp. 3-23, 2009.
5. Stylianos N. Kounalakis, Nickos D. Geladas, "The role of pulse transit time as an index of arterial stiffness during exercise", *Cardiovascular engineering*, vol. 9, no. 3, pp. 92-97, 2009.
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7. Joern Rittweger, Boštjan Šimunič, Giancarlo Bilancio, Natale Gaspare De Santo, Massimo Cirillo, Gianni Biolo, Rado Pišot, Ola Eiken, Igor B. Mekjavić, Marco Narici, "Bone loss in the lower leg during 35 days of bed rest is predominantly from the cortical compartment", *Bone*, vol. 44, no. 4, pp. 612-618, 2009.
8. Daniel Yogev, Igor B. Mekjavić, "Behavioral temperature regulation in humans during mild narcosis induced by inhalation of 30% nitrous oxide", *Undersea hyperb. med.*, vol. 36, no. 5, pp. 359-371, 2009.

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1. Jadran Lenarčič, Leon Žlajpah, Bojan Nemec, Aleš Ude, Jan Babič, Damir Omrčen, Igor B. Mekjavić, "Recent advances in intelligent robots at J. Stefan Institute", In: *Towards intelligent engineering and information technology*, (Studies in computational intelligence, vol. 243), Imre J. Rudas, ed., Berlin, Heidelberg, Springer-Verlag, cop. 2009, pp. 235-245.

Published Conference Papers

Regular papers

1. Jan Babič, "Biarticular legged robot: design and experiments", In: *IEEE ROBIO 2008*, International Conference on Robotics and Biomimetics, Bangkok, Thailand, February 21-25, 2009, [S. l.], IEEE, 2009, pp. 155-159.
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13. Ladislav Lenart, Jan Babič, "Optimalno vodenje modelov z diferenčnimi enačbami: enostavni primeri", In: *Z inteligentnimi sistemi do strateške prednosti: zbornik prispevkov*, Dnevi slovenske informatike 2009 - DSI, Portorož, Slovenija, 15.-17. april 2009, 1. izd., Ljubljana, Slovensko društvo Informatika, 2009, 7 pp.
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Textbooks and Lecture Notes

1. Drago Matko, Peter Omersel, Anton Ružić, Marjan Mihelin, Vinko Kunc, *Računalniško podprto načrtovanje*, Ljubljana, Fakulteta za elektrotehniko in računalništvo, 1988-.

Theses

Ph. D. Thesis

1. Andrej Gams, *Control of periodic and aperiodic robotic motion with the use of nonlinear oscillators: doctoral dissertation*, Ljubljana, [A. Gams], 2009.

M. Sc. Thesis

1. Mojca Amon, *Effect of "sleep high-train low" hypoxic training on cold induced vasodilatation (CIVD) response in fingers and toes: master's thesis*, Ljubljana, [M. Amon], 2009.

DEPARTMENT OF SYSTEMS AND CONTROL

E-2

The department is engaged in the analysis, control and optimization of systems and processes. The activities of the department are focused on the research of new methods and algorithms for automatic control, the development of procedures and tools to support the design 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.

Head:
Prof. Stanislav Strmčnik

Basic and applied research

The basic and applied research in 2009 was devoted to three sub-areas: methodologies for analysis and control systems design; tools and building blocks for implementation; and applied research in the priority problem domains.

The sub-area **methodologies for analysis and control systems design** included three topics. The first topic addressed the modelling and identification of nonlinear and complex dynamical systems. One part of this topic was devoted to research on modelling using Gaussian processes, where the emphasis was on the modelling of dynamic systems with models of fixed structure and variable parameters, which are represented as Gaussian process models; and the applicability of these kinds of models for control systems design was studied as well. The other part of this topic was related to the identification of stochastic nonlinear dynamical systems, where the main problem was on how to estimate the model parameters in the case of non-measurable system states. An iterative procedure for calculating the maximum-likelihood estimate of model parameters based on the Expectation-Maximization algorithm together with the Unscented Kalman filter (for a system-states estimation) has been designed.

Within the Zois awards and distinctions, the highest awards of the Republic of Slovenia in the area of science, research and development activities, issued by the Slovenian Ministry of Higher Education, Science and Technology, the Zois distinction for important achievements in the area of the control of wastewater-treatment processes was this year granted to our colleagues Dr. Nadja Hvala, Dr. Darko Vrečko and Dr. Aljaž Stare.

The second topic was (advanced) control. One part of this topic was a continuation of the research and development of parametric predictive controllers based on linear and hybrid models; the emphasis was on the research of options for simplifying the partitions of parametric controllers by the sparse placing of constraints, and on improving the reliability of degeneracy handling during a controller-partition calculation. The other part of this topic was related to PID control. In 2009 a newly developed method for tuning PID controller parameters was tested. The advantage of the method is that all the required data can be obtained implicitly by the operator during open-loop experiments.

The third topic of interest was condition monitoring and fault diagnosis. Here, research was focused on the design of sensitive and reliable algorithms for the early detection of incipient faults in rotational machines and drives by means of sensor fusion. The main contribution concerns a detector of insufficiently lubricated bearings by means of a vibrations analysis. By employing a cyclostationary analysis and the analysis of spectral kurtosis, it was shown that a reliable distinction between normal and poorly lubricated bearings could be achieved. This important result found an immediate application in an end-quality assessment in the production of electronically commutated electrical motors (Fig.2). A part of the work, also related to condition monitoring, dealt with the problem of monitoring the depth of anesthesia. Our recent studies have shown that during the transition between deep and shallow anesthesia, changes occur in the strength of the directionality indexes of the amplitude couplings between selected EEG frequency bands. Our new results indicate that these changes are robust physiological phenomena and are unaffected by moderate hypothermia. We predict that changes in the amplitude couplings between the EEG frequency bands can detect the transition between the deep and shallow phases of anesthesia for different types of anesthetics.

Figure 1: Left: Photo from the award ceremony of the 2009 ISA Transactions Best Paper Award (from the right: the first author of the awarded paper Mr. Matej Gašperin and Vice president, ISA publication Department Mr. Vitor Finkel) Right: Photo of the award.

The sub-area **tools and building blocks for implementation** also included three parts. The first part of our work was devoted to a further development of the program package for rapid prototyping of advanced control algorithms. In the past year the package was enhanced by algorithms for the detection of the non-linearity and tuning of multivariable controllers.

Our department members Matej Gašperin, Prof. Dr. Đani Juričić and Dr.Bojan Musizza, and the Automatics, Biocybernetics and Robotics Department member Prof. Dr. Igor Mekjavić, are the recipients of the 2009 ISA Transactions Best Paper Award for the paper entitled "A model-based approach to the evaluation of flame-protective garments". The award was determined by a five-member review committee from 45 papers (Fig. 1).

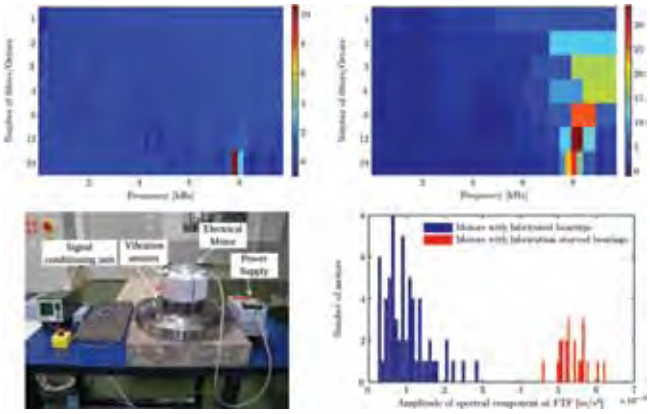

Figure 2: Spectral kurtosis of a normal motor (upper left) and a poorly lubricated motor (upper right), the prototype of the test bed (lower left), statistics of the diagnostic systems demonstrating the strong isolation capabilities (lower right).

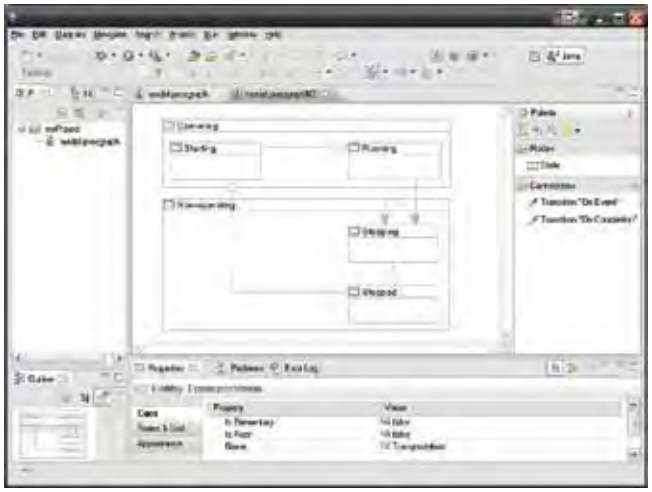

Figure 3: Screenshot of the development environment prototype for the ProcGraph language.

At the 4th Slovenian Innovation Forum, the innovation "PLCbatch – a tool for PLC-based batch process control" was ranked in the group of 10 best innovations. The first author as well as the principal developer of the tool is our department member mag. Giovanni Godena.

The second part included activities related to the development of tools and methods for control SW design, where we developed the first prototype of an integrated development environment for our domain-specific modelling language, ProcGraph. The development was carried out based on a model-driven engineering approach, and using a sophisticated metaCASE tool (Fig 3).

In the third part, further work on the environment, which enables the design of embedded control and digital signal processing systems, was carried out to fulfil our needs for the development of new electronic devices. The emphasis was given to the development of new tools related to the design of ARM-microcontroller-based modules for different applications.

Applied research in the priority problem domains was the third sub-area of our interest.

In this frame a substantial part of our activities was devoted to the development of the specific control systems described below.

In the past year we successfully completed our participation in the international 6FP project "PEGASE", which was focused on the automatic landing of aircraft, based on onboard-camera-generated images. In this final year we developed a new predictive visual servoing control scheme to control the aircraft's landing-path.

Within polymerization process control, research was devoted to a more accurate parameter estimation of an already developed complex mathematical process model, and to an analysis of the impact of the operating parameters on the process performance. As a result, the control algorithms for online-reactants dosing were designed, which keep the reactor temperature in a narrow region and maximize the reaction rate of the process.

Control of wastewater-treatment plants is a traditional research area of ours. Within the applied research project, which is performed for the Domžale-Kamnik wastewater-treatment plant, a simulation model of the SBR process for plant upgrading was designed and tested under a dynamic input load. Recent research was directed to the modelling of the existing anaerobic digestion process for sludge treatment with the purpose of optimising this treatment.

Production control is also an important domain of our research work. The major problems in manufacturing today still relate to unexpected breakdowns and the degradation of product quality with no obvious reasons. To cope with these problems, the concept of product quality and system condition monitoring has been designed and applied to the manufacturing of collectors. The research project was carried out in close cooperation with the company Kolektor Sinabit. We have also proceeded with an evaluation of the hierarchical concept of model-based production control developed in previous years. In 2009 different modelling, control, and optimization methods were tested in a case study of a chemical batch process and on the Tennessee Eastman benchmark process.

In recent years, a part of our work was focused on the area of fuel cells. Research activities in 2009 encompassed the following: an estimation of the actual efficiency of fuel-cells-based systems, an assessment of the actual energy and material flows inside fuel-cell-based systems, and an estimation of the water balance inside the reformer/fuel-cells system. These findings are very important for the future design of various systems, which include a fuel-cells-based generator set.

R&D projects for industry and other users

A significant part of the development activities of our department is oriented towards the implementation of fuel cells in various applications, and to the development of special-purpose modules for fuel-cells-based generator sets (projects "GCCOGEN", "TESTLAB", and "HyCORE"). In 2009 the

development project of the mobile-dwelling container unit with an in-built fuel-cells-based cogeneration system for the logistic needs of the Slovenian Army has been completed (Fig.4). The implemented cogeneration system effectively exploits the waste heat energy produced as a surplus during the production of electrical energy in the in-built fuel-cells-based generator set. The development in the area of fuel-cells-based systems applications will also be continued in the frame of the Centre of Excellence for Low-carbon Technologies that was approved for funding in 2009. The multidisciplinary project "Kerapro" is also related to fuel cells. Within this project a fuel reformer is being developed, which will represent a source of hydrogen for miniature fuel cells. In recent years we have studied the efficiency of the reforming process as a function of operating conditions and the type of catalyst.

Our department members taking part in the project entitled "Development of demonstration prototype of mobile cogeneration fuel cell based system for military purposes" were given an award by the Ministry of Defense of the Republic of Slovenia and the Slovenian Technology Agency for a very successful project implementation.

Based on a contract with the Domel company, Železniki, a diagnostic system for electronically commutated motors (0.75 to 6 kW) was designed and produced (Fig. 5). The system provides a quality assessment of motors at the end of a production line. It includes the following: measurement of the basic electrical parameters of the free-running motor, bearing-fault detection, a determination of rotor unbalance, and a detection of general deviations, performed at the free run-out of the motor.

Figure 4: Presentation of the mobile-dwelling cogeneration unit to the Slovenian Minister for Development and European Affairs, Mitja Gaspari M. Sc.; at the JSI, October 2009

A substantial part of the activities was, in the past year, performed in close cooperation with the INEA company. One of the activities was the development of a new version of the batch control tool entitled PLCbatch, which has some important advantages, in particular the new object model of equipment and recipes. The model is based on the overlapping of equipment classes, which allows a reduction in the repetition of information in the recipes, resulting in an increased recipe reuse.

Another activity was related to the "KIBERNET" project, where we have developed the functional requirements for the module for estimation of the reliability of the prediction of electrical energy consumers' adaptation. The output data from this module will assist the optimization algorithm in building a set of consumers that will be involved in the adaptation of energy consumption.

The last activity was the design of a communication node, which was designed using an ARM Cortex M3 microcontroller LM3S6965 (TI-Luminary Micro). This communication module connects the GSM communication network with an Ethernet-based LAN and a universal serial bus, which is based on the AnyBus modules. It also handles some digital I/O and flash memory cards.

A project entitled "Truck positioning under a crane", which was carried out jointly with the Port of Koper, also represented a part of our activities in 2009. In the first phase of the project, all the relevant algorithms for detecting the object (truck) and calculating the object's position have been successfully tested in a real environment.

Figure 5: Diagnostic system for electronically commutated motors.

Other projects

In June 2009 the activities on the project "Promoting Innovation in the Industrial Informatics and Embedded Systems Sector through Networking (I3E)" started. The project is funded by the South East Europe Transnational Cooperation Programme. The project's main objective is the promotion of innovation and entrepreneurship in Southeast Europe with the emphasis on the development of advanced products and services in the sectors of industrial informatics and embedded systems.

Education and training activities

Some members of the department give lectures and practical courses at different faculties and the universities: the Faculty of Electrical Engineering, University of Ljubljana, the Faculty of Logistics, University of Maribor, the University of Nova Gorica and the "Jožef Stefan" International Postgraduate School. They also act as supervisors of M.Sc. and Ph.D. students. Special care was given to post-qualification training for engineers from industry. In 2009,

The paper entitled "Modelling, Simulation and Control of a Semi-Batch Industrial Polymerization Reactor", authors Dr.Nadja Hvala, Teodora Miteva and Dr. Dolores Kukanja, was one of nine nominated papers for the best paper award at the Industrial Simulation Conference in UK.

three one-week courses were organized. These courses were organized in close cooperation with the Faculty of Electrical Engineering, University of Ljubljana and the Information Technologies Knowledge Transfer Centre at the JSI.

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, p. 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, p. 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, p. 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 Vrančić, Aleš Svetek, Stane Černe, Miroslav Štrubelj)
2. A mobile dwelling container unit with in-built fuel-cells-based cogeneration system, 2009, (in cooperation with companies Domel and INEA) (Vladimir Jovan, Janko Petrovčič, Aleš Svetek, Stane Černe, Miroslav Štrubelj)

Awards and appointments

1. Matej Gašperin, Prof. Đani Juričić, Dr Bojan Musizza and Automatics, Biocybernetics and Robotics Department member Prof. Igor Mekjavić, are the recipients of the 2009 ISA Transactions Best Paper Award for the paper entitled "A model-based approach to the evaluation of flame-protective garments". The award was determined by a five-member review committee from 45 papers.
2. Giovanni Godena: at the 4th Slovenian Innovation Forum, the innovation "PLCbatch – a tool for PLC-based batch process control" was ranked in the group of 10 best innovations. The first author as well as the principal developer of the tool is our department member.
3. Dr Nadja Hvala, Dr Darko Vrečko, Dr Aljaž Stare: within the Zois awards and distinctions, the highest awards of the Republic of Slovenia in the area of science, research and development activities, issued by the Slovenian Ministry of Higher Education, Science and Technology, the Zois distinction for important achievements in the area of control of wastewater-treatment processes
4. Dr Vladimir Jovan, Dr Janko Petrovčič, Aleš Svetek, Stane Černe, Miroslav Štrubelj: our Department members taking part in the project entitled "Development of demonstration prototype of mobile cogeneration fuel cell based system for military purposes" were awarded by the Ministry of Defense of the Republic of Slovenia and the Slovenian Technology Agency for very successful project implementation.

Organization of conferences, congress and meetings

1. Production management and information systems: continuing education (specialisation) course in Control Technology, Ljubljana, 2-6 February 2009
2. Automation and information technology projects: continuing education (specialisation) course in Control Technology, Ljubljana, 30 March to 3 April 2009
3. Building blocks for computer automation: continuing education (specialisation) course in Control Technology, Ljubljana, 2-6 November 2009

INTERNATIONAL PROJECTS

1. 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 Gerkšič, Dr. Vladimir Jovan
2. HelicoPter and aEronef naviGation Airborne System Experimentations
   PEGASE
   6. FP, AST5-CT-2006-030839
   EC; Bruno Pattin, Claire Lallemand, Dassault Aviation, Paris, France
   Prof. Stanko Strmčnik, Dr. Gregor Dolanc
3. Probalistic Bayesian Soft Sensor - A Tool for On-line Estimation of the Key Process Variable in Cold Rolling Mills
   ProBaSensor, EUROSTARS
   COMPUREG Plzen, s.r.o., Czech Republic
   Prof. Đani Juričič

4. Promoting Innovation in the Industrial Informatics and Embedded Systems Sectors through Networking
   I3E, South East Europe Programme
   SEE/A/219/1.1/X
   Dr. Athanasios Kalogeras, Industrial Systems Institute / Research Centre ATHENA, Patras, Greece
   Dr. Vladimir Jovan
5. Application of Gaussian Processes to the Modelling and Control of Complex Stochastic Systems
   BI-BG/09-10-005
   Dr. Alexandra Grancharova, Institute of Control and System Research, Bulgarian Academy of Sciences (ICSR-BAS), Sofia, Bulgaria
   Prof. Juš Kocijan

R & D GRANTS AND CONTRACTS

1. Identification and model analysis for dynamic systems control design with Gaussian process priors
   Prof. Juš Kocijan
2. Integrated diagnostic system for drive assemblies
   Prof. Đani Juričić
3. Modelling and control of wastewater treatment plants for improving the effluent quality and energy effective operation
   Dr. Darko Vrečko
4. Advanced model-based procedures for product quality control and management in complex production processes
   Prof. Đani Juričić
5. Simplified explicit predictive controller
   Prof. Stanislav Strmčnik
6. Rapid prototyping of advanced control algorithms in industrial environment
   Asst. Prof. Damir Vrančić

NEW CONTRACTS

1. Specification of the procedural control for the Synthesis process at Color company
   Inea, d. o. o.
   Giovanni Godena, M. Sc.
2. Specification of the batch server
   Inea, d. o. o.
   Giovanni Godena, M. Sc.
3. Determination and analysis of diagnostic procedures for the quality assessment of electronically commutated motors for HVAC applications
   Domel, d. d.
   Dr. Janko Petrovčič
4. Specification of the models and control recipes according to S88.01
   Inea, d. o. o.
   Giovanni Godena, M. Sc.
5. Prototype of a system for industrial load control in electrical distribution network
   Inea, d. o. o.
   Prof. Đani Juričić
6. Diagnostic system for electronically commutated motors with external rotors for HVAC applications
   Domel, d. d.
   Dr. Janko Petrovčič
7. Support for the research programme of Aleksander Preglej in the field of advanced control algorithms
   Inea, d. o. o.
   Dr. Samo Gerkšič
8. HyCore - development of the key subassemblies for HT PEM fuel cell
   Inea, d. o. o.
   Dr. Vladimir Jovan

RESEARCH PROGRAM

1. Program systems and control
   Prof. Đani Juričić

VISITORS FROM ABROAD

1. Pavle Boškoski, Faculty of Electrical Engineering, Ss. Cyril and Methodius University, Skopje, R. Macedonia, 1 January to 31 December 2009
2. Edrisi Muñoz Mata, Department d'Enginyeria Química – CEPIMA, Universitat Politècnica de Catalunya, ETSEIB, Barcelona, Spain, 3 April 2009
3. Marta Moreno Benito, Department d'Enginyeria Química – CEPIMA, Universitat Politècnica de Catalunya, ETSEIB, Barcelona, Spain, 3 April 2009
4. Assist. Prof. Alexsandra Grancharova, Institute of Control and System Research, Bulgarian Academy of Sciences, Sofija, Bulgaria, 12– 20 May 2009
5. Hristina Hristova, Institute of Control and System Research, Bulgarian Academy of Sciences, Sofija, Bulgaria, 12 –20 May 2009
6. Aleksander Krastov, Institute of Control and System Research, Bulgarian Academy of Sciences, Sofija, Bulgaria, 12 –20 May 2009
7. Dr Pavel Ettler, Compureg Plzen, Plzen, Czech Republic, 23–25 November 2009

STAFF

Researchers
1. Dr. Gregor Dolanc
2. Dr. Samo Gerkšič
3. Dr. Nadja Hvala
4. Dr. Vladimir Jovan
5. Prof. Đani Juričić
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15. Dr. Alenka Žnidaršič*

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16. Matej Gašperin, B. Sc.
17. Giovanni Godena, M. Sc.
18. Tomaž Lukman, B. Sc.
19. Satja Lumbar, B. Sc.
20. Jernej Mrovlje, B. Sc.
21. Dejan Petelin, B. Sc.
22. Aleš Svetek, M. Sc.

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23. Stanislav Černe, B. Sc.
24. Primož Fajdiga, B. Sc.
25. Dr. Zoran Marinšek*

Technical and administrative staff
26. Maja Janežič, B. Sc.
27. Miroslav Štrubelj

Note:
* part-time JSI member

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1. Fernando Aller, Dolores Kukanja, Vladimir Jovan, Michael C. Georgiadis, "Modelling the semi-batch vinyl acetate emulsion polymerization in a real-life industrial reactor", *Math. comput. model. dyn. syst.*, vol. 15, no. 2, pp. 139-161, 2009.
2. Kristjan Ažman, Juš Kocijan, "Fixed-structure Gaussian process model", *Int. J. Syst. Sci.*, vol. 40, no. 12, pp. 1253-1262, 2009.
3. Sašo Blažič, Igor Škrjanc, Samo Gerkšič, Gregor Dolanc, Stanko Strmčnik, Mincho B. Hadjiski, Anna Stathaki, "Online fuzzy identification for an intelligent controller based on a simple platform", *Eng. appl. artif. intell.*, vol. 22, no. 4/5, pp. 628-638, Jun. 2009.
4. Andrew Crossan, Roderick Murray-Smith, Stephen Brewster, Bojan Musizza, "Instrumented usability analysis for mobile devices", *International journal of mobile computer interaction*, vol. 1, no. 1, pp. 1-20, 2009.
5. Matej Gašperin, Đani Juričić, "The uncertainty in burn prediction as a result of variable skin parameters: an experimental evaluation of burn-protective outfits", *Burns*, vol.35, no. 7, pp. 970-982, 2009.
6. Giovanni Godena, "A new proposal for the behaviour model of batch phases", *ISA trans.*, vol. 48, no. 1, pp. 3-9, 2009.
7. Janko Petrovčič, Vladimir Jovan, Aleš Svetek, "Agregat na gorivne celice v uporabi v SV", *Slov. vojs. (Tisk. izd.)*, vol. 17, no. 2, pp. 25-28, 2009.
8. Stanko Strmčnik, Đani Juričić, Bojan Musizza, Janko Petrovčič, "Od senzorja do prave odločitve", *Ventil (Ljubl.)*, vol. 15, no. 3, pp. 254-262, 2009.
9. Jure Vindišar, Vladimir Jovan, "Mobilna kogeneracijska enota na gorivne celice", *Ventil (Ljubl.)*, vol. 15, no. 6, pp. 552-553, 2009.
10. Darko Vrečko, Narcis Vodopivec, Stanko Strmčnik, "An algorithm for calculating the optimal reference temperature in buildings", *Energy build.*, vol. 41, no. 2, pp. 182-189, 2009.
11. Sebastjan Zorzut, Dejan Gradišar, Vladimir Jovan, Gašper Mušič, "Use of a procedural model in the design of production control for a polymerization plant", *Int. j. adv. manuf. technol.*, vol. 44, no. 11/12, pp. 1051-1062, 2009.
12. Sebastjan Zorzut, Vladimir Jovan, Dejan Gradišar, Gašper Mušič, "Closed-loop control of a polymerisation plant using production performance induced (PIs)", *Int. j. comput. integr. manuf.*, vol. 22, no. 12, pp. 1128-1143, 2009.

Published Conference Papers

Regular papers

1. Pavle Boškoski, Bojan Musizza, Janko Petrovčič, Đani Juričić, "Bearing fault detection in brushless DC motors: a sensitivity study", In: *Proceedings of the 10th International PhD Workshop on Systems and Control, Hluboká and Vitavou, Czech Republic, September 22-26, 2009,*, R. Hofman, ed., Václav Šmídl, ed., L. Pavelková, ed., Prague, Department of Adaptive Systems, Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic, 2009, 6 pp.
2. Pavle Boškoski, Damir Vrančić, Anton Urevc, Jože Vižintin, "Condition monitoring of rotational machines", In: *Avtomatizacija v industriji in gospodarstvu: zbornik konference AIG'09, 29. junij - 3. julij 2009*, Nenad Muškinja, ed., Milan Rotovnik, ed., Maribor, Društvo avtomatikov Slovenije, 2009, 5 pp.
3. Matej Gašperin, Pavle Boškoski, Đani Juričić, "Gear health monitoring and prognosis", In: Proceedings of the 10th International PhD Workshop on Systems and Control, Hluboká and Vitavou, Czech Republic, September 22-26, 2009,, R. Hofman, ed., Václav Šmídl, ed., L. Pavelková, ed., Prague, Department of Adaptive Systems, Institute of Information Theory and Automation, Academy of Sciences of the Czech Republic, 2009, 6 pp.
4. Samo Gerkšič, Boštjan Pregelj, "Disturbance rejection tuning of a tracking multi-parametric predictive controller", In: *Future technology in service of regional industry: proceedings*, IEEE-ICIT'09 Australia, 2009 IEEE International Conference on Industrial Technology, 10-13 February 2009, Monash University, Gippsland, Australia, [S. l.], IEEE, 2009, pp. 65-70.
5. Samo Gerkšič, Boštjan Pregelj, Igor Steiner, "O zmanjševanju kršitev izhodnih omejitev s prediktivnim regulatorjem", In: *Avtomatizacija v industriji in gospodarstvu: zbornik konference AIG'09, 29. junij - 3. julij 2009*, Nenad Muškinja, ed., Milan Rotovnik, ed., Maribor, Društvo avtomatikov Slovenije, 2009, 4 pp.
6. Dejan Gradišar, P. J. Copado, E. Muñoz, M. Moreno-Benito, Antonio Espuña, Luis Puigjaner, "Communication within an integrated batch control", In: *MATHMOD Vienna 09: proceedings*, (ARGESIM Report, no. 35), 6th Vienna Conference on Mathematical Modelling, February 11-13, 2009, Vienna University of Technology, Austria, Inge Troch, ed., Felix Breitenecker, ed., Vienna, ARGESIM, cop. 2009, pp. 2490-2493.
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8. Dejan Gradišar, Juš Kocijan, "Nelinearni proizvodni model sistems Tennessee Eastman: Nonlinear production model of TE system", In: *Zbornik Osemnajste mednarodne elektrotehniške in računalniške konference - ERK 2009, 21-23. september 2009, Portorož, Slovenija*, Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2009, zv. A, pp. 305-308.
9. Alexandra Grancharova, D. Nedialkov, Juš Kocijan, H. Hristova, A. Krastev, "Application of Gaussian processes to the prediction of zone concentration in the air of Burgas", In: *Proceedings: John Atanasoff celebration days*, International conference Automatics and Informatics '09, Bulgaria, Sofia, 29.09 -4.10.09, Sofia, Union of Automation and Informatics, 2009, pp. IV-17-IV-20.
10. Marko Hrovat, Darko Belavič, Gregor Dolanc, Primož Fajdiga, Jurka Batista, Stanko Hočevar, Marina Santo-Zarnik, Janez Holc, Marija Kosec, Iztok Stegel, "LTCC ceramics based micro-reactor; fuel processor for PEM fuel cells - preliminary results", In: *SET-150 specialists meeting on "Energy technologies for portable power supplies and energy management for military applications", Brdo pri Kranju, 4-5 May 2009*, [S.l., s.n.], 2009, 11 pp.
11. Marko Hrovat, Darko Belavič, Gregor Dolanc, Primož Fajdiga, Stanko Hočevar, Marina Santo-Zarnik, Janez Holc, Marija Kosec, "A ceramics-based microreactor: 3D LTCC structures and a preliminary evaluation", In: *Proceedings*, 33nd International IMAPS-IEEE CPMT Poland Conference, 21-24 September 2009, Pszczyna Poland, [S. l.], IMAPS, 2009, pp. 155-158.
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13. Marko Hrovat, Darko Belavič, Gregor Dolanc, Primož Fajdiga, Marina Santo-Zarnik, Janez Holc, Mitja Jerlah, Stanko Hočevar, Marija Kosec, "3D structures realised in the LTCC technology - ceramic micro-reactor", In: *Proceedings*, 45th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Photovoltaic Devices and Technologies, September 9 - September 11, 2009, Postojna, Slovenia, Marko Topič, ed., Janez Krč, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2009, pp. 179-183.
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Processing, September 21-23, 2009, Istanbul, Turkey, [S. l., s. n.], 2009, 6 pp.
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19. Satja Lumbar, Gregor Dolanc, Stanko Strmčnik, Darko Vrečko, Drago Matko, "Prediktivno vodenje letala s pomočjo strojnega vida", In: *Avtomatizacija v industriji in gospodarstvu: zbornik konference AIG'09, 29. junij - 3. julij 2009*, Nenad Muškinja, ed., Milan Rotovnik, ed., Maribor, Društvo avtomatikov Slovenije, 2009, 5 pp.
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27. Jože Vižintin, Anton Urevc, Blaž Suhač, Đani Juričić, Pavle Boškoski, "Developing laboratory test rig for studying automatic intelligent diagnostic system", In: *CM 2009 and MFPT 2009*, The Sixth International Conference on Condition Monitoring and Machinery Failure Prevention Technologies, Dublin, June 23-25, 2009, Northampton, Comadit, 2009, pp. 489-496.
28. Darko Vrečko, Anton Ložar, Vladimir Vrečko, Vladimir Jovan, "Računalniški program za določanje urnika sarž v pripravi surovin v Cinkarni Celje", In: *Avtomatizacija v industriji in gospodarstvu: zbornik konference AIG'09, 29. junij - 3. julij 2009*, Nenad Muškinja, ed., Milan Rotovnik, ed., Maribor, Društvo avtomatikov Slovenije, 2009, 5 pp.

THESES

Ph. D. Theses

1. Jani Kleindienst, *Monitoring of the product quality in manufacturing industries: doctoral dissertation*, Ljubljana, [J. Kleindienst], 2009.
2. Boštjan Pregelj, *Use of hybrid systems for disturbance handling in low-level process control: doctoral dissertation*, Ljubljana, [B. Pregelj], 2009.
3. Sebastjan Zorzut, *Production control in process industry using key performance indicators: doctoral thesis*, Ljubljana, [S. Zorzut], 2009.

M. Sc. Theses

1. Giovanni Godena, *Model-driven development of process-control software: master's thesis*, Maribor, [G. Godena], 2009.
2. Tomaž Lukman, *Business intelligence maturity levels in Slovenian organizations: master's thesis*, Ljubljana, [T. Lukman], 2009.
3. Aleš Svetek, *Design and implementation of electronic controller for electric motor driven valves: master's thesis*, Ljubljana, [A. Svetek], 2009.

B. Sc. Thesis

1. Dejan Petelin, *Incremental learning of Gaussian process models: undergraduate thesis*, Ljubljana, [D. Petelin], 2009.

LABORATORY FOR OPEN SYSTEMS AND NETWORKS E-5

The main activities of the laboratory are the R&D of next-generation networks, telecommunications technologies, components and integrated systems and information-society services and applications, especially those that assure an efficient and pervasive life-long learning concept.

Head:
Prof. Borka Jerman Blažič

In 2009, the research group implemented the research program "Future Internet Technologies: concepts, architectures, services and socio-economic issues". Research was also carried out in the EU 7FP projects "P2P-Next", "Eiffel" and "GLOBAL", the eContentPlus "ICOPER" and "OpenScout" projects, the "Merlab" and "e4VET" projects from the Leonardo da Vinci programme, the "Twin Tide" 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 coming from the most famous universities in the world, such as MIT, Stanford, Berkley, Oxford, Cambridge, Aachen, Tokyo and others. The results of "EIFFEL" are published as White Papers (http://www.fp7-eiffel.eu and http://www.future-internet.eu) and the discussion is moderated at the Future Internet "FIpedia" website (http://www.fipedia.org) maintained by the "EIFFEL" core-team, to which E5 researchers belong. Borka Jerman Blažič with co-authors was awarded for the best-ranked published paper entitled Factors and Sustainable Strategies Fostering the Adoption of Broadband Communications in an Enlarged European Union, among the researchers of the Faculty of Economics, University of Ljubljana.

The R&D of an open-source, efficient, trusted, personalized, user-centric and participatory television and media delivery system with a social and collaborative connotation 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. In 2009 the laboratory's contribution to the project was focused on the provision of security and trust-building services of the platform and the setting up of a Living Lab.

An important project in the field of research e-infrastructures is the "Global Linkage Over BroadbAnd Links (**GLOBAL**)" project. The project is building a virtual conference centre using advanced communication technologies and concepts in support of an efficient and world-wide-accessible e-infrastructure. With the ISABEL videoconference tool being part of the open-source site known as the Global Plaza (http://vcc.dit.upm.es/) virtual conference centre the GLOBAL partners are connecting infrastructures in South America, India and Africa and providing, in addition to the e-infrastructure services, the necessary spread up and transfer of knowledge. In 2009 ten virtual events were organized, the last - The fifth International Belief symposium - in December 2009 in Johannesburg in the Republic of South Africa.

Figure 1: Borka Jerman Blažič receiving the award from the Dean of FE, prof. Dušan Mramor

Under the Infrastructure program in research organizations 2009 – a **video-conferencing centre** has been established. The main objective of the video-conferencing centre is to provide the Jožef Stefan Institute with some support services that allow better communications between members of the research programs, especially in the programmes that are multi-disciplinary and the merging of multiple geographically distributed institutions. The video-conferencing centre provides support to the Simple online communications and Advanced online communications services, which allow participants a direct view and cooperation at a distance across Europe and around the world, but their use depends on the purpose and complexity of the event.

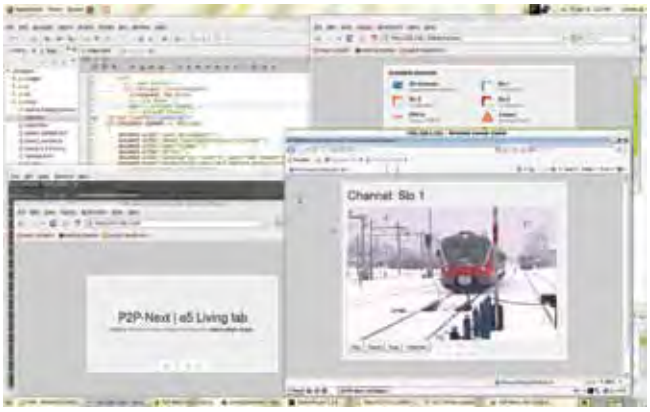

Figure 2: P2P content-delivery platform.

Technology-enhanced learning

In 2009 we concluded research on the basic building blocks of educational networks that are based on social software, enable personalized access to distributed heterogeneous knowledge repositories and provide learners security and privacy. To increase the effectiveness of technology-enhanced learning a bridge between competency definitions and educational content needs to be developed. Learning outcomes and competencies are the main research theme of the "Interoperable Content for Performance in a Competency-driven Society (**ICOPER**)" project from the European eContentplus programme. Here, the members of the laboratory explore and look for solutions to problems that appear in the learning-outcome-based learning, such as the specification and formal description of learning outcomes, the formal description of a learning process, the preparation and search of units of learning in line with expected learning outcomes, and the evaluation of the obtained skills and competencies. The project is evaluating the technology-enhanced learning standards (e.g., IMS LD or IMS QTI) and is developing good-practices approaches in using these standards. The findings of the evaluation and the studied good practices are planned to be part of the updated e-learning standards and components for the new reference model for competency-driven learning. In 2009 we analyzed the standards for the learning-outcomes description and the technology-enhanced evaluation of learning outcomes. The results were used for a formal description of a learning-outcome profile and the preparation of a framework for version 1 of the ICOPER reference model.

Part of the eContentplus programme is also the "Skill based scouting of open user-generated and community-improved content for management education and training (**OpenScout**)" project that aims at providing an education service in the internet that enables users to easily find, access, use and exchange open content for management education and training.

The main objective of the project "IC0904 - Towards the Integration of Transectorial IT Design and Evaluation (**TwinTide**)", which was launched in November 2009 and is a continuation of the recently successfully finished project "COST 294 - Towards the Maturation of IT Usability Evaluation (MAUSE)", is to harmonize and integrate research findings and achievements with practice during the process of designing and evaluating information technologies across various sectors and disciplines.

The "Innovative Remote Laboratory and the E-training of Mechatronics (**MeRLab**)" project, funded by the Leonardo da Vinci Programme - Transfer of Innovation, introduced best practices in the field of vocational training of Mechatronics and further supported them with the state-of-the-art information-communication technology, as well as with established methodological and didactical approaches. The goal was to improve the quality and efficiency of vocational training and to contribute to a greater recognition and attractiveness of the profession. This should have a positive influence on the reduction of disparities between the supply and demand of qualified mechatronic staff on the market. In the framework of the project an e-course was developed and carried out, which was attended by 70 participants. The e-course represents a completely new way of vocational training for this profile because both theoretical and practical training were entirely conducted online. The practical work was carried out through an innovative virtual laboratory for practical work, based on web technology, which allowed the performance of the real mechanical-electrical and programming-related experiments in the physical laboratory.

Another European e-learning project that is coordinated by the laboratory is the "**e^4 VET**" project. This project is primarily aimed at the promotion of the attractiveness of the VET (Vocational Education and Training) schools by establishing an **EduCenter** (http://www.educenter.eu) by building a network of different open-source educational systems and tools. The project helps the teachers of general and vocational subjects, and teachers specializing in adult education and training, to learn about the innovative and easy-to-use tools for developing e-learning materials and an access to a broad variety of e-learning materials.

An important part of the laboratory's scientific research work is represented by an empirical study, which 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 was developed to test the impact of technology-enhanced organizational learning on companies' business performance with more than 50 employees. In accordance with stakeholder theory and a balanced scorecard, both financial and non-financial aspects of the performance is considered. The results of the survey prove a statistically significant, strong and positive impact of ICT and technology-enhanced learning on organizational learning and the decisive influence of organizational learning on financial and non-financial business results. Those companies which systematically incorporated the various advanced education and training tools into their daily work and ensured high-quality information and communication technologies equipment also recognized the role of organizational

learning as the most effective process for the production, dissemination and application of knowledge. In addition, the positive effects of organizational learning on the financial and non-financial business results confirm that this concept really guarantee the achievement of higher performance in both financial as well as in non-financial terms.

Security, dependability and privacy in information systems

The provision of security, privacy and dependability services is crucial for modern information society. Apart from the previously mentioned research on security and trust in P2P networks we had in 2009 in this field a chapter on security patterns at the organisational and technical level that provided trusted long-term archiving published in a book by Springer. The research is the result of participation in the FP6 IP project "**SERENITY**". The security patterns and developed solutions were integrated into a run-time environment in order to timely identify potential threats or attacks and adapt the under-threat and attacked system or applications. The patterns capture the security expertise in a form available for automated processing.

Figure 3: Web page of the video-conferencing centre (http://konferenca.e5.ijs.si)

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. Co-organization of the 2nd International conference for ccTLD registriers and registrars of CIS, Central and Eastern Europe, Bled, 7 – 8 Sep. 2009.

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. Integracija načrtovanja in evalvacije IT na različnih področjih
   COST IC0904, EC
   Matija Pipan, M. Sc.
6. Towards the Maturation of IT Usability Evaluation
   MAUSE
   COST 294, EC
   Prof. Borka Jerman Blažič
7. 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
   Center Republike Slovenije za mobilnost in evropske programe izobraževanja in usposabljanja - CMEPIUS, Ljubljana, Slovenia
   Tanja Arh, M. Sc.
8. 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.
9. Skill based Scouting of Open User-generated and Community-improved Content for Management Education and Training
   OpenScout
   eContentplus, ECP-2008-EDU-428016
   EC; Jyväskylän Yliopisto, University of Jyväskylän, Jyväskylä, Finland
   Asst. Prof. Tomaž Klobučar
10. 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
11. European Association for Technology-Enhanced Learning (EATEL) Summer School 2008
    EATEL
    EC; Nunzio Santoro, Délégué à la Valorisation, Direction de la Recherche, Telecom & Management SudParis, Evry, France
    Asst. Prof. Tomaž Klobučar
12. Quality and Usability Evaluation of Online Courses and Web 2.0 Tools in E-learning
    BI-HR/09-10-005
    Dr. Goran Bubač, University of Zagreb, Faculty of Organization and Informatics Varaždin, Varaždin, Croatia
    Prof. Borka Jerman Blažič

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. 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 genaration networks
   Prof. Borka Jerman Blažič

VISITORS FROM ABROAD

1. Dr. Maggie McPherson, University of Leeds, Leeds, GB, 12 Jan. 2009.
2. Piotr Rypson, WiedZanet, Krakow, Poland, 12 Jan. 2009.
3. Maria Mokina, Coordination Center for TLD RU., Moscow, Russia, 23 Jun. 2009.
4. Prof. Liljana Gavrilovska, Vladimir Atanasovski Ristevski Pece, M. Sc., Faculty of Electric Engineering and Information technology, Ss. Cyril and Methodius University of Skopje, Macedonia, 18 Nov. 2009.
5. Martin Mihajlov, M. Sc., Faculty of Economy, Skopje, Ss. Cyril and Methodius University of Skopje, Macedonia, 3 Dec. 2009.

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5. Tanja Ažderska, B. Sc.
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7. Aleksej Jerman-Blažič*, M. Sc.
8. Vladimir Jovanovikj, B. Sc.
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10. Matija Pipan, M. Sc.

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11. Tatjana Martun

Note:
* part-time JSI member

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Original Articles

1. Kajetan Dolinar, Jan Porekar, Aleksej Jerman-Blažič, "Design patterns for a systemic privacy protection", *International journal of advances in security*, vol. 2, no. 2/3, pp. 267-287, 2009.
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4. Matija Pipan, Tanja Arh, Borka Jerman-Blažič, "Advanced eVocational education of mechatronic professions", *Int. j. educ. inf. technol.*, vol. 3, no. 1, pp. 12-19, 2009.

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1. Helena Halas, Tomaž Klobučar, "Business models and organizational processes changes", In: *Risk assessment and management in pervasive computing: operational, legal, ethical, and financial perspectives*, Varuna Godara, ed., Hershey, London, Information Science Reference, cop. 2009, pp. 155-168.
2. Jan Porekar, Tomaž Klobučar, Svetlana Šaljić, Dušan Gabrijelčič, "Applying the SERENITY methodology to the domain of trusted electronic archiving", In: *Security and dependability for ambient intelligence*, (Advances in information security, vol. 55), George Spanoudakis, ed., Antonio Maña Gomez, ed., Spyros Kokolakis, ed., New York, London, Springer, 2009, pp. 343-357.

Published Conference Papers

Invited Papers

1. Tanja Arh, Matija Pipan, Borka Jerman-Blažič, Matjaž Debevc, Marija Mojca Peternel, "Enhancing in e-learning in vocational education and training with VET community portal", In: *Recent advances in e-activities, information security and privacy: proceedings of the 8th WSEAS International Conference on E-activities (E-ACTIVITIES '09), proceedings of the 8th WSEAS International Conference on Information Security and Privacy (ISP '09), Puerto De La Cruz, Tenerife, Canary Islands, Spain, December 14-16, 2009*, (Electrical and computer engineering series), Cornelia A. Bulucea, ed., [S. l.], WSEAS Press, 2009, pp. 99-104.
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1. Tanja Arh, Vlado Dimovski, Borka Jerman-Blažič, "Informacijsko komunikacijske tehnologije in tehnološko podprto učenje kot dejavnik uspešnosti poslovanja podjetij", In: *Nove tehnologije, novi izzivi: zbornik 28. mednarodne konference o razvoju organizacijskih znanosti: proceedings of the 28th International Conference on Organizational Science Development*, Vladislav Rajkovič, ed., Kranj, Moderna organizacija, 2009, pp. 76-84.
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4. Matija Pipan, Tanja Arh, "Enhanced e-learning in the field of mechatronic: case study", In: E-learning in Balcan Academic

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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-communication and sensor 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, advanced bio-signal processing, the education of young researchers, and the transfer of knowledge and new technologies to industry.

Head:
Prof. Gorazd Kandus

The 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 2009 related to telecommunications systems were concentrated in the areas of cognitive networks, wireless-sensor networks and also on different access-segment technologies, enabling the end-user to access new multimedia services and applications. The research emphasis was in the following areas: radio transmission; multiple-input, multiple-output (MIMO) antenna systems; 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, whose aim is to improve the utilization efficiency of scarce radio resources and to support the provision of quality of service. We were 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 the solutions providing network robustness, security and quality of services.

- **We developed software modules for radio-wave propagation modelling in mobile communication systems, which can be integrated into existing open-source geographic information systems (GIS).**
- **We proposed the advanced access architecture SmartA for efficient service delivery in heterogeneous wireless networks based on the general concept of cognitive networks.**

In the area of radio transmission we studied the radio interface and the propagation of the radio signal. Our research and applied work consisted of the measurement and modelling of the radio-wave propagation in long road and railway tunnels, which is of particular importance for the design of emergency communication systems. We also commenced with the development and implementation of software modules for radio-wave propagation modelling in mobile communication systems and with their integration into existing open-source geographic information systems (GIS). The latter are used as an interface to GIS and other relevant databases.

We investigated the utilisation of wireless-communication technologies in mesh networks and developed the model of a base-station based on mobile WiMAX specifications, consisting of the access and relay parts. We used the proposed model in the simulation tool OPNET Modeler and tested the physical layer parameters and the parameters of the higher layers of the protocol stack. Using this simulation model we also contributed to the design of algorithms and protocols for the WiMAX pico base-station with mesh-router functionality in a national development project.

Special emphasis was given to the transmission schemes of next-generation mobile communications. By combining the principles of orthogonal frequency division multiplexing (OFDM) and time division multiplexing (TDM) we evaluated the OFDM/TDM transmission scheme, which has a two-dimensional signal structure and offers new opportunities for dynamic radio-resource management. The scheme makes it possible to simultaneously combine frequency- and time-division multiple access on a frame-by-frame basis, as well as adaptive shaping of the radio-signal frequency spectrum. The latter offers the possibility for multiple systems to harmlessly coexist in the same frequency band.

Figure 1: WLAN mesh router mounted on a hot-air balloon for radio-wave propagation measurements in emergency situations

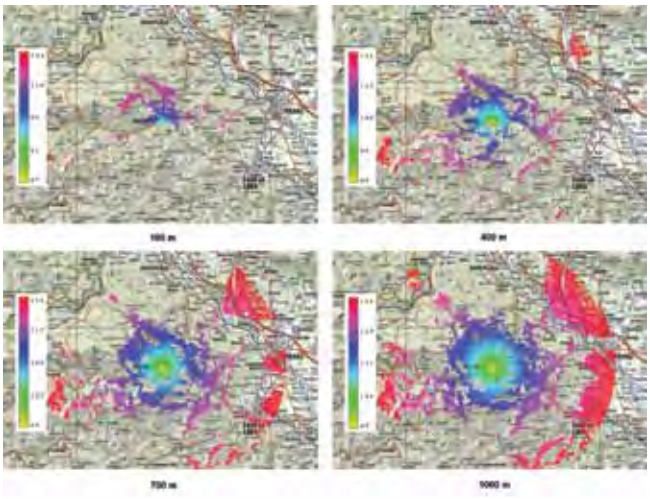

Figure 2: Radio-signal coverage at 2.4 GHz (received signal level in dB) for the Železniki area using a free-space loss-propagation model (transmitter alitudes considered at 100 m, 400 m, 700 m and 1000 m)

- **For the implementation of a seamless vertical handover in heterogeneous wireless networks we proposed the 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 prototype of a two-tiered wireless-sensor network and a prototype of the wireless sensor node for connection with user devices such as smart phones and PDAs.**
- **We co-edited the book Parallel Computing: Numerics, Applications, and Trends, which was published in May 2009 by Springer, and contributed two chapters.**

Figure 3: Radio-wave propagation measurements in a tunnel

In the area of radio-resource management we were working on the development and implementation of adaptive modulation and coding schemes and methods to estimate and predict the quality and state of a 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 were also investigating transmission techniques that make use of the space diversity during the transmission and reception and are providing an increase in the system capacity and/or link reliability without additional bandwidth and transmission-power requirements.

We continued the research on cognitive networks that will make use of new approaches in the area of telecommunications, such as cross-layer design and the optimisation of communication protocols, and technologies from the area of artificial intelligence in support of more autonomous operation and the management of communication devices and networks. In the access segment we focused on the development of the advanced access architecture SmartA for efficient service delivery in heterogeneous wireless networks based on the general concept of cognitive networks. We developed a test-bed for demonstrating the autonomous selection of the access network and vertical handover. In the transmission segment we investigated on-demand end-to-end dynamic transport service composition and solutions for the provision of autonomous network management.

On the network layer we continued with the investigations of fixed-mobile convergence and hierarchical mobility as well as with simulations of telecommunications networks. The emphasis in fixed-mobile convergence was on the mobility management in convergent networks, in particular on the seamless vertical handover between networks based on different access technologies. We were focusing on the provision of the requested quality of user experience in the target network. We proposed an adaptive mechanism based on the SIP communication protocol, which detects the congestion level in the target network. For a more detailed performance evaluation and an analysis of the proposed procedures and protocols for a seamless handover we developed a simulation model of the heterogeneous communication system composed of WLAN and HSDPA networks using the discrete-event simulation tool OPNET Modeler. In the area of simulations of the telecommunication networks we were focusing on an analysis of the introduction of new services in the network such as Time Shift and the migration of IPTV from multicast to unicast technology. In particular, we were evaluating the impact of new services on the performance of the access network using a purpose-built simulation model.

We also continued with the optimisation of hierarchical mobility management in the internet and improved the simulation model for the evaluation of algorithms for the selection of mobility anchor points so as to allow an evaluation of those algorithms also in realistic internet network models.

With our research work in the areas of stratospheric and satellite communication systems and wireless-sensor networks we participated in the 6 and 7 FP projects "Satellite Communications Network of Excellence "(SatNEx)" and "Wireless Sensor Networks and Remote Sensing - Foundation of a modern agricultural infrastructure in the region (AgroSense)". We were also investigating the possibility of providing communication links via aerial platforms in the case of an emergency.

In collaboration with the Department of Knowledge Technologies (E8) and the Centre for Knowledge Transfer (CT3) we established the Laboratory for Wireless Sensor Networks (SensorLab). We are developing a modular sensor node that can be used as a development platform for research work or as a baseline for the actual deployment of wireless-sensor networks. We developed and implemented a prototype of a two-tiered wireless-sensor network that makes use of ZigBee and GPRS technologies and a prototype of a Bluetooth-based wireless-sensor node for connection with user devices such as smart phones and PDAs. Particular emphasis is given to the use of semantic technologies in sensor networks enabling an autonomous search for sensors and the more efficient utilisation of sensor resources by the sharing of sensors and sensor data and the composition of virtual sensor networks.

With the Department of Low and Medium Energy Physics (F2) we established the Laboratory for Mathematical Methods in Nuclear Instrumentation and Cooperation. Research activities within the laboratory were targeting communication architectures for data-acquisition systems needed in the detector systems for particle experiments, digital signal processing required by the detector systems and the translation of the corresponding real-time algorithms in field-programmable arrays. We participated in the FAIR initiative, which would result in Slovenia joining the countries building a major new accelerator facility for beams of ions and antiprotons in Darmstadt. We are also involved in setting up the Centre of Excellence for Biosensors, Instrumentation and Process Control (CO-BIK), which will unite national state-of-the-art technologies in the fields of chemistry, biology, bioengineering, control systems and precision electrical instrumentation in the years ahead.

Parallel and Distributed Systems

In 2009 a formal cooperation was initiated with two research groups from the University of Ljubljana, Laboratory for Machine Vision, Faculty for Electrical Engineering and Laboratory for Algorithms and Data Structures, Faculty for Computing and Informatics. We cooperate on a substantial part of the research topics in the scope of the program group Parallel and Distributed Computing. Our cooperating researchers come also from industry (Turboinstitut d.d and Xlab d.o.o.) and from medicine (Clinical Center Ljubljana).

Computer algorithms for 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 Ljubljana University and the hi-tech company Turboinstitut d.d. 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 meshfree methods and the possibilities for their parallelization. The work resulted in a paper in the eminent journal Computers and Structures. Team members have contributed to the book Parallel Computing: Numerics, Applications, and Trends (edited by Roman Trobec, Marian Vajteršič and Peter Zinterhof), which was published in May 2009 by Springer, in the Computer Communications and Networks (CCN) series.

We cooperated successfully in 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 in the theory of parallel and distributed computing and communication.

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 Clinical Centre Ljubljana (CCL). We improved the simulation of the heat transfer in biological tissues, including 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 CCL team members. After publishing the research results in a journal paper in Computers in Biology and Medicine the representative of the Belgian medical company Weagener, which develops and produces cooling equipment for human body parts, contacted us for a future industrial cooperation.

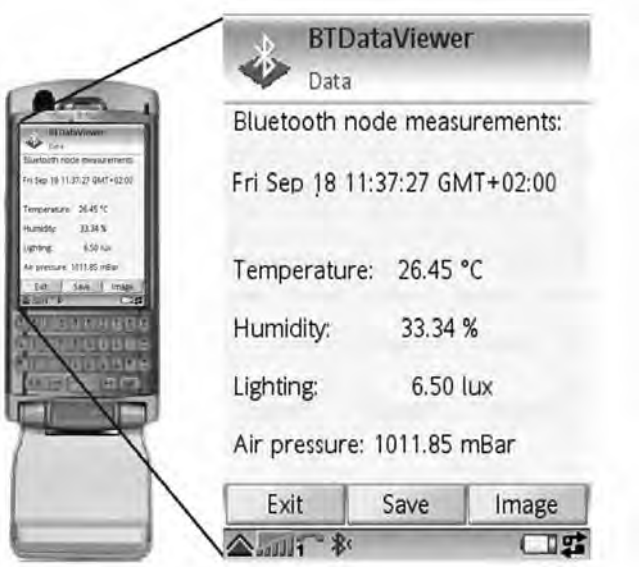

Figure 4: Representation of measurements from the wireless-sensor node on a smart phone

- **We have estimated the asymptotic calculation complexity of meshless numerical methods for the solution of differential equations.**
- **We developed a system for the wireless access of bio-potentials from the human body. We implemented an algorithm for the time alignment of wirelessly obtained measurements that are usually asynchronous. We synthesised, to the best of our knowledge, for the first in the world, a standard 12-channel ECG from just three bipolar wireless electrodes.**

Figure 5: Sensor (left) and gateway (right) nodes in a two-tiered wireless-sensor network

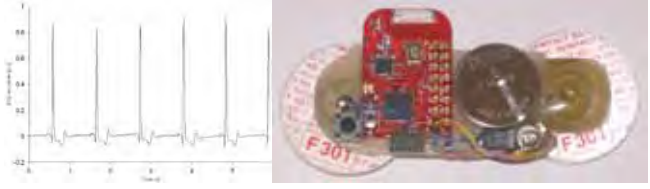

Figure 6: The prototype of a wireless body electrode (WBE) (left) an example of an ECG recorded wirelessly with the WBE (right).

Figure 7: Medical multimedial data and doctor-to-doctor assistance and support: Neurology - telestroke, Psychiatry - telecare system for the elderly, Trauma – rehabilitation, Surgery – telecare.

We investigated possible options and indications for the heart's reinervation after transplantation. A new investigation method for the detection of a possible heart reinervation was introduced based on the concurrent time analysis of breathing and heart-beat signals. The shape and the relation of both regulation functions possibly indicate the amount of reinervation after the heart's transplantation.

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 a segment-based test synthesis. As its specialization, we then developed a method that generalizes a large family of established methods for checking the sequence construction and the facilitates synthesis of cheaper tests also for distributed testing with no coordination between the testers.

Some outstanding publications in 2009

1. Carolina Fortuna, Mihael Mohorčič. Dynamic Composition of Services for End-to-End Information Transport. IEEE Wireless Communications. August 2009, 56-62.
2. Carolina Fortuna, Mihael Mohorčič. Trends in the development of communication networks: Cognitive networks. Computer Networks 53(2009), 1354-1376.
3. Roman Novak, Matjaž Vencelj. Gauss-Seidel iterative method as a real-time pile-up solver of scintillation pulses. IEEE trans. nucl. sci., 2009, vol. 56, no. 6, 3680-3687.
4. Matjaž Vencelj, Klemen Bučar, Roman Novak, H. J. Woertche. Event by event pile-up compensation in digital timestamped calorimetry. Nucl. instrum, methods phys res., Sect. A, Accel.. 2009, vol. 607, no. 3, 581-586.
5. Roman Trobec, Marjan Šterk, Borut Robič. Computational complexity and parallelization of the meshless local Petrov-Galerkin methods. Comput. struct., 2009, 87(1/2), 81-90.
6. Roman Trobec, Marian Vajteršic, Peter Zinterhof (eds.). Parallel Computing: Numerics, Applications, and Trends. Dordrecht, Springer, 540 p, 2009.

Awards and appointments

1. Carolina Fortuna: 4WARD Innovation Award, Bremen, Germany, FISS 09 Summer school , Essay: "What can be the biggest networking innovation in the Future Internet, which technologies are required to implement it, and which business ideas would be enabled by it?".

Organization of conferences, congress and meetings

1. The Third Meeting of the Management Board of FP7 AgroSense Project, Ljubljana, 6-8 April 2009
2. Meeting of the Management Board of FP7 AgroSense Project, Ljubljana, 7 May 2009
3. Networking Meeting of FP7 AgroSense Project, Ljubljana, 12 June 2009
4. ProSense Workshop Ljubljana 2009, Ljubljana, 17-21 November 2009

INTERNATIONAL PROJECTS

1. Enabling the Knowledge Powered Enterprise
   ACTIVE
   7. FP, 215040
   EC; Philip Hewitt, British Telecommunications plc, London, Great Britain
   Asst. Prof. Mihael Mohorčič, Mitja Jermol, M. Sc., Marko Grobelnik, Asst. Prof. Dunja Mladenič
2. 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
   Prof. Roman Trobec
3. 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
4. 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
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; German Aerospace Center, Office KN PA, Weßling, Germany
   Prof. Gorazd Kandus
6. Cognitive Radio and Networking for Cooperative Coexistence of Heterogeneous Wireless Networks
   COST IC0902, EC
   Asst. Prof. Mihael Mohorčič
7. Open European Network for High Performance Computing on Complex Environments
   COST IC0805, EC
   Prof. Roman Trobec

8. Propagation Tools and Data for Integrated Telecommunication, Navigation and Earth Observation Systems
   COST IC0802
   EC
   Prof. Gorazd Kandus
9. Prevasive Mobile & Ambient Wireless Communications
   COST 2100
   EC; Prof. Roberto Verdone, DEIS- Università degli Studi di Bologna, Bologna, Italy
   Asst. Prof. Tomaž Javornik
10. 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
11. 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
12. 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
13. Acceleration of Matrix Operations on a Reconfigurable Computing Architecture Based on the Whole Silicon Wafer
    BI-UA/09-10-001
    Dr. Andriy Lutsyk, Institute of Physics and Mechanics, Lviv, Ukraine
    Prof. Roman Trobec

R&D GRANTS AND CONTRACTS

1. Lightweight services for security, privacy and trust management
   Prof. Denis Trček, Asst. Prof. Roman Novak
2. Multiple antenna system for mobile WiMAX
   Prof. Gorazd Kandus

RESEARCH PROGRAMS

1. Telecommunication systems
   Prof. Gorazd Kandus
2. Parallel and Distributed Systems
   Asst. Prof. Roman Trobec

NEW CONTRACTS

1. Information and communication system for management and control in the implementation of emergency services
   Computel, d. o. o.
   Prof. Gorazd Kandus
2. Co-financing L2-1109-0106-08: Multiple antenna system for mobile WiMAX
   Telsima, d. o. o.
   Prof. Gorazd Kandus
3. Uninterrupted provision of communication services in emergency situations
   Telekom Slovenije, d. d.
   Asst. Prof. Mihael Mohorčič
4. Design of the software modules for radio coverage calculation and visualisation
   Mobitel, d. d.
   Asst. Prof. Tomaž Javornik
5. Critial investigation of algorithms, funcionality and protocols for WiMAX pico base station for urban and rural areas
   Cosylab, Laboratory for Control Sistems, d. d.
   Asst. Prof. Tomaž Javornik

VISITORS FROM ABROAD

1. Vladan Minić M.Sc.E.E., Faculty of Technical Sciences, Novi Sad, Serbia, 19-31 January 2009
2. Francesco Chiti, University of Florence, Firence, Italy, 6-8 April 2009
3. Laura Pierucci, University of Florence, Firence, Italy, 6-8 April 2009
4. Romano Fantacci, University of Florence, Firence, Italy, 6-8 April 2009
5. Prof. Jovan Crnobarac, Faculty of Agriculture, Novi Sad, Serbia, 6-8 April 2009
6. Prof. Branko Marinković, Faculty of Agriculture, Novi Sad, Serbia, 6-8 April 2009
7. Boris Antić M. Sc. EE, Faculty of Technical Sciences, Novi Sad, Serbia, 6-8 April 2009
8. Borislav Brunet, Provincial Secretariat of Agriculture, Water Economy and Forestry, Novi Sad, Serbia, 6-8 April 2009
9. Prof. Vladimir Crnojević, Faculty of Technical Sciences, Novi Sad, Serbia, 6-8 April 2009
10. Dr Dubravko Ćulibrk, Faculty of Technical Sciences, Novi Sad, Serbia, 7 May 2009
11. Čedomir Stefanović, Faculty of Technical Sciences, Novi Sad, Serbia, 7 May 2009
12. Prof. Vladimir Crnojević, Faculty of Technical Sciences, Novi Sad, Serbia, 7 May 2009
13. Dr Petra Hössl, Lakeside Labs, Klagenfurt, Austria, 10 June 2009
14. Thomas Ladstätter B.Sc., Lakeside Labs, Klagenfurt, Austria, 10 June 2009
15. Claudia Prüggler B.Sc, Lakeside Labs, Klagenfurt, Austria, 10 June 2009
16. Helmut Adam, University of Klagenfurt (Institute for Networked & Embedded Systems), Klagenfurt, Austria, 10 June 2009
17. Dr Wilfried Elmenreich, University of Klagenfurt (Institute for Networked & Embedded Systems), Klagenfurt, Austria, 10 June 2009
18. Prof. Christian Bettstetter, University of Klagenfurt (Institute for Networked & Embedded Systems), Klagenfurt, Austria, 10 June 2009
19. Goran Dimić M.Sc., Institute Mihajlo Pupin, Belgrade, Serbia, 15– 17 June 2009
20. Bogdan Ivan, University Cluj-Napoca, Cluj, Napoca, Romania, 21. 6.-26. 8. 2009
21. Zoltan Padrah, Univerza Cluj-Napoca, Cluj, Napoca, Romania, 13 July to 18 September 2009
22. Prof. Erich Leitgeb, Technische Universität Graz, Graz, Austria, 24-26 October 2009
23. Konrad Lang, Waegener Medical Technologies, Beerse, Belgium, 26 October 2009
24. Martin De Prycker, Waegener Medical Technologies, Beerse, Belgium, 26 October 2009
25. Prof. Liljana Gavrilovska, Faculty of Electrical Engineering and Information Technologies, Skopje, Macedonia, 18-21 November 2009
26. Srđan Krčo, LM Ericsson Ireland, Dublin, Ireland, 18-21 November 2009
27. Vladimir Milutinović, University of Belgrade, Electro Technical Faculty, Serbia, 18-21 November 2009
28. Ivan Tomašič, Ruđer Bošković Institute, Zagreb, Croatia, 18-21 November 2009
29. Aleksandar Crnjin, University of Belgrade, Electro Technical Faculty, 18-21 November 2009
30. Oleksiy Lutsyk, Institute of Physics and Mechanics of the National Academy of Science of Ukraine, Lviv, Ukraine, 23-27 November 2009
31. Andriy Lutsyk, Institute of Physics and Mechanics of the National Academy of Science of Ukraine, Lviv, Ukraine, 23-27 November 2009

STAFF

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23. Tomaž Krištofelc

Note:
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BIBLIOGRAPHY

Original Articles

1. Kemal Alič, Andreja Istenič Starčič, Jurij F. Tasič, Matej Zajc, "Razvoj interaktivnih multimedijskih televizijskih učnih vsebin v okolju DVB-T", *Elektroteh. vestn.*, vol. 76, no. 5, pp. 269-274, 2009.
2. Tine Celcer, Tomaž Javornik, Andrej Hrovat, Gorazd Kandus, "Channel aware scheduling algorithm for multiuser MIMO uplink", *The Mediterranean journal of electronics and communications*, vol. 5, no. 3, pp. 73-82, 2009.
3. Tine Celcer, Tomaž Javornik, Mihael Mohorčič, Gorazd Kandus, "Virtual multiple input multiple output in multiple high-altitude platform constellations", *IET communications*, vol. 3, no. 11, pp. 1704-1715, 2009.
4. Carolina Fortuna, Mihael Mohorčič, "Dynamic composition of service for end-to-end information transport", *IEEE wirel. commun.*, vol. 16, no. 4, pp. 56-62, 2009.
5. Carolina Fortuna, Mihael Mohorčič, "Trends in the development of communication networks: cognitive networks", *Comput. networks (1999)*, vol. 53, no. 9, pp. 1354-1376, 2009.
6. Tomaž Javornik, Igor Jelovčan, S. Sheikh Muhammad, Gorazd Kandus, "Simplified soft value extraction for M-PPM-modulated signals in FSO systems", *AEÜ, Int. j. electron. commun. (Print)*, vol. 63, no. 7, pp. 595-599, 2009.
7. Igor Jelovčan, Gorazd Kandus, Tomaž Javornik, "An adaptive zero forcing maximum likelihood soft input soft output MIMO detector", *IEICE trans. commun.*, vol. E92-B, no. 2, pp. 507-515, 2009.
8. Monika Kapus-Kolar, "An action refinement operator for E-LOTOS with true concurrency", *Comput. stand. interfaces*, vol. 31, no. 1, pp. 77-87, 2009.
9. Monika Kapus-Kolar, "Improvements to a roll-back mechanism for asynchronous checkpointing and recovery", *Informatica (Ljubl.j)*, vol. 33, no. 4, pp. 511-519, 2009.
10. Monika Kapus-Kolar, "Reversible enhanced event structures: towards reversible E-LOTOS", *Comput. stand. interfaces*, vol. 31, no. 5, pp. 942-947, 2009.
11. Monika Kapus-Kolar, "Three generalizations to a generic integrated test generation method for finite state machines", *Comput. j.*, vol. 52, no. 6, pp. 599-625, 2009.
12. Juš Kšela, Jurij-Matija Kališnik, Viktor Avbelj, Piotr Suwalski, Grzegorz Suwalski, Borut Geršak, "Ventricular arrhythmic disturbances and autonomic modulation after beating-heart revascularization in patients with pulmonary normotension", *Wien. Klin. Wochenschr.*, jg. 121, hft. 9-10, pp. 324-329, 2009.
13. Juš Kšela, Jurij-Matija Kališnik, Viktor Avbelj, Gaj Vidmar, Piotr Suwalski, Grzegorz Suwalski, Kazimierz B. Suwalski, Borut Geršak, "Short- versus long-term ECG recordings for the assessment of non-linear heart rate variability parameters after beating heart myocardial revascularization", *Comput. biol. med.*, vol. 39, no. 1, pp. 79-87, 2009.
14. Mihael Mohorčič, Carolina Fortuna, Andrej Vilhar, Joachim Horwath, "Evaluation of wavelength requirements for stratospheric optical transport networks", *Journal of communications*, vol. 4, no. 8, pp. 588-596, 2009.
15. Sajid Sheikh Muhammad, Tomaž Javornik, Igor Jelovčan, Zabih Ghassemlooy, Erich Leitgeb, "Comparison of hard-decision and soft-decision channel coded M-ary PPM performance over free space optical links", *Eur. trans. telecommun.*, vol. 20, no. 8, pp. 746-757, 2009.
16. Farukh Nadeem, Vaclav Kvicera, Saleem Awan, Erich Leitgeb, Sajid Sheikh Muhammad, Gorazd Kandus, "Weather effects on hybrid FSO/RF communication link", *IEEE j. sel. areas commun. (Print)*, vol. 27, no. 9, pp. 1687-1697, 2009.
17. Roman Novak, Matjaž Vencelj, "Gauss-Seidel iterative method as a real-time pile-up solver of scintillation pulses", *IEEE trans. nucl. sci.*, vol. 56, no. 6, pp. 3680-3687, 2009.
18. Igor Ozimek, Miha Smolnikar, Andrej Hrovat, Mihael Mohorčič, Gorazd Kandus, "Uporaba tetra za daljinsko merjenje in krmiljenje pri varovanju pred naravnimi in drugimi nesrečami", *Ujma (Ljubl.j.)*, no. 23, pp. 160-166, 2009.
19. Roman Trobec, Urban Borštnik, Dušanka Janežič, "Communication performance of d-meshes in molecular dynamics simulation", *J. math. chem.*, vol. 45, no. 2, pp. 503-512, 2009.
20. Roman Trobec, Marjan Šterk, Borut Robič, "Computational complexity and parallelization of the meshless local Petrov-Galerkin methods", *Comput. struct.*, vol. 87, no. 1/2, pp. 81-90, 2009.
21. Matjaž Vencelj, Klemen Bučar, Roman Novak, H. J. Woertche, "Event by event pile-up compensation in digital timestamped calorimetry", *Nucl. instrum, methods phys res., Sect. A, Accel.*, vol. 607, no. 3, pp. 581-586, 2009.

Review Articles and Chapters in Books

1. Firas Albalas, et al. (29 authors), "Mobility support", In: *Traffic and QoS management in wireless multimedia networks: COST 290 final report*, (Lecture notes in electrical engineering, vol. 31), Yevgeni Koucheryavy, ed., New York, Springer, 2009, pp. 151-200.
2. Manuel Alvarez-Campana, et al. (22 authors), "Performance evaluation and traffic modeling", In: *Traffic and QoS management in wireless multimedia networks: COST 290 final report*, (Lecture notes in electrical engineering, vol. 31), Yevgeni Koucheryavy, ed., New York, Springer, 2009, pp. 89-150.
3. Torsten Braun, Gorazd Kandus, Mihael Mohorčič, (13 authors), "Services, optimization, and economic aspects", In: *Traffic and QoS management in wireless multimedia networks: COST 290 final report*, (Lecture notes in electrical engineering, vol. 31), Yevgeni Koucheryavy, ed., New York, Springer, 2009, pp. 267-304.
4. Bogdan Filipič, Matjaž Depolli, "Parallel evolutionary computation framework for single- and multiobjective optimization", In: *Parallel computing: numerics, applications, and trends*, Roman Trobec, ed., Marian Vajteršic, ed., Peter Zinterhof, ed., Dordrecht ... [etc.], Springer, 2009, pp. 217-240.
5. Roman Trobec, "Parallel computer simulations of heat transfer in biological tissues", In: *Parallel computing: numerics, applications, and trends*, Roman Trobec, ed., Marian Vajteršic, ed., Peter Zinterhof, ed., Dordrecht ... [etc.], Springer, 2009, pp. 307-358.
6. Roman Trobec, Krešimir Matković, Karolj Skala, "IVAB: interactive visual analysis of bio-signals", In: *Scientific results of the SEE-ERA.NET: pilot joint call*, Jana Machačová, ed., Katarina Rohsmann, ed., 1st ed., Vienna, Centre for Social Innovation, 2009, pp. 151-159.
7. Marian Vajteršic, Peter Zinterhof, Roman Trobec, "Overview - paralel computing: numerics, applications, and trends", In: *Parallel computing: numerics, applications, and trends*, Roman Trobec, ed., Marian Vajteršic, ed., Peter Zinterhof, ed., Dordrecht ... [etc.], Springer, 2009, pp. 1-42.

Published Conference Papers

Invited Paper

1. Gorazd Kandus, "Mobilne komunikacije preko stratosferskih platformi", In: *Mobilne i bežične komunikacije: stanje i perspektive*, (Naučni skupovi, Odjeljenje prirodnih nauka, knj. 97, knj. 12), Igor Đurović, ed., Podgorica, Crnogorska akademija nauka i umjetnosti, 2009, pp. 33-61.

Regular papers

1. Kemal Alič, Aleš Švigelj, Miha Smolnikar, Mihael Mohorčič, Denis Škrabl, Tomaž Javornik, Gorazd Kandus, "On remote sensing techniques in agriculture", In: *BioSense09*, The First International Workshop on Sensing Technologies in Agriculture, Forestry and Environment, 14-15 October 2009, Novi Sad, Serbia, [S. l.], AgroSense, 2009, 4 pp.
2. Viktor Avbelj, "Vpliv magnetizma na občutljivost oči - je v ozadju magnetni čut?", In: *Zbornik 12. mednarodne multikonference Informacijska družba - IS 2009, 12.-16. oktober 2009: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Olga S. Fomichova, ed., Vladimir Fomichov, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2009, pp. 361-363.
3. Gregor Berke, Miha Smolnikar, Mihael Mohorčič, Tomaž Javornik, Gorazd Kandus, "Two-tiered wireless sensor network for monitoring

in agriculture", In: *BioSense09*, The First International Workshop on Sensing Technologies in Agriculture, Forestry and Environment, 14-15 October 2009, Novi Sad, Serbia, [S. l.], AgroSense, 2009, 4 pp.
4. Gregor Berke, Miha Smolnikar, Mihael Mohorčič, Gorazd Kandus, "Dvokrožno brezžično senzorsko omrežje na osnovi tehnologij ZigBee in GPRS", In: *Zbornik Osemnajste mednarodne elektrotehniške in računalniške konference - ERK 2009, 21-23. september 2009, Portorož, Slovenija*, Baldomir Zajc, ed., Andrej Trost, ed., Ljubljana, IEEE Region 8, Slovenska sekcija IEEE, 2009, zv. A, pp. 216-219.
5. Laurent Castanet, Tomaž Javornik, (12 authors), "Channel modelling activities related to atmosperic effects in the SatNEx project", In: *EUCAP 2009*, 3rd European Conference on Antennas and Propagation, 23-27 March 2009 in Berlin, Germany, [S. l., s. n.], 2009, pp. 1697-1711.
6. Carolina Fortuna, Bogdan Ivan, Zoltan Padrah, Luka Bradeško, Blaž Fortuna, Mihael Mohorčič, "Demonstration: wireless access network selection enabled by semantic technologies", In: *Proceedings*, (Lecture notes in computer science, Lecture notes in artificial intelligence, LNCS 5823), 8th International Semantic Web Conference, ISWC 2009, October 25-29, 2009, Chantilly, Va, USA, New York, Springer-Verlag, 2009.
7. Carolina Fortuna, Mihael Mohorčič, "A local knowledge base for service oriented access network selection", In: SIGCOMM'09: procedings of the 2009 SIGCOMM Conference and co-located Workshops MobiHeld'09, PRESTO'09, VISA'09, WOSN'09, & WREN'09, August 17-21, 2009, Barcelona, Spain, Danvers, ACM, 2009, 2 pp.
8. Andrej Hrovat, Gorazd Kandus, Tomaž Javornik, "Four slope channel model for TETRA direct mode operation inside the road tunnels", In: *Proceedings of Mosharaka International Conference on Communications, propagation and Electronics, (MIC-CPE 2009), 6-8 February 2009, Amman, Jordan*, [S. l., s. n.], 2009, 6 pp.
9. Erich Leitgeb, Tomaž Javornik, Gorazd Kandus, (12 authors), "Current optical technologies for wireless access", In: *ConTEL 2009: proceedings of the 10th International Conference on Telecommunications, Zagreb, Croatia, June 8-10, 2009*, Ivana Podnar Žarko, ed., Boris Vrdoljak, ed., Zagreb, University of Zagreb, Faculty of Electrical Engineering and Computing, cop. 2009, 11 pp.
10. Erich Leitgeb, Tomaž Javornik, Gorazd Kandus, (11 authors), "Investigations of free-space optical links within SatNEx II", In: *EUCAP 2009*, 3rd European Conference on Antennas and Propagation, 23-27 March 2009 in Berlin, Germany, [S. l., s. n.], 2009, pp. 1707-1711.
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13. Farukh Nadeem, Gorazd Kandus, (5 authors), "Evaluation of switch-over algorithms for hybrid FSO-WLAN systems", In: *Proceedings*, WiRELESS VITAE'09, 1st International Conference on Wireless Communications, Vehicular Technology, Information Theory and Aerospace & Electronic Systems Technology, May 17-20, 2009, Aalborg, Denmark, Denver, IEEE, 2009, pp. 565-570.
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THESES

Ph. D. Thesis

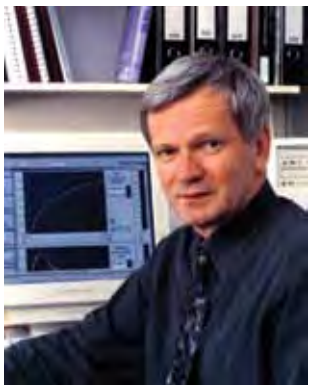
1. Andrej Vilhar, *Optimization of procedures for hierarchical mobility management in the internet: doctoral dissertation*, Ljubljana, [A. Vilhar], 2009.

B. Sc. Thesis

1. Gregor Berke, *Hierarchical wireless sensor network for environmental monitoring: undergraduate thesis*, Ljubljana, [G. Berke], 2009.

DEPARTMENT OF COMPUTER SYSTEMS E-7

The department is concerned primarily with the design automation of computing structures and systems. Within this broad area, we are concentrating particularly on the meta-heuristic approach to engineering design and logistics problems as well as system design and test. 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



Head:
Prof. Franc Novak

An important part of our research activities is related to the development of meta-heuristic 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.

Within a project with Gorenje, d. d., Velenje, we developed and designed a program tool for the simulation of temperatures inside a refrigerator. In an optimised refrigerator the desired temperature is sustained with the lowest possible power demand. The simulator allows the simulation of temperatures inside the refrigerator for different modes of regulation. It replaces the parts of the measurements that are time consuming due to the slow thermal processes. Besides the shorter measurement time, the development costs of the refrigerator are also lowered. Next, we upgraded the simulator with an advanced optimization algorithm, to automatically find the optimum regulation of the refrigerator. According to known, measured, temperature responses, the optimizer finds the optimal refrigerator control parameters. The developed tools allow the substitution of a several-day observation of a refrigerator with a several-second simulation. This, again, substitutes a large set of measurements and lowers the development costs. Computer simulation of a refrigerator suggests almost unlimited possibilities for improvements and optimization of prototype refrigerators in order to shorten the time-to-market.

In collaboration with Gorenje d.d. we developed a program tool for the simulation of the temperatures inside a refrigerator and optimized the control parameters.

Working in cooperation with Eta Cerkno, d. o. o., Cerkno, we simulated their manufacturing process and produced an optimized plan for the production of cooking plates, so the time from order to production is as short as possible, while taking into account all the restrictions. So in the worst case, all the work has to be carried out in required time (for example, prior to dispatch). The final computer model will replace the expert who prepares the plans by hand, which makes this process very time consuming and inefficient.

We have developed a differential ant-stigmergy approach suitable for solving discrete as well as continuous numerical optimization problems on several real-world applications. In collaboration with Domel d.d., Železniki, we increased the efficiency of a radial impeller of a vacuum-cleaner motor.

In the research area of computer-based menu planning, collaborating with the SME Sonce.net, Digitalni marketing d.o.o., Oncology Institute Ljubljana and Paediatric Clinic, we performed a research project "Open Platform for Clinical Nutrition". The aim of the project is to develop a system of e-contents and e-services to support nutrition screening and the assessment of oncology and paediatric patients. To develop an e-service for menu planning we use a knowledge of meta-heuristic optimization with evolutionary algorithms. In cooperation with the company Poslovni sistem Mercator d.d., the Slovenian Consumers' Association, the Slovenian Heart Association and the Institute of Public Health of the Republic of Slovenia we run a project "Mobile Application for Informing Consumers on Food Composition". In the project we are developing an embedded application and services for the 1D (EAN-13) barcode recognition using camera-equipped mobile phones, and for the provision of the food product's nutritional information in real-time. Last but not least, we are active in the European Network of Excellence "European Food Information Resource Network (EuroFIR - FP6-CT-2005-513944)".

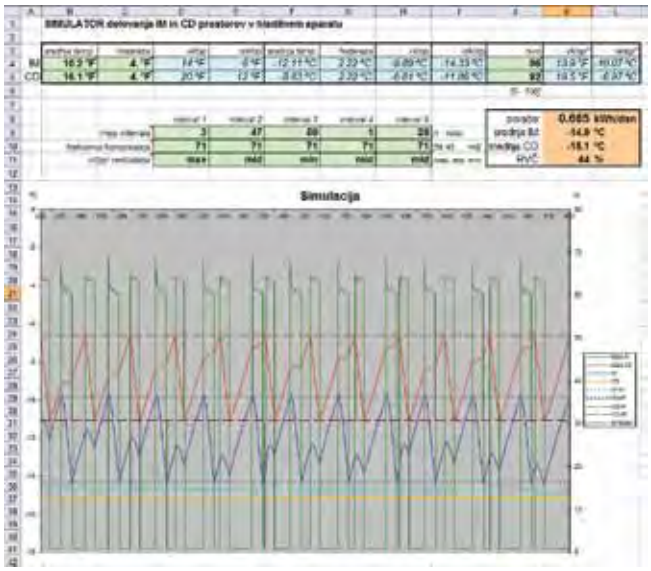


Figure 1: Simulator of the temperatures inside a refrigerator at different parameters of regulation.

In the frame of the EUREKA project "DIPIMAM" we successfully applied neural networks in an analysis of the injection-moulding process and the prediction of the quality of moulded shafts.

We have also studied the problem of the parameter estimation of nonlinear dynamic systems represented by ordinary differential equations with evolutionary and stigmergic approaches. More precisely, we address the parameter estimation of the dynamics of Rab5-to-Rab7 conversion in endocytosis.

We were involved as a partner in the EUREKA project "DIPIMAM" (2008-2010) where the main goal was to improve the quality of ceramic products in the company Hidria AET Tolmin. We continued to apply artificial neural networks to discover the relationships between various phases of the injection-moulding process. In 2009 we investigated two possible applications of neural networks: modelling the relationship between the geometry of the ceramic parts and the technological parameters of injection moulding, and the prediction of the quality of moulded shafts from the same parameters. The relationship between the geometry and the technological parameters was modelled by a three-layer peceptron trained by backpropagation. The model exhibited a high correlation to the measurements with an average correlation coefficient of 0.95. The quality prediction of the moulded shafts was made by a similar neural network trained with 192 measurements, and achieved an 87% correlation.

Figure 2: Searching for the optimized plan in the production of cooking plates.

In the field of pattern recognition we developed a procedure for earthquake prediction from concentrations of the noble gas radon. It involves distinction of concentration anomalies due to seismic activity from anomalies due to environmental parameters. Using this procedure we processed data from Krško basin for the two years period and correctly determined 10 earthquakes out of 13.

In the field of computer vision we developed an optical measurement system for measuring a knee's angular displacement based on the Wartenberg pendulum test. During the measurement a video camera records the time dependency of the movement of a human leg equipped with passive markers, which enables the determination of the knee angle's temporal dependency afterwards. This method is useful in orthopaedic diagnostics.

In the field of electronic tests we are investigating 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-a-Chip test infrastructure. We implemented a histogram-based ADC built-in self-test in the IEEE Std 1500 test wrapper. In the area of digital tests we have developed a new approach to the application-oriented test of processor cores suitable for an SoC implemented in FPGA. In order to evaluate the proposed solution we developed an automated fault-emulation environment using the features of a partial FPGA reconfiguration.

In the frame of the "Open Platform for Clinical Nutrition" project we developed a system of e-contents and e-services to support nutrition screening and the assessment of oncology and pediatric patients.

In collaboration with FERI, University of Maribor, we continued our work on the setting up of Delaunay triangulation benchmarks and the supporting verification tools.

Some outstanding publications in the past three years

1. B. Koroušić Seljak, "Computer-based dietary menu planning", J. Food Compos. Anal., 2009, vol. 22, no. 5, pp. 414-420.
2. P. Korošec, J. Šilc, " The distributed multilevel ant-stigmergy algorithm used at the electric-motor design", Eng. Appl. Artif. Intell., 2008, vol. 21, no. 6, pp. 941-951.
3. 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.
4. M. Pavlin, F. Novak, "Yield enhancement of piezoresistive pressure sensors for automotive applications". Sens. Actuators, A, Phys., 2008, vol. 141, štev. 1, pp. 34-42.
5. M. Santo Zarnik, D. Belavič, F. Novak, "Finite-element model-based fault diagnosis, a case study of a ceramic pressure sensor structure", Microelectron. Reliab., 2007, vol. 47, no. 12, pp. 1950-1957.

Patent granted

1. SI 22693 A, Ljubljana: The Slovenian Intellectual Property Office, 30th June 2009 , Title: » The device and procedure for the transfer of a personal food composition table and dietary reference values from a computer program to the nutrition scale
   Authors: KOROUŠIĆ-SELJAK, B; PAPA, G; JSI

Awards and appointments

1. Barbara Koroušić Seljak; An Industry Inovation Prize at the Technology Transfer Conference at JSI, for project: Computer-based dietary menu planning.

Organization of conferences, congress and meetings

1. 14th workshop of Bio-inspired algorithms, Ljubljana, IJS, 29. 5. 2009
2. 15th workshop of Bio-inspired algorithms. University of Maribor, FERI, 11.12.2009

INTERNATIONAL PROJECTS

1. Enhancing Lifelong Learning for the Electrical and Information Engineering Community
   ELLEIEC – Surveyor
   ERASMUS
   EC; M. Hamed Yahoui, L'Université Claude Bernard Lyon 1, Villeurbanne, France
   Prof. Franc Novak
2. 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 Koroušić Seljak
3. Development and Implementation of New PIM Binder System Using Advanced Methods
   DIPIMAM
   EUREKA
   Hidria AET d.o.o., Tolmin, Slovenia
   Dr. Drago Torkar
4. Open Platform for Clinical Nutrition: OPKP
   E-contents and E-services
   3211-09-000538
   Zoran Trojan, SONCE.NET d.o.o, Ljubljana, Slovenia
   Asst. Prof. Barbara Koroušić Seljak

R & D GRANTS AND CONTRACTS

1. Optimization of packaging, loading and transportation of pre-fabricated building elements
   Asst. Prof. Peter Korošec

RESEARCH PROGRAM

1. Computing structures and systems
   Prof. Franc Novak

NEW CONTRACT

1. Refrigerator simulator and optimizer
   Gorenje Household Appliances
   Asst. Prof. Gregor Papa
2. Mobile application for informing consumers on nutrient content of food
   Ministry of Health, Slovenian Radiation Protection Administration
   Asst. Prof. Barbara Koroušić Seljak

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5. Asst. Prof. Jurij Šilc

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8. Dr. Drago Torkar

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10. Katerina Tashkova, B. Sc.
11. Vida Vukašinović, B. Sc.
12. Peter Mrak**, B. Sc.
13. Uroš Bole**, B. Sc.

Technical and administrative staff
14. Jolanda Jakofčič

Note:
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** young researcher financed by industry

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Original Articles

1. Peter Korošec, Jurij Šilc, "High-dimensional real-parameter optimization using the differential ant-stigmergy algorithm", *Int. j. intell. comput. cybern. (Print)*, vol. 2, no. 1, pp. 34-51, 2009.
2. Peter Korošec, Jurij Šilc, "A stigmergy-based algorithm for continuous optimization tasted on real-life-like enviornment", In: *Applications of evolutionary computing: proceedings*, (Lecture notes in computer science, vol. 5484), Mario Giacobini, Berlin, Heidelberg, New York, Springer, 2009, vol. 5484, pp. 675-684, 2009.
3. Barbara Koroušić-Seljak, "Computer-based dietary menu planning", *J. food compos. anal.*, vol. 22, no. 5, pp. 414-420, 2009.
4. Barbara Koroušić-Seljak, "Prehranske tabele na spletu", *Kemija v šoli in družbi*, vol. 21, no. 3, pp. 30-33, 2009.
5. Barbara Koroušić-Seljak, Cirila Hlastan-Ribič, "Škodljive maščobe v prehrani", *Za srce (Ljubl.)*, vol. 18, no. 3/4, pp. 1-2, 2009.
6. Uroš Legat, Anton Biasizzo, Franc Novak, "Partial runtime reconfiguration of FPGA, applications and a fault emulation case study", *Int. Rev. Comp. Softw. (Testo stamp.)*, vol. 4, no. 5, pp. 606-611, 2009.

7. Peter Mrak, Franc Novak, Anton Biasizzo, "Generation of sequential diagnostic procedures including symmetrical, asymmetrical and multi-valued tests", *Int. Rev. Comp. Softw. (Testo stamp.)*, vol. 4, no. 1, pp. 113-118, 2009.
8. Gregor Papa, Drago Torkar, "Visual control of an industrial robot manipulator: accuracy estimation", *Stroj. vestn.*, vol. 55, no. 12, pp. 781-787, 2009.
9. Maja Rotovnik, Jurij Šilc, Janez Žerovnik, "Optimalno permutacijsko usmerjanje v heksagonalnih omrežjih", *Elektroteh. vestn.*, vol. 76, no. 1/2, pp. 19-24, 2009.
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11. Drago Torkar, Gregor Papa, "Ocena natančnosti sistema robotskega vida", *Elektroteh. vestn.*, vol. 76, no. 1/2, pp. 25-30, 2009.
12. Mariusz Wegrzyn, Franc Novak, Anton Biasizzo, "Functional testing of processor cores in FPGA-based applications", *Comput. inform.*, vol. 28, no. 1, pp. 97-113, 2009.

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1. Peter Korošec, Jurij Šilc, "Applications of the differential ant-stigmergy algorithm on real-world continuous optimization problems", In: *Evolutionary computation*, Wellington Pincheiro dos Santos, ed., Vukovar, In-Teh, 2009, pp. 199-218.
2. Gregor Papa, Tomasz Garbolino, Franc Novak, "Evolutionary-based design of deterministic test pattern", In: *Artificial intelligence: new research*, Randal B. Bernstein, ed., Wesley N. Curtis, ed., New York, Nova Science Publishers, cop. 2009, pp. 415-428.

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1. Peter Korošec, Jurij Šilc, "The differential ant-stigmergy algorithm applied to dynamic optimization problems", In: *2009 IEEE Congress on Evolutionary Computation, IEEE CEC 2009, 18th to 21st May 2009, Trondheim, Norway: programme & abstracts*, Piscataway, IEEE, 2009, pp. 407-414.
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4. Peter Korošec, Jurij Šilc, "A stigmergy-based algorithm for black-box optimization: noisy function testbed", In: *Genetic and evolutionary computation conference: GECCO 2009*, A recombinatin of the 18th International Conference on Genetic Algorithms, (ICGA) and the 14th Annual Genetic Programming, (GP), July 8-12, 2009, Montréal, Canada, New York, Association for Computing Machinery, cop. 2006, pp. 2375-2381.
5. Barbara Koroušić-Seljak, "Primer sodobnega informacijskega sistema za načrtovanje prehrane", In: New trends in contemporary nursing - promoting research, education, and multisector partnership: proceedings of lectures with peer review: zbornik predavanj z recenzijo, 2nd International Scientific Conference, September 17-18, 2009, Ljubljana, Slovenia = 2. mednarodna znanstvena konferenca, Brigita Skela-Savič, ed., Boris Miha Kaučič, ed., Bojana Filej, ed., Jesenice, College of Nursing, = Visoka šola za zdravstveno nego, 2009, pp. 371-377.
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7. Uroš Legat, Anton Biasizzo, Franc Novak, "Fault simulation with partial reconfiguration of FPGA", In: *Proceedings*, 45th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Photovoltaic Devices and Technologies, September 9 - September 11, 2009, Postojna, Slovenia, Marko Topič, ed., Janez Krč, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2009, pp. 157-160.
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1. Peter Korošec, Andrej Kramar, *Sistemi I: 1. stopnja: dodiplomski program Računalništvo in informatika (1. letnik)*, [Koper], Fakulteta za matematiko, naravoslovje in informacijske tehnologije, 2008/2009.
2. Franc Novak, *Computer structures and systems: (lecture slides)*, Ljubljana, Jožef Stefan International Postgraduate School, 2009.
3. Franc Novak, *Računalniška periferija: (zapiski predavanj) za študijsko leto 2008/2009*, Ljubljana, Institut Jožef Stefan, 2009.
4. Franc Novak, *Računalniška periferija: zbirka vprašanj in rešenih nalog*, Ljubljana, Institut Jožef Stefan, 2009.

Patent

1. Barbara Koroušić-Seljak, Gregor Papa, *The device and procedure for the transfer of a personal food composition table and dietary reference values from a computer program to the nutrition scale: patent SI 22693 A*, Ljubljana, Urad RS za intelektualno lastnino, 30. jun. 2009.

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, semantic web, social network analysis, language technologies and computational linguistics, 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. Apart from knowledge-technologies research, we also develop applications in environmental sciences and ecology, medicine and health care, biomedicine and genetics, the economy and marketing.

Head:
Prof. Nada Lavrač

The Knowledge Technologies research programme has been 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 2004-2009 we have collaborated in 30 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 (a) developed an algorithm and a methodology for contract set mining through subgroup discovery, and successfully applied it to uncover distinguishing characteristics of two groups of brain-stroke patients with ischemia, caused by thrombosis and embolism, respectively; the work was published in the Journal of Biomedical Informatics. (b) We further elaborated the conceptual framework of supervised descriptive rule induction, showing that methods for subgroup discovery, contrast set mining and emerging pattern mining, represent special cases of supervised descriptive rule-induction methods; this work was published in the Journal of Machine Learning Research. (c) We continued the development of semantic data mining which enables the use of ontologies in machine learning, by using ontologies as background knowledge in the domain of analyzing differential expression of genes based on the ontology of gene functions, processes and interactions. (d) We have upgraded this approach to bisociative knowledge discovery, as explored in the FP7 FET project "BISON", by using the semantic knowledge discovery step for finding gene groups that are differentially expressed, and then creatively exploring bisociative links using the publicly available Biomine graph-mining software. Also, an approach to literature mining aimed at creative knowledge discovery from text documents was further developed and published in the Journal of Biomedical informatics. (e) We continued the development of a service-oriented knowledge-discovery platform which resulted in an operational Orange4WS data-mining platform. (f) We further explored the means for detecting genetically modified organisms in food and feed, and proposed a new knowledge-technology-based methodology for the discovery of unauthorized genetically modified organisms, published in Anal. bioanal. chem. journal.

The VIDEOLECTURES.net portal that we co-manage with the Centre for Technology Transfer at the JSI got a World Summit award for creative and innovative e-content.

We successfully concluded the FP6 project "European Embryonal Tumor Pipeline (EETP)", which was concerned with gathering and analyzing data about embryonal tumors. Different types of data were collected within the project, including genomic data (copy number variation/array CGH), transcriptomic (expression data in the form of microarrays and exon arrays), and proteomic data (mass spectrometry), as well as patient records. In addition, different types (entities) of embryonal tumors were considered (neuroblastoma, medulloblastoma, Ewing's sarcoma, Wilm's and rhabdoid tumors). The major data-analysis tasks considered within the project were to identify signatures (e.g., groups of genes) characteristic of individual tumor entities, as well as signatures common across the different entities. To this end, we developed techniques for evaluating ranked gene lists and aggregations thereof. These were applied to microarray data for the different tumor entities, producing ranked gene lists for each entity, which were then aggregated to obtain ranked gene lists for entity groups and all the entities

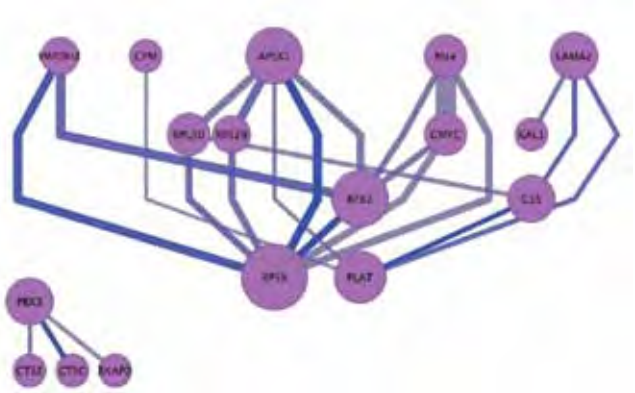

Figure 1: Gene interaction network for Ewing's sarcoma (a specific type of embryonal tumor). The network was constructed automatically from the gene expression data and shows genes (nodes) and their interactions (edges) that play the most important role in the development of the disease.

together. For the highly ranked genes, biological explanations were constructed (through a search for enriched gene sets), as well as networks of interactions between the genes.

We continued the development of approaches to mining complex data, such as predictive clustering trees and rules for short time series data and ensembles of decision trees for hierarchical multi-label classification, as well as equation discovery approaches for modelling dynamic systems. These were used on a variety of practical problems from the areas of environmental and life sciences, such as predicting the structure of diatom communities, modelling the gene flow between GM and conventional crops, and the hierarchical classification of medical images. The method development activities are a part of two national and one FP7 project focused on the topic of data analysis for systems biology.

Boštjan Pajntar received an industry innovation prize award at the Technology Transfer Conference at the JSI.

A long-term goal in the area of **decision support** is to develop methods and techniques of decision modelling, support them with software and integrate them with data-mining systems. In 2009 we have extended our software for qualitative multi-criteria decision making DEXi with capabilities for importing, exporting and searching the components of decision models and new operations of attribute merging. The latest version, 3.02, is freely available from the web page: http://kt.ijs.si/MarkoBohanec/dexi.html.

For the EU project "Co-Extra" we have developed several decision models and applications for the support of decisions about the use of genetically modified plants in food. We would especially like to emphasize two complex models for the evaluation of analytical (laboratory) methods for the detection of genetically modified organisms. The models were developed in collaboration with the National Institute for Biology. The models are supported with a database and a web application that enables their simple and widespread use.


NEWSLETTER

First Conference Day...

Invited Talk: Shai Ben-David

Figure 2: Front page of a daily newsletter from the international ECML/PKDD conference that we organized in September 2009 at Bled.

In the EU project "HEALTHREATS", which aims at developing a decision-support system for a rapid, efficient and coordinated response to threats to health, we have continued with the development of models for the internal evaluation of the work and the results of the project.

We have successfully finished an interdisciplinary research project "Methodological aspects of cognitive process research - learning and decision-making" and published the results in a book Konteksti odločanja (Decision making contexts).

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 user-evaluation trials of machine translation and cross lingual information retrieval on the one hand and experiments testing the performance of technologies developed in SMART without requiring the involvement of actual users. We have also developed techniques for cross-lingual document categorization based on CCA and SVM. We have successfully concluded our work on the FP6 project "Image-based Navigation in Multimedia Archives (IMAGINATION)" focusing mainly on the integration of the components for enriching the existing textual metadata of images. Activities on the FP7 Network of Excellence "Pattern Analysis, Statistical Modeling and Computational Learning 2 (PASCAL2)", 2008-2013 were mainly on research in text mining and natural language processing.

In the area of the **semantic web** we have successfully concluded two FP6 projects. "Transitioning Applications to Ontologies (TAO)" resulted in a methodology for cross-modal data analysis focused on connecting textual data and graph/network applied on three real-world case studies. "Semantic Web Services Interoperability for Geospatial Decision Making (SWING)" resulted in the semantic annotation engine OntoBridge evaluated in several scenarios on real-world data. Our activities in the FP6 "Lifecycle Support for Networked Ontologies (NeOn)" resulted in an extension of the NeOn Toolkit with several plug-ins related to contextualized access to ontologies. (1) We have developed an extension of the web application SearchPoint, which enhances ontology web-search scenarios with the use of other ontologies that provide context for the search. Since SearchPoint easily upgrades any textual search engine, it effectively contextualizes any textual general knowledge by re-ranking it in accordance with the user-selected importance of the concepts in the ontology. (2) A prototype was developed as an integration of the Cyc ontology and AnswerArt technology that enables answering a question given in natural language based on a domain-specific collection of documents provided by the user. Cyc ontology together with any other domain-specific ontology is used to provide semantic information in the form of synonyms and generalizations of the terms that occur in the documents. The prototype was demonstrated on data relevant for the project case study (ASFA abstracts) using the ASFA thesaurus and WordNet in addition to Cyc. Activities on the FP7 IP project "Enabling the Knowledge Powered Enterprise (ACTIVE), 2008-2011, were mainly in direction of modelling informal knowledge processes in an organization based on context mining.

We have successfully organized the ECML/PKDD 2009 conference in Bled.

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 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 are continuing with 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)" with the focus on modelling internal processes and competences for large distributed organizations. We have continued with the very successful development of the 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 started to merge data-driven and knowledge-driven methods including Cyc. Last year's developed prototypes in an implementation as web services have been implemented as services in the FP7 project "Enabling the Knowledge Powered Enterprise (ACTIVE)" with the tools and methods for enterprise "hidden" knowledge formalization.

Figure 3: A collection of decision and evaluation models for a decision-support system that we have developed in the Co-Extra project.

In the area of **language technologies** we have finished work on the Slovenian basic research project "Linguistic annotation of Slovene language: methods and resources (JOS)", where we have been developing linguistically annotated corpora of the Slovene language, for the levels of morphosyntax, syntax and semantics. The developed resources are freely available under the Creative Common License from http://nl.ijs.si/jos/. As a partner in the Slovenian basic research project "Slovene translation studies - resources and research", led by the Dept. for Translation at the Ljubljana University, we have started work on the linguistic annotation of a number of parallel bi-lingual corpora which combine major European languages with Slovene. As a partner in the Slovene applied research project "Unknown 17th and 18th century manuscripts of Slovenian literature: information-technology aided register, scholarly editions and analyses" and the targeted research project "Digital text centre with multimedia communication", led by the Scientific Research Center of the Slovenian Academy of Sciences and Arts, we have been working on digital editions of Slovenian literature, in particular (in cooperation with the JSI F9 department) in developing a platform for the presentation and searching of documents and a web interface for the up-conversion of documents into XML, which is compliant with the Text Encoding Initiative Guidelines.

In 2009 we have successfully finished six EU, six national and two bilateral projects.

In the scope of the EU MondiLex project, "Conceptual Modeling of Networking of Centers for High-Quality Research in Slavic Lexicography and their Digital Resources", and in cooperation with the JSI F9 department, we have investigated the possibilities of using Grid technologies for the processing and dissemination of large corpora, have extended the MULTEXT-East multilingual language resources by several new Slavic languages, and have organized a project meeting and open workshop with published proceedings. In the EU project "Fostering Language Resources Network (FlareNet)", we continued working on the compilation of language resources for the Slovene language and in the scope of the bilateral project with France Definition of syntactic-semantic structure of the Slovene verb we have established cooperation with the INALCO institute in Paris.

Some outstanding publications in the past three years

1. Petra Kralj Novak, Nada Lavrač, Geoffrey I. Webb. Supervised descriptive rule discovery : a unifying survey of contrast set, emerging pattern and subgroup mining. J. mach. learn. res., 2009, vol. 10, pp. 377-403.
2. Marko Grobelnik, Dunja Mladenić, Blaž Fortuna. Semantic technology for capturing communication inside an organisation. IEEE internet computing, 2009, vol. 13, no. 4, pp. 59-66.
3. Aneta Ivanovska, Ljupčo Todorovski, Marko Debeljak, Sašo Džeroski. Modelling the outcrossing between genetically modified and conventional maize with equation discovery. Ecol. model., 2009, vol. 220, no. 8, pp. 1063-1072.
4. Dragi Kocev, Sašo Džeroski, Matt D. White, Graeme R. Newell, Peter Griffioen. Using single- and multi-target regression trees and ensembles to model a compound index of vegetation condition. Ecol. model., 2009, vol. 220, no. 8, pp. 1159-1168.
5. Ingrid Petrič, Tanja Urbančič, Bojan Cestnik, Marta Macedoni-Lukšič. Literature mining method RaJoLink for uncovering relations between biomedical concepts. Journal of biomedical informatics, 2009, vol. 42, no. 2, pp. 219-227.

Awards and appointments

1. An Industry Innovation Prize at the Technology Transfer Conference at JSI, Boštjan Pajntar.
2. World Summit Award in E-Science & Technology, Monterrey, Mexico, United Nations, Videolectures.Net portal

Organization of conferences, congress and meetings

1. MLSB 2009
   Third International Workshop on Machine Learning in Systems Biology, Ljubljana, 5.-6. 9. 2009
2. ECML PKDD 2009, European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases, Bled, 7.-11. 9. 2009
3. First ACTIVE Summer School Bled, 4.-6. 9. 2009.
4. Meeting of the EU project MONDILEX, Ljubljana, 15.-17-10-2009

INTERNATIONAL PROJECTS

1. Gender Debate in the European Research Area
   GENDERA
   7. FP, 244499
   EC; Dr. Dora Groo, Hungarian Science and Technology Foundation, Tudomanyos Es Technologiai Alapitvany, Budapest, Hungary
   Asst. Prof. Dunja Mladenič
2. Systems Biology of Phagosome Formation and Maturation, Modulation by Intracellular Pathogens
   PHAGOSYS
   7. FP, 223451, HEALTH-F4-2008-223451
   EC; Dr. Brian D. Robertson, Imperial College London, Centre for Molecular Microbiology and Infection, London, Great Britain
   Prof. Sašo Džeroski
3. Bisociation Networks for Creative Information Discovery
   BISON
   7. FP, 211898
   EC; Prof. Michael Berthold, Universität Konstanz, Konstanz, Germany
   Prof. Nada Lavrač
4. Conceptual Modelling of Networking of Centres for High-Quality Research in Slavic Lexicography and Their Digital Resources
   MONDILEX
   7. FP, 211938
   EC; Prof. Ludmila Dimitrova, Institute of Mathematics and Informatics of the Bulgarian Academy of Science, Sofia, Bulgaria
   Asst. Prof. Tomaž Erjavec, Jan Jona Javoršek, B. Sc.
5. Enabling the Knowledge Powered Enterprise
   ACTIVE
   7. FP, 215040
   EC; Dr. Paul Warren, British Telecommunications plc, London, Great Britain
   Marko Grobelnik, Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc., Asst. Prof. Mihael Mohorčič
6. Pattern Analysis, Statistical Modelling and Computational Learning 2
   PASCAL 2
   7. FP, 216886
   EC; Prof. John Shawe-Taylor, University of Southampton, Southampton, Great Britain
   Asst. Prof. Dunja Mladenič, Marko Grobelnik, Mitja Jermol, M. Sc.
7. European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics
   EURIDICE
   7. FP, 216271
   EC; Dr. Paolo Paganelli, INSIEL - Informatica per il Sistema degli Enti Locali s.p.a, Trieste, Italy
   Marko Grobelnik, Asst. Prof. Dunja Mladenič, Mitja Jermol, M. Sc.
8. Collaboration and INteroperability for networked enterprises
   COIN
   7. FP, 216256
   EC; Claudia Guglielmina, TXT e-Solutions Spa, Milan, Italy
   Asst. Prof. Dunja Mladenič, Marko Grobelnik, Mitja Jermol, M. Sc.
9. 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
10. 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, Mitja Jermol, M. Sc.
11. 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
12. 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, Mitja Jermol, M. Sc., Prof. Marko Mikuž
13. 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, Mitja Jermol, M. Sc.
14. 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, Mitja Jermol, M. Sc.
15. Integrated Decision Support System for HEALTH THREATS and Crises Management
    HEALTHREATS
    Public Health program (PHEA)
    2006203
    EC; Carmelo Scarcella, Azienda Sanitaria Locale di Brescia (ASL Brescia), Brescia, Italy
    Prof. Nada Lavrač, Dr. Martin Žnidaršič
16. Visualising the Impact of the Legislation by Analysing Public Discussions Using Statistical Means
    VIDI
    e-PARTICIPATION, EP-08-01-014
    EC; Nenad Stojanović, Forschungszentrum Informatik an der Universität Karlsruhe, Karlsruhe, Germany
    Asst. Prof. Dunja Mladenič, Marko Grobelnik
17. Fostering Language Resources Network
    FLaReNet
    e-Contentplus
    ECP-2007-LANG-617001
    EC; CNR-ILC, Consiglio Nazionale delle Ricerche, Rome, Italy
    Asst. Prof. Tomaž Erjavec
18. Communication in Slovenian Language
    MSS
    Dr. Simon Krek
19. Mladinska mreža razvoja raziskovalnih vrednot mladih
    SIM-RIS, 3311-09-986011
    Asst. Prof. Dunja Mladenič
20. The Use of a Dedicated Service on the Http Server of IJS http:///nl.ijs.si to be used by FP for Uploading and Storing Texts which Constitute the FP Corpus of XIX 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

21. Information Fusion for Data Mining in Bioinformatics and Biomedicine
BI-CZ/08-09-007
Prof. Olga Štepánková, Czech Technical University in Prague, Prague, Czech Republic
Prof. Nada Lavrač
22. The Effects of Genetically Modified Maze on Conventional Maize Production: Co-existance Advisory System (CAS)
BI-FR/09-10-PROTEUS-018
PROTEUS
Dr. Florenco Leprince, Montardon, France
Asst. Prof. Marko Debeljak
23. Definition of a Syntaxico-Semantic Verbal Frame of the Slovenian on the Model of Czech Vallex (Action Coordinated with a Barrande Project)
BI-FR/09-10-PROTEUS-015
PROTEUS
Prof. Patrice Pognan, Inalco et Universite de Paris 4, Paris, France
Asst. Prof. Tomaž Erjavec
24. Decision Support System for a Safe Vegetable Production on Garden Soils in Urban Environments (Gardentox)
BI-FR/09-10-INRA-003
Prof. Christophe Schwartz, Nancy Université, INPL (ENSAIA) / INRA, UMR 1120, Laboratoire Sols et Environnement (Laboratory for Soil and Environment), Vandoeuvre-lès-Nancy, France
Asst. Prof. Marko Debeljak
25. Inductive Rule Learning
BI-HR/09-10-019
Dr. Dragan Gamberger, Rudjer Boškovic Institute, Zagreb, Croatia
Prof. Nada Lavrač
26. Japanese/Slovene Resources for Second Language Learners
BI-JP/08-10/006
Prof. Yoshiko Kawamura, Tokyo International University, Kawagoe, Saitama, Japan
Asst. Prof. Tomaž Erjavec
27. Sustainable Crop System in Scotland
LAND-EME
P019512, P019513
SCRI, Living Technology, Dundee, Scotland, Great Britain
Asst. Prof. Marko Debeljak

R & D GRANTS AND CONTRACTS

1. Advanced ML methods for automated modelling of dynamic systems
Prof. Sašo Džeroski
2. Data mining for integrative data analysis in systemic biology
Prof. Sašo Džeroski
3. Semantic rule discovery in the field of web services
Prof. Nada Lavrač
4. Linguistic annotation of the Slovene language: methods and resources
Asst. Prof. Tomaž Erjavec
5. Systemic biology approaches to analyzing interactions between pathogens and plants
Prof. Nada Lavrač
6. Slovene translation studies - resources and research
Asst. Prof. Tomaž Erjavec
7. Methodological aspects of cognitive process research - learning and decision making
Prof. Marko Bohanec
8. Slovene terminology web portal
Jan Jona Javoršek, B. Sc., Simon Krek, B. Sc.
9. Crisis management simulator
Asst. Prof. Dunja Mladenić
10. Development of knowledge management system for SV
Marko Grobelnik, B. Sc.
11. Digital text centre with multimedia communication
Asst. Prof. Tomaž Erjavec
12. Analysis and scenario of development and exploration of forests in Slovenia
Prof. Marko Debeljak
13. Unknown 17th and 18th century manuscripts of Slovene literature: information-technology aided register, scholar editions and analysis
Asst. Prof. Tomaž Erjavec
14. Guidelines for national strategy of preservation of forest trees genefond due to the introduction of genetically modified organisms in agriculture
Prof. Marko Debeljak

RESEARCH PROGRAM

1. Knowledge technologies
Prof. Nada Lavrač

NEW CONTRACT

1. Prototype decision support system
National Institute for Biology
Prof. Nada Lavrač

VISITORS FROM ABROAD

1. Timo Aho, Tampare University of Technology, Department of Software Systems, Tampere, Finland, from 1 Oct. 2008 to 31 Mar. 2009.
2. Hu Jia, Huang Yi, Kim Kono, Saltlux, Korea, 14 Jan. 2009.
3. Nenad Stojanović, Sinan Sen, Cyrilom Betuš in Robert Kamaromi, 2–3 Feb. 2009.
4. Alexandra Moraru, Technical University, Cluj-Napoci, Faculty of Computer Science, Cluj, Romania, 8–20 Feb. 2009.
5. Dr. Florence Leprince iz ARVALIS - Institut du végétal, Paris, France, 16–19 Feb. 2009.
6. Chris Winter (all from New Venture Partners), John Davies, John Shiangoli, John Witgraff (all from British Telecom), London, Great Britain, 25–27 Feb. 2009.
7. Monika Žakova, Czech Technical University, Prague, Czech, from 2 Mar. to 29 May 2009.
8. Nataša Milić-Frayling, Microsoft Research, Cambridge, Great Britain, 6–8 Mar. 2009.
9. Stephane Clinchant, Kimmo Valtonen, Vladimir Poroshin, University of Helsinki, Špela Arhar, Miro Romih and Peter Haložan (all from Amebis), 19 Mar. 2009.
10. Jeroen Sebastian de Bruin, LIACS (Leiden University of Advanced Computer Science), Leiden, The Netherlands, from 20 Mar. to 7 April 2009.
11. Werner Dubitzky, Tom Ruttnig, Danny Morisset, Paola Velardi, Roberto Navigli, 23–24 Mar. 2009.
12. Graham Begg, Scottish Crop Research Institute, Invergowrie, Dundee, Scotland, from 25 Mar.–1 Apr. 2009.
13. John Shawe-Taylor, Luce Jacovela, Simon Prince (all University College London) and David R. Hardoon (London's Global University), London, Great Britain, 26 Mar. 2009.
14. Dr. Florence Leprince from ARVALIS - Institut du végétal, Paris, France, 20–23 Apr. 2009.
15. Lise Getoor, University Maryland, Maryland, USA, 22 Feb.–15 Apr. 2009 and 25 Apr.–22 June 2009.
16. Peter Zuse, NASA, USA, 23 May 2009.
17. Dr. Michael Witbrock, Austin, Texas, USA, 23 May 2009.
18. Prof. Renee Miller, University Toronto, Canada, 23–25 May 2009.
19. Nenad Stojanović, FZI-Forschungszentrum Informatik Karlsruhe, Germany, Simon Delakorda, INePA-Institute for Electronic Participation, Ljubljana, Balázs Cseh, Corvinno Technology Transfer Centre, Budapest, Hungary, from 15 June 2008 to 16 Mar. 2009.
20. Dr. Hendrik Blockeel, Katholieke Universiteit Leuven, Leuven, Belgium, from 26 July to 9 Aug. 2009.
21. Dr. Jan Struyf, Katholieke Universiteit Leuven, Leuven, Belgium, from 26 July to 2 Aug. 2009.
22. Baptiste Lecroart, INRA, Paris, France, from 29 July to 31 Aug. 2009.
23. Dr. Dragan Gamberger, Institut Rudjer Bošković, Zagreb, Croatia, 24–25 Aug. 2009.
24. Dr. Johannes Fuernkranz, Technical University Darmstadt, Hessen, Germany, 24–25 Aug. 2009.
25. Abe Hsuan, Nested Media, USA, 1 Sept. 2009.
26. Assist. Prof. Eng. Radu Razvan Slavescu, Technical University of Cluj-Napoca, Faculty of Automation and Computer Science, Computer Science Department, Cluj, Romania, 3–7 Sept. 2009.
27. Pat Moore, Bloomberg, New York, USA, 4–6 Sept. 2009.
28. Prof. Shai Ben-David, University of Waterloo, Canada, 7–11 Sept. 2009.
29. Prof. Nello Cristianini, University of Bristol, Great Britain, 7–11 Sept. 2009.
30. Dr. Mark Greaves, Vulcan, USA, 7–11 Sept. 2009.
31. Dr. Rosie Jones, Yahoo!, USA, 7–11 Sept. 2009.
32. Dr. Ralf Steinberger, European Commission - Joint Research Centre, Italy, 7–11 Sept. 2009.
33. Prof. John Shaw Taylor (UCLA, London), prof. Wray Buntine (NICTA, Avstralia), prof. Lisse Getour from USA and Radu Razvan Slavescu, Tehnical University, Cluy-Napoca, Romania, 7–11 Sept. 2009.
34. Dr. Dragan Gamberger, Institut Rudjer Bošković, Zagreb, Croatia, 22 Sept. 2009.
35. Dr. Tomislav Šmuc, Institut Rudjer Bošković, Zagreb, Croatia, 22 Sept. 2009.
36. Dr. Radovan Garabik, Slovaška akademija znanosti, Bratislava, Slovakia, from 26 Sept. to 4 Oct. 2009.
37. Dr. Dragan Gamberger, Institut Rudjer Bošković, Zagreb, Croatia, 7–8 Oct. 2009.
38. Dr. Johannes Fuernkranz, Technical University Darmstadt, Hessen, Germany, 7–8 Oct. 2009.
39. Nenad Stojanović, FZI-Forschungszentrum Informatik Karlsruhe, Germany, 12 Oct. 2009.

40. Yannis Kalaidzidis, Max Planck Institute of Molecular Cell Biology and Genetic, Dresden, Germany, 15—18. Oct. 2009.
41. Brigitte Degen, European Commission, Brussels, Belgium, 17 Oct. 2009.
42. Rayid Ghani, Accenture, Chicago, USA, from 27 Nov. to 1 Dec. 2009.
43. Jose Manuel Gomez, iSOCO, Vancouver, Canada, from 30 Nov. to 1 Dec. 2009.
44. Bojan Orel, Faculty of Informatics, Ljubljana, Slovenia, 1 Dec. 2009.
45. Prof. Patrice Pognan, Inalco, Paris, France, 1—10 Dec. 2009.
46. Dr. Dragan Gamberger, Institut Rudjer Bošković, Zagreb, Croatia, 3—4 Dec. 2009.
47. Primož Skraba, INRIA, Paris, France, 21—24 Dec. 2009.

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. Petra Kralj Novak
12. Dr. Bernard Ženko
13. Dr. Martin Žnidaršič

Postgraduates
14. Janez Brank, M. Sc.
15. Darko Čerepnalkoski, B. Sc.
16. Jure Ferlež, M. Sc.
17. Blaž Fortuna, B. Sc.
18. Valentin Gjorgjioski, B. Sc.
19. Miha Grčar, B. Sc.
20. Elena Ikonomovska, M. Sc.
21. Aneta Ivanovska, B. Sc.
22. Mitja Jermol, M. Sc.
23. Matjaž Juršič, B. Sc.
24. Dragi Kocev, B. Sc.
25. Simon Krek*, B. Sc.
26. Blaž Novak
27. Panče Panov, B. Sc.
28. Vid Podpečan, B. Sc.
29. Jan Rupnik, B. Sc.
30. Tadej Štajner, B. Sc.
31. Mitja Trampuš, B. Sc.
32. Dr. Miha Volovšek*
33. *Miha Vuk, B. Sc., left 01.07.09*

Technical officers
34. Dr. Igor Mozetič
35. *Nina Novinec, M. Sc., left 01.05.09*
36. Marjana Plukavec, B. Sc.

Technical and administrative staff
37. Tina Anžič, B. Sc.
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5. Nataša Atanasova, Ivan Bratko, Marko Debeljak, Sašo Džeroski, Andrej Kobler, Boris Kompare, Ljupčo Todorovski, Bernard Ženko, *Analysis of environmental data with machine learning methods: Ljubljana, May 4-8, 2009. Part 2*, Ljubljana, Jožef Stefan Institute, Center for Knowledge Transper in Information Technology, 2009.
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Ph. D. Thesis

1. Petra Kralj Novak, *Supervised descriptive rule induction: doctoral dissertation*, Ljubljana, [P. Kralj Novak], 2009.

M. Sc. Thesis

1. Elena Ikonomovska, *Efficient incremental learning of regression and model trees from data streams: master's thesis*, Skopje, [E. Ikonomovska], 2009.

B. Sc. Thesis

1. Tina Anžič, *Survey and analysis of research projects in the field of intelligent textile in the European Union: undergraduate thesis*, Ljubljana, [T. Anžič], 2009.
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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 program "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 fast-developing research area. It aims at introducing the technology into our everyday environment in a friendly and unobtrusive way, making it usable without any special knowledge. Due to the rapid aging of the population, one of the area's main goals is care for the elderly. The department was developing methods for posture and movement recognition with an emphasis on fall detection. Data from various sensor types were used as inputs. We were also investigating the recognition of common patterns of behaviour in general and 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.

We implemented a new algorithm for energy-flow optimization in the distribution network. The algorithm is a building block of an e-service that is under development in a collaboration with the INEA company and other academic and industrial partners.

In the area of **data mining** we dealt with automatic web-genre identification. As part of doctoral research we developed the algorithm SEMEA, designed for text-categorization problems, such as the genre classification of web pages. Its main characteristics are: Semantic representation, Multi-label classification and Evolutionary-Algorithm-based discovery of classification rules. The framework was tested on the web-genre identification domain and its performance was compared to the state-of-the-art algorithms for text categorization. As part of future work, we intend to substitute the bag-of-words representation with the bag-of-concepts representation and introduce the concept generalization-specification genetic operation. We anticipate further improvements with the introduction of these changes.

Figure 1: The control panel of the intelligent security system ("PDR" project), where the situation in the surveilled rooms is presented with a live picture, a symbolic-graphical and textual description.

We study **search algorithms** for path-finding and other applications. We explained many cases of pathological behaviour of these algorithms, i.e., achieving worse results at a greater search depth. We also identified several factors that influence the benefits of a deeper search.

In the field of **speech and language technologies** we dealt 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 the biometric/forensic speaker recognition has been studied. As for syntactic parsing, the first experiments were made using the newly built corpus of Slovene JOS Treebank.

Evolutionary computing is a subfield of computer science concerned with theoretical studies, design and applications of search procedures motivated by biological evolution and known as evolutionary algorithms. Our work in this area includes the development and analysis of evolutionary algorithms for solving problems of engineering design and optimization. It is focused on the design of efficient algorithms for multi-objective optimization problems with conflictive objectives where a set of solutions is of interest to the user. We dealt with the parallelization of our DEMO (Differential Evolution for Multiobjective Optimization) algorithm. Its implementation on a computer cluster was used to study the speedup in solving a test problem of tuning process parameters in a metallurgical production process. The results were presented in a chapter of the edited volume Parallel Computing: Numerics, Applications and Trends, published by Springer.

A significant part of our applied research was devoted to **energy efficiency**. A preliminary technical and economical evaluation of an alternative energy-supply system based on photovoltaic

The FP7 project "Confidence" is intended to extend the independent living of the elderly by increasing their security at home and outside. Confidence users will wear a number of tags on their bodies, which will make it possible to detect falls, changes in behaviour that may indicate a disease, and call for help. We were successful in obtaining three additional international projects: "EUSAS", "CHIRON" and "MIRACLE".

modules was performed to find trade-offs between its reliability and costs. In addition, we implemented a new algorithm for energy-flow optimization in the distribution network that is a building block of an e-service that is under development in a collaboration with the INEA company and other academic and industrial partners. Finally, we participated in the submission of a European FP7 project proposal in the area of Information and Communication Technologies for Energy Efficiency entitled "Micro-Request-Based Aggregation, Forecasting and Scheduling of Energy Demand, Supply and Distribution (MIRACLE)". The project was approved and will be carried out in the period 2010–2012.

Figure 2: The 4th Slovenian Innovations Forum, the award for the best innovation among the research organizations for the development of an intelligent security system for the surveillance of personnel and equipment in high-security buildings ("The Commander's Right Hand" project).

Research in the field of **agent modelling** was presented in the book Handbook of Ambient Intelligence and Smart Environments published by Springer. With partners, we have prepared a successful proposal for the EUSAS project (European Defence Agency). Methods for multi-agent modelling of asymmetric conflicts will be developed during this project.

In the **European FP7 project** called "**Confidence**", we intend to extend the independent living of the elderly by increasing their security at home and outside. Confidence users will wear a number of tags on their bodies. The locations of the tags will be detected by radio sensors; 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 admission. Changes in behaviour that may indicate a disease or a similar problem will also be detected.

In collaboration with the Faculty of Electrical Engineering of the University of Ljubljana and the company Špica International, we have successfully finished the "**Commanders Right Hand**" **project**, which was a part of the Targeted Research Project financed by the goal research program Science for Security and Peace 2006–2010. The result of the project is a working prototype of an intelligent security system for high-security buildings. It received the award for the best innovation among the research organizations at the 4th Slovenian Innovations Forum. The advanced security is achieved with a real-time location system, computer-vision methods and artificial intelligence methods. The system learns the normal behaviour patterns of an employee, recognizes the unusual behaviour, such as thefts, sabotages, staff negligence and insubordination, in real-time. It informs the supervisor with an alarm message in natural language, a graphical explanation and video recordings. Besides the unusual behaviour, the system also recognizes forbidden events, such as the entrance of an unauthorized person. The prototype learns and adapts automatically to new situations.

During the "**Intelligent Home Telekom**" **project**, we upgraded a universal virtual interface for interactive user communications. We improved the performance and the visual outlook. An important advantage of the interface is its adaptability. This was demonstrated by adapting the system to the needs of the various partners. We started the "**Universal Interface for Intelligent Home**" project, where we began to develop an interface for managing home entertainment centres.

A traditional activity of the Department of Intelligent Systems is the **organization of the International Multiconference Information Society**. In October 2009, the 12th multiconference was held in Ljubljana, consisting of eleven independent conferences.

An intelligent system for communication in natural language is being developed. The user enters a question into the web page and the program retrieves answers, presenting them to the user in natural language.

Figure 3: Intelligent virtual assistant provides information about the Department of Intelligent Systems at the Jožef Stefan Institute (the web page dis.ijs.si).

Some outstanding publications in the past three years

1. D. Marinčič, T. Tušar, M. Gams, T. Šef, Analysis of automatic stress assignment in Slovene, Informatica (Vilnius), 20 (2009), 35–55.
2. J. Valentinčič, B. Filipič, M. Junkar, Machine learning induction of a model for online parameter selection in EDM rough machining, International Journal of Advanced Manufacturing Technology, 41 (2009) 865–870.
3. I. Fister, M. Mernik, B. Filipič, Optimization of markers in clothing industry, Engineering Applications of Artificial Intelligence, 21 (2008), 669–678.
4. M. Luštrek, Pathology in heuristic search. AI Communications, 21 (2008) 211–213.
5. M. Možina, J. Žabkar, I. Bratko, Argument based machine learning, Artificial Intelligence, 171 (2007), 922–937.

Patent granted

1. Patent Granted 22822 in Slovenia; Procedure and device for intelligent entry control; Matjaž Gams, Tea Tušar, Andrija Pušić, Mitja Kolbe; Jozef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia and Špica d. o. o., Pot k sejmišču 33, 1231 Ljubljana, Slovenia.

Awards and appointments

1. The award for first place between the research and development organizations with the firm Špica International d.o.o. and the Faculty of Electrical Engineering, University of Ljubljana, the 4th Slovenian Innovation Forum in Ljubljana, 1.–2. 12. 2009, the innovation title: Intelligent security system for indoor personnel and equipment monitoring. Authors: Matjaž Gams, Rok Piltaver, Erik Dovgan, Bogdan Pogorelc, Matej Kristan, Janez Pers, Andrej Planina, Gašper Pintarič.
2. The Award for outstanding contribution to the development and promotion of the Information Society, Ljubljana, 13 10. 2009, Program and Organizing Committee of the Information Society Multiconference 2009. Award Recipient: prof. dr. Vladislav Rajkovič

Organization of conferences, congress and meetings

1. 14th Workshop on Nature-Inspired Algorithms, Jožef Stefan Institute, Ljubljana, 29. 5. 2009
2. 12th. International Multiconference Information Society IS 2009; independent conferences:

– Intelligent Systems,
– Collaboration, Software and Services in Information Society,
– Data Mining and Data Warehouses,
– Education in Information Society,
– Facing Demographic Challenges in Europe,
– Cognitive Sciences,
– Robotics,
– Cognitonics - workshop,
– MONDILEX Fifth Open Workshop "Research Infrastructure for Digital Lexicography"
– The Second Mini Conference on Theoretical Computer Science 2009,
– Increasing Interests for Higher Education in Science and Technology, Jožef Stefan Institute, Ljubljana, 12.–16. 10. 2009

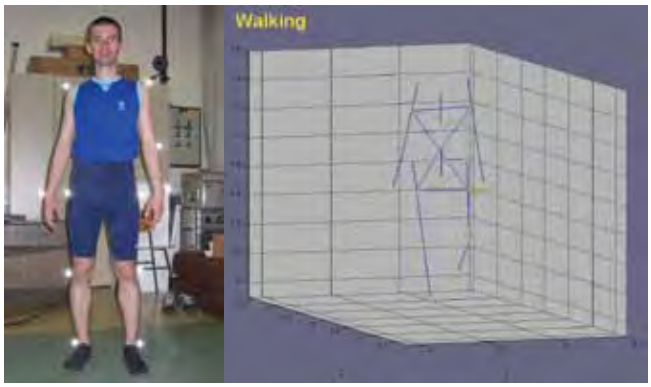

Figure 4: Placement of tags on the body (a) and visualization of tags on the computer screen (b) of the system for prolonging the independence of elderly, which we develop in the FP7 project "Confidence" and other research studies in the field of ambient intelligence. Methods, which we develop, automatically in real-time detect, falls and other health-related changes in the behaviour of the elderly, using the locations of tags on the body.

During the "Commanders Right Hand" project, which was a part of the Targeted Research Project Science for Security and Peace 2006-2010, we developed an intelligent system for the control of the movement of personnel and equipment in high-security buildings. The project received the award for the best innovation among the research organizations at the 4th Slovenian Innovations Forum.

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 Žlajpah
2. Intelligent Information System for Health Laboratory Service: I-LAB
   E-contents and E-services
   3211-09-000535
   Marko Lotrič, LOTRIČ d.o.o, Selca, Slovenia
   Dr. Mitja Luštrek
3. Universal Interface for Intelligent Home: UVID
   E-contents and E-services
   3211-09-000524
   Tone Stanovnik, Podjetje Špica International d.o.o., Ljubljana-Črnuče, Slovenia
   Prof. Matjaž Gams
4. Multiobjective Optimization of Technological Processes
   BI-FI/09-007
   Dr. Erkki Laitinen, University of Oulu, Department of Mathematical Sciences, Oulu, Finland
   Asst. Prof. Bogdan Filipič
5. New Methods for Automatic Identification Based on Intelligent Devices and Intelligent Agents –IntelliDAM
   BI-RO/08-09/0015
   Dr. (PhD. Eng.) Vlad Madalin Stefan, Faculty of Automatic Control and Computer Science, University Politehnica, Bucharest, Romunia
   Prof. Matjaž Gams

R & D GRANTS AND CONTRACTS

1. Forensic speaker identification
   Dr. Tomaž Šef
2. Research of intelligent home telekom
   Prof. Matjaž Gams
3. AvID: audiovisual speaker identification and emotion detection for secure communications
   Dr. Tomaž Šef
4. Commander's right hand
   Prof. Matjaž Gams

RESEARCH PROGRAM

1. Artificial Intelligence and Inteligent Systems
   Prof. Matjaž Gams

NEW CONTRACTS

1. An optimization algorithm for relieving the energy transmission grid
   INEA, d. o. o.
   Prof. Bogdan Filipič
2. Investigation, development and implementation of a database to keep records of wall painting fragments
   Institute for the Protection of Cultural Heritage of Slovenia, Restoration Center
   Prof. Bogdan Filipič

VISITORS FROM ABROAD

1. Dr. Madalin Stefan Vlad, Politehnica University of Bucharest, Faculty of Automatic Control and Computer Science, Bucharest, Romania, 29. 1.–12. 2. 2009
2. Dr. Maria Corduneanu, Politehnica University of Bucharest, Faculty of Automatic Control and Computer Science, Bucharest, Romania, 29. 1.–12. 2. 2009
3. Martin Doolan, M. Sc., Lancon d.o.o, Zagreb, Croatia, 11.–18. 5. 2009
4. Dr. Wilfried Elmenreich, University of Klagenfurt, Institute of Networked and Embedded Systems, Lakeside Labs, Klagenfurt, Austria, 10. 6. 2009
5. Prof. dr. Gernard Friedrich, University of Klagenfurt, Faculty of Engineering, Department of Intelligent Systems and Business Informatics, Klagenfurt, Austria, 10. 6. 2009
6. Prof. dr. Erkki Laitinen, University of Oulu, Department of Mathematical Sciences, Finland, 6.–10. 9. 2009
7. Dr. Madalin Stefan Vlad, Politehnica University of Bucharest, Faculty of Automatic Control and Computer Science, Bucharest, Romania, 14.–16. 10. 2009
8. Dr. Maria Corduneanu, Politehnica University of Bucharest, Faculty of Automatic Control and Computer Science, Bucharest, Romania, 14.–16. 10. 2009
9. Mircea Stan, Versita, Warsaw, Poland, 8. 12. 2009

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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 modeling of basic thermal-hydrodynamic phenomena, thermal-hydraulic safety analyses of design-basis and severe accidents, structural safety analyses and probabilistic safety assessment. Most of our research activities are part of international cooperation programs. The research results are incorporated in projects for industry and for the regulatory authorities, and in graduate-studies programmes.

Head:
Prof. Borut Mavko

Modeling of basic thermal-hydrodynamic phenomena

In the field of fluid mechanics and heat-transfer research, the new computer code NEPTUNE_CFD, which is being specially developed for multidimensional simulations of two-phase flow in nuclear facilities, as well as in-house codes were used to analyze inter-phase heat, mass, and momentum transfer in a horizontally stratified flow of cold liquid water and hot steam. We have modeled a horizontal pipe filled with hot steam and flooded with cold liquid water, and a horizontal pipe partially filled with cold liquid water with the injection of hot steam. Our own computer codes were used to test and propose new numerical schemes for simulations of stratified two-phase flows. The activities were part of the EU's 7th Framework Programme (FP) project "NURISP".

Heat loadings on a divertor cooled by multiple helium jets were investigated within the frame of the DEMO fusion reactor conceptual studies. The efficiency of cooling by helium jets at given operating conditions can be influenced by the distribution and the geometry of the jet nozzles. The impact of the inlet nozzle's geometry on the heat transfer and pressure drop was analyzed by numerical simulations and compared with experimental data. The main purpose of the calculations was the determination of an optimal geometry of the nozzle, ensuring efficient cooling of the material, while minimizing the pressure drop. Studies were included in the EU's 7th FP and were carried out within the frame of the EFDA (European Fusion Development Association).

New numerical schemes were developed for simulations of stratified two-phase flows.

In the field of research on water-hammer transients, the one-dimensional computer code WAHA, which was developed within the EU's 5th FP project "WAHALoads", is being upgraded. A new version of the code is being improved with new models of stratified and slug flow.

A steam explosion might occur during a hypothetical severe accident in a nuclear power plant if the molten reactor core would pour into the water in the reactor cavity. Within the OECD project "SERENA", where we are leading the analytical activities, we carried out comprehensive calculations of the first five performed steam-explosion tests with the European code MC3D. The experiments are being performed on the complementary KROTOS (Commissariat à l' Energie Atomique - CEA, France) and TROI (Korea Atomic Energy Research Institute) facilities. The main purpose of the comparative calculations was to evaluate the MC3D code and identify areas where better models would be needed. We developed an improved melt-droplets solidification model and the corresponding melt-droplets fragmentation criteria. The developed model is being implemented in the standard version of the MC3D code. These activities are being carried out within the "SARNET-2" Network of Excellence (EU's 7th FP).

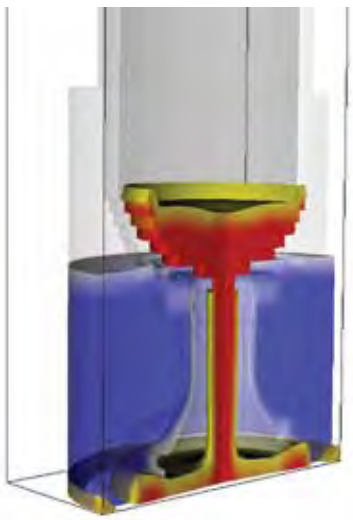

Figure1: Simulation of the fuel-coolant interaction during reactor-core melt release from a failed reactor pressure vessel.

Thermal-hydraulic safety analyses

The reference design basis calculations for the Krško nuclear power plant (NPP) full scope simulator validation were analyzed with the latest RELAP5/MOD3.3 code to obtain the source data needed for the development of a plant animation model. Six scenarios were analyzed in total: two scenarios of a small-break loss-of-coolant accident, two scenarios of a loss of main feedwater, a scenario of anticipated transient without scram, and a scenario of steam generator tube rupture.

Animation masks of the Krško NPP, using the suite of integrated applications SNAP designed to simplify safety analyses, were created for the primary and secondary system, plant signals and control systems. The use of SNAP for the animation of the plant analyses allows a better understanding of the calculated physical phenomena and processes, which improves the quality of the safety analyses.

In the field of modeling of containment phenomena, we have simulated with the European ASTEC severe accident code, in the frame of the OECD SETH-2 project, experiments on air-helium atmosphere stratification breakup with air injection. The experiments were performed in the MISTRA facility at CEA Saclay (France).

In the OECD project "SERENA", we are leading the analytical steam-explosion research activities

We have also simulated with the CONTAIN code, in the frame of the OECD International standard problem no.49, an experiment on hydrogen combustion, which was performed in the ENACCEF facility in the ICARE centre at the Centre National de la Recherche Scientifique in Orléans (France).

Structural safety analyses

The long-term research spotlight is the development of multiscale computational simulation tools for polycrystalline metallic materials. An advanced constitutive model of crystal plasticity is combined with random grain sizes and shapes, based either on the experimental data or Voronoi tessellations. The microscopic stress fields in randomly oriented and shaped grains are then obtained using the finite-element solver ABAQUS.

In 2009 we continued 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 the 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 are first 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.

We have also started the development of a thermo-mechanical model of a divertor cooling finger for the upcoming DEMO fusion reactor. The work is carried out in collaboration with Forschungszentrum Karlsruhe (Germany). The research is oriented towards the development of a design that will ensure sufficient heat-removal capability and safe operation of the divertor of the fusion reactor.

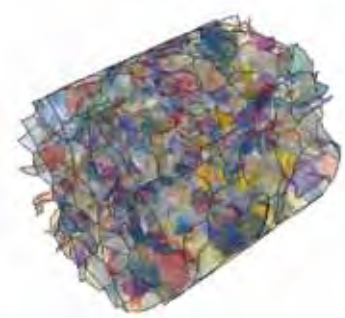

Figure 2: Reconstruction of grain boundaries in AISI 304 stainless steel.

The list of research partners also includes the EU Joint Research Center in Petten (Netherlands), CEA (France) and AIB-Vinçotte Nucléaire (Belgium). We are also members of the European Network of Excellence on nuclear-plant lifetime prediction "NULIFE".

Probabilistic safety assessment

The consideration of ageing and its application within probabilistic safety assessment models was investigated. Probabilistic models, which are based on constant failure rate, were transformed into more detailed models, which include the time-dependent increase of the failure rate as a consequence of ageing. The results obtained with the new models are highly uncertain.

Methods for the optimization of maintenance activities in nuclear power plants, applying heuristic algorithms, have been developed. The maintenance optimization is modeled as a combinatorial problem. The minimal cut sets identified in probabilistic safety assessment are used to assess the risk in the optimization function, which is solved using genetic algorithms, with simulated annealing and with a particle swarm. The results show that optimization of the maintenance lowers the risk and thus contributes to an improvement in plant safety.

The applicability of the current risk criteria, which are the standpoint for risk-informed decision-making, was investigated. The comparison of the results of risk analyses confirmed that existing criteria, which are applicable for current plants, should be improved to be applicable for future plants, as these will express significantly smaller risk measures.

We develop and evaluate new designs for divertor components of the forthcoming DEMO fusion reactor.

Technical cooperation, consulting services and education

In 2009, the Reactor Engineering Department's researchers also cooperated in projects for industry and the state administration. The Jozef Stefan Institute issues permissions for recriticality and regular operation of the Krško NPP after each regular outage. Members of the department are also actively involved in the Nuclear Engineering Doctoral Studies 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-III".

Some outstanding publications in the past three years

1. I. Simonovski, L. Cizelj, The influence of grains' crystallographic orientations on advancing short crack, International Journal of Fatigue 29 (2007) 2005-2014
2. A. Prošek, B. Mavko, The state-of-the-art theory and applications of best-estimate plus uncertainty methods, Nuclear Technology 158 (2007) 69-79
3. L. Cizelj, M. Leskovar, M. Čepin, B. Mavko, A method for rapid vulnerability assessment of structures loaded by outside blasts, Nuclear Engineering and Design 239 (2009) 1641-1646
4. L. Štrubelj, I. Tiselj, B. Mavko, Simulations of free surface flows with implementation of surface tension and interface sharpening in the two-fluid model, International Journal of Heat and Fluid Flow 30 (2009) 741-750

5. M. Babić, I. Kljenak, B. Mavko, Simulations of TOSQAN containment spray tests with combined Eulerian CFD and droplet-tracking modelling, Nuclear Engineering and Design 239 (2009) 708-721
6. M. Leskovar, M. Uršič, Estimation of ex-vessel steam explosion pressure loads, Nuclear Engineering and Design 239 (2009) 2444-2458
7. A. Volkanovski, M. Čepin, B. Mavko, Application of the fault tree analysis for the power system reliability, Reliability Engineering and System Safety 94 (2009) 1116-1127

Awards and appointments

1. Martin Draksler, Award for Young Author, International Conference "Nuclear Energy for New Europe", Bled, Slovenia, Nuclear Society of Slovenia, paper: "A numerical investigation on a submerged, axis-symmetric jet impingement" (co-authored by Boštjan Končar)
2. Mitja Uršič, Matjaž Leskovar, Award for the best poster, International Conference "Nuclear Energy for New Europe", Bled, Slovenia, Nuclear Society of Slovenia, poster: "Modelling of Solidification Influence on Steam Explosion Efficiency in MC3D"

Organization of conferences, congresses and meetings

1. International Conference: "Nuclear Energy for New Europe", Bled, Slovenia, September 14 – 17, 2009

INTERNATIONAL PROJECTS

1. European Nuclear Education Network Training Schemes
   ENEN-III
   7. FP – EURATOM, 232629
   EC; Dr. Peter De Regge, ENEN Association, European Nuclear Education Network Association
   p/a Centre CEA de Saclay, Gif-sur-Yvette, France
   Prof. Leon Cizelj
2. Network of Excellence for a Sustainable Integration of European Research on Severe Accident Phenomenology and Management - Phase 2
   SARNET 2
   7. FP – EURATOM, 231747
   EC; IRSN, France
   Dr. Matjaž Leskovar
3. Nuclear Reactor Integrated Simulation Project
   NURISP
   7. FP – EURATOM, 232124
   EC; Commissariat a l'Energie Atomique (CEA), Paris, France
   Prof. Iztok Tiselj
4. 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
5. 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
6. Nuclear Plant Life Prediction
   NULIFE
   6. FP, 036412
   EC; Valton Teknillinen Tutkimuskeskus (VTT), VTT, Finland
   Prof. Leon Cizelj
7. European Platform for Nuclear Reactor Simulations
   NURESIM
   6. FP, 516560
   EC; Maryline Rougier, CEA Saclay, DEN/DSOE, Gif-Sur-Yvette, France
   Prof. Iztok Tiselj
8. 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, Bruseels, 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
9. Steam Explosion Resolution for Nuclear Applications
   SERENA
   OECD/NEA
   Jean Gauvain, OECD Nuclear Energy Agency, Agence de l'OCDE pour l'Energie Nucleaire, Issy-les-Moulineaux, France
   Dr. Matjaž Leskovar
10. SETH-2 Project to Resolve Key Computational Issues for the Simulation of Thermal-Haydraulic Conditions in Water Reactor Containments
    SETH-2, OECD/NEA
    Jean Gauvain, OECD Nuclear Energy Agency, Agence de l'OCDE pour l'Énergie Nucléaire, Issy-les-Moulineaux, France
    Prof. Borut Mavko, Dr. Ivo Klenjak
11. 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, Director, Donna-Maria Perez, Office of Nuclear Regulatory Research, United States Nuclear Regulatory Commission (US NRC), Washington, D. C., USA
    Prof. Borut Mavko
12. Calibration of a Crystal Plasticity Based Model using Monocrystal Samples
    BI-CZ/09-10-009
    Dr. Jaromir Kopeček, Institute of Physics, Academy of Sciences CR, Prague, Czech Republic
    Dr. Igor Simonovski
13. Incorporation of Age-depended Reliability Parameters and Data into Probabilistic Safety Assessment Models
    IE.B104899
    Andrei Rodionov, European Commission-Directorate General JRC, Institute for Energy, ZG Petten, The Netherlands
    Asst. Prof. Marko Čepin

R & D GRANTS AND CONTRACTS

1. Direct contact condensation in stratified two-phase flow
   Prof. Iztok Tiselj
2. Modelling of material influence on steam explosion
   Dr. Matjaž Leskovar
3. Improvement of safety of existing and new nuclear power plants with probabilistic safety assessment
   Asst. Prof. Marko Tomaž Čepin
4. Multiscale model of small crack initialization and propagation in pressure boundary components of an NPP
   Dr. Igor Simonovski
5. Modeling of fluid transport in nanotubes
   Asst. Prof. Ivo Kljenak
6. Simulations of two-phase thermohydraulic phenomena in nuclear engineering by computational fluid dynamics methods
   Dr. Boštjan Končar
7. Strategic role of nuclear power production in comparison to other sources and impact on the Slovenian economy
   Prof. Borut Mavko

8. Development of knowledge, indispensable for evaluation, assessment and surveillance of ageing management in nuclear facilities
   Prof. Leon Cizelj, Prof. Borut Mavko
9. Simulation of hydrogen combustion experiments in the ENACCEF experimental facility
   Asst. Prof. Ivo Kljenak
10. Modelling of condensation induced water hammer and boiling crisis in subcooled boiling flow
    Dr. Boštjan Končar

RESEARCH PROGRAM

1. Nuclear engineering
   Prof. Borut Mavko

NEW CONTRACTS

1. Expert opinion on USAR and NEK – TS change based on "Replacement of the DEH turbine control system, turbine emergency trip control system and MSR control"
   Krško Nuclear Power Plant
   Ljubo Fabjan, M.Sc.
2. Cooperation with the International Research Program CAMP (Code Aplications and Maintenance Program)
   Ministry of Environment and Spatial Planning, Slovenian Nuclear Safety Administration
   Dr. Andrej Prošek
3. Expert opinion on Krško NPP tests and repairs during refueling at the end od fuel cycle 23
   Milan Vidmar Electroinstitute, Ljubljana
   Ljubo Fabjan, M.Sc.
4. Description of safety characteristics of potential reactors for NEK II NPP
   GEN energija, d. o. o., Krško
   Ljubo Fabjan, M.Sc.

VISITORS FROM ABROAD

1. Dr. Imre Barna, KFKI Atomic Energy Research Institute, Budapest, Hungary, 23.-28. 03. 2009
2. Prof.dr. Josef Mittlemann in Prof.dr. Eric Suuberg, Brown University PRIME, Rhode Island, USA, 24. 09. 2009
3. Mr. David Gonzalez Rodriguez, University of Manchester, Manchester, Great Britain, 12. 05.-01. 06. 2009
4. Dr. Imre Attila, KFKI Atomic Energy Research Institute, Budapest, Hungary, 18.-21. 05. 2009
5. Dr. Nikola Jakšič, Institute for Energy, Joint Research Center, Petten, The Netherlands, 16. 06. 2009
6. Mr. Ovidu Adrian Berar, dipl.inž., Technical University Cluj – Napoca, Romania, 01.- 23. 10. 2009
7. Prof. Charles S.Martin, Georgia Institute of Technology, Atlanta, USA, 12.-13. 10. 2009
8. Prof.dr. George Yudigaroglu, ETH Zürich, Switzerland, 15.-17. 10. 2009
9. Dr. Jaromir Kopeček, Institute of Physics, AS CR, Prague, Czech Republic, 07.-11.12. 2009
10. Dr. Renaud Meignen, (IRSN) in dr. Stephane Picchi (CS), France, 10. 12. 2009

Visitors students by the International Association for the Exchage of Students for Technical Experience (IAESTE):

1. Mr. Rico Belder, University of technologies, Dresden, Germany, 06. 07.- 31. 10. 2009

STAFF

Researchers

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7. Dr. Matjaž Leskovar
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15. Blaže Gjorgiev, B. Sc.
16. Duško Kančev, B. Sc.
17. Zoran Petrič, B. Sc.
18. *Dr. Luka Štrubelj, left 01.11.09*
19. Mitja Uršič, M. Sc.

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20. Armando Francisco Quiles Agustin, B. Sc.
21. Andrej Sušnik, B. Sc..

Technical and administrative staff

22. Tanja Klopčič
23. Zlata Vrhovec Mikolič

Note:
* part-time JSI member

BIBLIOGRAPHY

Original Articles

1. Miroslav Babić, Ivo Kljenak, Borut Mavko, "Simulations of TOSQAN containment spray tests with combined Eulerian CFD and droplet-tracking modelling", *Nucl. Eng. Des.*, vol. 239, no. 4, pp. 708-721, 2009.
2. Leon Cizelj, Matjaž Leskovar, Marko Čepin, Borut Mavko, "A method for rapid vulnerability assessment of structures loaded by outside blasts", *Nucl. Eng. Des.*, vol. 239, no. 9, pp. 1641-1646, 2009.
3. Marko Čepin, "IJS-HRA - a method for human reliability analysis", *Asigur. calit.*, vol. 15, no. 57, pp. 21-27, 2009.
4. Marko Čepin, Andrej Prošek, "Vpliv analize zanesljivosti človeka na rezultate verjetnostnih varnostnih analiz jedrske elektrarne", *Elektroteh. vestn.*, vol. 76, no. 3, pp. 139-144, 2009.
5. Marko Čepin, Andrija Volkanovski, "Consideration of ageing within probabilistic safety assessment models and results", *Kerntechnik (1987)*, vol. 74, no. 3, pp. 140-149, 2009.
6. Marko Čepin, Andrija Volkanovski, "Nova faktorja pomembnosti v elektroenergetskih sistemih", *Elektroteh. vestn.*, vol. 76, no. 4, pp. 177-181, 2009.
7. Matjaž Leskovar, "Pressure load estimation during ex-vessel steam explosion", *J. eng. gas turbine power*, vol. 131, no. 3, pp. 032901-1-032901-7, 2009.
8. Matjaž Leskovar, Mitja Uršič, "Estimation of ex-vessel steam explosion pressure loads", *Nucl. Eng. Des.*, vol. 239, no. 11, pp. 2444-2458, 2009.
9. D. Lucas, Iztok Tiselj, (15 authors), "An overview of the pressurized thermal shock issue in the context of the NURESIM project", *Sci. Technol. Nucl. Install. (Print)*, vol. 2009, pp. 583259-1-583259-13, 2009.
10. Dirk Lucas, Iztok Tiselj, Luka Štrubelj, (25 authors), "Main results of the European project NURESIM on the CFD-modelling of two-phase Pressurized Thermal Shock (PTS)", *Kerntechnik (1987)*, vol. 74, no. 5/6, pp. 238-242, 2009.

11. Andrej Prošek, Matjaž Leskovar, "Extensions of the fast Fourier transform based method for quantitative assessment of code calculations", *Elektroteh. vestn.*, vol. 76, no. 5, pp. 251-256, 2009.
12. Andrej Prošek, Borut Mavko, "RELAP5/MOD3.3 best estimate analyses for human reliability analysis", *Sci. Technol. Nucl. Install. (Print)*, vol. 2009, pp. 797193-1-797193-12, 2009.
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15. Andrija Volkanovski, Marko Čepin, Borut Mavko, "Application of the fault tree analysis for the power system reliability", *Reliab. eng. syst. saf.*, vol. 94, no. 6, pp. 1116-1127, 2009.
16. Andrija Volkanovski, Marko Čepin, Borut Mavko, "Optimization of reactive power compensation in distribution networks", *Elektroteh. vestn.*, vol. 76, no. 1/2, pp. 57-62, 2009.

Review Articles and Chapters in Books

1. D. Bestion, Boštjan Končar, (15 authors), "Review of available data for validation of NURESIM two-phase CFD software applied to CHF investigations", *Sci. Technol. Nucl. Install. (Print)*, vol. 2009, pp. 214512-1-214512-14, 2009.

Published Conference Papers

Invited Papers

1. Andrej Prošek, Borut Mavko, "Animated RELAP5 calculations for Krško NPP", In: *Spring CAMP meeting: 17.-19. June 2009, München, Garching, Germany*, München, Lehrstuhl für Nucleartechnik, Technische Universität, 2009, 48 pp.
2. Andrej Prošek, Borut Mavko, "Status of CAMP activities in Slovenia", In: *Proceedings*, 2009 FALL CAMP Meeting Williamsburg, Virginia, USA November 4-6, 2009, [S. l., s. n.], 2009, 30 pp.

Regular papers

1. Leon Cizelj, Borut Mavko, "Evropska mreža za izobraževanje na področju jedrske tehnike", In: *Zbornik prispevkov na posvetu na institutu "Jožef Stefan", 20. oktobra 2009*, Posvet Položaj in vloga inženirjev v Sloveniji, Ljubljana, 20. oktobra 2009, Peter Glavič, ed., Boris Žemva, ed., Ljubljana, Inženirska akademija Slovenije - (IAS), 2009, pp. 65-70.
2. Leon Cizelj, Igor Simonovski, "Fatigue relevance of stratified flows in pipes: a parametric study", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 8 pp.
3. Marko Čepin, "Risk-informed decision-making related to the on-line maintenance", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 7 pp.
4. Marko Čepin, Rudolf Prosen, "Probabilistic safety assessment for other modes than power operation", In: *Safety, reliability and risk analysis: theory, methods and applications: proceedings of the European Safety and Reliability Conference, ESREL 2008, and 17th SRA-Europe, Valencia, Spain, September 22-25, 2008*, Sebastián Martorell, ed., C. Guedes Soares, ed., Julie Barnett, ed., Boca Raton ... [etc.], CRC Press, 2009, zv. 4, pp. 2883-2889.
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6. Romana Jordan-Cizelj, "Sladkorna bolezen - nevarnost za sodobnega človeka", In: *Spremenimo diabetes: od preventive in zdravljenja do strategije celovitega obvladovanja diabetesa: zbornik*, (Zbirka Diabetes), Darja Lovšin, ed., Ljubljana, Zavod za izobraževanje o diabetesu, 2008, pp. 7-8.
7. Duško Kančev, Marko Čepin, "The price of risk reduction: optimization of test and maintenance integrating risk and cost", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 8 pp.
8. Ivo Kljenak, Borut Mavko, "Simulation of containment phenomena during the Phebus FPT2 test with the CONTAIN code", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 8 pp.
9. Ivo Kljenak, Borut Mavko, "Simulation of containment thermal-hydraulic phenomena in the Marviken blowdown experiment with the CONTAIN and ASTEC CPA codes", In: *The 17th International Conference on Nuclear Engineering, ICONE 17, July 12-16, 2009, Brussels, Belgium*, The 17th International Conference on Nuclear Engineering, ICONE 17, July 12-16, 2009, Brussels, Belgium, [S. l.], ASME, 2009, 7 pp.
10. Ivo Kljenak, Borut Mavko, "Simulation of containment thermal-hydraulics in the Marviken blowdown experiment with ASTEC and CONTAIN codes", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 8 pp.
11. Boštjan Končar, "Jet array optimization in cooling finger Of He-cooled divertor", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 8 pp.
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15. Igor Simonovski, Leon Cizelj, "Small crack in a simulated columnar polycrystalline aggregate with random 2D and 3D lattice orientations", In: *Engineering against fracture: proceedings of the 1st conference, [Patras, Greece, May 28-30, 2008]*, Spiros Pantelakis, ed., Chris Rodopoulos, ed., Dordrecht, London, Springer, 2009, pp. 235-247.
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Research Monographs

1. Francesco D'Auria, Borut Mavko, *Deterministic safety analysis for nuclear power plants: specific safety guide*, (IAEA safety standards series, no. SSG-2), Vienna, IAEA, 2009.
2. Gerhard Nagel, Leon Cizelj, Ivo Kljenak, (210 authors), *The strategic research agenda of the sustainable nuclear energy technology platform*, Brussels, European Commission, 2009.
3. Andrej Prošek, Borut Mavko, *Quantitative code assessment with fast Fourier transform based method improved by signal mirroring*, (International agreement report, NUREG/IA-0220), Washington, U. S. Nuclear Regulatory Commission, 2009.
4. Andrej Prošek, Borut Mavko, Marko Čepin, *Estimation of operator action time windows by RELAP5/MOD3.3*, (International agreement report, NUREG/IA-0219), Washington, U. S. Nuclear Regulatory Commission, 2009.

Theses

Ph. D. Thesis

1. Luka Štrubelj, *Numerical simulations of stratified two-phase flows with two-fluid model and interface sharpening: doctoral thesis*, Ljubljana, [L. Štrubelj], 2009.

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 staff also cooperate in other activities requiring specialists skilled in work with sources of radiation and in reactor technology, such as the servicing of industrial radioactive sources and 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 (from 15. 9. 2009):
Asst. Prof. Borut Smodiš

Head (to 14. 9. 2009):
Prof. Matjaž Ravnik

In 2009, the reactor operated for 123 days. A total of 1002 samples were irradiated, 819 of them in the rotary specimen rack and 183 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 in accordance with the annual plan.

The Hot Cell Laboratories, mainly used for the work with strong radioactive sources, were formally included in the reactor as a nuclear installation by the decree of the SNSA.

The reactor was mainly used for neutron-activation analysis. The reactor operated mainly for the needs of the JSI's research departments: the Environmental Science Department, the Reactor Physics Department, the Experimental Particle Physics Department 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 manipulations with radioactive samples.

The results of this research were published in approximately 20 scientific papers. and three young researchers performed their research at the reactor.

Practical exercises for the students of physics at Ljubljana University were preformed. The post-graduate students of nuclear engineering attended some of these exercises as well. For these purposes the reactor operated for approximately 30 days. The reactor was also used for practical exercises within the training program for the reactor operators of NPP Krško. Also, some post-graduate students of nuclear engineering at the Faculty of Mathematics and Physics of Ljubljana University participated at the exercises. The exercises were prepared and carried out by the reactor personnel in cooperation with Nuclear Training Center and the Department of Reactor Physics.

In 2009, there were more than 50 short group visits to the reactor. The visitors were mainly foreign scientists, students and more than 30 groups of school children. The total number was more than 900.

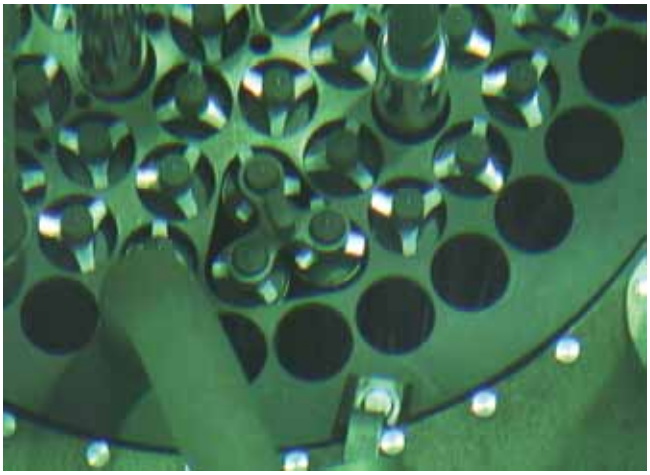

Figure 1:Close-up view of the fuel elements in the TRIGA reactor core. Picture taken with the newest equipment for inspection of the reactor fuel and core.

INTERNATIONAL PROJECT

1. Training in Radioactivity Measurement for Practitioners from Countries Eligible under the JRC Enlargement & Integration Policy
   54018
   Ivan Celen, European Commission, Joint Research Center (JRC), Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
   Asst. Prof. Borut Smodiš, Asst. Prof. Ljudmila Benedik

STAFF

Researchers

1. Prof. Matjaž Ravnik, died 08.10.09

2. Asst. Prof. Borut Smodiš, Head

Postdoctoral associates

3. Dr. Luka Snoj

Technical officers

4. Dr. Tinkara Bučar
5. Bojan Huzjan, M. Sc.

Technical and administrative staff

6. Darko Kavšek, B. Sc.
7. Bojan Oman, retired 01.11.09
8. Marko Rosman
9. Darinka Stich

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.

Head:
Vladimir Alkalaj, M. Sc.

STAFF

Technical officers
1. Vladimir Alkalaj, M. Sc., Head
Technical and administrative staff
2. Ivan Ivanjko
3. Matjaž Levstek
4. Mark Martinec, B. Sc.
5. Janez Srakar
6. Matej Wedam

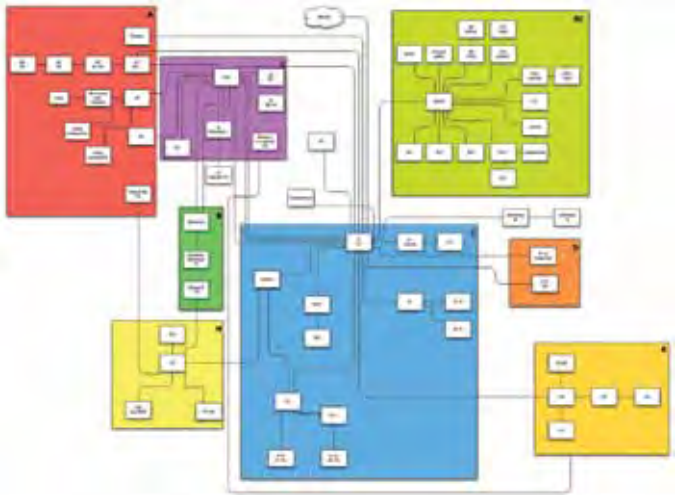

Figure 1: JSI connectivity structure

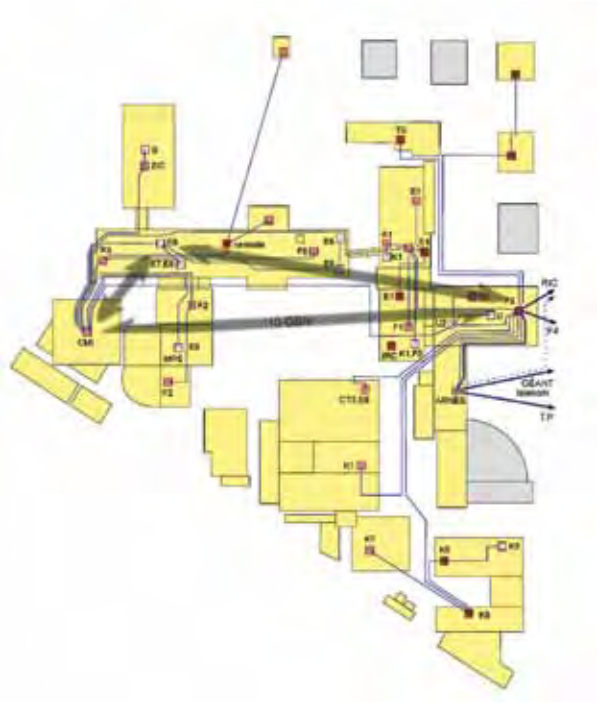

Figure 2: Layout of JSI communication network

SCIENCE INFORMATION CENTRE SIC

The Jožef Stefan Institute 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 the bibliographic data of the Institute staff, as requested by the funding ministry.

Head:
Dr. Luka Šušteršič

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 WWW site.

We supplement our comprehensive print collection of core journals with the electronic editions, offered through our WWW site. We subscribe to the electronic collections offered by ScienceDirect, Springer Link, Stanford HighWire Press, ACS online editions, AIP electronic editions, IoP online journals, and 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 of last year's work are included as part of this report.

STAFF

Technical Officers
1. **Dr. Luka Šušteršič, Head**
2. Marjan Verč, M. Sc.

Technical and administrative staff
3. Suzi Korošec, B. Sc.
4. Jasna Malalan
5. Katarina Modic, B. Sc.
6. Joško Per
7. Alenka Sosič, B. Sc.
8. Jože Škulj
9. Slavka Šmuc, B. Sc.
10. Branka Štrancar
11. Nada Tratnik
12. Saša Žnidar

BIBLIOGRAPHY

M. SC. THESIS

1. Marjan Verč, From invention to enterprise at the technology park: master's thesis, Ljubljana, [M. Verč], 2009.

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-gas emissions. The Centre is a focal point for the collection and transfer of energy-efficiency technologies to energy users, the state, energy service and equipment providers, and other interested agencies. At the same time it covers the environmental effects of energy use and conversion. The most significant part of the EEC's activities is thus a cooperation with state institutions in the preparation of strategic documents and legislation in the field of efficient energy use, energy planning, distributed electricity production, and emission trading; nevertheless, it remains strongly connected by its consulting and training role in energy, with industrial companies and other institutions. In 2009, the Centre celebrated 15 years of operation and 25 years of activities in this field.

Head:
Stane Merše, M. Sc.

Energy and the environment

The year 2009 can be marked as crucial and especially important in the 15-year period of the Energy Efficiency Centre's activities. The centre, with its professional work, was included in the preparation of key strategic development documents in the field of energy planning and the reduction of greenhouse-gas emissions.

In April, a Green Paper, as an advising document with the starting points for the preparation of a new National Energy Programme, was carried out and put to public discussion. The document was well accepted by the broader professional public and it encouraged professional discussion and consideration on actual questions and dilemmas about energy in Slovenia, which is, as regards development, in a crucial period facing new strategic directions of the transition to a low-carbon society, the current economic crisis and the new investment cycle in production facilities.

The R&D work of the Energy Efficiency Centre, which in 2009 celebrated 15 years of its operation and 25 years of being active in this field, is an important contribution to the preparation of key documents in Slovenia in the field of energy development, energy efficiency, renewables' exploitation and the transition of Slovenia to a low-carbon society, at the same time supporting industry to increase competitiveness and development restructuring.

In the summer, the centre, as a leader of a consortium started to prepare a new National Energy Programme (NEP), which represents the greatest professional task and challenge in the period of its existence. The preparation of professional starting-points and a quantitative analysis for the preparation and evaluation of sub-programmes in all key sectors required the integrated renovation of programme tools, especially the Referential energy environment model of Slovenia REES-SLO2, which has been entirely updated in the modernized MESAP environment. Intensive activities for the preparation of the strategic document NEP continue in 2010.

The accepted EU climate-energy package, set for Slovenia, new ambitious goals regarding an increase of energy efficiency, the exploitation of renewables and a reduction of greenhouse-gas emissions. Achieving a 25% share of RES in the final energy use up to 2020 presents the greatest development challenge. In autumn, the centre signed a contract with the Ministry of the Economy to prepare an action plan for RES exploitation to achieve the share that Slovenia has to present to the European Commission by June 2010.

The European Commission confirmed in November a new support scheme for electricity production from renewable energy sources (RES) and cogeneration, which represents a new development initiative for the quicker development of distributed electricity production as well as larger RES and cogeneration units in our country. For the new support scheme the centre carried out strategic studies and cooperated intensively with the Ministry of the Economy during the preparation and execution of the new scheme.

In the field of reducing greenhouse-gas emissions, the centre in April carried out an updated Operative programme of greenhouse-gas emissions reduction up to the year 2012, which is a key action document with a detailed sector plan of the necessary measures for fulfilling the obligations of Slovenia from the Kyoto Protocol. Carrying out the transitional programme

Figure 1: Main activities and areas of work for the Energy Efficiency Centre

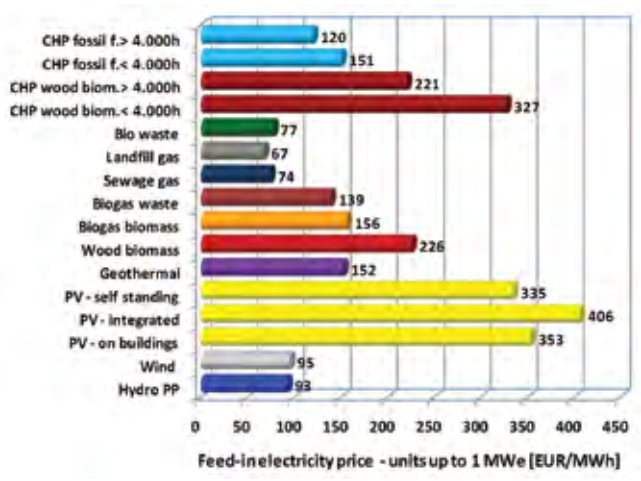

Figure 2: Feed-in electricity prices for electricity generation from renewables and cogeneration for units up to 1 MWe.

was comprehensively evaluated in the document "Monitoring of the Carrying out of the Operative Programme of Greenhouse Gases Emissions Reduction". For the Ministry of the Environment new projections of greenhouse-gas emissions were also elaborated for the 5th UNFCC Report and pollutants emissions from the NEC directive.

The Energy Efficiency Centre continues with activities of the state referential centre for energy and in 2009 it refreshed and broadened the list of indicators for energy and environment.

The directive on energy services and the accepted climate energy package also set Slovenia binding goals as regards an increase in energy efficiency up to 2016 and 2020, respectively. In 2009 the centre continued by carrying out a project for the preparation of the evaluation methodologies for carrying out energy-efficiency measures, which will be a key instrument for the presentation of the fulfilment of set goals. A project financed by the Ministry of the Environment and Spatial Planning is included in other European projects for the preparation of evaluation methodologies, as the EU wants to establish harmonized approaches in all member states also in this field.

Promotion of efficient energy use and energy consulting

The activities of the Energy Efficiency Centre in 2009 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 third cyclus of the training of energy managers in the framework of the European programme "EUREM". 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 2009 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 conclusion of the execution of the energy audit in Thermopower plant Ljubljana, which confirmed the supposition that also in larger units for electricity production there is still a great potential for an energy-efficiency increase. 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 for directing the consumption and inclusion of demand-side management into network planning and development.

The Centre also prepared the programme and cooperated in the execution of the eleventh largest Slovenian conference of energy managers "Energy Managers Days", the annual meeting of energy managers, with more than 200 participants, 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 public media as well as taking part in radio and television broadcasts.

International cooperation

In 2009 the EEC carried out as many as 11 international projects, financed from the European Union's resources in the framework of the 6th Framework Programme and European Commission programme "Intelligent Energy for Europe".

Projects cover activities in the fields of:

- monitoring of energy consumption trends and energy efficiency in the EU – project "ODYSSEE MURE"
- 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 the EU directive on energy services and an evaluation of energy-efficiency measures – project "Concerted Action – Energy Service Directive (CA-ESD)",
- project "European Energy Service Initiative (EESI)",
- examples of good practice of changes in energy services and strategies – project "ChangeBest",
- monitoring and dissemination of cogeneration in Europe – project "CODE"
- and others.

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 the EEC staff took part in numerous

foreign professional meetings and visits. For the Intelligent Energy for Europe projects, the EEC acquired partial co-financing from the Ministry of the Environment and Spatial Planning.

Some outstanding achievements in 2009

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 (Green paper and preparation of the National Energy Programme)
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, the exploitation of wood biomass and others.

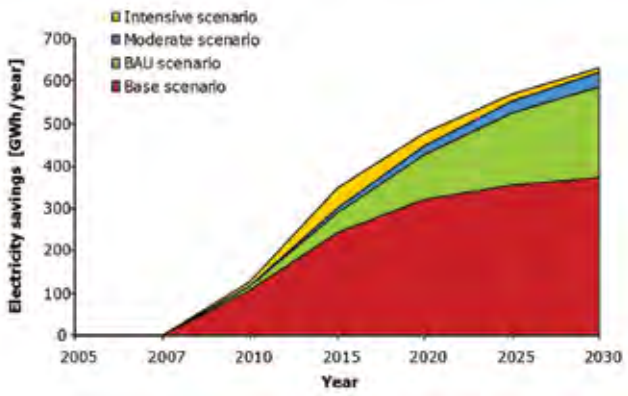

Figure 3: Potential scenarios for large households' electricity savings with appliances

Awards and appointments

1. Energy Efficiency Centre: Special award, Ljubljana, Network of social – business usefulness Sinergija, professional support in the campaign "Save up to 30% of energy by washing at 30°C"
2. Energy Efficiency Centre: Special award, Ljubljana, Network of social – business usefulness Sinergija, professional support in the campaign "Known faces advise" within the campaign "You are energy, be efficient"
3. Andreja Urbančič: Award for excellent cooperation, Ljubljana, Elaphe – development and sale of electric vehicles and energy sources, work on the project National Energy Programme

Organization of conferences, congresses and meetings

1. Energy Managers Days 2009 – 11th Meeting of Energy Managers of Slovenia, Portorož, 20. - 21.4.2009
2. European Energy Manager Training, Ljubljana, 18.-20.3., 6.5.-8.5., 18.6. and 21.10.-23.10.2009

INTERNATIONAL PROJECTS

1. 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
2. European Energy Service Initiative
   EESI
   IEE Programme
   IEE/08/581/SI2.528408
   EC; Michael Geissler, Berliner Energiagentur GmbH (BEA), Berlin, Germany
   Barbara Petelin Visočnik, M. Sc.
3. Good Practice Examples of Changes in Energy Service Business, Strategies and Supportive Policies and Measures in the Course of the Implementation of Directive 2006/32/EC
   ChangeBest
   IEE Programme
   IEE/08/434/SI2.528383
   EC; Wuppertal Institut für Klima, Umwelt, Wuppertal, Germany
   Evald Kranjčevič, M. Sc.
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 Energy Managers
   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. Cogeneration Observatory and Dissemination Europe
   C.O.D.E
   IEE Programme
   IEE/07/564/SI2.499462
   EC; COGEN EUROPE, Brussels, Belgium
   Stane Merše, M. Sc.
8. Concerted Action Supporting Transposition and Implementation of Directive 2006/32/EC of the Council
   CA ESD
   IEE Programme
   IEE/CA/08/001/SI2.503473
   EC; Rob Boeree, SenterNovem, Sittard, The Netherlands
   Damir Staničić, M. Sc.

9. 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 Kranjčevič, M. Sc.

R & D GRANTS AND CONTRACTS

1. Slovenia - low carbon society
Andreja Urbančič, M. Sc.
2. Determination of the applied potential of agricultural biomass and definition of environmentally friendly technologies used for its exploitation
Dr. Fouad Al-Mansour

RESEARCH PROGRAM

1. Environment impact: modelling and assessment
Dr. Borut Smodiš, Dr. Fouad Al-Mansour

NEW CONTRACTS

1. Monitoring of energy use and energy efficiency erands in Slovenia
Ministry of Environment and Spatial Planning
Dr. Fouad Al-Mansour
2. Effect of demand side management (DSM) on the usage in a transmission network
University of Ljubljana, Faculty of Electronic Engineering
Stane Merše, M. Sc.
3. Development and testing of methods for monitoring and evaluation of effects of instruments and measures for energy efficiency increase
Ministry of Environment and Spatial Planning
Evald Kranjčevič, M. Sc.
4. Energy audit of the Combined Heat and Power Production Plant Ljubljana
Combined Heat and Power Production Plant Ljubljana
Damir Staničić, M. Sc.
5. Editing of Energy Efficiency newsletter
Ministry of Environment and Spatial Planning
Barbara Petelin Visočnik, M. Sc.
6. Preparation of the Green Book for the RS National Energy Programme 2009
Ministry of Economy
Andreja Urbančič, M. Sc.
7. Report on monitoring of greenhouse gas emissions and implementing the Kyoto Protocol according to the 280/2004/ES directive
Ministry of Environment and Spatial Planning
Matjaž Česen
8. Strategic studies for the preparation of the Report on Implementing the Operative Programme of Greenhouse Gas Emissions Reduction by 2012
Ministry of Environment and Spatial Planning
Matjaž Česen
9. Strategic studies for changes and supplements of the Operative Programme of Greenhouse Gas Emissions Reduction by 2012
Ministry of Environment and Spatial Planning
Damir Staničić, M. Sc.
10. Strategic studies for energy planning
Geoplin Pipelines
Andreja Urbančič, M. Sc.
11. National Energy Programme of Slovenia 2009
Ministry of Economy
Andreja Urbančič, M. Sc.
12. Annual energy review for 2008
Ministry of Economy
Matjaž Česen
13. Strategic studies for Energy Planning and Fulfilling of Climate-Energy Package Goals
Slovenian Power Plant Holding
Andreja Urbančič, M. Sc.
14. Strategic studies for Energy Planning and Fulfilling of Climate-Energy Package Goals
GEN, d. o. o.
Andreja Urbančič, M. Sc.
15. Development of a system for electricity production from low temperature waste heat
INEA, d. o. o.
Stane Merše, M. Sc.
16. National Action Plan for Renewable Energy Sources for the Period of 2010 - 2020
Ministry of Economy
Damir Staničić, M. Sc.
17. Implementing of National Energy Reference Centre services
Ministry of Environment and Spatial Planning
Matjaž Česen
18. Eleventh meeting of Energy Managers 2009
Finance magazine
Stane Merše, M. Sc.
19. European Energy Manager education
Other clients from the industry
Boris Sučić, M. Sc.
20. Energy audit of the Slovenian Rehabilitation Institute
Slovenian Rehabilitation Institute
Marko Pečkaj
21. Professional support of the introduction and implementing of the new support scheme RES - CHP
BORZEN
Stane Merše, M. Sc.
22. Analysis of energy use in the industry and public lighting in the Ljubljana municipality
Municipality of Ljubljana
Marko Pečkaj
23. Fifth state report to the Conference of Contractors of the UN framework convention on climate changes
Ministry of Environment and Spatial Planning
Matjaž Česen

VISITORS FROM ABROAD

1. Diane Lescot, Observ` ER, Paris, France, 15.1. – 16.1.2009
2. Gaetan Fovez, Observ` ER, Paris, France, 15.1. – 16.1.2009
3. Robert Bruckmann, Eclareon, Berlin, Germany, 15.1. – 16.1.2009
4. Beurskens Luuk, ECN, Amsterdam, The Netherlands, 15.1. – 16.1.2009
5. Eric Vesine, ADEME, Paris, France, 15.1. – 16.1.2009
6. Grzegorz Wiśniewski, EC BREC IEO, Warsaw, Poland, 15.1. – 16.1.2009
7. Reinond Segers, Statistics of Netherlands, Amsterdam, The Netherlands, 15.1. – 16.1.2009
8. Christian Brandt, Focus, Ljubljana, 15.1. – 16.1.2009
9. Amber Sharick, Ministry of Environment and Spatial Planning, Berlin, Germany, 15.1. – 16.1.2009
10. prof. dr. Vladan Karamarković, Ministry of Mining and Energy of the Republic of Serbia, Belgrade, Serbia, 8.4.2009
11. Gojko Baletić, Ministry of Mining and Energy of the Republic of Serbia, Belgrade, Serbia, 8.4.2009
12. Sladjana Vukmirica, Ministry of Mining and Energy of the Republic of Serbia, Belgrade, Serbia, 8.4.2009
13. Andjela Lazarević, Ministry of Mining and Energy of the Republic of Serbia, Belgrade, Serbia, 8.4.2009
14. Vladimir Kolarević, Ministry of Mining and Energy of the Republic of Serbia, Belgrade, Serbia, 8.4.2009
15. dr. Predrag Stefanović, Institute "Vinča", Belgrade, Serbia, 8.4.2009
16. prof.dr. Miroslav Stanojević, Faculty of Mechanical Engineering, Belgrade, Serbia, 8.4.2009
17. prof. dr. Predrag Stefanov, Faculty of Electrotechnics, Belgrade, Serbia, 8.4.2009
18. prof. dr. Vladimir Stevanović, Faculty of Mechanical Engineering, Belgrade, Serbia, 8.4.2009
19. Vera Ražnatović, Chamber of Economy of Serbia, Belgrade, Serbia, 8.4.2009

STAFF

Researchers
1. Dr. Fouad Al-Mansour
2. Evald Kranjčevič, M. Sc.
3. Stane Merše, M. Sc., Head
4. Damir Staničić, M. Sc.
5. Andreja Urbančič, M. Sc.

Technical officers
6. Matjaž Česen, B. Sc.
7. Polona Lah, B. Sc.
8. Marko Pečkaj, B. Sc.
9. Barbara Petelin Visočnik, M. Sc.
10. Aleš Podgornik, M. Sc.
11. Boris Sučić, M. Sc.

Technical and administrative staff
12. Roza Pergarec, B. A.
13. Matevž Pušnik, B. Sc.
14. Igor Ribič
15. Milan Simončič, B. Sc.

BIBLIOGRAPHY

Published Conference Papers

Regular papers

1. Fouad Al-Mansour, "Development of utilization of bio-energy resources in Slovenia", In: *CD proceedings*, 5th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, September 29 - October 3, 2009, Dubrovnik, Croatia, Zvonimir Guzović, ed., Neven Duić, ed., Marko Ban, ed., [S. l., s. n.], 2009, 16 pp.
2. Fouad Al-Mansour, "Energy efficiency trends and policy in Slovenia", In: *CD proceedings*, 5th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems, September 29 - October 3, 2009, Dubrovnik, Croatia, Zvonimir Guzović, ed., Neven Duić, ed., Marko Ban, ed., [S. l., s. n.], 2009, 16 pp.
3. Fouad Al-Mansour, Tomaž Poje, "Izkoriščanje in potencial bioplina v Sloveniji", In: *Zbornik*, 18. Mednarodno posvetovanje Komunalna energetika, 12. do 14. maj 2009, Maribor, Slovenija, Jože Voršič, ed., Maribor, Fakulteta za elektrotehniko, računalništvo in informatiko, 2009, 12 pp., 2009.
4. Evald Kranjčevič, "Kaj čaka podjetja v emisijskem trgovanju po letu 2012?", In: *Tehnološke in poslovne možnosti za uveljavljanje energetske učinkovitosti: [zbornik predavanj]*, Barbara Petelin-Visočnik, ed., Stane Merše, ed., Ljubljana, Časnik Finance, 2009, 5 pp., 2009.
5. Boris Sučić, Jurica Kovač, "Ekonomično gospodarjenje z vodo in električno energijo v javnih vodovodnih sistemih", In: *Zbornik referatov: [simpozij z mednarodno udeležbo]*, Vodni dnevi 2009, Portorož, 21.-22. oktober 2009, Milenko Roš, ed., Ljubljana, Slovensko društvo za zaščito voda, 2009, pp. 85-92, 2009.

Research Monographs

1. Maks Babuder, Andreja Urbančič, Jože Volfand, ed., *Obnovljivi viri energije (OVE) v Sloveniji*, (Zbirka Zelena Slovenija), Celje, Fit media, 2009.
2. Dunja Fadljević, Jelena Kremenjaš, Boris Sučić, Marko Bišćan, Marko Capek, *Vodič kroz zeleni ured: Priručnik*, Zagreb, UNDP Hrvatska, 2009.
3. Zoran Morvaj, Boris Sučić, *Priručnik za provedbu preliminarnih energetskih pregleda u industrijskim poduzećima*, Zagreb, Fakultet elektrotehnike i računarstva, 2009.
4. Boris Sučić, Jelena Kremenjaš, Boris Sučić, Marko Bišćan, Marko Capek, *Vodič kroz zeleni ured: Radna knjiga*, Zagreb, UNDP Hrvatska, 2009.
5. Vlasta Zanki, Vanja Lokas, Sanja Horvat, Boris Sučić, Iva Nekić, Petra Gjurić, *200 savjeta: kako efikasnije koristiti energiju, živjeti kvalitetnije i plaćati manje*, Zagreb, UNDP Hrvatska, 2009.

Review Articles and Chapters in Books

1. Andreja Urbančič, Damir Staničić, Matjaž Česen, " Obnovljivi viri energije kot pomemben del energetske bilance in oskrbe z energijo Slovenije ", In: *Renewable energy sources in Slovenia*, (Zbirka Zelena Slovenija), Jože Volfand, ed., Celje, Fit media, 2009, pp. 37-49.

CENTRE FOR ELECTRON MICROSCOPY CEM

The Center for Electron Microscopy (CEM) has the function of a supporting infrastructure center at the JSI that manages the equipment for electron microscopy that 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 this 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 equipment of the CEM represents two scanning electron microscopes (JSM-840A and JSM-5800) and two transmission electron microscopes (JEM-2000FX and JEM-2010F). CEM co-workers also manage the transmission electron microscope JEM-2100 that belongs to the Center of Excellence NiN, and in 2009 the newly installed field-emission scanning electron microscope JSM-7600F that was a joint purchase by 10 JSI departments and also the faculties NTF and FKKT of the University Ljubljana.

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 microscale are also possible. Since only a few μm^3 of the material are non-destructively analyzed, the term electron-probe microanalysis (EPMA) is used for such analytical work. Apart from EDXS and WDXS the new FEG-SEM JSM-7600F is also equipped with electron lithography.

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 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 analysis (EDS, EELS). The CEM also has equipment for SEM and TEM specimen preparation, which is the first step for all electron-microscopy observation procedures. Especially important are the high- and low-energy ion-millers, which enable the preparation of thin foils that are transparent to high-energy electrons.

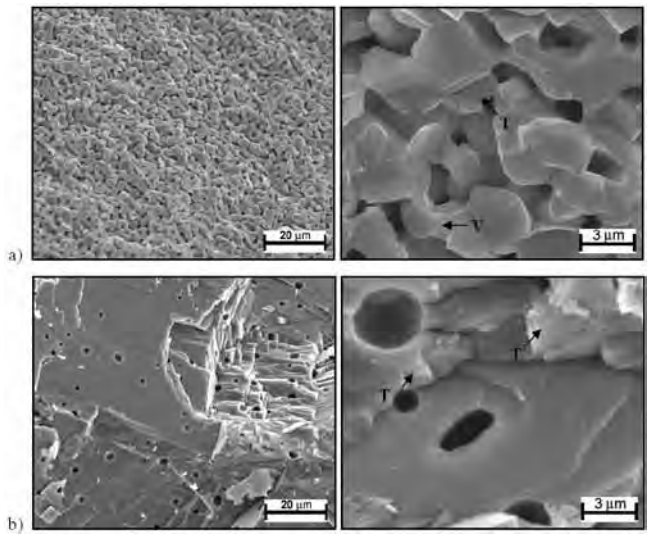

Figure 1: Microstructural development of sodium niobate, synthesized from mechanically activated sodium carbonate powder. The pictures show the fracture surfaces of the samples, sintered at different temperatures: a) 1250 °C and b) 1350 °C. The densification process and the fracture type were investigated (intergranular (V) and transgranular (T)). SEM Jeol, JSM 5800; secondary electrons. Electronic Ceramics: Jurij Koruza, diploma thesis

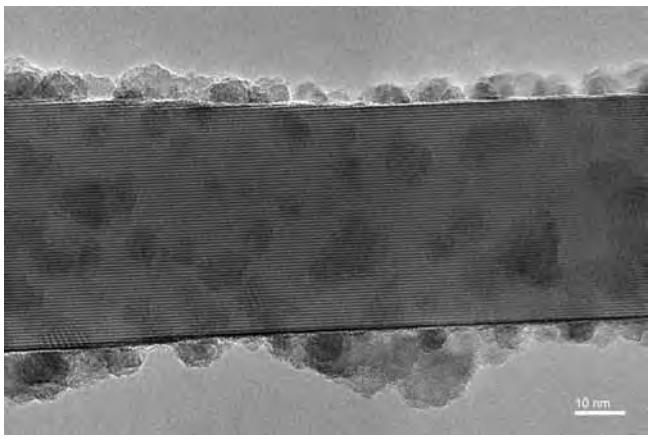

Figure 2: TEM-micrograph of TiO_2-coated Si_3N_4 powder after calcinations at 600 °C for 2h in air. Engineering Ceramics: A. Maglica

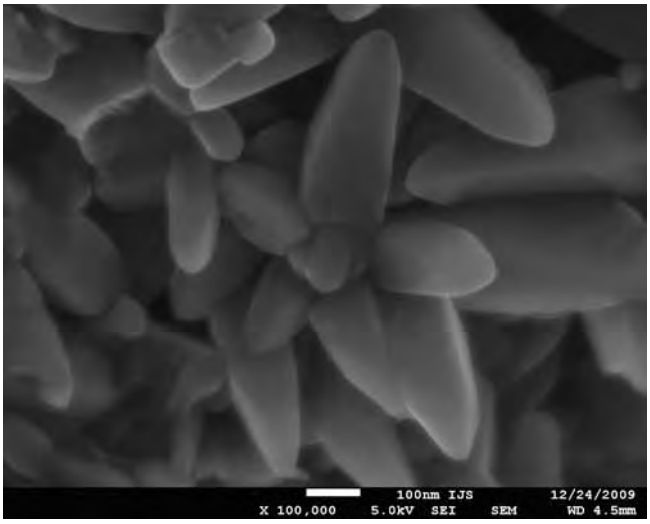

Figure 3: High-resolution image of anatase (TiO2) nanocrystals recorded using the FEGSEM microscope JEOL JSM-7600F.
Nanostructured Materials: Z.Samardžija.

The analytical work that is performed on the CEM equipment varies, in terms of both the investigated materials and/or the used electron microscopy techniques. While scanning electron microscopy is used mainly for the microstructural characterization and chemical analyses of polycrystalline ceramic materials (functional ceramics, engineering ceramics, bio-ceramics, and composites), magnetic materials, glasses, metals, alloys, etc., transmission electron microscopy is used for structural and chemical investigations of grain boundaries, planar faults, dislocations and precipitates within the same materials. The structural and chemical analysis of grain boundaries is especially important since it is known that the final physical properties to a great extent depend on the structure and chemistry of the grain boundaries.

In order to be able to perform electron microscopy investigations it is imperative that the equipment in the CEM is well maintained. In view of this, one of the main tasks is to attain the maximum possible operational time of the microscopes. This complex and expensive equipment needs regular daily maintenance, apart from 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.

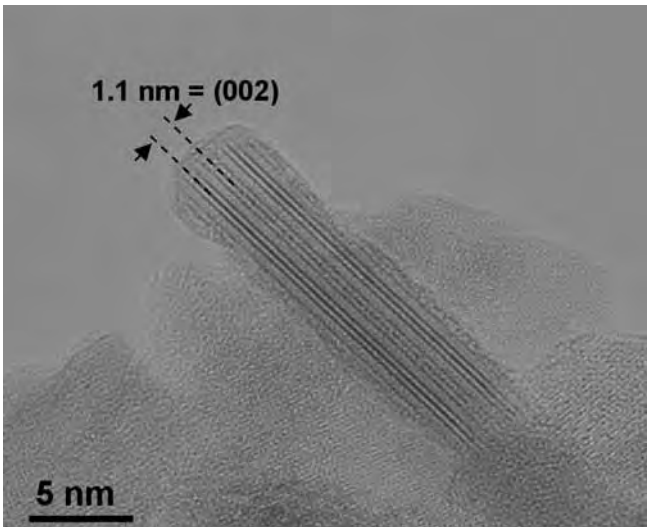

Figure 4: Transmission electron micrograph of $BaFe_{12}O_{19}$ nanoparticles. The basal plane of the hexagonal nanoparticle in the middle of the image is oriented parallel to the electron beam.
Synthesis of Materials: D. Makovec.

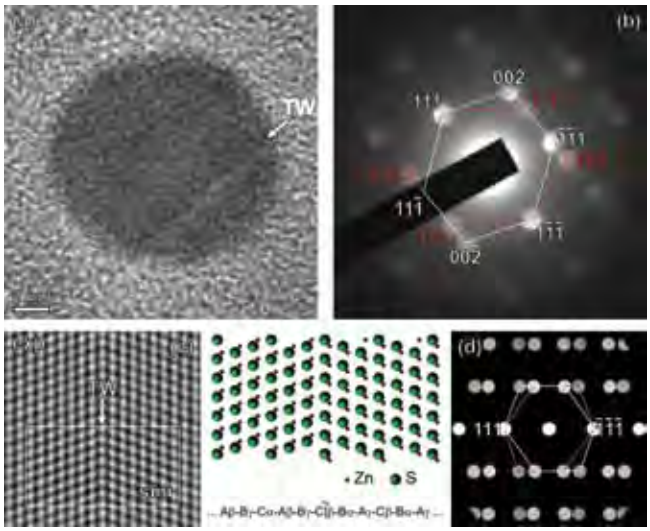

Figure 5: (a) (111) twin boundary in the spherical sphalerite nanocrystal synthesized within the polyelectrolyte multilayer thin film. (b) Experimental electron microdiffraction pattern (c) A close-up of the processed HRTEM image with a simulated inset based on the (111) twin model for sphalerite (middle). (d) Simulated microdiffraction pattern for a 10-nm ZnS crystal
Advanced Materials: M. Logar in collaboration with A.Rečnik

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Technical and administrative staff
2. Hamdija Hodžić, B. Sc.

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.

Head:
Mitja Jermol, M. Sc.

By partnering and active engagement in different 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 2009 the centre was active in several European projects: from the FP6 "Lifecycle Support for Networked Ontologies (NEON)", "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 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)".

The Laboratory for Communication and Technology Transfer operates within The Center for Knowledge Transfer. The core activities of the laboratory include supporting knowledge and technology transfer from research to the business and educational sphere (networking and establishing conditions for and dealing with contract research with industry, licensing and spinning-off), research work in innovation and innovation management and the implementation of specific technology projects.

The center prepares and organizes carefully designed educational events, such as: conferences, seminars, workshops, and summer schools. They are targeted at experts who would like to apply the latest knowledge and achievements from intelligent data analysis, knowledge technologies, data mining, text mining and decision support to the areas of the network organizations, ecology, medicine, business decisions, finance, marketing, automation and process control. Special consideration is given to managers and decision makers who are aware of the strengths and benefits of the success of their business.

All the educational events are designed to transfer basic, additional and the latest expert knowledge to companies, research and educational organizations. In order to make this knowledge transfer efficient, we combine traditional and ICT-supported training methods. For this purpose we are operating a number of training web portals. The most popular one is http://videolectures.net/. It now offers more than 10,000 recorded tutorials from different scientific events and is visited daily by an average of 7500 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. For the second year we have successfully collaborated within the Videolectures.net portal with some of the top ten American universities, including MIT (Massachusetts Institute of Technology), 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 analysis of European research. The user can perform several simple and complex analyses, predictions and detect trends in research. The database currently contains data about 100,000 research organizations, 42,500 research projects and around 2 million

- **The centre operates two web portals. The first one is http://videolectures.net/, which is now becoming a reference portal for presenting high-quality scientific lectures, and the second one is http://www.ist-world.org, which offers services for automatic data collection and analysis of European research.**
- **For the second year the portal http://videolectures.net/ is collaborating with the Massachusetts Institute of Technology - MIT, YALE, University of California - Berkeley, University of Ljubljana, and with the European Organization for Nuclear Research - CERN**

Figure 1: The World Summit Award, awarded by the United Nations for the Videolectures.net portal

Figure 2: Kenneth A. Goldman, lecturer from MIT (KTT)

experts from Europe. This is an exceptional web service that is being visited daily by an average of 10,000 unique visitors.

In 2009 we organized the 4th Student Competition in Computer Science, attended by 132 students from Slovenian secondary schools and three seminars for participants from industry. We also organized an international seminar "Analysis of environmental data with machine-learning methods", and six project meetings for different EU projects. In the autumn we organized the international conference ECML/PKDD 2009, attended by 380 experts from machine learning and organized the collocated event 1. ACTIVE summer school on Advanced Technologies for Knowledge-Powered Enterprise. At the same time we organized the 3rd international workshop "Machine Learning in Systems Biology"-MLSB, attended by 61 participants. The Laboratory for Communication and Technology Transfer organized three workshops: "All about business plan", "Spinning-off on the basis" and "Intellectual property, patent protection and academic entrepreneurship" and "Technology Transfer Conference", attended by 140 participants.

Our role in the FP7 integrated projects "COIN", "EURIDICE", "ACTIVE" and in one Network of Excellence "Pattern Analysis, Statistical Modelling and Computational learning (PASCAL2)" is to coordinate all the educational and dissemination activities as well as the knowledge transfer.

The unit KTT was established on 1 July 2009 under CT3 as financial sub-unit, with projects transferred there from the Technology Transfer Office/U9. In 2009 the KTT ran a total of 9 projects. FP6/FP7 projects: ICT RTD Technological Audit for Slovenia, Medossic, kidsINNscience and Cosmos; the national projects: TT-PRO technology transfer from public research organizations in the industry (TIA) and KTT-Communication and Technology Transfer (MHEST) and the internal projects: JSI technology transfer, Communication of technology, JSI cyclotron.

Through research we improve our knowledge of the economy and work together with many Slovenian and foreign organizations in creating innovation and development policies.

Research carried out in 2009: (a) Analysis of the financing the technology transfer and integration of science with the school system [International Conference PODIM09], (b) A comparative study of the effectiveness of the commercialization of new technologies in 16 European institutes, and especially for high-energy physics [CERN TT Network], (c) Study of the results of the research community in the field of ICT in FP6/FP7 [ICT Audit project], (d) Study on environmental technologies and eco-innovation [Medossic project], (e) The methodology for assessing effectiveness of technology transfer [project PRO TT], (f) A study on the need for pre-incubators in the PRO and the possible procedures for the spinning-off at JRO [project KTT].

We have established an online entry point to the IJS with a list of the JSI's competences for communication with industry and the public: http://tehnologije.ijs.si. We obtained funding for patent applications in Slovenia and the PCT applications, which allows for assessments of commercialization and exploration strategies for the commercialization of industrial property, in cooperation with the Commission of the Industrial Property Protection. We advised in seven cases on spinning-off and in more than 10 cases on patent applications. One inventor of the JSI we connected with foreign venture capital investors, we supported financially five Slovenian and 11 PCT patents, and we also pay the ongoing maintenance fees for 22 patents. We have helped one company (a JSI start-up on the basis of intellectual property of the JSI) in obtaining funds from the Enterprise Fund, which they invested in equipment for their further development and growth.

As experts for the commercialization of RTD results, other inventors, researchers and entrepreneurs from Slovenia are also approaching us for advice. In 2009 we helped five (Sava, Brest, ETA, + 2 more) to carry out contract research. To increase active cooperation between researchers and industry we were involved in writing one successfully obtained research investment project (TIA) and one interdisciplinary project (JAPTI) and assisted more JSI departments with the preparation and submission of EU projects.

- **The KTT Laboratory is supporting knowledge and technology transfer from research to the business and educational sphere.**
- **Innovation, innovation management and the implementation of specific technology projects are our main research work in cooperation with CERN, MIT, KU Leuven, EPFL and others.**

Together with the Department F2, we carried out coordination meetings in order to implement the project Cyclotron, with the Ministry of Finance and MHEST and the project has now been supported by several Slovenian institutions (COSYLAB, Oncology Institute, FKKT).

To increase networking and technology-transfer abilities of domestic and foreign scientists' we organized several seminars, workshops and round tables and lectured within them. The most important are: (a) the lecture "Intellectual property, patent protection and academic entrepreneurship"

for young researchers at the Chemistry Institute, (b) the round table "Modernization of universities and institutes to increase the commercialization of technology: we are lagging behind changes" and "Businesses on the wings of innovation", both in the 4th Slovenian Innovation Forum, (c)" the 2nd International Conference on technology transfer ", (d) workshop "The spinning-off" in the context of this conference, (e)" the 2nd Annual Workshop on Materials for the study group of teachers of secondary schools", (f) two consecutive "Seminars on writing a business plan and academic entrepreneurship".

In 2009 more than 130 joint presentations of the departments were held. The Open Day visitors reached 250 at the Reactor Center and 600 at the Institute on Jamova street, the Institute was visited by a total of more than 1500 visitors. Businesses (17) have met with researchers through workshops and/or tours of the laboratories of the IJS; we also held presentations for school children and students (a total of around 1300 people), teachers in secondary schools (around 50), foreign researchers and various delegations and visits to various public services (five visits, for example, NATO, Lakeside Labs, students in Singapore, OECD delegation, the delegation ESA).

Figure 3: Three circles work of the KTT Laboratory.

We are the editors of the information center for journalists, the online newsletter IJSplet and publish the online newspaper IJSplet, which is then received 10 times annually by more than 140 journalists. We are active as foreign reviewers for the Austrian Ministry for Science in the new scientific program "Sparkling Science" and are listed among JAPTI and TIA reviewers for technology projects.

Some outstanding publications in the past three years

1. Michael J. Witbrock, Marko Grobelnik, Mitja Jermol, Jaro Berce, Peter Papler, Vlado Dimovski. An integrated analytical environment for irregular warfare using advanced semantic, knowledge and context technologies. V: RTO-MP-SAS-071 Analytical Tools for Irregular Warfare. [S. l.]: NATO Research and Technology Organisation, 2009-, 20 str. http://www.rto.nato.int/Pubs/RDP.asp?RDP=RTO-MP-SAS-071.
2. Jaro Berce, Darko Štamfelj, Vlado Dimovski, Sandra Penger, Judita Peterlin, Marko Grobelnik, Mitja Jermol, Dunja Mladenić. "Razvoj sistema upravljanja z znanji v Slovenski vojski" : poročilo. Ljubljana: Univerza v Ljubljani, Fakulteta za družbene vede, Center za metodologijo in informatiko: Institut "Jožef Stefan": Univerza v Ljubljani, Ekonomska fakulteta, 2009. 105 f., ilustr.

Awards and appointments

1. Mitja Jermol: World Summit Award in E-Science & Technology, Monterrey, Mexico, United Nations, Videolectures.Net portal

Organization of conferences, congress and meetings

1. Opening meeting of the EU project VIDI, Bled, 2.2.–3.2.2009
2. Seminar "Production management and informatics", Ljubljana, 2.2.–6.2.2009
3. 4th Student competition in computer science, Ljubljana, 28.3.2009
4. Seminar "Automation and information projects", Ljubljana, 30.3.–3.4.2009
5. International seminar "Analysis of Environmental Data with Machine Learning Methods", Ljubljana, 4.5.–8.5.2009
6. Pascal 2 workshop "Open Knowledge – video as a 'first-class citizen'", Bled, 20.5.–22.5.2009
7. 2nd plenary meeting of the EU project VIDI, Bled, 16.6.2009
8. Project meeting of the EU project NeON, Dubrovnik, 24.–26.6.2009
9. First Active Summer School on Advanced Technologies for Knowledge-Powered Enterprise, Bled, 4.9.–6.9.2009
10. Third International Workshop on Machine Learning in Systems Biology (MLSB), Ljubljana, 5.9.–6.9.2009
11. The European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML PKDD), Bled, 7.9.–11.9.2009
12. Project meeting of the EU project Pascal 2, Bled, 12.9.2009
13. General meeting of the EU project COIN, Bled, 9.10.–11.10.2009
14. Seminar "Building blocks for computer automation", Ljubljana, 2.11.– 6.11.2009

15. All about business plan Workshop, Ljubljana, 21.12.2009
16. Spinning-off on the basis of five submitted cases from public research organizations in Slovenia Workshop, Ljubljana, 1.10.2009
17. Intellectual property, patent protection and academic entrepreneurship Workshop, Ljubljana, 9.10.2009
18. Technology transfer Conference, Ljubljana, 1.10.-2.10.2009
19. Opening meeting of the EU project VIDI, Bled, 2.2.–3.2.2009
20. Seminar "Production management and informatics", Ljubljana, 2.2.–6.2.2009
21. 4th Student competition in computer science, Ljubljana, 28.3.2009
22. Seminar "Automation and information projects", Ljubljana, 30.3.–3.4.2009
23. International seminar "Analysis of Environmental Data with Machine Learning Methods", Ljubljana, 4.5.–8.5.2009
24. Pascal 2 workshop "Open Knowledge – video as a 'first-class citizen'", Bled, 20.5.–22.5.2009
25. 2nd plenary meeting of the EU project VIDI, Bled, 16.6.2009
26. Project meeting of the EU project NeON, Dubrovnik, 24.–26.6.2009
27. First Active Summer School on Advanced Technologies for Knowledge-Powered Enterprise, Bled, 4.9.–6.9.2009
28. Third International Workshop on Machine Learning in Systems Biology (MLSB), Ljubljana, 5.9.–6.9.2009
29. The European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML PKDD), Bled, 7.9.–11.9.2009
30. Project meeting of the EU project Pascal 2, Bled, 12.9.2009
31. General meeting of the EU project COIN, Bled, 9.10.–11.10.2009
32. Seminar "Building blocks for computer automation", Ljubljana, 2.11.– 6.11.2009
33. All about business plan Workshop, Ljubljana, 21.12.2009
34. Spinning-off on the basis of five submitted cases from public research organizations in Slovenia Workshop, Ljubljana, 1.10.2009
35. Intellectual property, patent protection and academic entrepreneurship Workshop, Ljubljana, 9.10.2009
36. Technology transfer Conference, Ljubljana, 1.10.-2.10.2009

INTERNATIONAL PROJECTS

1. Cooperation of Space NCPs as a Means to Optimise Services
   COSMOS
   7. FP, 218813
   EC; Dr. Adrien Klein, Deutsches Zentrum für Luft und Raumfahrt e.v., (DLR), Köln, Germany
   Dr. Špela Stres, Dr. Boris Pukl, Prof. Spomenka Kobe
2. Innovation in Science Education - Turning Kids on to Science
   KidsINNscience
   7. FP, 244265
   EC; Nadia Prauhart, Markus Meissner, Austrian Institute of Ecology, Österreichisches Ökologie-Institut, Vienna, Austria
   Dr. Špela Stres, Tomaž Ogrin, M. Sc.
3. European Inter-Disciplinary Research on Intelligent Cargo for Efficient, Safe and Environment-friendly Logistics
   EURIDICE
   7. FP, 216271
   EC; Paolo Paganelli, INSIEL - Informatica per il Sistema Degli Enti Locali s.p.a, Trieste, Italy
   Mitja Jermol, M. Sc., Marko Grobelnik, Asst. Prof. Dunja Mladenič
4. Enabling the Knowledge Powered Enterprise
   ACTIVE
   7. FP, 215040
   EC; Dr. Paul Warren, British Telecommunications plc, London, Great Britain
   Mitja Jermol, M. Sc., Marko Grobelnik, Asst. Prof. Dunja Mladenič, Asst. Prof. Mihael Mohorčič
5. Pattern Analysis, Statistical Modelling and Computational Learning 2
   PASCAL 2
   7. FP, 216886
   EC; John Shawe Taylor, University of Southampton, Southampton, Great Britain
   Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
6. 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
7. 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; Tudomanyos es Technologiai Alapitvany, Budapest, Hungary
   Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Marko Grobelnik
8. 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
9. 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 Mikuž
10. 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
    Mitja Jermol, M. Sc., Asst. Prof. Dunja Mladenič, Prof. Marko Mikuž
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. Slovenia - RTD Technological Audit 2009/0030
    30-CE-0262075/00-96
    EC; Dr. Stephan Pascall, DG INFSO, Brussels, Belgium
    Dr. Špela Stres
14. Opencast Matterhorn Project
    University of California, Berkeley, CA, USA
    Mitja Jermol, M. Sc.

NEW CONTRACTS

1. Development of the first part of the integrated environment for the profit intelligence application "Business Introspector"
   3TRIS, d.o.o.
   Mitja Jermol, M. Sc.
2. Analysis of the condition of Inner Karst and the Southeast regions and synthesis of analysis of the condition of the area of the MEDOSSIC project partners
   RDA of the Inner Karst Region
   Dr. Špela Stres
3. TT-PRO Technology Transfer from Public Research Organizations to the industry (TIA)
   Public Agency for Technological Development of Slovenia
   Dr. Špela Stres
4. KTT - Communication and technology transfer: financing the operation of public universities and public research institutes in the field of technology transfer
   Ministry of Higher Education, Science and Technology
   Dr. Špela Stres
5. ICT RTD Technological audit for Slovenia
   DG INFSO
   Dr. Špela Stres

VISITORS FROM ABROAD

1. John Davies, British Telecom, GB, 16.2.2009
2. Paul Warren, British Telecom, GB, 16.2.2009
3. John Shawe-Taylor, University College London, GB, 27.3.2009
4. Tobias Bürger, STI Innsbruck, Austria, 4.9.–6.9.2009
5. Rayid Ghani, Accenture Technology Labs, USA, 4.9.–6.9.2009
6. Michael Witbrock, Cycorp.Inc, USA, 4.9.–6.9.2009
7. Lise Getoor, University of Maryland, USA, 4.9.–6.9.2009
8. Neel Sundaresan, eBay, USA, 4.9.–6.9.2009
9. Pat Moore, Bloomberg, USA, 4.9.–6.9.2009
10. Paolo Paganelli, Insiel, Italy, 4.9.–6.9.2009
11. Denny Vrandečić, Karlsruhe Institute of Technology, Germany, 4.9.–6.9.2009
12. Marcel Tilly, European Microsoft Innovation Center, Germany, 4.9.– 6.9.2009
13. Ian Mulvany, Nature, GB, 4.9.–6.9.2009
14. Ugo Negretto, ENICMA, Italy, 22.9.–25.9.2009
15. Kenneth A. Goldman, MIT, USA, 1.10.– 2.10.2009
16. Matteo Ametis, Veneto Inovazione, Italy, 1.10.–2.10.2009
17. Bernard Denis, CERN, Switzerland, 1.10.–2.10.2009
18. Rudi Cuyvers, K.U. Leuven R&D, Belgium, 1.10.–2.10.2009
19. Gabriel Clerc, EPFL, Switzerland, 1.10.–2.10.2009
20. Ashok Devata, MBA/EMC, USA, 1.10.–2.10.2009
21. Andrea Di Anselmo, META-group, Italy, 1.10.–2.10.200
22. Jean-Marie Le Goff, CERN, Switzerland, 1.10.–2.10.2009
23. Domagoj Oreb, Rudjer Innovations, Croatia, 1.10.–2.10.2009
24. Claudia Prueggler, MBA, Lakeside Labs, Austria, 1.10.–2.10.2009
25. Jarno Salonen, VTT, Finland, 1.10.–2.10.2009
26. Ugo Negretto, ENICMA, Italy, 4.11.–6.11.2009

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6. Marjana Plukavec, B. Sc.
7. Špela Sitar, B. Sc.

Technical and administrative staff
8. Sebastjan Mislej

BIBLIOGRAPHY

Published Conference Papers

Regular papers

1. Marko Grobelnik, Dunja Mladenić, Jure Ferlež, "Probabilistic temporal process model for knowledge processes: handling a stream of linked text", In: *Zbornik 12. mednarodne multikonference Informacijska družba - IS 2009, 12.-16. oktober 2009: zvezek A: volume A*, (Informacijska družba), Marko Bohanec, ed., Matjaž Gams, ed., Vladislav Rajkovič, ed., Tanja Urbančič, ed., Mojca Bernik, ed., Dunja Mladenić, ed., Marko Grobelnik, ed., Marjan Heričko, ed., Urban Kordeš, ed., Olga Markič, ed., Jadran Lenarčič, ed., Leon Žlajpah, ed., Andrej Gams, ed., Olga S. Fomichova, ed., Vladimir Fomichov, ed., Andrej Brodnik, ed., Ljubljana, Institut Jožef Stefan, 2009, pp. 222-227.
2. Špela Stres, "The challenges of R & D activities in public research domain for profitable products: (social capital and technology flows)", In: *The winning products: [challenges of developing profitable products and services]: proceedings of the 29th Conference on Entrepreneurship and Innovation Maribor - PODIM, Maribor, 25th - 26th March 2009*, Miroslav Rebernik, ed., Barbara Bradač, ed., Matej Rus, ed., Maribor, IRP Institute for Entrepreneurship Research, 2009, pp. 245-247.
3. Michael J. Witbrock, Marko Grobelnik, Mitja Jermol, Jaro Berce, Peter Papler, Vlado Dimovski, "An integrated analytical environment for irregular warfare using advanced semantic, knowledge and context technologies", In: *RTO-MP-SAS-071 Analytical Tools for Irregular Warfare*, [S. l.], NATO Research and Technology Organisation, 2009-, 20 pp..

Research Monograph

1. Špela Stres, Marjeta Trobec, France Podobnik, *Raziskava o stanju inovacijske dejavnosti v Sloveniji s predlogom aktivnih ukrepov za spodbujanje konkurenčnosti in inovativnosti v slovenskem gospodarstvu*, Ljubljana, Javna agencija RS za podjetništvo in tuje investicije, 2009.

MILAN ČOPIČ NUCLEAR TRAINING CENTRE ICJT

The mission of our centre is training in the field of nuclear technologies and radiation protection. In addition, we are actively informing the public about these technologies.

Head:
Prof. Igor Jenčič

Training in the area of nuclear technologies is our primary mission. After a couple of relatively modest years, we have faced a very high demand for this type of training in the last period. For the first time in the history of the Nuclear Training Centre, there were two courses in *Nuclear technology*, which is the initial training for future control-room operators, in the same calendar year. The first started in the autumn of 2008 and ended in the spring of 2009, and the second started in the autumn of 2009. In addition, two courses on the *Basics of nuclear technology* were conducted. These courses are intended for non-control-room personnel of a NPP, and there were also many participants from other organizations working in the area. The course *SNSA advanced training using simulators* was organized for the regulatory body. In collaboration with the Reactor Physics Division we have conducted two courses on the use of reactor-core calculation programs.

There were 29 **radiological protection training** courses for the medical, industrial and research use of radioactive sources.

Public information remains a very 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 180 groups, or 7507 visitors, this year. Since 1993, our information centre has been visited by a total of 120,692 pupils, teachers and other visitors. We have continued monitoring and analyzing media reports on nuclear energy. We have taken over the responsibility of running the *Fusion Expo,* which is financed by the European Fusion Development Agreement. This travelling exhibition on fusion has been set up in Ljubljana (Slovenia), Prague (Czech Republic), Koszalin, Szczecin, Łodz, Katowice (Poland), Dublin and Cork (Ireland).

We have taken over the responsibility of running the *Fusion Expo*. This travelling exhibition about fusion has been set up in 8 European cities.

Figure 1: Young cyclists are surprised at the effort necessary to light a few light-bulbs.

Figure 2: Nuclear technology course, theory (TJET10)

Figure 3: Model of ITER at the Fusion Expo

Figure 4: 20th anniversary of the Nuclear Training Centre

Table of training activities at Nuclear Training Centre in 2009

Date	Title	Partici-pants	Lecturers	Weeks	Participant x weeks
(10.11.08)–27.3.	Nuclear technology, theory	13	18	11.4	148.2
2.3.-13.3.	Additional training for radiation protection unit workers of Krško NPP	5	23	2	10
24.3.	Training Extension for RP Officers	10	2	0.2	2
30.3.-1.4.	Radiation protection for industrial and other practices (unsealed sources)	5	5	0.6	3
30.3.-15.7.	Radiation protection for medical and veterinary workers	3	6	0.6	1.8
30.3.-1.4.	Radiation protection for industrial and other practices (sealed sources)	4	4	0.6	2.4
7.4.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	10	4	0.2	2
7.4.	Radiation protection for industrial and other practices (unsealed sources) - Refresher Course	10	4	0.2	2
7.4.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	6	3	0.2	1.2
7.4.	Radiation protection for industrial and other practices (measurement of roadway density and humidity) - Refresher Course	4	5	0.2	0.8
9.4.	Training Extension for RP Officers	9	2	0.2	1.8
21.4.-23.4.	Radiation protection for industrial and other practices (Ministry of Defense)	17	2	0.6	10.2
4.5.-29.5.	Basics of nuclear technology, theory	17	10	4	68
18.5.-11.6.	SNSA advanced training using simulators	17	7	1.8	30.6
1.6.-26.6.	Basics of nuclear technology, systems	16	8	4	64
9.6.-11.6.	Radiation protection for industrial and other practices (Ministry of Defense)	27	2	0.6	16.2
10.6.-12.6.	Use of programs FAR, LOADF, BORDIL in INHOUR	6	4	0.6	3.6
17.6.-18.6.	Radiation protection for Cinkarna Celje Workers - Refresher Course	10	1	0.4	4
5.10.-7.10.	Radiation protection for industrial and other practices (sealed sources)	10	4	0.6	6
5.10.-7.10.	Radiation protection for medical and veterinary workers - Nuclear medicine workers	3	5	0.6	1.8
5.10.-9.10.	Radiation protection for industrial and other practices (unsealed sources)	3	11	1	3
9.10.-13.10.	Radiation protection for Nuclear Medicine Dpt. - Refresher Course	3	6	0.4	1.2
12.10.-6.11.	Basics of nuclear technology, theory	14	10	4	56
13.10.	Radiation protection for industrial and other practices (sealed sources) - Refresher Course	17	4	0.2	3.4
13.10.	Radiation protection for industrial and other practices (measurement of roadway density and humidity) - Refresher Course	4	4	0.2	0.8
13.10.	Radiation protection for industrial and other practices (radiography) - Refresher Course	2	4	0.2	0.4
15.10.	Training Extension for RP Officers	9	2	0.2	1.8
20.10.-22.10.	Radiation protection for industrial and other practices (Ministry of Defense)	27	4	0.6	16.2
26.10.	Radiation protection for industrial and other practices (Ministry of Defense, Occasionally Exposed workers)	13	4	0.2	2.6
29.10.-2.11.	Radiation protection for industrial and other practices (sealed sources) (Ministry of Defense)	14	3	0.6	8.4
5.11.	Radiation protection for industrial and other practices (Ministry of Defense, Occasionally Exposed Workers)	16	3	0.2	3.2
9.11.-4.12.	Basics of nuclear technology, systems	13	8	4	52

Date	Title	Partici-pants	Lecturers	Weeks	Participant x weeks
16.11.	Radiation protection for industrial and other practices (Ministry of Defense, Occasionally Exposed Workers)	16	3	0.2	3.2
18.11.-20.11.	Radiation protection for industrial and other practices (Ministry of Defense)	9	4	0.6	5.4
24.11.-26.11.	Radiation protection for industrial and other practices (Ministry of Defense)	18	3	0.6	10.8
8.12.-17.12.	Use of programs for core analysis (LOADF, SHUFFLE in INCORE-3D)	4	4	0.6	2.4
16.11.-(9.4.2010)	Nuclear technology, theory	20	21	6	120
TOTAL		416	220	49.2	681.6

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 Support Action under EFDA Workprogramme
   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., Asst. Prof. Igor Lengar, Asst. Prof. Saša Novak Krmpotič, Štefan Kolenko
3. Production of Plasma Ball Support Structure, Appropriate for Transport
   SI2.
   O. Quintana Trias, European Commission, DG RTD J.1; CDMA, Brussels, Belgium
   Melita Lenošek, B. Sc.

NEW CONTRACTS

1. Operation of the Nuclear Information Centre in 2009
   GEN, d. o. o.
   Prof. Igor Jenčič
2. Inplementation of 2009 training program for Krško NPP
   Krško Nuclear Power Plant
   Prof. Igor Jenčič
3. Operation of the Nuclear Information Centre in 2009
   Arao
   Prof. Igor Jenčič
4. Implementation of the training program in the field of radiation protection
   Other national buyers
   Matjaž Koželj, M.Sc.
5. Implementation of the training program Technology of Nuclear Power Plants - Theory
   GEN, d. o. o.
   Prof. Igor Jenčič

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3. *Peter Jan, B. Sc., left 29.10.09*
4. *Andrej Kavčič, B. Sc., left 01.10.09*
5. Matjaž Koželj, M. Sc.
6. Tomaž Skobe, B. Sc.

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8. Matejka Južnik, M. Sc.
9. Melita Lenošek, B. Sc.
10. Borut Mavec, B. Sc.

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1. Bruno Cvikl, Matjaž Koželj, "On the difference between drift and drift-diffusion interpretation of electron current in single layer metal/organic semiconductor structure", In: *Proceedings*, 45th International Conference on Microelectronics, Devices and Materials and the Workshop on Advanced Photovoltaic Devices and Technologies, September 9 - September 11, 2009, Postojna, Slovenia, Marko Topič, ed., Janez Krč, ed., Iztok Šorli, ed., Ljubljana, MIDEM - Society for Microelectronics, Electronic Components and Materials, 2009, pp. 69-74, 2009.
2. Radko Istenič, Igor Jenčič, "Public opinion about nuclear energy - year 2009 poll", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 4 pp.
3. Matjaž Koželj, Igor Jenčič, "Current status of functions, responsibilities and training of radiation protection officers in Slovenia", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 5 pp.
4. Luka Snoj, Saša Novak, Igor Lengar, Melita Lenošek, "Promotion of fusion in Slovenia: current activities and future chalenges", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 6 pp.

RADIATION PROTECTION UNIT SVPIS

The SVPIS has been involved in ionizing-radiation measurements and radiation protection since the commissioning of the TRIGA Reactor in 1966. The responsibility of the SVPIS is the radiation control of all the activities at the Institute dealing with ionizing radiation. Our main task is the supervision of the Reactor and the 17 laboratories that use sources of 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 SVPIS 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 the accredited method EN ISO/IEC 17025.

Head:
Matjaž Stepišnik, M. Sc.

Personal dosimetry

The personal doses of 106 workers that regularly or occasionally deal with ionizing radiation were monitored with Thermo Luminescent Dosimeters (TLDs). The maximum individual yearly dose was 0.08 mSv. This is only 0.4 % of the regulatory limit for occupational workers (20 mSv per year) and 8 % of the limit for the general public (1 mSv per year). The collective dose at JSI in 2009 was 0.37 man mSv.

Supervision of the 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 2009 we performed 22 inspections of radiation levels and contamination in the JSI laboratories. At present, 101 sources of radiation are used, which require the regulatory control of the Nuclear Safety Administration, and 361 low-activity sources are also used.

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 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 2009 due to the 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, 38 radiological control investigations were carried out in industrial, medical and research institutions. Some exposure-assessment reports for occupational workers were prepared as well.

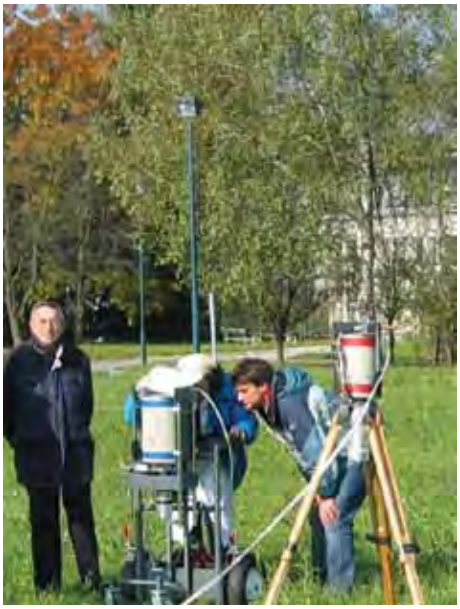

Figure 1: In-situ measurements at the reactor site

NEW CONTRACT

1. Inspections of the sources of ionizing radiation
   Institute of Occupational Safety
   Matjaž Stepišnik, M. Sc.

STAFF

Technical officers
1. Dr. Tinkara Bučar

Technical and administrative staff
2. Emira Bašić, B. Sc.
3. Thomas Breznik, B. Sc.
4. Bogdan Pucelj, M. Sc.
5. **Matjaž Stepišnik, M. Sc., Head**

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1. Bogdan Pucelj, "Doza zunanjega sevanja", In: *Meritve radioaktivnosti v okolici Nuklearne elektrarne Krško: poročilo za leto 2008*, Boštjan Črnič, ed., Denis Glavič-Cindro, ed., Ljubljana, Institut "Jožef Stefan", 2009, pp. 93-158-105-158.
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4. Matjaž Stepišnik, "Ocena letnih doz referenčne skupine za savske prenosne poti za leto 2005", In: *Meritve radioaktivnosti v okolici Nuklearne elektrarne Krško: poročilo za leto 2008*, Boštjan Črnič, ed., Denis Glavič-Cindro, ed., Ljubljana, Institut "Jožef Stefan", 2009, pp. 133-158-138-158.

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2. Matjaž Stepišnik, Bogdan Pucelj, Luka Snoj, Matjaž Ravnik, "Activity analysis of primary coolant in TRIGA Mark II research reactor", In: *Proceedings*, International Conference Nuclear Energy for New Europe 2009, Bled, Slovenia, September 14-17, Leon Cizelj, ed., Boštjan Končar, ed., Matjaž Leskovar, ed., Ljubljana, Nuclear Society of Slovenia, 2009, 5 pp.

TECHNOLOGY TRANSFER OFFICE U-9

The Technology Transfer Office's activities are focused on:

- ***increasing the number of applied-development projects at the Institute,***
- ***ensuring the best environment for the development and work of technologically demanding and entrepreneurial projects,***
- ***searching for and performing new ways of technology and knowledge transfer from the Institute into the business environment.***

The activities in 2009 were implemented through the following projects:

- ***Participation in the "Enterprise Europe Network" project.***
- ***Work within the project "Act Clean".***
- ***Involvement in the UN (United Nations) and NATO (North Atlantic Treaty Organization) activities related to the legacy of Uranium extraction and its impact on the environment in Central Asia.***
- ***Collaboration with the Jožef Stefan International Postgraduate School.***

Head:
Prof. Peter Stegnar

Within the "**Enterprise Europe Network**" project, we supported research organisations, as well as enterprises, professional and sectorial associations, technological centres and all others to make the best use of the opportunities in the European Union. "Enterprise Europe Network" was established at the beginning of 2008 by the European Commission, General Directorate for Enterprise and Industry. The biggest entrepreneurial support network in Europe was created by joining the Euro Info Centres (EICs) and the Innovation Relay Centre (IRC) networks and is now active in over 40 countries. Six Slovenian partners, co-ordinated by our office, offer assistance in three areas: a) assistance at internationalisation activities, b) assistance at innovation, technology and knowledge transfer and c) assistance in applying for EU projects. The Technology Transfer Office was, within this project, assisting researchers and entrepreneurs mostly by establishing national and international contacts that led to discussions about concrete technology & development co-operation and with establishing partnerships for applications on EU calls. We visited over 60 researchers and entrepreneurs, answered to over 90 individual questions about open calls, financing possibilities, possible development partnerships, etc. We identified and promoted through the network 22 Slovenian innovations. Based on these and other activities, 4 international contracts for R&D co-operations were signed, Slovenian researchers and enterprises submitted six EU projects with our assistance.

With our help, the company Lotrič, d. o. o. successfully submitted a project proposal for the call of the Slovenian Ministry of Higher Education, Science and Technology. Based on this they will, for the first time, cooperate with JSI – they will be developing an intelligent information system for healthcare laboratories together with the Department of Intelligent Systems.

Act Clean

EU directives and regulations require enterprises to comply with environmental standards and ensure eco-efficient production processes.

As a response, Central European countries have substantially increased their capacity in the field of environmental technologies and management systems in recent years. Nevertheless, the problem remains that this capacity is not sufficiently applied throughout the area.

On one site, many SMEs still struggle or even fail to respond to the EU requirements, as they do not have access to the existing technological or managerial solutions developed in other parts of the region. On the other hand, those SMEs that offer eco-efficient technologies and management tools often have no access to the markets where demand for their products exists.

To overcome this mismatch, "Act Clean" creates the first Central Europe-wide network for cleaner production. "Act Clean" connects outstanding national institutions in the field of cleaner production from all over the region.

The project's partners are: Federal Environmental Agency from Germany – lead partner, Cleaner Production Center Austria Ltd., CENIA – Czech Environmental Information Agency, Hungarian Cleaner Production Centre/

Figure 1: Over 4500 international innovations and technologies can be seen on the project's web page www.een.si

Figure 2: Field work at the uranium tailings pile Digmay, Tajikistan

Corvinus University of Budapest, Jozef Stefan Institute (JSI) from Slovenia, Italian National Agency for New Technologies, Energy and Environment, Central Mining Institute Poland and Slovak Cleaner Production Centre/ PROVENTUS.

We started the project in 2009 with a kick-off meeting in Berlin and we also met at the first "Act Clean" workshop in Graz, where all the partners presented Country Reports on the environmental situation regarding EU directives and regulations in their own countries. These reports serve as a basis for further work. We have also presented good practices from Slovenia and the needs for new technologies.

From the JSI, in addition to the Technology Transfer Office, the Department of Inorganic Chemistry and Technology and Department of Environmental Sciences is also participating in the project.

Activities:

- Exchange of experience among cleaner-production experts and institutions across Central Europe and the development of joint working procedures.
- Identification of the most apparent needs of SMEs in each country to enhance cleaner production.
- Identification of cleaner-production highlights throughout the region.
- Matchmaking of supply and demand for environmentally friendly technologies and activities between SMEs in Central Europe.
- Development and promotion of a transnational toolbox, bringing together the best available tools to support SMEs in their cleaner-production efforts.

Outputs:

- The transnational "Act Clean" network with permanent national contact points, connecting 200 outstanding institutions in the field of cleaner production.
- A good-practice database with over 1000 good-practice examples of environmentally friendly technologies and activities.
- A minimum of 2500 SMEs reached via the "Act Clean" network.
- A cleaner-production toolbox providing SMEs with selected tools for eco-efficiency.
- Policy recommendations on incentives for the introduction of eco-innovations in SMEs.

The Technology Transfer Office was involved in the UN (United Nations) and NATO (North Atlantic Treaty Organization) activities related to the legacy of Uranium extraction and its impact on the environment and human health in the Central Asian (CA) countries of Kazakhstan, Kyrgyzstan, Uzbekistan and Tajikistan. This involvement was offered to, and implemented at, the regional UNDP (United Nations Development Programme) office in Bishkek, Kyrgyzstan, and concluded with the regional conference in Bishkek and the donors' conference in Geneva. A Framework Document was prepared and dealt with the environmental protection issues related to uranium legacy sites and their potential impact on the environment, in particular in the densely populated, socially and politically sensitive Ferghana Valley in the CA region. Several priority projects were prepared for remediation/ rehabilitation purposes of the affected areas and presented to international donor institutions for funding.

Figure 3: Radioactive, chemical and biological hazards in Central Asia

A NATO SPS (Science, Peace, Security) project related to uranium legacy issues was completed and the final report is in process. The scientific/research institutions from CA that actively participated in the project received analytical equipment for environmental radioactivity measurements and the scientists involved in the project were trained in dedicated training courses and field missions. The results obtained showed the relatively low impact of radioactive substances on the environment and human health. However, in some of the legacy sites, specific situations associated with the elevated exposure of the resident public to ionizing radiation, were observed. These situations requested the implementation of immediate countermeasures to minimize the exposure of people to radioactivity, in particular at the places with high possibilities of the expected natural threats due to earthquakes, landslides and flooding.

The Technology Transfer Office was, as in the previous years, actively involved in the education process at the Jožef Stefan International Postgraduate School. The majority of Ph.D. students are involved in the SPS project in CA, while others are engaged with radioactivity research in other environments and medicine. The students are presenting the results of their work alone or jointly with their supervisors and publishing the most important findings in internationally revised scientific journals.

Organization of conferences, congress and meetings

1. Technology Innovation International (TII) Summer School, Ljubljana, 7. 9. 2009 – 11. 9. 2009
2. Opportunities and cooperation with Israel in the field of life science, Ljubljana, 15. 4. 2009

Figure 4: The Enterprise Europe Network Slovenia Team

INTERNATIONAL PROJECTS

1. EIC&IRC Services in Support of Business and Innovation
   EACI-EIC&IRC Slovenia 1
   CIP - Competitiveness and Innovation
   European Commission, Executive Agency for Competitiveness and Innovation (EAIC), CIP Network Project Management Unit, Brussels, Belgium
   Prof. Peter Stegnar
2. 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
   Andrej Gyergyek, B. Sc., Asst. Prof. Sonja Lojen, Dr. Andrej Stergaršek
3. Uranium Extraction and Environmental Security in the Central Asian Republics
   NATO SfP - Uranium Extraction Legacy
   ESP.EAP.SFPP 981742
   NATO Public Diplomacy Division, North Atlantic Treaty Organisation, Brussels, Belgium
   Prof. Peter Stegnar

VISITORS FROM ABROAD

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4. Tefta Demeti, MBA, Ministry of Economy, Trade and Energy, Tirana, Albania, Gavril Lasku, ALBINVEST (Albanian Business and Investment Agency), Tirana, Albania, Gordana Prutki-Pečnik, Eracon, Zagreb, Croatia, 22. 9. 2009

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5. Marjeta Trobec, B. Sc.
Technical and administrative staff
6. Sonja Živkovič

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