

ČASOPIJS '22

The Jožef Stefan Institute in 2022



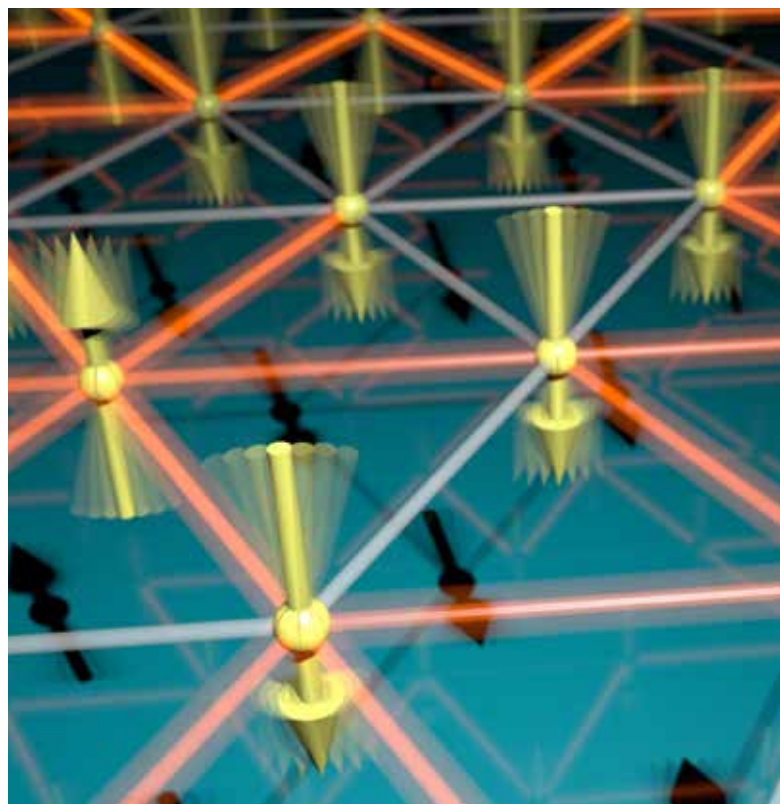
Dear Readers,

This brochure from the Jožef Stefan Institute (JSI) presents some of the many researchers who work in various fields and employ a wide range of techniques, but with a single aim – science. The Institute, with its almost 1,200 employees, can never hope to present all its scientific activities, nor can it show the efforts of every researcher who has played a part. However, this brochure, with its presentation of our researchers' many achievements during 2022, is a step in the right direction: describing our work and our Institute as vividly as possible. Researchers – indeed all those who work in science – are special people, often typified by a reluctance to step into the limelight. However, by showing you some of our achievements from last year, we would like to introduce you to our people and their work, and invite you to become a participant. At the Institute we are world-leading scientists, but we are also ordinary people who like to socialise, chat and come up with solutions to problems.

We would like to hear your feedback regarding this first edition of ČasopisJS, because your response will be central to deciding whether we should establish a tradition and continue to publish this brochure in future years. We look forward to hearing from you.

Prof. Dr Boštjan Zalar

Director of the Jožef Stefan Institute



ČasopisJS

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casopijs@ijs.si



Slovenian physicists discover a new form of quantum spin fluid

Ljubljana, 5 January 2022

Since 1950, when the Swiss physicist Gregory Hugh Wannier first predicted the state of a spin liquid (even at a temperature of absolute zero), an experimental confirmation has remained elusive. That was until a group from the JSI's Department of Condensed Matter Physics led by Assoc. Prof. Andrej Zorko discovered a new form of quantum spin liquid as part of an extensive experimental study of neodymium heptatantalate crystals. This investigation was able to confirm Wannier's theory, with the discovery being reported in the prestigious journal *Nature Materials*.

Magnetic materials, the magnetic character of which originates from the magnetic moments (spins) of individual ions in the crystal, are generally ordered at low temperatures. An example known since ancient times is magnetite, in which the neighbouring spins align in the same direction well above room temperature – ferromagnetically.

Nowadays, it is impossible to imagine life without such permanent magnets, as they are found in many devices, such as electric motors and generators, telephones, televisions, computers, etc. Magnetic ordering is associated with matter in the solid state. On the other hand, at a sufficiently high temperature, the individual spins can point in any direction. This so-called paramagnetic state is uncorrelated and is analogous to the gaseous state.

Spin fluids lie somewhere in between. They are a magnetic analogue of the liquid state, since the spins are disordered, but at the same time they are strongly correlated. In crystals where the geometry of the lattice

does not favour magnetic ordering, the spin-liquid state can be present, even at a temperature of absolute zero. This was first predicted by G. H. Wannier in 1950 for the case of a triangular lattice of spins with Ising antiferromagnetic coupling, which favours the ordering of spins in opposition along a certain direction. This prediction remained unconfirmed until this year. A group of Slovenian physicists from the JSI, consisting of Tina Arh, Matej Pregelj and Andrej Zorko, together with colleagues from the Institute for Mathematics, Physics and Mechanics and research institutions from India, the UK, France and the USA, reported on the first experimental evidence for such a state. The key to their breakthrough was the study of a magnetically uninvestigated compound using a wide range of complementary experimental techniques.

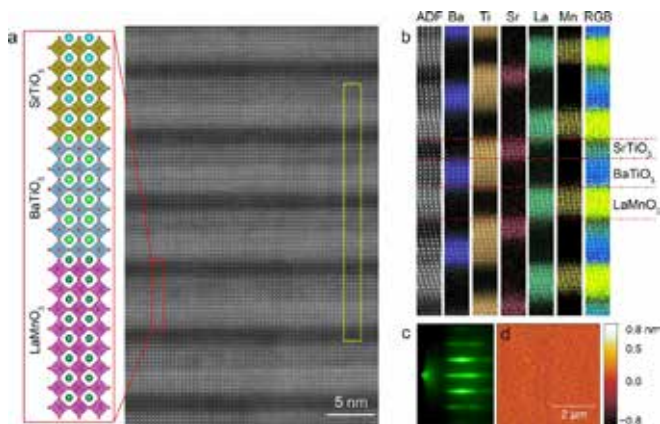
The extensive research activities, which were conceived and led by Assoc. Prof. Andrej Zorko, were carried out at various beamlines of the Rutherford Appleton

Laboratory (RAL) in the UK, the Institute Laue-Langevin (ILL) in France and at the National High Magnetic Field Laboratory (NHMFL) in the USA. Using a combination of neutron scattering, muon spectroscopy and electron-spin resonance, the researchers were able to show that in neodymium heptatantalate crystals the basic magnetic state is disordered, even at the lowest experimentally attainable temperatures (40mK, or $-273.11\text{ }^{\circ}\text{C}$), yet the neighbouring spins are antiferromagnetically correlated along the selected Ising direction. The state itself remains dynamic due to quantum fluctuations and introduces a new type of quantum-entangled spin liquid.

In addition to the scientific aspects, this discovery is potentially important in the context of modern quantum technologies. Spin fluids are some of the most promising platforms for quantum computing. The importance of the discovery is demonstrated by the fact that it was reported in the prestigious journal *Nature Materials*.

Matjaž Spreitzer participates in the development of the asymmetric heterostructure $\text{LaMnO}_3/\text{BaTiO}_3/\text{SrTiO}_3$

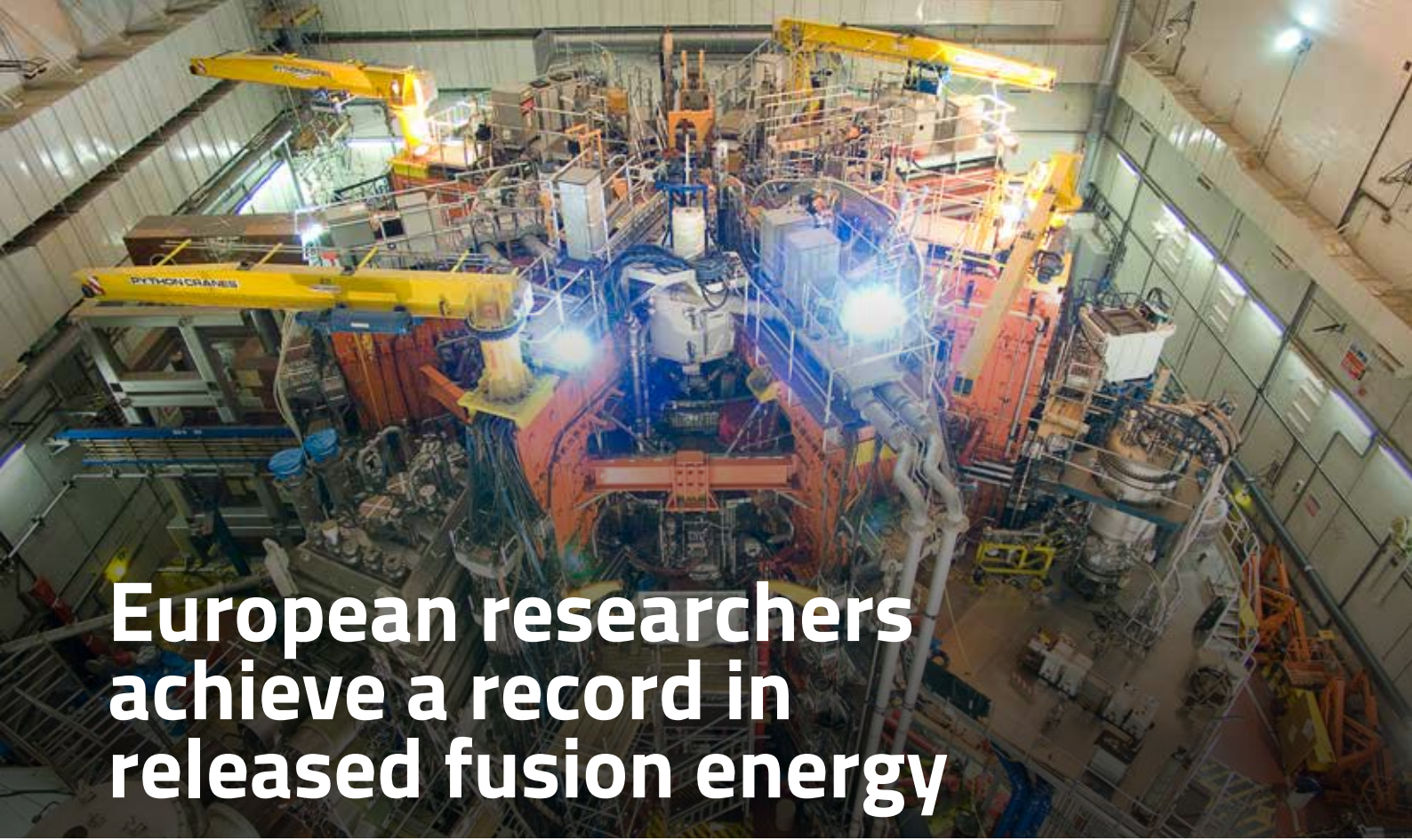
To incorporate the various functionalities of transition-metal oxides into modern electronics, it is essential to integrate oxide layers with controlled properties using a silicon platform. In collaboration with researchers from the Netherlands, Belgium, Switzerland and China, Assist. Prof. Matjaž Spreitzer from the Department of Advanced Materials at the JSI was involved in the development of the non-symmetrical heterostructure $\text{LaMnO}_3/\text{BaTiO}_3/\text{SrTiO}_3$, produced on silicon by controlling the layer thickness at the level of the primitive cell. By exploiting the coherent stress between the constituent layers, the researchers were able to prevent any biaxial thermal stress from the silicon, stabilize the BaTiO_3 layer with a *c*-axis orientation and increase the tetragonality of the compound. The results of the research were published in the prestigious journal *Nature Communications* in an article entitled *Signatures of enhanced out-of-plane polarization in asymmetric BaTiO_3 superlattices integrated on silicon*. The work was carried out under the guidance of Prof. Dr Gertjan Koster, a visiting scientist at the JSI's Department of Advanced Materials.



JSI signs letter of intent between the Slovenian and Carinthian governments to intensify cooperation with the Lakeside Science & Technology Park

Prof. Dr Simona Kustec, the Slovenian Minister of Education, Science and Sports, and Dr Peter Kaiser, the Governor of Carinthia, signed a letter of intent for cooperation between the Government of the Republic of Slovenia and the Government of the Land of Carinthia in the field of higher education, science and research on 2 February 2022. The initiative for the agreement came from Dr Špela Stres, Head of the Center for Technology Transfer and Innovation at the JSI, as a follow on from the excellent cooperation between the Institute and the Lakeside Science & Technology Park, Klagenfurt. "On the basis of this letter of intent, we will emphasise direct cooperation between research institutions and technology parks, knowledge exchange, cooperation in joint projects and cooperation between higher-education institutions, especially in the field of information and communication technologies." The same signed letter of intent will also be the basis for a special letter of intent between the JSI and the Lakeside Science & Technology Park, as well as for other forms of cooperation.





European researchers achieve a record in released fusion energy

Ljubljana, 9 February 2022

European researchers from the EUROfusion consortium, which includes 40 researchers from the JSI, achieved a breakthrough at the JET (Joint European Torus) experimental fusion reactor in Oxford, UK. The record 59 MJ of fusion energy proves the potential of fusion energy, which can ensure safe and efficient low-carbon energy production in the future.

The researchers of the EUROfusion consortium, which is co-financed by the European Commission and brings together 4,800 scientists, engineers, experts and students from all over Europe, including researchers from the JSI, associated in the Slovenian Fusion Association (SFA), are using the JET and produced a record 59 megajoules (MJ) of fusion energy.

At JET, the world's largest operating fusion device based at the UK Atomic Energy Authority (UKAEA) in Oxford, they more than doubled the previous record of 21.7 MJ achieved using the same device in 1997. The record was achieved as part of a carefully planned experimental campaign by the EUROfusion consortium and reflects more than two decades of progress in fusion research. The main goal of the campaign

is to provide as much scientific data as possible to support its operation, even during the construction of the larger and more advanced ITER fusion device in France.

ITER is an international fusion-research project based in the south of France. The aim of the project, which is supported by the European Union, Japan, the USA, China, India, South Korea and Russia, is to prove the scientific and technological feasibility of obtaining fusion energy.

With the growing drive for decarbonized energy production, success at JET is a major step in the development of fusion as a safe, efficient, low-carbon energy source in the battle against the global energy crisis.

Boštjan Zalar, the Director of the JSI: "The Institute is the largest, multidisciplinary scientific research institute in Slovenia.

Fusion research is an extremely important area of its activity, and we also run the Slovenian Fusion Association. More than 40 researchers of the Institute are involved in the EUROfusion consortium in various fields. A breakthrough in fusion research is therefore also a great success for JSI researchers."

Boštjan Končar, head of the Slovenian Fusion Association (SFA): "JET has produced almost three times more fusion energy than ever before. This is a giant leap towards sustainable fusion energy. The achievement is also the fruit of many years of hard work by the researchers of the Slovenian Fusion Association, especially in the field of neutron-transport calculations for JET, diagnostics, analysis and the preparation of fusion experiments."

JSI researchers among the recipients of the Prometheus of Science awards for excellence in communication for 2021

On 15 February 2022 the Slovenian Science Foundation announced the recipients of the Prometheus of Science Awards for Excellence in Communication for 2021. Among those chosen were Prof. Dr Igor Mekjavič, from the Department of Automation, Biocybernetics and Robotics, and Dr Melita Tramšek, from the Department of Inorganic Chemistry and Technology, and among the groups Prof. Dr Maja Remškar, from the Department of Condensed Matter Physics with colleagues Assist. Prof. Anton Gradišek, Dr Luka Pirker and Anja Pogačnik Krajnc. With the establishment of the Space Physiology Laboratory in Planica in October 2021 Prof. Dr Mekjavič solidified his status of excellent promoter of research in the field of environmental physiology in the recent years. Dr Melita Tramšek has brought science closer for more than 1,500 young people as part of the annual programme of the School of Experimental Chemistry; from 2019–2021 she organized the European Night of Researchers within the Institute. For the past two years, Prof. Dr Maja Remškar, together with her colleagues, has contributed through their professional and calm public presence to raising public awareness about the effectiveness of protective masks.



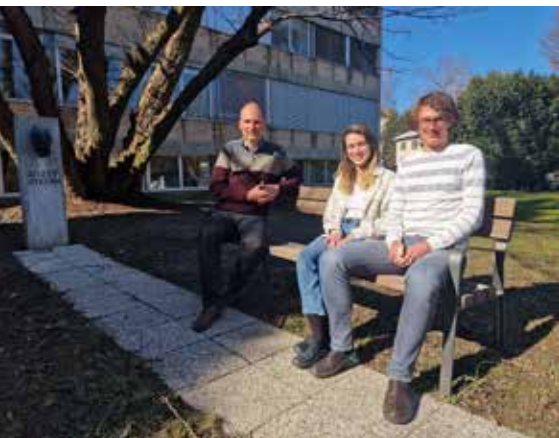
Giulia Della Pelle and Dr Save Stojanov among the winners of the CrossNano awards

The second CrossNano, Crossborder Workshop in Nanoscience and Nanotechnology, took place on 22–24 February 2022. The workshop was organized by the University of Trieste, the Jožef Stefan International Postgraduate School and the JSI. The workshop's aims are stronger crossborder cooperation between the participating institutions and our future scientists. Fifty-three students of nanoscience and nanotechnology from the PhD School in Nanotechnology from the University of Trieste, the Jožef Stefan International Postgraduate School, the University of Ljubljana and the University of Maribor participated this year. Giulia Della Pelle (Department of Nanostructured Materials, JSI) and Valeria Chesnyak (University of Trieste) received the *Fernando Tommasini* award for the most comprehensive presentation. Spase Stojanov (Department of Biotechnology, JSI) and Veronika Kost (University of Trieste) received the *Alessandro de Vita* award for the highest level of multidisciplinary and scientific curiosity. Congratulations to all the winners and their mentors.

11 February: International Day of Women and Girls in Science

On 11 February 2022 we celebrated the International Day of Women and Girls in Science, with the aim to end the differences when it comes to the representation of women and girls in this area. The equal representation of genders in science is also central to achieving internationally agreed goals for sustainable development. To ensure full and equal access to science for women and girls and to promote the role and participation of women and girls in the area, while continuing to achieve gender equality, in 2015 the United Nations General Assembly declared 11 February as the International Day of Women and Girls in Science. The special adviser to UN General Assembly president, Darja Bavdež Kuret, believes that we have strong foundations for the promotion of women in Slovenia. According to the data of the statistical office, the number of women enrolled in third-level higher education has been increasing since 2015/2016, with the share of female doctoral students being approximately 53%. The JSI also joins the International Day of Women and Girls in Science.





Discovery of distinct differences between domestic and wild strains of common yeast

Ljubljana, March 2022

Research groups from France, Sweden, Italy and Slovenia investigated the effect of domestication on the common yeast *Saccharomyces cerevisiae* and discovered distinct differences between domesticated and wild strains in the ability to reproduce sexually and grow under different conditions. The main contribution of the research group from the JSI's Department of Molecular and Biomedical Sciences led by Prof. Dr Uroš Petrovič is the discovery of the possibility of eliminating or introducing the properties of domesticated yeasts by editing the genome. The research was reported in the journal *Nature Ecology & Evolution*.

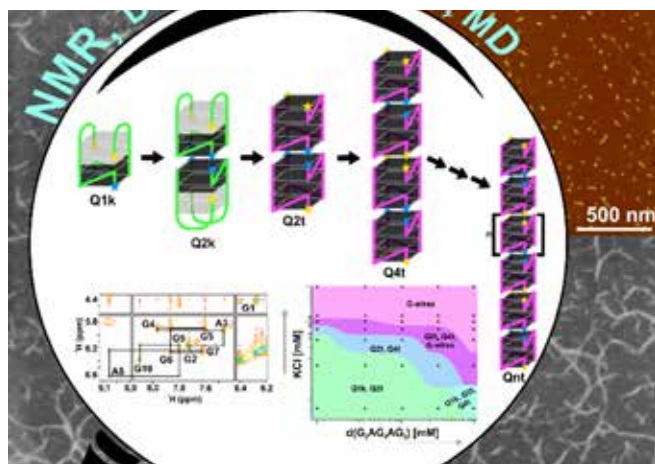
The yeast *Saccharomyces cerevisiae* has been known and used for thousands of years, in baking and the production of alcoholic beverages, and more recently for the production of biofuels and medicines such as insulin. The pioneer and one of the most important researchers of yeast biology and its genetics Dr Gianni Liti from Nice, France, who is also the author of the review of all domesticated yeasts, invited years ago a research group from the Department of Molecular and Biomedical Sciences of the JSI to participate. Researchers Gašper Žun, Katja Doberšek and group leader Prof. Dr Uroš Petrovič are using and developing a special technique for editing the genome, the so-called genetic scissors, discovered 10 years ago, and in 2020 Emmanuelle Charpentier and Jennifer A. Doudna won the Nobel Prize in Chemistry for this. The main contributions of the research

group of the JSI were experiments with the technique of gene scissors, or genome editing with CRISPR-Cas technology. In the study, research groups from France, Sweden, Slovenia and Italy investigated the effect of domestication on the common yeast *S. cerevisiae*, which, in addition to general use, is also one of the most important model organisms in biological research. They discovered distinct differences between the domesticated and wild strains in the ability to reproduce sexually and grow under different conditions. They determined the genetic origin of the characteristics of domesticated yeasts at the level of individual DNA nucleotides. What's more, they confirmed that these traits can be changed by editing the genome. Slovenian researchers answered one of the key questions of the research: can they change the characteristics of yeast with minimal genome editing? The answer is

yes, because they proved that by changing just one nucleotide, they could eliminate or introduce the specific properties of wild or domesticated yeasts. This was confirmed in the case of the ability to reproduce sexually. Slovenian researchers should have conducted a part of their research in the framework of this study in France, but due to the Covid-19 pandemic and the travel ban, all research took place in the laboratories of the JSI. Yeast strains were exchanged with French researchers by mail. Cooperation between the JSI and Dr Gianni Liti continues. Slovenian researchers also collaborate with other groups from Europe and Canada. All of them want to use the technique of genetic scissors to introduce biotechnologically important properties of yeasts, the research of which will certainly be important both for the food industry and for the development of biological medicines.

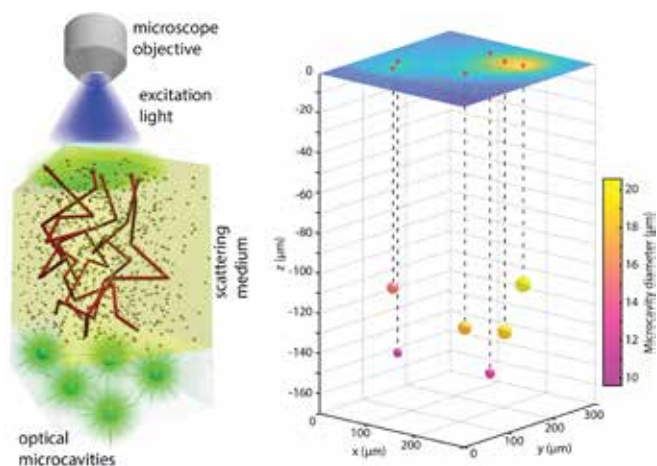
Researchers gain an insight into the behaviour of nanostructures at the molecular level

Dr Nerea Sebastian Ugarteche, Assist. Prof. Lea Spindler and Prof. Dr Irena Drevenšek-Olenik from the Department of Complex Matter of the JSI, together with researchers from other Slovenian institutions (KI, UL, UM, MPŠ, Center of Excellence EN-FIST) revealed, with the help of nuclear magnetic resonance, how guanine-rich DNA oligonucleotides spontaneously assemble into guanosine nanowires (G-wires). This has given them an insight into the behaviour of such nanostructures at the molecular level. Complementary methods such as CD, DLS, AFM, SEM and TEM were used to systematically characterise the G-wires. The key step in the uncovered self-assembly mechanism is the structural rearrangement of the kinetically controlled G-quadruplex into the thermodynamically preferred G-quadruplex. Understanding the details of this mechanism made it possible to synthesize G-strings in a controlled manner. The discovery is important both for the further development of DNA nanotechnology, as well as for an in-depth understanding of the fundamental properties of G-quadruplex aggregates, which can be formed in many biological processes. The results of the study were published in the journal *Nature Communications*.



Researchers present a new method for depth imaging based on scattering

Aljaž Kavčič, Dr Maja Garvas, Matevž Marinčič and Assist. Prof. Matjaž Humar, researchers from the Department of Condensed Matter Physics, and Dr Boris Majaron from the Department of Complex Matter, of the JSI, in collaboration with researchers from Graz University, published a paper in *Nature Communications* entitled *Deep tissue localization and sensing using optical microcavity probes*. In the paper they presented a new method of imaging through scattering tissues, based on the localization of whispering-gallery-mode microresonators with a spectrally narrow emission that enables the decomposition of a diffuse signal into the contributions from individual microresonators. The method combines the ability to accurately localise at the cellular level with the possibility to sense various parameters, such as temperature, pH and refractive index, which makes it a versatile tool in the field of deep-tissue imaging. The first author of the paper, Aljaž Kavčič, presented the results of this work in his master's thesis, for which he was awarded the *Prešeren Prize* by the University of Ljubljana.





FAIR – the universe in a laboratory

Ljubljana, 16 March 2022

While the construction of one of the world's largest accelerators for basic research, FAIR, is progressing rapidly in Darmstadt, Germany, researchers from all over the world are already gaining valuable experience by participating in the *Phase 0* operations of the research programme. During a visit to Ljubljana, the scientific director Prof. Dr Paolo Giubellino and technical director Mr. Joerg Blaurock, met with the main representatives of Slovenia in the fields of science, economy and the Ministry of Education, Science and Sports.

FAIR will be "space in a laboratory", a laboratory where researchers will produce and investigate matter that normally only exists in the depths of outer space. Its construction is progressing rapidly, and the current accelerator facilities of the Helmholtz Center for Heavy Ion Research (GSI) are already under way. *Phase 0*, for example, is dedicated to the immediate application of new detector systems, the implementation of an attractive physics programme, and the education and training of the next generation of scientists and engineers for FAIR. Prof. Dr Paolo Giubellino explained that "The tunnel for the SIS 100 accelerator is finished and the construction of the

experimental halls is progressing. The components of other accelerators in development are also beginning to arrive at the GSI campus in Darmstadt. Although we will only be able to realise the actual scientific impact of FAIR when all the accelerators and storage rings are completed and operational, some experimental detectors and devices are already available".

Cooperation as part of the FAIR Center opens up exceptional research opportunities for the scientists of the JSI, which joined the GET_INVolved programme last November and strengthened their cooperation with the FAIR team. Researchers from the Department of Low

and Medium Energy Physics are already participating in the *Phase 0* operations, and experience is also being offered in the field of new technologies for accelerators, detectors, electronics and high-performance computers. Prof. Dr Boštjan Zalar, the Director of the JSI has said, "These technologies will enable cutting-edge research in the fields of nuclear structure, astrophysics, hadron physics and fundamental antiproton beam physics, compressed nuclear matter physics, plasma physics, atomic physics, materials research and biomedical applications, so the Institute will strive to include as many of its researchers as possible in FAIR". Such dynamic, international investigative

environments offer a unique learning experience for technological awareness, leadership and soft skills to young researchers at the start of their careers.

In addition to the JSI, representatives of the Ministry of Education, Science and Sport and the Tehnodrom consortium are also participating in the project. Tehnodrom, a consortium of 12 Slovenian high-tech companies, develops and supplies high-tech research equipment specified by the FAIR Center. "The cooperation of Slovenian high-tech companies in large scientific projects, such as FAIR, is important because of the stronger development competences based on joint work with experts from all over the world and obtaining international references. It is also useful from the point of view of the exchange of scientific findings and experience in practice, and at the same time it brings multiplier effects for the investment in Slovenia: companies participating in FAIR will generate several hundred million euros in taxable income in the next 5 years. So far, they have already increased the number of high-tech personnel by more than 300. These are mainly people who would otherwise have moved abroad. In the future, they are planning to employ more experts. The establishment of a scholarship scheme, with the help of which high-tech companies could offer project work to scientists, would be welcome here," stressed Dr Mark Pleško, co-founder and director of the company Cosylab, which is the main partner of the project, in addition to Instrumentation Technologies.



Researchers demonstrate the possibility of using magnetic nanoparticle heating of a composite Ru catalyst

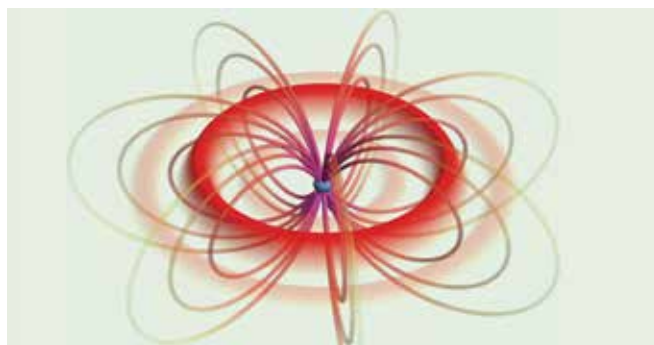
Assist. Prof. Sašo Gyergyek and Prof. Dr Darko Makovec, researchers from the Department of Synthesis of Materials, in collaboration with researchers from the Department of Catalysis and Reaction Engineering of the National Institute of Chemistry, published a paper in *Green Chemistry* entitled *Electro-hydrogenation of biomass-derived levulinic acid to γ -valerolactone via the magnetic heating of a Ru nanocatalyst*. In the paper they demonstrate the application of heating magnetic nanoparticles embedded within a Ru-based composite catalyst when exposed to an alternating magnetic field that drives the chemical reaction. The in-depth analysis and modelling of the surface processes showed that the surface of the catalyst reached a higher temperature than the bulk of the medium, resulting in an increased rate of conversion and thus an increase in the yield of γ -valerolactone under mild conditions. The research demonstrates the tremendous potential of magnetic heating for heterogeneous reaction systems with a thermally labile reactant, such as biomass components.

Results of the SCORE 2021 International Survey on Illicit Drug Use

On 17 March 2022 the European Centre for Monitoring Drugs and Drug Addiction published the results of the SCORE 2021 international survey on illicit drug use, in which researchers from the Department of Environmental Sciences of the JSI under the guidance of Prof. Dr Ester Heath have participated since 2017. Among Slovenian cities, the research records the largest amounts of benzoylecgonine (a biomarker of cocaine) in Koper, amphetamine and MDMA in Velenje, and methamphetamine and THC-COOH (a biomarker of THC) in Ljubljana. The average amounts of biomarkers in Slovenian cities were below the SCORE average for 2021 for methamphetamine and MDMA, while the average amounts of benzoylecgonine in Koper and amphetamine in Velenje were above average. The average amount of THC-COOH was above the SCORE average in all Slovenian cities. Compared to European and world capitals, Slovenian cities rank in the top half of the participating cities in terms of THC-COOH and benzoylecgonine content, and in the bottom half in terms of the remaining biomarkers. The exception is amphetamine in Velenje.

Certificates of Honour of the Jožef Stefan Institute awarded

At the Institute, as part of the 30th Jožef Stefan Days, we awarded certificates of honour to four companies and seven individuals in recognition of the successful transfer of scientific and technological achievements and knowledge created at the Institute to the social and economic sphere. These are important collaborations in the field of digitization, corrosion protection, implementation of surface modifiers, demonstration robot cells and algorithms for the control of forging processes. Based on a proposal from the Laboratory for Open Systems and Networks and the Department of Communication Systems, the certificates were awarded to Mag. Uroš Salobir, Dr Janko Kosmač and the company ELES d. o. o. (in the photograph). Based on a proposal from the Department of Automation, Biocybernetics and Robotics and the Department of Intelligent Systems, they were awarded to Samo Gazvoda and the company Gorenje d. o. o. and Mag. Jože Ravničan and the company UNIOR d.d. Based on a proposal from the Department of Nanostructured Materials, they were awarded to Ludvik Kumar, Dr Boris Saje, Mag. Karla Kosmač and the company Kolektor Group d.o.o.



Researchers use light to magnetize matter on a nanometre scale

As a part of our ongoing research into twisted light (light that carries orbital angular momentum) conducted in collaboration with researchers from the University of Nova Gorica and the Institute of Physics at the University of Halle, Špela Krušič, Assist. Prof. Andrej Mihelič and Prof. Dr Matjaž Žitnik from the Department of Low and Medium Energy Physics published an article in *Physical Review Letters* (PRL) showing that light can magnetise matter on a nanometre scale. With a short and strongly focused XUV light pulse from the FERMI free-electron laser, a large portion of helium atoms in the gas target was transferred from the ground state to a singly excited state, and from there to a 'rotating' Rydberg state with a simultaneous pulse of twisted IR light. The analysis of dichroism in the photo-electron signal showed that the atomic current loops of the rotating Rydberg wave packets generate a magnetic field that is localized along the axis of the twisted light beam and is stable on a time scale determined by the lifetime of the Rydberg state. A figure from the article was featured on the cover of PRL, and the article is highlighted in *Synopsis in Physics*.

Researchers solve technological challenges for companies needing better solutions

The Centre for Technology Transfer and Innovations at the JSI acts as a Digital Junction, and together with the company Senso4s d.o.o. submitted a proposal to the Digital Junction World Tender. In the application, the cooperation of researchers from the JSI was also foreseen, so the researchers of the Department of Knowledge Technologies and the Department of Intelligent Systems were included in the partnership. Based on the approved application, a scale based on Bluetooth technology was upgraded for the remote measurement and monitoring of the gas level in gas cylinders, and at the same time an algorithm was developed to optimize the delivery routes for gas cylinders. In this way, it will be possible for households and other users to replace gas cylinders in time when they run out of gas, and distributors will be able to deliver gas cylinders in a planned way without redundant routes, at lower costs and with a smaller carbon footprint due to the customized transport. This cooperation has once again confirmed the advantages of connecting the technological challenges of companies with the knowledge of researchers.

Golden Emblems awarded at the Jožef Stefan Institute

Ljubljana, 24 March 2022

At a ceremony sponsored by the President of the Republic of Slovenia, Borut Pahor, at the JSI, the Jožef Stefan Golden Emblem awards were presented for the 30th year in a row to the most high-profile doctorates in the fields of natural, mathematical, technical and life sciences. The keynote speaker was adviser to the President of the Republic, academician Dr Boštjan Žekš. This year's award winners were Dr Pavel Kos, Dr Žiga Kos and Dr Matija Gatalo.

The JSI awards the Jožef Stefan Golden Emblem to the most high-profile PhD thesis in the Republic of Slovenia in the past 3 years within natural, mathematical, technical and life sciences. The award is to encourage young people to be even more engaged with their scientific research, which is also a kind of appeal to responsible people in society to use this knowledge as effectively as possible.

The keynote speaker at the event was academician Dr Boštjan Žekš, adviser to the President of the Republic, responsible for higher education, science and technology. At the 30th anniversary of the award he recalled the beginnings of the award as he had been a participant. "The main credit for the success in these 30 years goes to all the directors, all the management boards, the scientific councils and the committees for the Golden Emblem, who insisted on the highest criteria, although it must have been difficult at times. If only one of these participants was to have relaxed once, there would have been no success.", he highlighted the reasons for the high standards in deciding on the winners of the awards.

The chairman of the Committee for the Golden Emblem award, Prof. Dr Jadran Lenarčič, said that this year the committee received 19 proposals. "They were all of exceptional quality and deciding on the winners was not easy."

The Golden Emblem of Jožef Stefan was awarded to Dr Pavel Kos for the high profile of his doctoral work *Exact solutions to many-particle quantum chaotic systems*. He was nominated for the award by his mentor Assoc. Prof. Dr Miha Ravnik from the Faculty of Mathematics and Physics of the University of Ljubljana and Assist. Prof. Lev Vidmar from the JSI. Dr Kos is a theoretical physicist who researches in the field of quantum chaos. The topics of his research are the models and mechanisms that explain some of the important properties of quantum chaos in systems of spin chains and qubit circuits. The results of his research could be used, among other things, to calibrate the first generation of

quantum computers. The results of his research were published in high-ranking journals and received positive responses. There has also already been success in replicating some of his results with an ion quantum simulator. The results of his investigations also generated an avalanche of related research by other authors around the world, and in November 2021 the Indian Institute of Technology in Madras even organized an online workshop on studies stimulated by the articles of Dr Kos and his colleagues. Dr Kos is continuing his activities with one of the world's most dynamic research groups, at the Max Planck Institute for Quantum Optics in Garching, Germany.



The Golden Emblem of Jožef Stefan was awarded to Dr Žiga Kos for the popularity and high profile of his doctoral research on *Microfluidic structures based on nematic liquid crystals*. He was nominated for the award by his mentor Assoc. Prof. Miha Ravnik from the Faculty of Mathematics and Physics of the University of Ljubljana. Dr Kos is a theoretical physicist who researches in the field of soft matter, more specifically in the field of nematic liquid crystals and active fluids. Non-equilibrium active nematic materials are important in the context of the broader life sciences for understanding the ordering and material properties of biological substances, such as cell monolayers and muscle fibres. Dr Kos's research has brought breakthrough discoveries, which is demonstrated by his many excellent publications and many citations. The results of the work have brought fruitful collaborations with several experimental and theoretical groups around the world, and they also represent an excellent basis for further theoretical and experimental basic studies, as well as the development of new materials. Two topics of Dr Kos's research stand out as being particularly interesting for applications: surface-patterned liquid-crystal switches and driving microfluidic flows with laser beams or electric fields. His research is at the very top of this field, which is also demonstrated by him being offered a post-doctoral position at MIT in Boston, USA.

The Golden Emblem of Jožef Stefan was awarded to Dr Matija Gatalo for the impact of his doctoral work *Development of the synthesis of nanoparticles of binary and ternary platinum alloys on a carbon support as an electrocatalyst*. His mentor was Prof. Dr Miran Gaberšček from the Institute of Chemistry, and he was nominated for the award by Assoc. Prof. Nejc Hodnik from the National Institute of Chemistry. The doctoral thesis of Dr Gatalo addresses the topic of the European Green Deal and hydrogen technologies. He developed a process for preparing a catalyst for fuel cells that contain only a small amount of expensive platinum.

Instead of the pure platinum, he used alloys of platinum and transition elements such as copper, nickel or cobalt as the catalyst. Using an innovative combination of different synthesis procedures, he showed that catalysts prepared in this way can be very active and at the same time stable. It is particularly important to point out that his new process enables the preparation of large quantities of morphologically and chemically homogeneous alloys, which means that it is also suitable for use on an industrial scale. Therefore, the impact of Dr Matija Gatalo's doctoral work is not only expressed in the large number of citations of articles related to his work, but also in its usefulness. Due to the great interest of industry, Dr Gatalo has founded a spin-off company dealing with the marketing of PhD-prepared catalyst materials. The European Research Council (ERC) awarded the proposal for further research of the synthesis idea developed in the PhD with a Proof-of-Concept award. For his invention Dr Gatalo received many other awards at well-established Slovenian innovation forums (GZS, OZ GZS, MOS, Rector's Award for the best innovation).

Researchers from the Jožef Stefan Institute win the University of Ljubljana *Dragonhack* hackathon

Boshko Koloski and Ilija Tavchioski of the Department of Knowledge Technologies of the JSI won the largest and longest Slovenian university hackathon *Dragonhack*, which was organized on 14–15 May 2022 by the Faculty of Computer Science of the University of Ljubljana and the Association of Computer Scientists of Slovenia. The competition featured 39 teams and a total of more than 150 participants, who demonstrated their knowledge and skills to solve real-life problems using software and hardware in a non-stop 24-hour session. Koloski and Tavchioski presented a creative solution to the problem of bulky waste collection: first, they connected people who drop off bulky waste with seekers of used equipment, thus reducing the amount of bulky equipment, and in addition, they also optimized the collection planning. *Dragonhack* is a fantastic opportunity to network and meet like-minded people, and for the top performers, a moment to showcase their skills and impress the panel and other professionals.



E-manual for managing digital intellectual property in companies

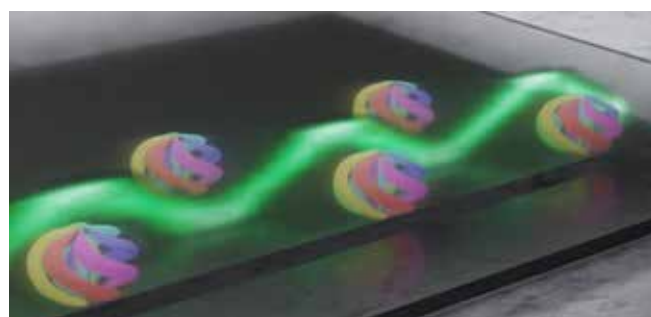
Together with the publication of the e-manual for the digital management of intellectual property in companies on 30 April 2022, the SRIP ToP Factory of the Future Centre at the Institute completed the Go-DIP project called *Digital Intellectual Property Management in Digital Enterprise Digitization Processes*. The project addresses the current challenges of the European community in the access, use and re-use of data, ethical use and trust in data in artificial intelligence and open data. The Go-DIP project monitored various aspects of the digital management of intellectual property practices in companies in three areas: digital data sharing and digital data-based innovation, software intellectual property management and data management, and data ownership and exploitation of data intellectual property. The manual is free and available for download. The Go-Dip project was implemented within the Horizon Innosup 2018–2020 programme. The total value of the project was €50,000. The participating partners in the project were Hub Inovazione Trentino from Italy and Innosquare from Freiburg in Switzerland.

The JSI awarded a project for an integrated approach to ensure a sustainable fish-and-seafood supply chain

The Department of Environmental Sciences was recently awarded a new Horizon Europe project, FishEUTrust: European integration of new technologies and socio-economic solutions for increasing consumer trust and engagement in seafood products, coordinated by Prof. Dr Nives Ogrinc. The four-year project, worth €5 m, involves 21 partners from 14 countries, including 11 SMEs and two international organizations, i.e., EUROFISH and the EU Aquaculture Society. The project aims to establish a comprehensive approach to ensuring a sustainable fish-and-seafood supply chain by developing new technological solutions for greater transparency and traceability, including metagenomic approaches combined with stable isotopes of light elements, sensor technologies and AI-based analysis to ensure safety and freshness as well as digitization. The project will also address consumer behaviour and promote sustainable aquaculture and the smart economy. The Department of Computer Systems will also participate in the project with ICT and data-science activities led by Prof. Dr Barbara Koroušič Seljak.

Researchers examining the phenomenon of the light-induced periodic arrangements of topological solitons publish in the journal *Nature Photonics*

Prof. Dr Slobodan Žumer of the Department of Condensed Matter Physics of the JSI and his Marie Skłodowska-Curie postdoctoral researcher Guilhem Poy at the Faculty of Mathematics and Physics, University of Ljubljana, in collaboration with the experimental soft-matter physics group of Professor Ivan I. Smalyukh at the University of Colorado Boulder, made an important contribution to the interpretation and successful realization of a controlled opto-mechanical interaction of optical and topological solitons in frustrated chiral nematic liquid crystals. The discovery of an unusual traction effect for particular optical solitons in such media allows the light-induced periodic arrangement of topological solitons, which in addition to the scientific aspect, has a potentially important relevance for use in soft-matter photonics. They recently published the results of this research in an article entitled *Interaction and co-assembly of optical and topological solitons in the journal Nature Photonics*.



JSI receives the Memorial Sign of the Government of the Republic of Slovenia for its work in the fight against Covid-19

The Government of the Republic of Slovenia gave the Institute and its researchers Dr Matjaž Leskovar and Prof. Dr Leon Cizelj from the Department of Reactor Engineering a Commemorative Emblem for selfless conduct in the fight against Covid-19. The Institute and its researchers immediately responded to the outbreak of the pandemic in March 2020 by searching for scientific solutions, with which they hoped to solve one of the largest health and social crises of recent times. With their selfless work, they made their marks in the areas of mask testing and sterilization, the setting up of an electrochemical biosensor, and the monitoring and forecasting of the pandemic with the Coronaviruswatch, XPRIZE, the Covid-19 tracker and the public announcements of analyses and forecasts, with which Dr Leskovar and Prof. Dr Cizelj informed the public daily. Their analyses and forecasts provided valuable support to decision-makers in controlling the pandemic, and enabled the medical staff to prepare the necessary equipment and mobilize staff in intensive-care units.

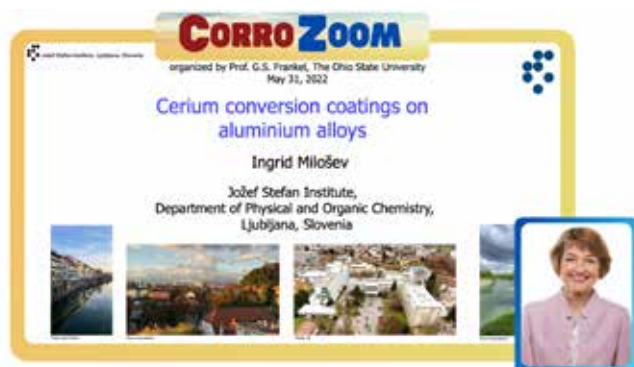


The TRIGA MARK II reactor in EARTO publication about Case Studies on Technology Infrastructures

The TRIGA MARK II reactor of the Institute is among the nine examples of technological infrastructure in the publication EARTO Case Studies on Technology Infrastructures. It represents a special recognition of the Institute's role within the research community. The publication was in response to the European Commission's report Towards the Implementation of an EU Strategy for Technology Infrastructures: Insights for the implementation of the ERA Policy Agenda, with recommendations for connecting the European Research Area in the field of technological infrastructure. This represents a key building block of the European green and digital transition and goals such as achieving technological independence and resilience of the European space. The EARTO case studies provide a valuable insight into the diversity of the technology infrastructure across Europe, with key features to consider when designing strategies, guidelines and other documents in the field. The presentation of the reactor for the EARTO publication was jointly prepared by the research departments U1, U6, R4, F8, RIC, ICJT and CTT.

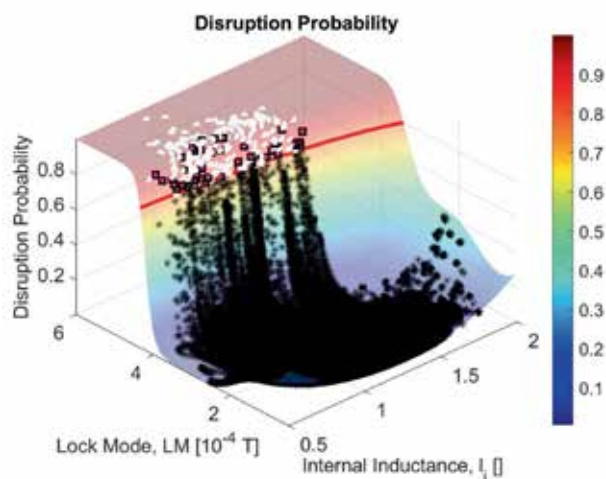
Prof. Dr Ingrid Milošev among the six leading scientists

On 31 May 2022, Prof. Dr Ingrid Milošev, Head of the Department of Physical and Organic Chemistry at the Institute, presented a webinar in the second season of the CorroZoom series organized by Prof. G. S. Frankel at The Ohio State University, Columbus, USA. This year, six leading scientists from all over the world gave lectures on different corrosion-related topics, with Prof. Dr Milošev having the honour of concluding this year's webinar season. Her lecture entitled *Cerium conversion coatings on aluminium alloys* covered some fundamental considerations of the chemistry of cerium salts and the general mechanisms of coatings' formation, followed by examples from her group's research work on this type of coating. The lecture, attended by around 300 participants worldwide, was followed by a wide-ranging discussion on the topic. Presenting at the CorroZoom webinar is a tremendous recognition of Prof. Dr Milošev's 30+ years of research work dedicated to corrosion protection, including conversion coatings.



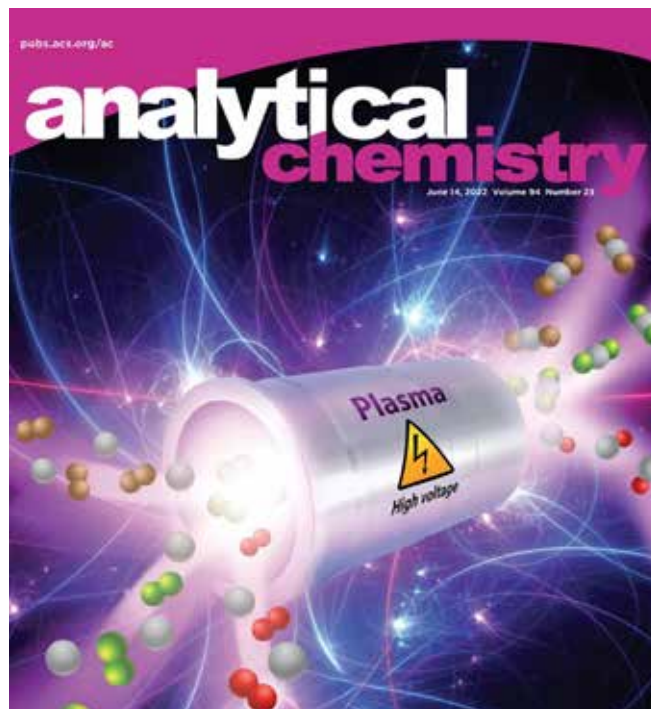
JSI researchers develop an algorithm that can predict plasma disruption

In fusion reactors, the plasma is heated to a temperature of more than 100 million kelvin, which enables the fusion of light nuclei and the release of energy. In tokamak-type reactors, the hot plasma is confined by a strong magnetic field in the shape of a torus. But it is prone to disturbances, which can cause it to suddenly cease. In such an event, large mechanical and thermal loads occur on the tokamak's components and, in extreme cases, it can be destroyed. In future fusion reactors, such as ITER (International Thermonuclear Experimental Reactor), when the plasma fails, forces greater than the weight of an Airbus A380 occur, and the temperature exceeds the melting point of the most resilient materials by more than ten times. Researchers from the Eurofusion consortium, which includes researchers from the Department of Reactor Engineering of the JSI, have developed an algorithm using artificial intelligence and machine learning that can predict the plasma's disruption with high probability. This makes it possible to act in time and prevent the interruption of the plasma, or at least reduce the consequences of the interruption. These findings were published in the journal *Nature Physics*.



JSI researchers develop a new method for producing oxidized mercury (Hg) species

Jan Gačnik and Dr Igor Živković, together with colleagues from the Department of Environmental Sciences and the Department of Gaseous Electronics of the JSI, and with Sergio Ribeiro Guevaraiz from Argentina, under the guidance of Prof. Dr Milena Horvat, developed a new method for producing oxidized species of mercury in the gas phase. The article *Calibration Approach for Gaseous Oxidized Mercury Based on Nonthermal Plasma Oxidation of Elemental Mercury* was featured on the cover of the journal *Analytical Chemistry*. In the article, the authors showed that it is possible to oxidize mercury in the gas phase to an oxidized species with the help of non-thermal plasma in the presence of reactive gases. The reproducible and metrologically traceable amounts of oxidized mercury species produced in this way represent a unique solution for the calibration of instruments at extremely low concentrations. In the future, this work will contribute to the comparability and reliability of mercury measurements in the atmosphere.



Cooperation initiated between the Jožef Stefan Institute and the Japanese RIKEN Institute

At the end of May, meetings were held in virtual form between researchers from the Institute and the Japanese RIKEN Institute to investigate the possibility of cooperation in joint and complementary research areas, also within the framework of European and other international projects. The gathering was addressed by Prof. Sadamichi Maekawa, Prof. Dr Denis Arčon, Dr Toshiyasu Ichioka and Dr Špela Stres, who presented previous joint projects involving both research institutes and put in place foundations for future cooperation. This was followed by separate virtual meetings between selected researchers, the purpose of which was to upgrade existing activities and establish new collaborations. Due to the many possible areas of cooperation between the two institutes, another set of meetings is planned for the autumn at the Centre for Technology Transfer and Innovations. The plans will be supported by the ARRS in a call for cooperation with Japan.

Round table on Science and Innovation as a Guarantee of Economic Growth

On 20 June 2022 the Institute held a round-table entitled Science and innovation as Guarantees of Economic Growth, which was attended by university rectors Prof. Dr Gregor Majdič, Prof. Dr Zdravko Kačič, Prof. Dr Klavdija Kutnar and Prof. Dr Boštjan Golob as well as Prof. Dr Robert Dominko from the Institute of Chemistry, the directors of the NIB and the JSI, Prof. Dr Maja Ravnikar and Prof. Dr Boštjan Zalar. They were joined by Dr Marko Pleško, the director of Cosylab, and Dr Igor Papič, the Minister of Education, Science and Sports. Dr Papič pointed out that with the planned unification of the ministry, the importance of innovation is changing, while at the same time funds are increasing: "A more optimistic forecast of funds for science does not in itself guarantee development. Our basic goal must be to change the paradigm of the development of our society. This is a key element of economic development and development in general." The participants agreed that Slovenia does not lack much when it comes to success: "With a vision and the principle of cooperation, we must lead the way to a better future together."

Awards for Excellence in Science Communication for 2021

On 21 June 2022 the Slovenian Science Foundation presented awards for excellence in science communication for 2021, which were largely aimed at improving the public's understanding of the Covid-19 virus. Among the fifteen recipients of the Prometheus of Science awards for excellence in science communication are a group and two individual researchers from the Institute. The group led by Prof. Dr Maja Remškar with her colleagues Assist. Prof. Anton Gradišek, Dr Luka Pirker and Anja Pogačnik Krajnc was rewarded for communicating about the suitability of protective masks from different manufacturers. Dr Melita Tramšek received the award for organization and achievements in the field of science popularization and informal education for an experimental chemistry school. Prof. Dr Igor Mekjavič received his award for the popularization of research and equipment in the field of space physiology. The honorary title of Communicator of Science in 2021 was awarded to Prof. Dr Alojz Ihan from the Faculty of Medicine of the University of Ljubljana for his trustworthy and professionally competent commentary during the pandemic.





10th anniversary of the discovery of the Higgs boson

Ljubljana, 4. July 2022

It was 10 years since the discovery of the Higgs boson at CERN. This represents one of the most important achievements of science in the 21st century. We are proud that a group of scientists from the Institute and the University of Ljubljana participated in the discovery, as part of the ATLAS experiment.

In honour of the anniversary, we prepared a celebratory event, which took place under the honorary patronage of the President of the Republic of Slovenia, Borut Pahor, in the Large Lecture Theatre of the JSI. After the opening speeches of the Director of the Institute, Prof. Dr Boštjan Zalar, and adviser to the President of the Republic, Acad. Dr Boštjan Žekš, memories and thoughts were presented by Prof. Dr Marko Mikuž, leader of the Slovenian scientists in the ATLAS experiment in CERN, Dr Miha Nemevšek from the Department of Theoretical Physics and Prof. Dr Borut Paul Kerševan, Head of the Department of Experimental Particle Physics. This was followed by a conversation with the journalist Maja Ratej. You can watch a recording of the celebratory event and moments from the celebration in the archive of TV IJS.







Prof. Dr Andrej Zorko wins 2022 Science Impact Award

Prof. Dr Andrej Zorko from the Department of Condensed Matter Physics was the recipient of the 2022 Science Impact Award for his work on quantum spin liquids. This award is given annually by the Science and Technology Facilities Council of the UK to celebrate the scientific impact of the research conducted at the ISIS, Rutherford Appleton Laboratory large-scale user facility in the last 5 years. This is a world-leading research centre that supports more than 2,000 researchers applying neutron scattering and muon spectroscopy to various fields of natural sciences. Andrej Zorko led an international research group that was awarded for their discovery of the first realization of a quantum spin liquid on a triangular spin lattice with dominant Ising antiferromagnetic exchange interactions, which has recently been published in *Nature Materials*. These results revealed that the family of rare-earth heptatantalates represents a novel framework for quantum spin liquids.



SILKNOW project wins the Europa Nostra 2022 European Heritage Award

The SILKNOW project, which involves groups from France, Germany, Italy, Poland and Spain and Slovenia, received the Europa Nostra 2022 award for European heritage. SILKNOW helps preserve the intangible heritage of ancient weaving techniques by using pre-existing digitized silk information to study, present and preserve digital silk collections. As stated by the awards jury, SILKNOW has created an innovative system to facilitate the transfer of knowledge about silk weaving, and the project is an important example of how craft and thus intangible heritage can be connected with digital tools and how these tools can be used to democratize access to technical knowledge. Prof. Dr Dunja Mladenić, together with researchers from the Department of Artificial Intelligence of JSI, participated in the development of the semantic marking of texts, a multilingual thesaurus and automatic prediction of the missing metadata based on deep learning from texts and images.

Important experiment completed by JSI researchers

A group of researchers from the Department of Low and Medium Energy Physics of the JSI, composed of Prof. Dr Matjaž Žitnik, Assist. Prof. Andrej Mihelič, Assist. Prof. Klemen Bučar and Dr Špela Krušič, with the help of researchers from Sweden, France and Italy, conducted an experiment in which the population of the short-lived $2s^2$ state in helium (5 fs) was controlled by the interference of two-photon absorption paths, $\omega_1 + \omega_1$ and $\omega_3 - \omega_1$. The relative strength of the interference element was determined by the phase difference between the fundamental frequency of the laser light ω_1 (44 nm) and its third harmonic frequency $\omega_3 = 3\omega_1$ (14 nm). Short, two-colour pulses of strong light with spatial and temporal coherence were generated with a FERMI free-electron laser. The researchers demonstrated the operation of the atomic interferometer by measuring the small time difference (9 as) that occurs when light of the first and third harmonics travels through a 5-m-long attenuator, in which nitrogen is at a pressure of 6.3×10^{-3} mbar. The results of the research have just been published in the journal *OPTICA*.

Prof. Dr Barbara Malič wins the IEEE Ferroelectrics Recognition Award for 2022

Prof. Dr Barbara Malič, Head of the Department of Electronic Ceramics, was the recipient of the IEEE Ferroelectrics Recognition Award for 2022. The award is given by the Ferroelectrics Committee of the Ultrasonics, Ferroelectrics and Frequency Control Society (UFFC-S) for achievements in the field of ferroelectricity or related sciences. Prof. Malič received the award for her outstanding contributions to explaining the relationships between chemical and physical properties in ferroelectric ceramics at the 2022 ISAF-PFM-ECAPD joint conference International Symposium on Applications of Ferroelectrics – Piezoresponse Force Microscopy International Workshop-European Conference on Applications of Polar Dielectrics, which took place from 27 June to 1 July 2022, in Tours, France. The award is not only a recognition of her research, but also a confirmation of the excellence of the ferroelectrics research within the Department of Electronic Ceramics, placing it among the best research groups in the field.



Completion of the project Consortium for the Transfer of Technologies

In June 2022 the 5-year project of the Consortium for the Transfer of Technologies from Public Research Organizations to the Economy, which was financially supported by the Ministry of Education, Science and Sports, was concluded. The technology-transfer offices of the Institute, the University of Ljubljana, the University of Maribor, the University of Primorska, the Faculty of Information Studies in Novo mesto, the Agricultural Institute of Slovenia, the National Institute of Chemistry and the National Institute of Biology participated in the project. During the project, the technology-transfer offices were properly integrated into the operations of the parent organizations, and the technology-transfer experts helped the researchers in filing more than 60 patent applications with full examination and in concluding research-and-development contracts worth more than €8.5 m, and concluding license agreements worth more than €1.9 m. At the conclusion, a conference with a round-table was organized, where the participants presented their views on the transfer of technologies and the functioning of the relevant offices.

Theoretical confirmation of the existence of the longest-lived exotic state consisting of quarks

Prof. Dr Saša Prelovšek Komelj from the Department of Theoretical Physics and M. Padmanath from Mainz found evidence for the longest-lived exotic state composed of quarks. Their article in *Physical Review Letters* establishes this state with an ab-initio study based on a fundamental theory for the first time. The state consists of two charm quarks together with the antiquarks u and d , and was experimentally discovered at CERN by the LHCb collaboration in July 2021 (*Nature Physics*). It contains more than three quarks and therefore represents an exotic hadron. Conventional hadrons, for example, the proton and neutron, are composed of up to three quarks. Investigations of exotic hadrons reveal whether the mechanisms responsible for their existence are analogous to those that bind protons and neutrons to nuclei, which are in turn responsible for the energy released in nuclear fusion and fission.

Prof. Dr Aleksander Rečnik receives an honorary award from the Pannonian University in Veszprém

Prof. Dr Aleksander Rečnik received the prestigious Pannonia Award following his 20-year collaboration with the Department of Geology and Environment, Faculty of Engineering at the Pannonian University, and his support of Hungarian doctoral students working on the electron microscopy of interfaces in their studies of phase transformations in materials. The joint research involved in-situ TEM experiments to study solid-state reactions. In January 2022 a fundamental NKFIH–ARRS research project on aragonite twinning was approved for funding, where Hungarian and Slovenian researchers will jointly tackle the problems related to the formation of aragonite under atmospheric conditions, which is one of the fundamental issues in mineralogy. The award was given by the Academic Senate of the University of Pannonia and honours outstanding personalities with long-standing collaborations that substantially contributed to the development of new research areas at their university.

The JSI uses air-quality measurements to control the consequences of severe fires

In the third week of July 2022, there were severe forest fires in the Karst area on the border between Slovenia and Italy. Since this is the location of the Soča front during the First World War, there are still a lot of explosives from those times. As part of ELME, the Ecological Laboratory with a mobile unit of the JSI, Dr Jože Kotnik carried out air-quality measurements, including mercury, in the area where the fires were most intense. The results showed very high levels of particulate matter in the air, PM10 up to 1,000 $\mu\text{g}/\text{m}^3$ and PM2.5 up to 300 $\mu\text{g}/\text{m}^3$. CO₂ and ozone levels were also elevated, and the mercury showed very interesting values. On the basis of the already-burnt smoke, Hg concentrations were in the range 2–4 ng/m^3 , which are values comparable to Ljubljana. No other harmful substances were detected with the available instruments. Mercury in the atmosphere comes from two sources: burnt biomass, which is one of the main natural sources of Hg in the atmosphere, and mercury fulminate, which was used as a detonator for explosives during both world wars.

Prof. Dr Slobodan Žumer receives de Gennes award

At the International Liquid Crystal Conference ILCC 2022, which took place during 24–29 July 2022 in Lisbon, Portugal, Prof. Dr Slobodan Žumer, of the Department of Condensed Matter Physics of the Institute and the Faculty of Mathematics and Physics of the University of Ljubljana, received the de Gennes Prize. This is the highest award given by the International Liquid Crystal Society (ILCS). Prof. Žumer is an outstanding theoretician, pedagogue, professor, colleague, mentor and former president of the association, who significantly contributed to the impressive progress in liquid crystals. The Society's Board of Directors awarded him the recognition for his outstanding scientific achievements, his key role in the establishment of new research areas, ranging from confined liquid crystals to topological soft matter, his successful management of numerous doctoral students, extensive international cooperation and for his contributions to the society's activities both in the role of regional representative on the board of directors and a member of the board as the president of the association.



Assist. Prof. Lev Vidmar publishes a Tutorial article in *PRX Quantum* magazine

PRX Quantum Magazine recently began to publish a new category of articles under the Tutorial label. In the new edition of this magazine, researcher Assist. Prof. Lev Vidmar from the Department of Theoretical Physics of the Institute and the Faculty of Mathematics and Physics of the University of Ljubljana, together with colleagues from Penn State University in the USA and the University of Melbourne in Australia, published the Tutorial article *Volume-Law Entanglement Entropy of Typical Pure Quantum States*. In it, the authors describe in detail the essential properties of the entanglement entropy of typical pure quantum states, which have very similar properties to highly excited eigenstates in physical systems. Entanglement entropy quantifies to what extent the measurements in two parts of a quantum system are correlated with each other in a way that cannot be described by concepts of classical physics. The central purpose of the article is to provide a pedagogical introduction and analytical results for the entanglement entropy in different ensembles of pure quantum states. In the future, these results can serve as a useful tool for the detection of many-particle quantum chaos and help distinguish quantum-chaotic many-particle quantum systems from integrable systems.

DIGI-SI consortium acquires the status of a European Digital Innovation Junction

The DIGI-SI consortium obtained EDIH status, i.e., The European Digital Innovation Hub, for which 331 candidates competed at the European level. The members of the consortium are the coordinator, the University of Maribor, the JSI, DIH Slovenia, the Ljubljana Technology Park, Arctur, the Murska Sobota Innovation Technology Cluster and the Slovenian Tooling Cluster. The purpose of EDIH is to accelerate the digital transformation of the economy and the public sector with the help of the most modern digital technologies, such as artificial intelligence, high-performance computing, big data, and virtual reality, while ensuring cyber security and the necessary digital skills. The consortium will achieve results by supporting the economy and public administration in education and the awareness of advanced digital technologies and their use to accelerate development and operation, experimenting before investing in advanced digital solutions, conducting digital maturity assessments of organizations, connecting companies and organizations with researchers and the innovation ecosystem, and help with financing.

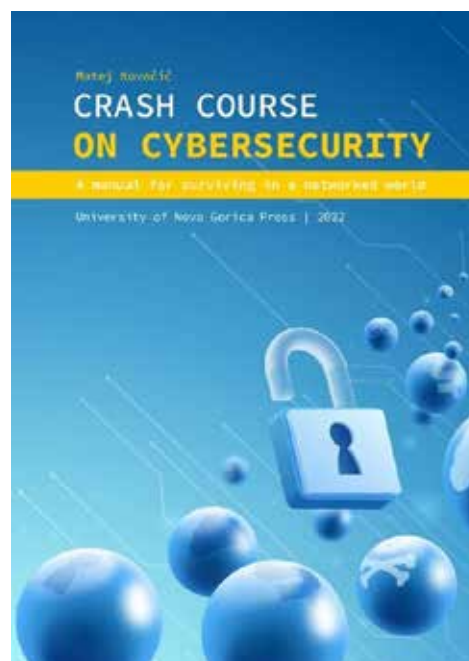
JSI researchers describe some of the central spectral properties of a new type of phase transition

In a recent edition of the journal *Physical Review Letters*, young researcher Jan Šuntajs from the Department of Theoretical Physics of the Institute published an article entitled *Ergodicity Breaking Transition in Zero Dimensions* with his mentor Lev Vidmar. In it, he describes some of the central spectral properties of a new type of phase transition: the transition between ergodic and non-ergodic many-particle quantum states. Despite the attention that such transitions have received in the last decade in the research of quantum many-particle systems, many questions about their key properties remain unanswered. The investigation revealed that there is a high degree of agreement between the analytical predictions and the results of intensive numerical simulations in the considered effectively zero-dimensional physical model. The results thus represent a foundation for future research on non-ergodic phase transitions in higher dimensions and at the same time explain some of the obstacles in the description of these transitions in one-dimensional systems, which Jan Šuntajs, together with his colleagues from the JSI and FMF UL, pointed out in his previous high-profile work.



New book published by Dr Matej Kovačič

Approaches to ensuring cyber security often focus too much on the technology, while neglecting the education of users. The book entitled *Crash Course on Cybersecurity: a Manual for Surviving in a Networked World* by Dr Matej Kovačič from the Centre for Knowledge Transfer in Information Technologies and the Department of Artificial Intelligence of the Institute tries to plug this gap. The book aims to provide a clear overview of the various aspects of cyber security that are important to businesses and other organizations. The book attempts to explain the complex field of cyber security in a comprehensible way, highlighting key information about how to protect yourself and/or your business from cyber-attacks, and provides technology-neutral advice for implementing cyber-attack protection. It is intended for managers in business organizations, as well as students and ordinary users of information technology, since users who are not aware of security threats often pose a great risk to the organization. The book was published as part of the European H2020 project CyberSANE under an open license and is freely available online.



Topological defects as computational elements

Dr Žiga Kos of the Department of Solid State Physics of the JSI and the Faculty of Mathematics and Physics of the University of Ljubljana, in collaboration with Jörn Dunkel from the Massachusetts Institute of Technology published an article entitled *Nematic bits and universal logic gates* in the journal *Science Advances*. In the article, the authors show that topological defects in nematic liquids can be used as computational elements. The article first introduces the mathematical formulation of nematic computational bits by analogy with a Poincaré or Bloch sphere and then shows that we can control their dynamics via an electric field. With different time-dependent electric fields, we can implement logical operations on individual nematic bits. Nematic elasticity, however, leads to strong correlations in systems of multiple nematic bits. Strong couplings can be used to implement universal logic gates, which is an important step towards the use of soft matter for information processing. The achievement was also highlighted in *New Scientist* magazine.

JSI monitors the events near the Zaporozhje nuclear power plant in Ukraine

The military occupation and operations in the immediate vicinity of Europe's largest nuclear power plant in Zaporozhye, Ukraine, bring a possible risk of radioactive contamination. Prof. Dr Leon Cizelj, head of the Reactor Engineering Department of the Institute and President of the European Nuclear Society (ENS) was explaining in some world media, like CNN and Politica, these threats and possible risks. The main points of his message are: (1) Russian forces have controlled the power plant since 4 March 2022 and can damage it even without shelling; (2) the plant is operated by Ukrainian crews operating under a lot of pressure from Russian forces; (3) even in the case of major damage to the power plant, the potentially significant consequences of radioactivity for health and the environment will be limited to a few tens of km. The ENS supports the objectives and implementation of the observation mission of the International Atomic Energy Agency. Links to papers are collected on the website of the European Nuclear Association.

Researchers of the Department of Electronic Ceramics make some of the most important achievements in the field

The researchers of the Department of Electronic Ceramics, Assist. Prof. Mojca Otoničar, Assist. Prof. Mirela Dragomir and Prof. Dr Tadej Rojac, have published a feature article in the *Journal of the American Ceramic Society* (JACerS) entitled *Dynamics of domain walls in ferroelectrics and relaxors*. The article presents the most important advances in the field of piezoelectric ceramics, focusing on the diverse and complex contributions of domain walls to the macroscopic functional properties of polycrystalline ceramics. Using nonlinear piezoelectric measurements supported by multiscale structural analysis, the JSI team showed how the local electrical conductivity in BiFeO_3 and the structural disorder inherent to PMN-PT affect the domain-wall dynamics and lead to new macroscopic effects. This feature article also provides evidence for analytical approaches to identify the key microscopic mechanisms that contribute to the macroscopic functional properties of ferroelectric and related materials. The authors also designed the cover of this issue of JACerS.



The Erasmus+ project 'TSAAI' launches a portal for teaching artificial intelligence

The Erasmus+ project TSAAI (Transversal Skills on Applied Artificial Intelligence) was launched to strengthen transversal skills in applied artificial intelligence (AI) in higher education, coordinated by the University of Malaga and involving seven international partners from Germany (Offenburg University of Applied Sciences), Croatia (University of Rijeka), Slovenia (JSI and Jožef Stefan International Postgraduate School), Spain (University of Malaga), Estonia (Tallinn University of Technology) and North Macedonia (International Balkan University). This project will create a portal for teaching AI to bring it closer to non-experts. The result will be the FUTUR-IA platform, and a 3-year period is planned for implementation. This initiative, committed to the internationalization of education, aims to promote learning in applied AI skills through transversal and inclusive content. The project's online platform is expected to be ready by the end of 2022.

JSI incentives for the proper management of intellectual property

In the new ExSACT project, the Center for Technology Transfer and Innovation of the JSI encourages research organizations, companies and the state administration to manage their intellectual property. The main goal of the project is to simplify and optimize public investments in research and technological infrastructure as well as the protection of intellectual property rights in collaborative projects between researchers and industry, with an emphasis on the regulation of state aid. As part of the umbrella project Obzorje 2020 ATTRACT – Phase 2, a socio-economic study is being carried out to define and establish the conditions for the active role of the state administration in reducing risks in a cooperation between the academic and business spheres, and the critical points of the transfer of intellectual property rights will be analysed. In addition, there will be guidelines prepared for the management of these rights within the framework of collaborative research projects, and an international review of systems for evaluating the market value of intellectual property rights will also be carried out.

JSI nuclear physics in the journal *Nuclear Physics News*

An article about nuclear physics at the JSI was published in the magazine *Nuclear Physics News*, written by Dr Jelena Vesić. In it, cooperation as part of the FAIR project is highlighted, where there is successful participation in several experiments. An overview of the large JSI infrastructure relevant to nuclear physics is presented, especially the TRIGA Mark II research reactor and the tandem ion accelerator, with a description of the measuring stations and research methods. The work of the Laboratory for Nuclear Astrophysics and the Structure of Hadron Systems group is described in more detail. Both projects are heavily involved in international collaborations: the experiments of the Structure of Hadron Systems group have been taking place for many years at the Thomas Jefferson National Accelerator Facility (TJNAF, Jefferson Lab) in the USA and at the Mainz Microtron Centre in Mainz. A photograph of the tandem accelerator from the Microanalytical Centre of the JSI in Podgorica landed on the front cover of the magazine.

JSI at the Junction of Science and Business

In September, at the International Craft Fair in Celje, the Ministry of Education, Science and Sport project *Intersection of Science and Economy* took place in its fifth edition. According to many, it was one of the best ever. The purpose of the project is to promote the achievements of Slovenian science and strive for a closer cooperation between the scientific and economic spheres. From the very beginning, the project manager has been Janez Škrlec. The fundamental guideline of the project is the presentation of work and scientific achievements by domestic institutes, universities, faculties and high-tech companies. The JSI was represented by the departments F2, K5, K7, F7 and CTT. The focus was also on digitization, Industry 4.0 and 5.0 and Society 5.0. The event was an excellent opportunity to present the fields of mechatronics, bionics, automation, robotics, electronics, energy, ICT, photonics and space technology. The presentation within the project was also focused on DARQ and NBIC convergent technologies. Within the framework of the junction, three Celje Fair awards were presented: bronze, silver and gold.



Researchers from the JSI are recipients of awards from the Slovenian Biochemical Society

Among the recipients of the awards of the Slovenian Biochemical Society for 2022, which were awarded on 29 September 2022 at the regular annual assembly of the society, were members of the Biotechnology Department of the Institute, Assist. Prof. Ana Mitrović and Prof. Dr Janko Kos. Assist. Prof. Ana Mitrović was the recipient of the Lapanje Award 2022 for outstanding achievements in the field of biochemical sciences and the development of biochemical sciences in Slovenia and internationally. Prof. Dr Janko Kos was the recipient of the Lapanje Award 2022 for many years of organizational work in the field of biochemical sciences, professional work in sections or bodies of the society, for services in promoting Slovenian biochemistry in society, for popularizing and presenting the achievements of scientific research work and achievements to the public, and for successful organizational and professional work in expanding biochemical activity and establishing new forms of activity that contribute to the development of biochemical sciences.

Awards at the 70th anniversary of the founding of the Slovenian Chemical Society

The 70th anniversary of the founding of the Slovenian Chemical Society was celebrated in 2021, and on 22 September 2022, the Celebratory Academy of the Slovenian Chemical Society was held at the Grand Hotel Bernardin, at which the Society awarded honorary titles to individuals and institutions that influenced and supported the development of the society, built a bridge between the academic sphere and industry and, through their involvement in the society, influenced generations of young chemists. The association awarded honorary members, meritorious members, meritorious institutions and awards for work in the editorial office of the journal *Acta Chimica Slovenica*. The Institute was among the winners of the meritorious institutions that contribute to the promotion and effective activities of the society. The director of the institute, Prof. Dr Boštjan Zalar, accepted the award at the ceremonial academy. Among the recipients of awards for their editorial work at the journal *Acta Chimica Slovenica* were Prof. Dr Barbara Malič, Dr Melita Tramšek, Prof. Dr Aleš Berlec and Assist. Prof. Mirela Dragomir.



European Researchers' Night

The Institute, in a consortium of partners, prepared a series of activities as part of the European Researchers' Night event, which took place on Friday, 30 September 2022. Activities were available at the Open House Evening at the Institute. At a lecture on Fukushima, researchers tried to answer questions related to nuclear safety. They presented smart coatings that protect against corrosion and sought answers to the questions of how we can see fundamental particles. They looked at NAO's future technologies, the world in miniature, superconductors, nanomaterials and magnetic fluids. They also presented the results of research on different kinds of food and where it comes from to arrive on our plates. At the Reactor Center, the participants were taken on a tour of the TRIGA research reactor, the operation of the nuclear power plant and the use of radiation in medicine and science were presented. They could also play with LEGO microbial cubes.



Council of Researchers at the Beginning of their Careers is established of the JSI

On Monday, 19 September 2022 the founding meeting of the Council of Early-Career Researchers of the Institute was held in the Large Lecture Theatre. At the meeting, which was also attended by the Director of the Institute, Prof. Dr Boštjan Zalar, the candidates for membership in the Council introduced themselves. After an interesting discussion about the challenges faced by researchers at this stage of their careers, the elections of the members of the Council were held. The following members were elected and appointed to the Council: Assist. Prof. Tome Eftimov and Assist. Prof. Tadej Petrič in the field of electronics, information technology, energy; Assist. Prof. Matjaž Humar, Dr Zala Lenarčič and Dr Nerea Sebastian in the field of physics and nuclear engineering; Assist. Prof. Slavko Kralj and Assist. Prof. Matic Lozinšek in the field of chemistry, biochemistry, materials and environment and independent centres. The first meeting of the Council will be organized shortly and you are cordially invited to attend.



University of Ljubljana prize of Dr Uroš Seljak for the best scientific articles by students

On 4 October 2022, the University of Ljubljana awarded, for the first time, the best student scientific papers with the Award of Dr Uroš Seljak. The prizes were awarded by the honorary patron, the President of the Republic of Slovenia, Borut Pahor, the donor Dr Uroš Seljak, University of Ljubljana, and the American-Slovenian Educational Foundation (ASEF). The award of Dr Uroš Seljak is intended to encourage and support scientific publications by students on first- and second-cycle study programmes in the Republic of Slovenia and to encourage the mentoring of students. Among the recipients of the award are colleagues from the Department of Solid State Physics of the JSI, young researcher Katja Gosar and young researcher Aljaž Kavčič. Katja Gosar received the award for a scientific publication in the field of quantum devices, and Aljaž Kavčič for a scientific publication in the field of bio-integrated photonics. Their mentors, Dr Peter Jeglič, head of the Laboratory for Cold Atoms, and Dr Matjaž Humar, head of the Laboratory for Biointegrated Photonics, were awarded a Mentor plaque.





Slovenian researchers discover microplastics in hail for the first time

Ljubljana, October 2022

Dr Matejka Podlogar, Tina Radošević and Damjan Vengust from the JSI, Dr Manca Kovač Viršek and Marko Kozjek from the Water Institute of the Republic of Slovenia, Dr Matej Butala from the Faculty of Biotechnology, Gregor Žitko from the Faculty of Chemistry and Chemical Technology, Dr Ivan Jerman from the Institute of Chemistry and Dr Nataša Toplak and Dr Simon Koren from Omega d.o.o. were the first in the world to find microplastics in hail, in addition to bacteria, fungi, diatoms, sand and cellulose and lignin fibres. Investigating the more than 10-centimetre hail that fell in the villages along the Kolpa in June 2019, which was put in freezers by locals due to its exceptional nature, polyester fibres were also found using an environmental electron microscope (at the CEMM) and a Raman spectrometer (at Nanocenter). The results suggest that microplastics in the air can contribute to the formation of such large hailstones.

In June 2019, south-eastern Slovenia was hit by a hailstorm that caused a lot of damage. In Poljanska Dolina near Kolpa and Bela Krajina, the hail was more than ten centimetres, and hailstones smashed roofs, buildings, cars and trailers in campsites. Thanks to the locals, the hailstones stored in freezers reached Slovenian researchers Dr Matejka Podlogar, Dr Manca Kovač Viršek and Dr Matej Butala, who were able to carry out precise analyses in the laboratories because of the size of the hail. The hailstones were first surface cleaned and sterilized, and then melted in layers.

Particles of living and non-living origin were identified in the hail, and they also found approximately half a millimetre long fibres from cellulose and lignin, substances from the woody parts of plants and microplastic fibres. "We found a fibre made of polyethylene terephthalate, otherwise known as polyester. The source of this microplastic fibre could be clothing. We also found a particle of ethylene-vinyl acetate. We don't know exactly what its origin is, as it is a material that is widely used, among other things, for sports equipment," explains Dr Matejka Podlogar from the JSI. Interestingly, some of the

cellulose fibres found in the hail were dyed with textile dyes.

The extraordinary diversity of bacteria in the hail samples was also surprising; their living environments are primarily lakes, the sea, and the earth's surface. Among them were also types of bacteria that synthesize proteins that affect the formation of ice. Some particles in the air can act as nuclei, around which ice forms and thus hail is formed. And given the amount of fibres and sand that the researchers found in the hail, there is a possibility that these very particles had an impact on the formation of such a large hailstone.



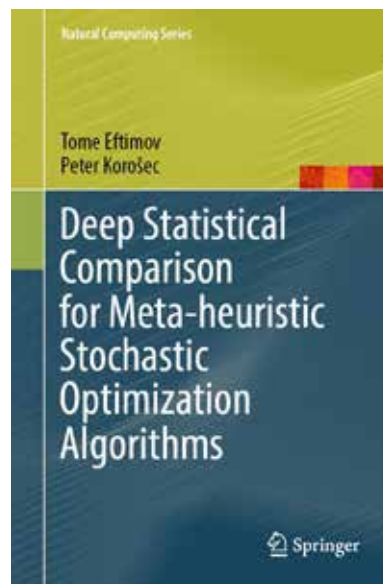
The JSI attends a meeting of experts in the field of rare-earth magnets

In Hanau, Germany, the first global meeting of experts in the field of rare-earth magnets (mining, motor design, magnet manufacturing and recycling of waste magnets) was held, with the aim to develop our own raw materials and gain independence from China. The initiative for huge investments in the field of critical raw materials, with the aim of increasing our own supply of key raw materials, strengthening circularity and supporting research and innovation comes from the top of the EU, with the ultimate goal of achieving a green and digital transition. The aim of the initiative is to strengthen the EU's capacity to monitor and strengthen the EU value chain – by identifying mineral resources and raw-materials projects in the EU's strategic interest, with strong environmental protection – as the EU's external policy on critical raw materials. The Department of Nanostructured Materials of the JSI was represented at the conference as a coordinator or partner in several European projects on the topic of recycling waste magnets (MaXycle, SUSMAGPRO, INSPIRES, RECO2MAG, REEsilience). Prof. Dr Spomenka Kobe participated in the panel discussion on this topic.



New book by Assist. Prof. Dr Tome Eftimov and Prof. Dr Peter Korošec

Assist. Prof. Tome Eftimov and Prof. Dr Peter Korošec from the Computer Systems Department have published a Springer book entitled *Deep Statistical Comparison for Meta-heuristic Stochastic Optimization Algorithms*. The book is focused on robust statistical methods for benchmarking single- and multi-objective optimization meta-heuristics. Robust statistical methods are crucial for fair benchmarking and to increase the reproducibility and replicability of experiments. The work presented in the book was supported by the postdoc project *Mr-BEC: Modern approaches for benchmarking in evolutionary computation* led by Assist. Prof. Tome Eftimov, and the European Union's Horizon 2020 research and innovation programme under grant agreement No. 692286 led by Prof. Dr Peter Korošec. The book provides approaches to trustworthy benchmarking that can easily be transferred to other research domains. The book is organized for researchers interested in basic and recent advances in statistical analysis.





JSI project accepted at the European Innovation Council tender

Ljubljana, 20 October 2022

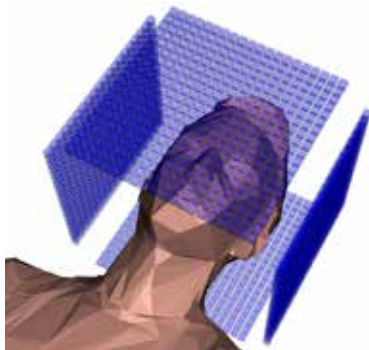
As the first project coordinator from Slovenia, the JSI succeeded in this year's European Innovation Council Pathfinder Open tender. The project to develop the next-generation fast positron emission tomograph with the PetVision time-of-flight will have a significant impact on more effective and cheaper cancer diagnosis and treatment, as it represents an important step from the current diagnostic technique based on very expensive positron emission tomography (PET) to a much more accessible, cheaper and flexible one in the PetVision device family. In the next 5 years, the Institute will coordinate a project worth €3.4 m together with Spain, Italy, Germany and the USA.

The European Innovation Council's Pathfinder Open call is aimed at funding the early stages of the development of new breakthrough technologies and solutions that have the potential to set new standards and shape new markets. Among this year's 858 evaluated applications, the EIC selected 57 projects in the fields of health, environment, energy, computing and

artificial intelligence. Among the selected projects is the project of the JSI, which envisages the development of the next generation of the fast-positron tomograph with the PetVision time-of-flight. The Centre for the Technology Transfer and Innovation also contributed significantly to the preparation of the application, which will also participate in the preparation of technology for exploitation.

The project will be led by Assoc. Prof. Rok Pestotnik from the Department of Experimental Particle Physics of the JSI, who was joined by partners from the University of Barcelona, the Institute for Instrumentation for Molecular Imaging in Valencia, the Bruno Kessler Foundation from Trento, the Rechst der Isar Clinic of the Technical University of Munich, Massachusetts General Hospital from Boston and Oncovision from Valencia. The project is expected to upgrade and

make cancer diagnosis cheaper over the next 5 years. Cancer incidence is predicted to increase 24% by 2035, when cancer will become the leading cause of death in the EU. Currently, the leading technique for diagnosing cancer is based on PET, but due to the high cost of implementation, it is only available in less than 0.5% of medical centres in the world. In the PetVision project, an ultra-fast detector of the annihilation gamma rays, will be developed with various technological innovations and used to manufacture innovative apparatus for functional medical diagnostics. The project envisages a package of groundbreaking innovations in the design of the detector, photo-sensor and front-end electronics, which would enable more effective cancer diagnosis and thus faster and more successful treatment of this disease.



Award for the best innovation from public research organizations

This year, the prize for the best innovation from public research organizations, which is awarded within the framework of the International Conference on Technology Transfer, was awarded to a group of researchers from the National Institute of Chemistry consisting of Maja Grdadolnik, Blaž Zdovc, David Pahovnik and Ema Žagar for the project *From polyurethane waste to raw materials with high added value* and a group of researchers from the Polish Gdynia Maritime University with members Paweł Kołakowski and Grzegorz Rutkowski for the project *Innovative equipment of intervention/service vessels: Mobile electromagnetic mooring system and flexible underwater bell for vessel maintenance Batychron*. At the conference, which is organized every year by the Centre for Technology Transfer and Innovation, expert Michel Neu from the French Commission for Alternative Energies and Atomic Energy presented their experiences of cooperation with companies, selected projects of excellent Slovenian researchers were presented, as well as research papers on transfer of technologies and intellectual property and the possibility of JSI cooperation with education. World Intellectual Property Organization awards were also presented.



Prof. Dr Jadran Lenarčič wins lifetime-achievement award in the field of computing and informatics

As part of the 25th international multi-conference Information Society 2022, on 14 October 2022, awards in the field of information society were presented. The award for lifetime achievement in the field of computing and informatics was presented at the ceremony to the former director of the Institute, Prof. Dr Jadran Lenarčič, who established himself mainly in the field of robotics, especially robot kinematics, and in the fields of biorobotics and humanoid robots. Prof. Dr Lenarčič is a member of the Engineering Academy of Slovenia and corresponding member of the Accademia delle Scienze in Bologna. He received two honorary titles, namely the Italian title of Cavaliere Ufficiale nell'Ordine al merito della Repubblica Italiana and the French title of Chevalier de l'ordre national du mérite. Until 2020, Springer published several books from the Advances and Robot Kinematics series, as well as two co-authored monographs entitled Robotics and Robot Mechanisms. At the ceremony, the prize for the achievement of the year in the field of information society in the past year was awarded to the group of the National Institute for Public Health, which introduced the zVem portal. The recipient of the prize, named The Information Strawberry, is the group that introduced the electronic identity card. The prize, named The Information Lemon was awarded to online censorship on social networks and the internet.



Dr Tina Vida Plavec receives the Large Krka Award

On Friday, 21 October 2022, at the presentation of the 52nd Krka awards, Dr Tina Vida Plavec from the Department of Biotechnology of the JSI received the Large Krka prize, which Krka awards to the highest-quality research projects. Dr Tina Vida Plavec received the award for her doctoral dissertation, which she completed under the supervision of Assoc. Prof. Aleš Berlec and the co-mentorship of Prof. Dr Borut Štrukelj. The main goal of the task was to prepare the lactic acid bacterium *Lactococcus lactis* so that it expresses proteins on its surface directed against tumour antigens characteristic of colorectal cancer. She demonstrated that with the help of surface-presented binding proteins, bacteria bind to the cells of colorectal tumour cell lines in a targeted manner. Targeting cancer cells with bacteria will open up the potential for new cancer treatment options in which a therapeutic protein is delivered to the site of action without affecting healthy cells. The award is a great recognition of the research work of Dr Tina Vida Plavec and confirmation of the research excellence of the Department of Biotechnology and the JSI.



Winners of Blinc awards for 2022

Ljubljana, 26 October 2022

The Institute and the Faculty of Mathematics and Physics of the University of Ljubljana awarded the fourth Blinc Prize for research and professional work in the field of physics. The Blinc Prize for physicists at the beginning of their career was awarded to Assist. Prof. Matjaž Humar. The Blinc Award for outstanding, unique achievements went to Dr Enej Ilievski and the Blinc Lifetime Achievement Award went to Prof. Dr Alojz Kodre. This time the event was held at the Jožef Stefan Institute, and the gathering was addressed by the Minister of Education, Science and Sports, Dr Igor Papič, Director of ARRS, Prof. Dr Mitja Lainščak and the Director of the Institute, Prof. Dr Boštjan Zalar.

Physics comes into everyday life in many ways and quickly spoils us with the technological advances it brings. In the last century, e.g., the strange effects of quantum mechanics have found many applications, from electronics and lasers, through advanced medical research, all the way to energy-saving light bulbs and solar panels. There is a rapidly developing field of research involving quantum sensors and computers, quantum networks, and secure quantum-encrypted communication. Experimental research with quantum entangled states, which underlies these technologies of the future, was awarded the Nobel Prize this year. With Blinc awards we awarded the best physicists as judged by Slovenian researchers.

The Blinc Prize for physicists at the beginning of a career was awarded to Assist. Prof. Matjaž Humar from the JSI. Assist. Prof. Matjaž Humar is one of the most dynamic and prolific physicists of the younger generation in Slovenia, as

evidenced by a wide range of scientific results, high-profile publications, invited lectures, reviewer and teaching work, as well as the very successful acquisition and management of Slovenian and European projects. Matjaž Humar introduced pioneering methods of sensorics and biomarkers based on micro lasers and laser microresonators in soft and biocompatible substances. The result of his work is the first Slovenian laboratory for Bio-integrated photonics at the Department of Solid State Physics at the JSI, which the researcher established with tireless persistence over the past 7 years. The "whispering gallery mode" method of micro resonator sensors, which he developed with his co-authors, provides the ability to localize at the level of individual cells by sensing various parameters, such as temperature, pH and refractive index, which represents a versatile and promising tool for deep-tissue imaging. He is the first author of eight articles in top international

journals such as Nature Photonics, Nature Communications, Physical Review Letters and Advanced Materials. His works have so far collected 1,600 pure citations. The awardee has presented as an invited lecturer at many top universities and conferences. He also obtained 12 projects, including six international ones, the most important of which are the ERC Starting Grant and the Human Frontier Science Program.

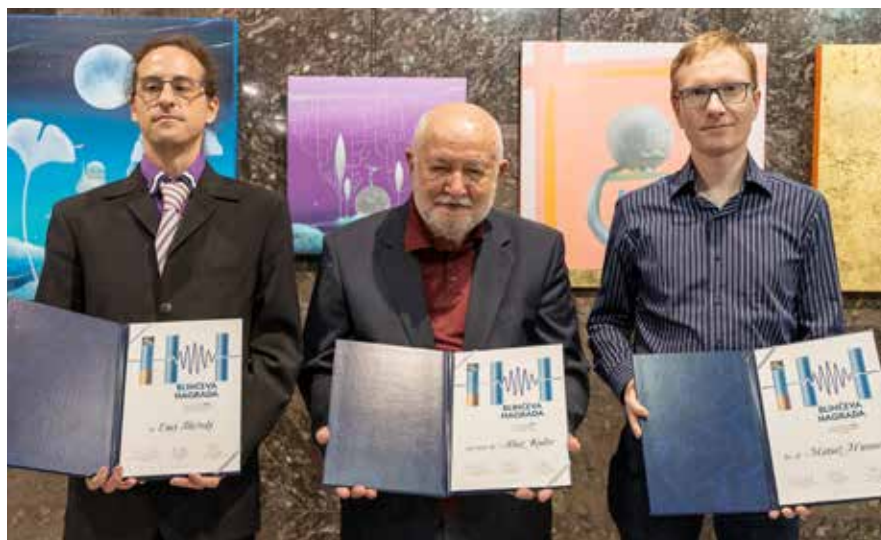
The Blinc Award for outstanding unique achievements in the field of physics was awarded to Dr Enej Ilievski from the Faculty of Natural Sciences and Mathematics of the University of Ljubljana. An article by Dr Enej Ilievski, which is the basis for the top achievement award, is in the field of transport theory in integrable quantum multi-particle systems. It has been known for more than two decades that systems such as the discussed Heisenberg spin chain can be ideal conductors even at high temperatures, which can be connected to the existence of quasi-local conservation laws that can serve to determine the lower limit for the so-called Drude weight that quantifies ideal transport. The most recent breakthrough in this area occurred in the last 5 years with the introduction of a new theoretical method of generalized hydrodynamics, where Dr Enej Ilievski is one of the key co-authors. In the article, Dr Ilievski shows a mapping between quasilocal conserved quantities and Bethe quasiparticles, i.e., strings. The result of his analysis shows that the lower bound is correct and that the Drude weight in the Heisenberg model at high temperatures is surprisingly nowhere continuous, but is a fractal function of the anisotropy parameter. The cited article was published in the most prestigious physics journal Physical Review Letters and has so far 160 citations according to the Google Scholar database. This work was followed by several articles by Dr Ilievsky, where he upgraded and expanded the use of the method of generalized hydrodynamics, and

these also have a great resonance among the professional public.

The Blinc Award for life's work in the field of physics was received by Prof. Dr Alojz Kodre from the Faculty of Mathematics and Physics of the University of Ljubljana. Emeritus Professor Dr Alojz Kodre is a Slovenian pioneer in introducing research in the field of X-ray absorption spectroscopy using synchrotron light, both for research in atomic physics and for the characterization of the atomic and molecular structure of materials. Thanks to him, Slovenian researchers have been involved in research at international synchrotron centres since the very beginning, when synchrotron particle accelerators, which were originally intended for research in elementary particle physics, were just starting to be introduced as extremely bright sources of X-ray light. He reported on the results of his research work at numerous lectures at foreign universities and international scientific conferences, thereby establishing the Slovenian school for the study of multi-electron co-excitations with X-ray spectroscopy. Knowledge of atomic physics and X-ray spectroscopic

methods provided by Prof. Dr Alojz Kodre was passed on to the younger generations during his master's and doctoral studies. He was a mentor to many graduates and four PhD students. Professor Alojz Kodre's contribution to the undergraduate course in physics is also invaluable. It is worth highlighting the long-term leadership of the Mathematical Physics course, which has gained almost mythical status, and also his introduction of the Model Analysis course, which plays a pioneering role in the education of computational physics at the University of Ljubljana.

Prof. Dr Alojz Kodre was, among other, the head of the Department of Physics at the Faculty of Mathematics and Physics and the president of the habilitation commission of the University of Ljubljana, and he always highlighted the importance of assessing an individual's competence before superfluous numerical criteria. Prof. Dr Alojz Kodre also has undeniable merits for the popularization of physics and science in general. He is undoubtedly best known to the public as a cult translator of science fiction, especially The Hitchhiker's Guide to the Galaxy, but he also translated many popular texts in the field of modern physics.



JSI approves its Plan for Gender Equality

On 20 October 2022 the Scientific Council of the JSI approved the Gender Equality Plan for the JSI. The adoption of the document represents an important milestone on the way to the sustainable transformation of organizational processes and culture with the aim of reducing or eliminating recognized imbalances and inequalities between the genders. To this end, it includes a set of measurable commitments and proposed measures to promote structural changes that will support equal opportunities for all employees, thereby contributing to a stimulating and safe working environment, research creativity and excellence in science. The plan was prepared by a consortium as part of the project Athena: Implementing gender equality plans to unlock research potential of RPOs and RFOs in Europe, which is financed by the European Union's framework program for research and innovation Horizon 2020. The preparation of the document included an analysis of the situation in the field of gender equality at the JSI, the in-depth preparation of measures and broad discussion through expert councils. The Committee for the Implementation of the Gender Equality Plan was also established.

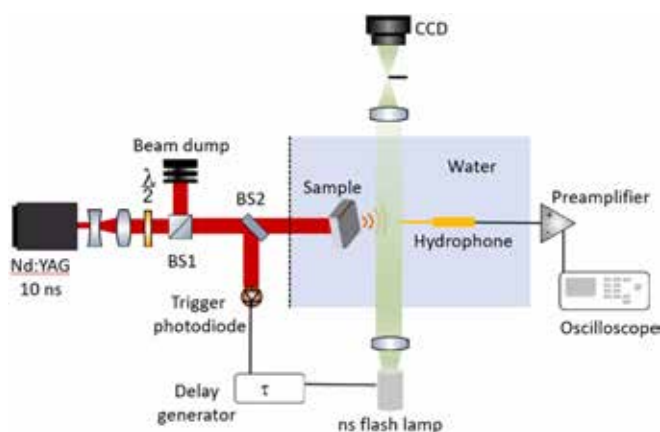


Prof. Dr Jean-Marie Dubois is a full member of the French Catholic Academy

After the unanimous election last February, Prof. Dr Jean-Marie Dubois, a member of the Department of Nanostructured Materials and honorary member of the Institute, became a full member of the Académie Catholique de France on 27 October 2022. This academy, created in 2018 in Paris, has several sections, among which one section covers basic sciences, technologies and medicine. Prof. Dr Jean-Marie Dubois, former director of the Institute Jean Lamour, CNRS, world-renowned scientist, honorary doctor of several world universities, and a member of a few academies will share his knowledge of metallurgy and materials science and contribute to the discussions and debates that the academy promotes to cope with the current rapid changes of our society. He was proposed for the award by Prof. Dr Gilberte Chambeau and Prof. Dr Christian Amatore, who were respectively head of the Chemistry Institute of CNRS and head of the Chemistry Department of Ecole Normale Supérieure in Paris.

Researchers prepare optoacoustic lenses from composite materials

Researchers from the Departments for Gas Electronics, Thin Layers and Surfaces and Complex Matter of the JSI and researchers from the LASTEh laboratory (Laser Technology Laboratory) from the Faculty of Mechanical Engineering of the University of Ljubljana have prepared optoacoustic lenses from the composite material graphene/ polydimethylsiloxane for photoacoustic ultrasound generation. They investigated the photo-acoustic response of thin films of various thicknesses, made from composites with different concentrations of graphene, when irradiated with a nanosecond pulsed laser and showed that the amplitude of the time-limited ultrasound wave is linearly dependent on the laser power. They recorded the formation of cavitation microbubbles in water and agar, which otherwise serves to simulate tissues. The paper explains some fundamental properties of photo-acoustic ultrasound generation and photo-acoustic parameters of the graphene-based composite, important for the preparation of photo-acoustic lenses. Possible uses in various biomedical and biochemical applications are also discussed. The results of the research were published in the journal *Photoacoustics*.



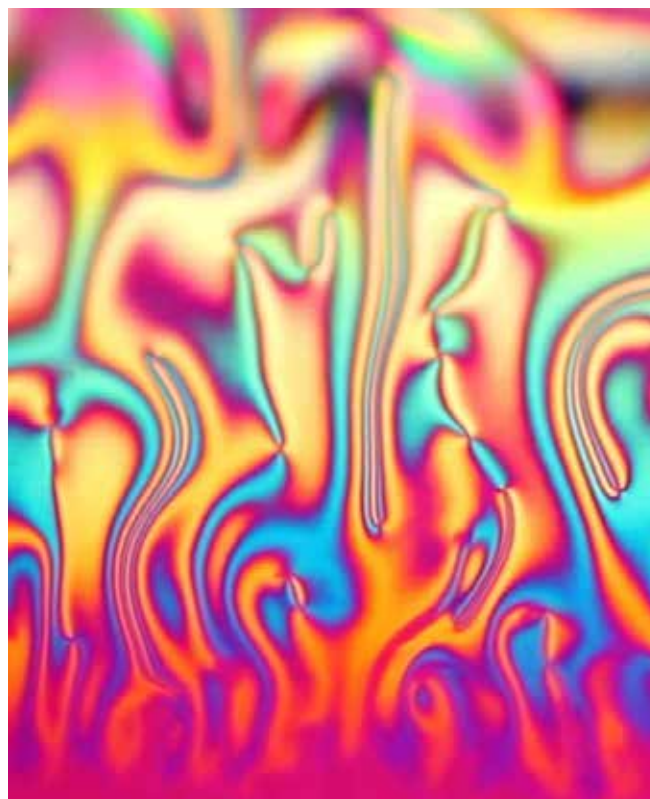
15th European Nuclear Energy Forum

On 10–11 November 2022, the European Nuclear Energy Forum met for the 15th time, in Prague. The forum is intended for broad discussions of the opportunities and challenges for nuclear energy in the European Union. The Forum is co-organized by Ms Kadri Simson, European Commissioner for Energy, and Mr Jozef Síkela, Czech Minister of Industry and Trade. Among the invited speakers was Prof. Dr Leon Cizelj, head of the Reactor Engineering Department of the Institute and president of the European Nuclear Society. One of his key messages was: “We have lived with nuclear power plant for a whole century. The enormous changes that take place in knowledge and society in one century oblige us all to actively co-create the future. The easiest way to do this is through active operation and the support of research and research-supported higher education. The need to actively co-create the future, binds the most those who have the most resources and power at their disposal.”



Topological defects in a passively driven nematic

Turbulent flows in active nematic liquid crystals lead to spontaneous topological defect creation. Researchers Dr Maruša Mur, Dr Žiga Kos, Prof. Dr Miha Ravnik and Prof. Dr Igor Muševič from the Department of Condensed Matter Physics at the Institute and the Faculty of Mathematics and Physics at the University of Ljubljana published a paper in *Nature Communications* entitled *Continuous generation of topological defects in a passively driven nematic liquid crystal*, where they studied a similar behaviour in a passively driven system. Here, the flow is driven by a concentration gradient of small organic molecules added into a thin film of a nematic liquid crystal. Counter-rotating vortex rolls are generated in the film. Above a velocity threshold the flow transitions from a laminar into a turbulent regime, where topological defects start forming continuously. In the paper the authors support their experimental findings by numerical simulations. The work describes one of the few mechanisms of topological defect creation in soft matter.





JSI researcher Dr Zala Lenarčič wins ERC Starting Grant in 2022

Ljubljana, 22 November 2022

A researcher at the Institute, Dr Zala Lenarčič, won a project in the European Research Council call for researchers starting their independent research careers. Dr Lenarčič impressed the European Commission with her innovative scientific proposal and obtained almost €1.5 m for her 5-year project *Weakly driven quantum symmetries (DrumS)*. For the JSI, this is the sixth ERC research project, but the first one won by a female researcher. And in this year's tender, the only Slovenian.

On 22 November 2022 the European Research Council announced the results of the call for researchers starting an independent research career (ERC Starting Grant 2022). We are happy to announce the news that the ERC has selected 408 projects for financing out of 2,932 considered project proposals from all scientific fields. This time we can congratulate Dr Zala Lenarčič from the JSI, who submitted her project *Weakly excited quantum symmetries (DrumS)* to the ERC panel for solid-state physics and the panel for basic building blocks of matter. At the first selected panel, 101 project proposals were received and only 15 proposals were selected for financing, which shows the significance of the success.

Dr Zala Lenarčič, head of the Quantum Systems Out of Equilibrium Group and a researcher at the Department of Theoretical Physics of the JSI, thus won the European Research Council (Starting Grant worth approximately

€1.5 m. The aim of the DrumS project is to explore the realistic potential of non-equilibrium quantum systems with symmetries. Strange symmetries are theoretically interesting in physics, but it is almost impossible to find them in nature or realize them in an experiment. The goal of the DrumS project is to show that exciting, real-world systems with approximate symmetries can induce exotic states that are fundamentally surprising, but could also have uses for quantum technologies.

Symmetries in physics imply conserved quantities. Approximate symmetries therefore imply approximately conserved quantities. An example of an everyday excited system with an approximately conserved amount is a warm sunbeam: the glass structure insulates the interior and approximately conserves the energy, and the losses are compensated by the excitation with the sun's rays. Thus, even on a cold winter day with weak

solar radiation, it can be quite hot in a warm bed. The DrumS project wants to show that even a weak excitation at the quantum level can have a similarly disproportionately large effect, if only it compensates for small losses of roughly preserved quantities and symmetries.

The DrumS project will develop theoretical predictions and protocol proposals for the stabilization of exotic quantum phenomena under realistic conditions, i.e., by the laser excitation of materials and in quantum simulators. The proposed fundamental concept of compensation of incomplete symmetries by excitation could revolutionize the fields of energy harvesting, high-temperature insulators, exotic superconductivity and the stability of quantum simulators. If the theory is followed by experimental confirmations by scientific partners across Europe, the DrumS project will pave the way for the new functionality of quantum technologies.

The 4th most powerful supercomputer in the world is also available in Slovenia

In Bologna, on 24 November 2022, the 4th most powerful supercomputer in the world, the EuroHPC Leonardo system, was launched at a ceremonial opening under the patronage of the President of Italy, Sergio Mattarella. The modular system with a total capacity of almost 240 PFLOP/s from the European manufacturer Atos will enable faster and more efficient research, especially in astrophysics, particle physics, artificial intelligence, life sciences, computational chemistry and biochemistry, environment, climate, quantum computing and the construction of digital twins. Slovenia had a special place in the Leonardo project as the seat of the first Vega supercomputer within the EuroHPC initiative and as a founding member of the consortium, which deepened the cooperation of researchers and engineers of the JSI with the engineers of the CINECA centre, which manages the system. Leonardo will be available through European tenders, and in Slovenia also through national tenders of the Slovenian National Supercomputer Network SLING, and researchers at the JSI, Prof. Dr Andrej Filipičič, Dr Jan Jona Javoršek and Mag. Barbara Krašovec.



Prof. Dr Boris Rogelj at the Portraits of Science exhibition

Prof. Dr Boris Rogelj, head of the Department of Biotechnology at the Institute, researches dementia and neuromuscular diseases associated with aging, with the aim of discovering new methods of treatment. This time he responded to the University of Ljubljana's invitation to participate in the Portraits of Science exhibition. The exhibition, which will be on view at the Kraków Embankment in Ljubljana until mid-January 2023, features innovative portraits of eighteen top researchers from the University of Ljubljana, as well as historical portraits of Dr Ana Kansky, recipient of the first doctorate at the University of Ljubljana, and Dr Fran Ramovš, who gave the first lecture at the newly founded university on 3 December 1919. The selection is not yet complete and the university promises to supplement it with new portraits in the future. The authors of the photographs are Arne Hodalič and Katja Bidovec, who in recent years have also specialized in photographing science by photographing motifs for the 70th anniversary of the Institute. With the exhibition, the university wants to emphasize the importance of science in society, research successes and connect the university even more with the city, its inhabitants and visitors.



A new method for identifying bacterial DNA

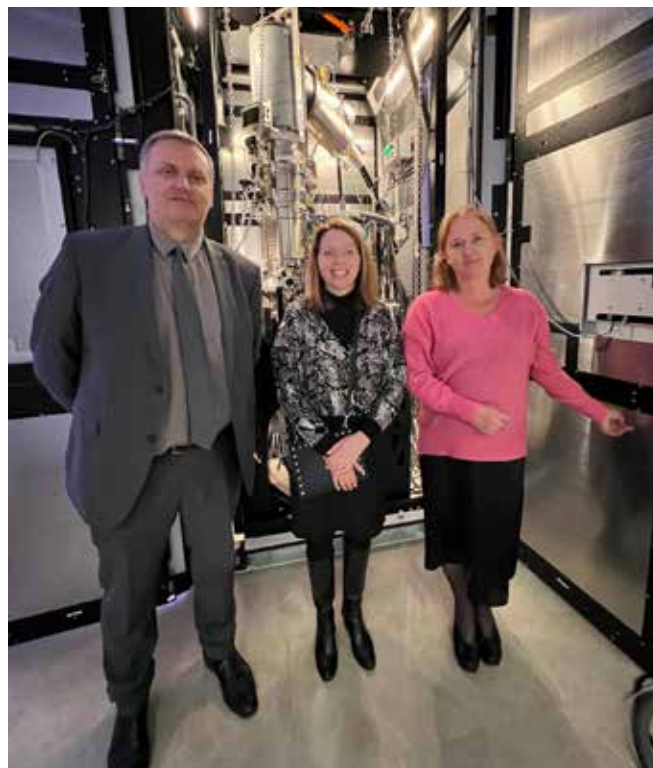
Researchers from the Department of Gaseous Electronics have achieved an ultrafast differentiation by genomic GC content of the bacterial DNA at a molecular level using surface-enhanced Raman spectroscopy and fine-tuned plasmonic gold nanocrystals. Their atmospheric-pressure plasma-designed truncated plasmonic particulates revealed truly exceptional optical response within nanometric gaps between gold dimers/chains, from where the molecular fingerprints of bacterial DNA fragments gained the strongest Raman signal enhancement. It allowed them not only to collect vibrational data from different DNA samples but also, for the first time, to distinguish reliably between bacterial species due to the intrinsically different compositions of nucleobases adenine, guanine, cytosine and thymine within the biological macromolecule. The realized approach was successfully validated by cutting-edge third-generation sequencing nanopore technology and published in *NanoLetters*.

Discovery of super-quiet high-entropy alloys for alternating-current applications

An article was published in the journal *Advanced Materials Interfaces* in which researchers from the Condensed Matter Physics Department, Dr Jože Luzar, Dr Stanislav Vrtnik, Dr Primož Koželj, Dr Andreja Jelen, Dr Magdalena Wencka, Dr Darja Gačnik, Peter Mihor, Prof. Dr Janez Dolinšek and a researcher from the Centre of Excellence for Nanoscience and Nanotechnology Dr Bojan Ambrožič, together with his colleagues from the Faculty of Chemistry and Chemical Technology of University of Ljubljana, the Institute of Chemistry and the Slovak University of Technology in Trnava, announced the discovery of super-quiet high-entropy alloys for AC applications. Ferromagnetic high-entropy materials AlCoFeNiCuX exhibit a combination of magnetic softness and zero magnetostriction, which does not mechanically vibrate in an alternating magnetic field and therefore does not emit annoying auditory sound waves, e.g., like the hum of mains transformers. The super-quietness is the result of the special three-phase nanostructure of these materials. The newly developed materials are suitable for the production of inaudible transformers, magnetocaloric refrigerators and other electromagnetic devices based on alternating magnetization and demagnetization with an electromagnetic field in the range of audible frequencies.

JSI visited by General Secretary of EARTO, Mrs Muriel Attané

On 29 and 30 November 2022, Muriel Attané, Secretary General of EARTO was visiting Slovenia. EARTO (European Association of Research and Technology Organizations) was founded in 1999 with the aim of promoting research and technology organizations (RTOs) and representing their interests in Europe and connecting more than 350 research organizations in more than 32 countries. EARTO members represent 150,000 highly skilled researchers who operate a wide range of research and technology infrastructures that aim to create technological and social innovations and systemic solutions that contribute to their economic, social and political impact. During the official visit, the Secretary General of EARTO met with representatives of the two Slovenian members of EARTO, the JSI and the National Institute of Chemistry, as well as representatives of the Ministry of Higher Education, Science and Sports and the Ministry of Economy and Technology, in discussions on upgrading cooperation in the field of measures of the European research area and the strengthening of bilateral relations between institutions.



JSI hosts the President of the European Patent Office, Antonio Campiños

On 30 November 2022, the Institute hosted a meeting of delegations from the European Patent Office (EPO), the Intellectual Property Office of the Republic of Slovenia (URSIL) and Slovenian research organizations in central Slovenia. During his visit to Slovenia, Antonio Campiños, President of the EPO, together with Michael Frölich, Director of European and International Legal Affairs (PCT), and Yann Ménière, Chief Economist at the EPO, met with mag. Karin Žvokelj, Director of URSIL, Prof. Dr Maja Klun, Vice-Rector of the University of Ljubljana, Prof. Dr Majo Ravnikar, Director of the National Institute of Biology, Prof. Dr Gregor Anderluh, Director of the Institute of Chemistry, and Prof. Dr Boštjan Zalar, Director of the Jožef Stefan Institute. They talked about the impact of the unified patent system on public research organizations and universities, the role of patent applications in the academic sphere, and the added value of proceedings before the EPO for research organizations and universities. After the exchange of opinions and views on the discussed topics, a tour of research work and research equipment was held at the Department of Advanced Materials and the Centre for Electron Microscopy and Microanalysis.



JSI researchers at the ARRS Day of Excellence in Science

On 1 and 2 December 2022, the traditional ARRS Day 2022: We Support Excellence was organized by the Public Research Agency of the Republic of Slovenia, ARRS, in the Grand Hotel Union in Ljubljana. First,



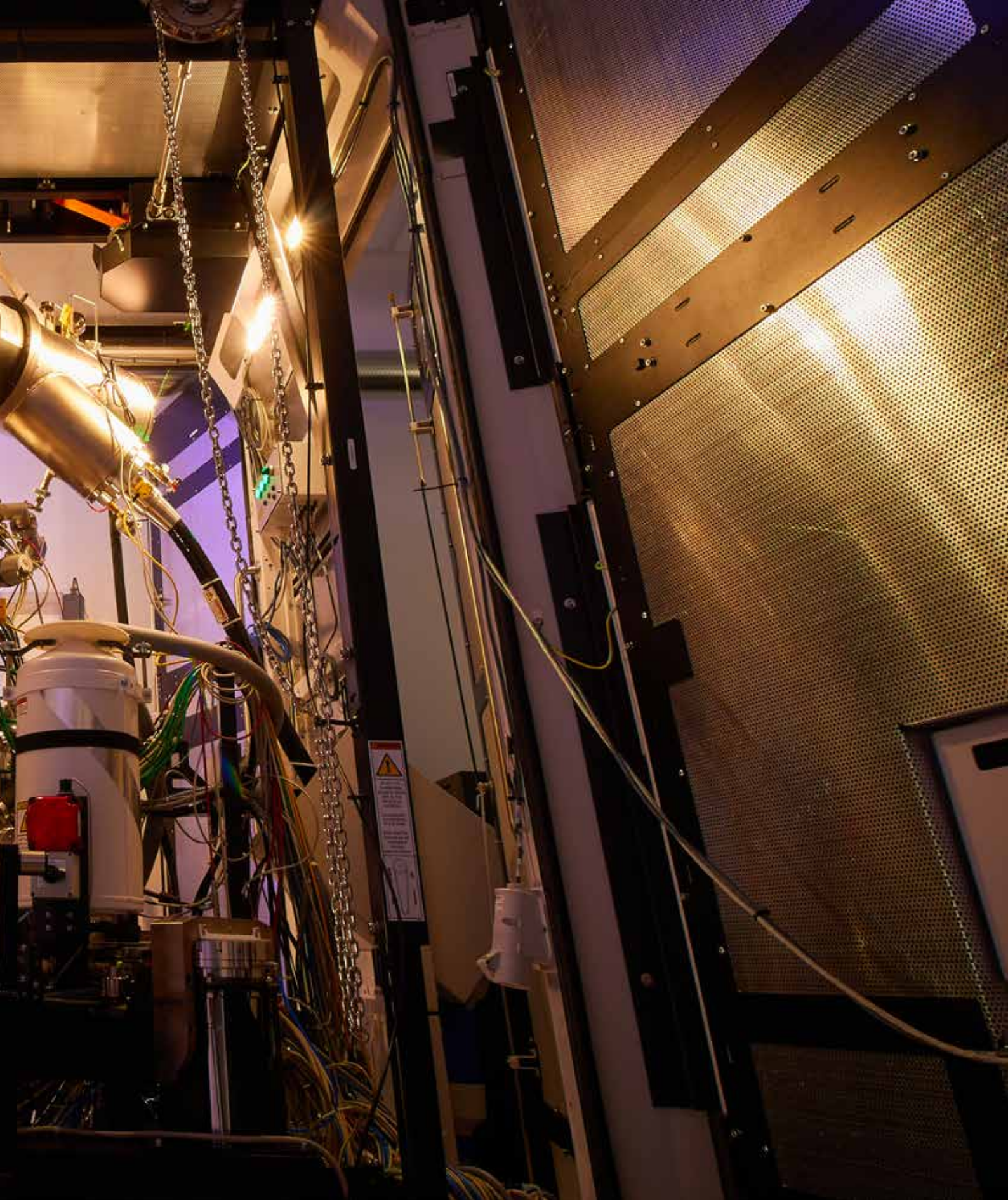
ODLIČNI V ZNANOSTI 2022

there were discussions on the topics of younger researchers in the region, the impact factor of scientific journals in Slovenia and the European Research Council (ERC) and Slovenia, in which the JSI's Assist. Prof. Matic Lozinšek took part. Subsequently, the Excellent in Science 2022 awards were presented for 52 research achievements. The awards were received by Prof. Dr Gregor Papa and Dr Vida Vukašinovič for the project *Electric bus routes in hilly urban areas: overview and challenges*, Assist. Prof. Ana Mitrovič, Dr Georgy Mikhaylov Knez, Dr vet. Med. Petra Matjan Štefin, Prof. Ddr Boris Turk and Prof. Dr Janko Kos for the project *Evaluation of new cathepsin X inhibitors in vitro and in vivo and their ability to improve cathepsin-directed antitumor therapy*. Prof. Dr Barbara Koroušič Seljak for the project *Energy and nutritional composition of school lunches in Slovenia: results of chemical analysis within the national research on school nutrition*, Prof. Dr Ester Heath for the project *Modern organic pollutants - how can we control them with algae?* and researchers from the Department of Condensed Matter Physics for the project *Impact of temperature inversions on mass concentrations of black carbon and particles in mountain areas*. Among all the projects, 21 were selected for presentation at the event, including four projects by a total of 19 researchers from the JSI. These are Tina Arh, Dr Matej Pregelj and Prof. Dr Andrej Zorko from the Department of Condensed Matter Physics with the project *Ising spin liquid*, Dr Vasyl Shvalya, Dr Martina Modic, Dr Nataša Hojnik, Assist. Prof. Janez Zavašnik, Jaka Olenik, Martin Košiček, Dr Gregor Filipič and Prof. Dr Uroš Cvelbar from the Department of Gaseous Electronics with the project *Plasmon surfaces for the recognition of mycotoxins*, Prof. Dr Tina Kosjek, Dr Agneta Annika Runkel, Dr Janja Tratnik Snoj, Dr Darja Mazej, Assist. Prof. Ingrid Falnoga and Prof. Dr Milena Horvat from the Department of Environmental Sciences with the project *Does our genetic record carry information about our sensitivity to exposure to phthalates?* for the field of Natural Sciences and Technology and Prof. Dr Boris Rogelj and Assist. Prof. Helena Motaln from the Department of Biotechnology with the project *The interaction of the polyGA dipeptide repeat reveals disturbances in the functioning of autophagy* for the field of Medicine and Biotechnology.



A new Spectra 300 line scanning electron microscope

In 2022, the JSI installed a new Spectra 300 line scanning electron microscope (Thermo Fisher Scientific). The Spectra 300 line scanning electron microscope is state-of-the-art research equipment, and one of the latest generation of scanning electron microscopes. It enables comprehensive structural and chemical characterizations of materials at the atomic and sub-atomic levels. The microscope has a field-emission gun electron source, a spherical aberration corrector and a monochromator, which enables the following transmission electron microscopy techniques to be performed: observation with a parallel electron beam (TEM, HRTEM), electron diffraction (SAED, CBED, PED), 4D STEM, qualitative and quantitative chemical analysis (EDXS, EELS), all with an ultimate imaging and analysis resolution at the atomic and sub-atomic levels.



JSI becomes a member of EIT Manufacturing to improve the innovation ecosystem

With its membership of EIT Manufacturing, the JSI is becoming part of the leading European community in the area of production. At a meeting on 12 and 13 December 2022, researchers and representatives of companies from Slovenia and Europe discussed possibilities for cooperation, with the aim of finding opportunities to improve the innovation environment as well as the business and managerial culture. The data are promising: in 2021, Slovenia ranked tenth in the world in terms of the density of installed robots in production per 10,000 employees, and was placed as high as third in Europe, right behind Germany and Sweden, and ahead of Switzerland. One of the examples of good practice is the SmartFlexCell innovation project, which the JSI coordinates within the framework of EIT Manufacturing with partners from Spain, Denmark and Lithuania, with the aim of producing a new, reconfigurable robotic cell. The product will be developed at the JSI as part of a spin-off and will enable personalized production in Europe. The participants also highlighted that the way to Society 5.0 is to invest in young professionals, as early as primary school, so guiding them towards a future based on innovation.



Prof. Dr Miran Čeh, winner of the prestigious Spiridion Brusina award

The Croatian Society of Natural Sciences awards one Spiridion Brusina medal each year to a distinguished foreign or Croatian scientist with a permanent residence abroad who has helped Croatian science with his or her work; or that he or she collaborated with Croatian scientists or worked scientifically in Croatia. In 2022, the winner of this prestigious award was Prof. Dr Miran Čeh from the Department of Nanostructured Materials and head of the Center for Electron Microscopy and Microanalysis (CEMM). Professor Čeh participated in a series of annual meetings of the Croatian Society for Microscopy (HMD), where he gave lectures on the use of electron-microscopy techniques and thus encouraged and educated young scientists to use such techniques in their scientific research. He also supported the work of the association by participating in Croatian microscopy congresses and symposia with invited and plenary lectures. In this way, he greatly contributed and continues to contribute to the development of microscopy and microscopic techniques in Croatia, thereby stimulating and improving the development of science in Croatia in general.





A new, important step towards a knowledge of the harmful substances in our environment

Brinje, 14 December 2022

The Department of Environmental Sciences of the JSI has acquired new infrastructure equipment that will enable detailed analyses of harmful substances in the environment, food and biological samples. The new Orbitrap Exploris™ 240 mass spectrometer, which enables extremely accurate determinations of the mass of molecules and their constituent parts, will remove another layer in the identification of pollutants in our environment, and will also contribute to monitoring human exposure and the search for harmful compounds in food and nutritional supplements, and especially improved our understanding of the potential harmful effects of hazardous chemicals that surround us in our daily lives.

In the modern world, with industrialization and the constant use of new materials, we are always exposed to a multitude of chemicals that are responsible for a variety of diseases. Their impact on an individual's health is influenced by both external factors, such as the chemical nature of these chemicals and the amount to which we are exposed in the short or long term, as well as the individual's sensitivity to certain substances or susceptibility to certain diseases. The identification of chemicals in the environment and biological samples is therefore crucial for evaluating the impact on human health and other organisms in the environment. Since chemical molecules are invisible to

the eye, they need to be detected using methods that detect, e.g., molecular weight as one of the basic physicochemical parameters. With spectroscopic methods, we gain an insight into the entire structure of molecules. Mass spectrometers differ in the accuracy of determining the mass of compounds and elements and the sensitivity for their detection. The Orbitrap Exploris™ 240 mass spectrometer, which is a new acquisition of the Department of Environmental Sciences at the JSI in 2022, represents a significant advance in the chemical analysis of organic compounds. Funding for the Orbitrap mass spectrometer in the amount of €690,000 was collected from the

department's programme funds, funds from the Infrastructure Centre for Mass Spectrometry and the ARRS equipment package. This spectrometer is just one of many research, analytical devices in the Department of Environmental Sciences, enabling major advances in environmental, food and health research. To the cost of purchasing the instrument, it is of course necessary to add just under €100,000 for the preparation of the laboratories in which this instrument is located.

In the laboratories of the Department of Environmental Sciences, they have several mass spectrometers that they used in organic, inorganic and isotopic analysis. Most spectrometers are coupled to a gas

or liquid chromatograph, which enables the separation of the components in the sample. Coupled with a high-performance liquid chromatograph, the new Orbitrap has significantly higher resolution than the 15-year-old Q-TOF Premier high-resolution mass spectrometer, meaning it can determine molecular mass to four decimal places, with an accuracy of better than 1 ppm. In addition, the molecular ion can also be split and analysed into its individual parts, thereby allowing the structure of the molecules to be determined.

A typical analysis, complete with chromatographic separation, takes about 10 minutes and will be able to extract data on thousands of different molecules at once. In this way, with complex analysis, they will be able to detect a huge number of different pollutants that can threaten the health of living beings, and they will connect the findings with genetic analyses, which are also the subject of their research. Genetic analysis can provide information on susceptibility to a certain type of disease, and it also enables research of the affects of the rate of metabolism and excretion of chemicals from the organism and indirectly of the sensitivity to chemicals from the

environment. This opens up many possibilities for research on the impact of the environment on health and linking the results of various studies, e.g., with meta analysis.

The Head of the Department of Environmental Sciences, Prof. Dr Milena Horvat, says that the more advanced analyses made possible by the new mass spectrometer will raise the level of excellence in the field of environmental research, thereby enabling better integration in the wider research space in Slovenia and especially in the EU. In addition to a top-notch and motivated staff, which today already includes more than 40 researchers and 20 doctoral students, the research infrastructure and high-tech equipment and laboratories are also crucial for carrying out this type of research. This is exactly what the department gained within the framework of the structural funds in 2015. This enabled the department to be firmly positioned in the European research area, strengthened cooperation with domestic and foreign partners, increased competitiveness, high-quality staff training and increased employment in the department and at participating organizations. With its new state-

of-the-art equipment, infrastructure and knowledge, the department has also become an attractive destination for education and the hosting of top foreign scientists. In 2022, this research infrastructure was upgraded with the Orbitrap mass spectrometry equipment. Of course, the story does not end there, they will continue in this direction in the future.

Prof. Dr Tina Kosjek is also looking forward to working with the new device. "Working with this instrument is one of the biggest challenges I have faced so far in my professional life. Not only are the expectations of colleagues from the department, the JSI and the partners of numerous research projects at home and abroad extremely high, we also have very diverse tasks in many areas, among them the environment, health and food, and also developments in diagnostics, drug development, clinical research, one day maybe even proteomics. This, of course, cannot be a task for a single person, but we will only be able to make full use of the capabilities of this device through excellent cooperation with top and motivated experts in the fields of bioinformatics, biostatistics, health sciences, biochemistry and others."



Relocation of the JSI's support-services staff to a new location at Tržaška 134

The Jožef Stefan Institute has been dealing with a shortage of space for a long time, which is not easy to solve given the diversity and specificity of the institute's activities. However, at least a temporary solution was achieved in 2022, as a part of the Institute moved to rented premises at Tržaška cesta 134. The organizational units Secretariat/Legal & Personnel, part of Commercial, Finance & Accounting, Service for Business Informatics and International Project Office as well as Smart Cities and Communities Centre, Centre Factories of the Future and Scientific Information Centre Library. Building at Gruda is not far from the main building, but it nevertheless proved how important the support services are for the smooth functioning of the Institute. On the one hand, despite the efforts of colleagues, certain essential work processes took longer due to dislocation, and on the other hand, with the new way of working, certain work processes were also optimized, as random meetings were replaced by pre-organized meetings. By moving, our colleagues acquired more modern and pleasant premises and parking lots, which is not insignificant considering the fact that we spend more and more time at work. On this occasion, we sincerely thank each and every one of you for your patience and understanding in a situation that is certainly the most favourable for our Institute.



Pregl's award for outstanding doctoral work goes to a researcher from the JSI

Dr Alja Prah from the Center for Network Infrastructure of the JSI received the Pregl Prize from the Institute of Chemistry for an outstanding doctoral thesis entitled *Investigation of the role of electrostatic interactions in the enzymatic catalysis of monoamine oxidases using a multilevel computational model*.



JSI participates in magnetic fusion research

In December 2022, at the Lawrence Livermore National Laboratory in California, American scientists successfully conducted a controlled nuclear fusion reaction for the first time in which more energy was generated than was needed to carry out the reaction itself. Nuclear fusion was achieved with so-called laser fusion, where a millimetre ball with fusion fuel is heated and compressed in a small chamber with a powerful laser pulse. When a sufficiently high temperature and density of the fuel is reached, fusion of the nuclei occurs and thus energy is released. Currently more technologically developed and more suitable for commercial use, is the so-called magnetic fusion, where the fusion of nuclei is achieved and maintained in a strong magnetic field for a long time (several seconds, eventually minutes and hours). Slovenian scientists, including those from the JSI, participate intensively, especially in research on the latter. The largest magnetic fusion plant ITER, which is being built in the south of France and will be the precursor to the first demonstrative fusion power plant, holds great promise.

The highest awards in Slovenia for scientific research achievements

Ljubljana, 19 December 2022

In Cankarjev dom in Ljubljana, the highest awards in Slovenia were awarded for achievements in the field of scientific research and development activities, as well as for inventions, technological and non-technological development achievements. Among the recipients of the awards and recognitions are also four researchers from the Institute.

Prof. Dr Nada Lavrač from the Department of Knowledge Technologies received the Zois Award for original data-presentation methods for effective machine learning. Prof. Dr Nada Lavrač from the JSI and the University of Nova Gorica is a leading researcher in the field of machine learning, the most important field of artificial intelligence. It focuses on the development of machine-learning methods for the analysis of complex relational data and networks and their application in medicine and bioinformatics. The breakthrough achievements of her research are original methods for the automatic conversion of complex data into a simpler tabular form. This data-representation approach, called representation learning, represents the cutting edge of machine learning as it simplifies and improves the use of all kinds of machine-learning methods. She and her co-authors also presented a selection of freely available methods for learning representations in a scientific monograph,

which was published by Springer in 2021. The Zois award for outstanding achievements in the use of organic analysis in the field of environment, food and health was received by Prof. Dr Ester Heath from the Department of Environmental Sciences. In her work, Ester Heath combines research in chemistry, the environment and wastewater-treatment technologies, as well as food and health. The main area of her research is studying the circulation and consequences of organic pollutant residues in the environment. These are potentially toxic substances such as residues of medicines, personal care products and industrial chemicals that can harm our health and the environment. Together with her colleagues, she developed new analysis procedures and cleaning technologies and was the first to evaluate the pollution of the Slovenian water environment. With this, she paved the way for other researchers and influenced social awareness of the danger of improper disposal of medicines. She



also pioneered the innovative approach of assessing drug use in the population based on the chemical analysis of wastewater and assessing the migration of organic pollutant residues from materials that come into contact with food. Assoc. Prof. Rok Žitko from the Department of Theoretical Physics received the Zois award for the development of the theory of nanoscopic quantum systems. Assoc. Prof. Rok Žitko works as a researcher at the JSI and at the Faculty of Mathematics and Physics of the University of Ljubljana. His research work covers many areas of solid-state physics and nanophysics, such as the physics of quantum impurities, the physics of surfaces and magnetic nanostructures, transport phenomena and superconducting devices. He was the first to introduce the numerical renormalization group method to Slovenia and developed a unique implementation of this method, with which he solved many previously unsolvable problems



Infineon, a major research company from Austria, visits the JSI

On 21 December 2022, the Institute was visited by representatives of Infineon, one of the strongest research companies in Austria. Infineon Technologies Austria AG is a subsidiary of the Infineon Technologies AG Group. The core global challenges that Infineon addresses with its semiconductor and system solutions are energy efficiency, mobility and security. The company's solutions are found in cars, telephones, household appliances, computer centres, robots, industrial equipment, etc. With 4,820 employees from approximately 73 countries, including 2,100 in research and development, the company achieved a turnover of €3.9 billion in the 2021 financial year. The JSI is with Infineon, and other 73 partners, in the joint European project iRel40 - Intelligent Reliability 4.0, whose general assembly was held 7–10 November 2022 in Ljubljana, with an emphasis on reviewing the activities of the upcoming project year. This time, however, company representatives met separately with several Institute research groups and identified potential future joint research topics with which they will deepen mutual cooperation.

of quantum impurities and devices consisting of quantum dots, and was the first to predict the unusual behaviour of these systems at low temperatures. The originality of his work also lies in the connection of theory with experimental predictions and observations. Although his work belongs to basic research, his discoveries will also have an important impact on the development of quantum technologies.

The Puh prize for life's work in the field of functional electrical stimulation and robotics went to a former colleague Assoc. Prof. Uroš Stanič. Retired scientific councillor of the JSI, Dr Uroš Stanič upgraded his long-term research work by developing the Ljubljana family of electrical stimulators as a basis for the rehabilitation of hemiplegic patients - the Ljubljana School of Rehabilitation. It is a method of treatment where, by means of electrical stimulation, the paralyzed muscles return functional movement to the patient, such as opening a spastic hand and allowing objects to be grasped, or lifting a drooping foot while walking and preventing limping. Based on Slovenian good practice, he took the initiative and was elected as the first President of the International Association for Functional Electrical Stimulation (IFESS). This is how he spread this effective method of rehabilitation from Ljubljana all over the world. Successes in rehabilitating the movement of lame patients were the basis for Gorenje's order for the development of the first Slovenian industrial robot GORO1.





Filming Chain Reaction at the JSI Reactor Infrastructure Center

Brinje, 19–21 October 2022

From the 19th to the 21st of October 2022, the JSI Reactor Infrastructure Center was transformed into a film set, with the center playing the part of the reactor in Vinča, Serbia, where on 15 October 1958 a nuclear accident occurred. The film crew, led by director Dragan Bjelogrić, filmed in the reactor, and were assisted by a team of JSI researchers.

Dr Anže Jazbec, one of the team leaders, said that he did not know the famous names from the world of film and that he was hearing about them all for the first time, but he had this to say about the reactor: "At the reactor we really worked hard for the needs of the filming. We slightly modified the entry procedure, and the protective clothing was optional. We removed all sources of radiation from the areas where the film crew was working. We also ensured that there was no radioactive contamination in these areas. All the members of the film crew wore personal dosimeters at all times, and upon exiting the reactor, they tested themselves on the personal contamination meter. We didn't have any unusual readings during the four days. I can say that the film crew was very understanding of our instructions and they followed them strictly. They packed their things by Sunday morning, and at 9:40 the last member left our reactor center. On Monday, 24 October the reactor was already able to operate normally for the purposes of educating physics

students from the University of Ljubljana. Thanks must go to the team from SVPIS, who transformed the reactor center into a nuclear institution from the 1950s, and then back into the TRIGA reactor of 2022." The plot: The President of Yugoslavia, Josip Broz Tito, ceremoniously, with the push of a button, as part of the Yugoslav nuclear dream, started the first research nuclear reactor in Vinča near Belgrade, on 17 May 1958. Unfortunately, in the same year, on October 15, a severe accident occurred, considered the world's first post-war nuclear accident.

On that day they were conducting an experiment with the goal of measuring the intensity of neutron sources of spontaneous fissions, which was a key part of the theses of two physics graduates at the Faculty of Natural Sciences in Belgrade. The radiation could not be accurately measured with any instrument at the institute, which meant only one thing: that the dose was lethal. In the course of the accident, six expert operators were exposed to large doses of radiation.

Since they would not be able to help them in Belgrade, all six were immediately transported to the Paris "Foundation Curie" hospital, where they didn't know exactly what to do. In an experimental treatment, the doctors decided on a bone-marrow transplant, which turned out to be the right solution, as five of them recovered and went on to live almost normal lives. The bone marrow was donated by Parisians, who risked their lives for the lives of strangers. In later times, both the Serbian physicists and French doctors forged extremely friendly bonds and spent the rest of their lives interacting with each other, going on vacations together and becoming really good friends. The accident was not written about at the time, but the incident inspired Prof. Dr Goran Milašinović to write the book "The Vinča Incident", which then encouraged the Serbian film legend Dragan Bjelogrić to shoot the film. Bjela will also play the lead role in the film. The film entitled Chain Reaction (original title Lančana reakcija) is scheduled to premiere in October 2023.





PRAVAC
EVAKUACIJE IZ
STEPENICE









Prof. Dr Luka Snoj collaborates in the theatre performance *Children in the SNG Drama*

At the end of September, the play *Children*, which is about a nuclear accident, had its premiere in Ljubljana's Drama theatre. As an expert consultant, head of Department of Reactor Physics Prof. Snoj was also involved in the preparations for the performance.

"The director and I went through the script in detail together, especially things related to radiation, nuclear physics, the consequences of radiation, etc., and placed the matter in context. The team of director Nina Šorak, the actors, the playwright, the costume designer and a few other people came to the reactor and we first briefly introduced nuclear energy to them, then explained all the myths about nuclear energy and later took them to the TRIGA research reactor, where we showed them the reactor in detail, demonstrated radiation and the basic principles of radiation protection and ionizing radiation measurements. We also described the work of operators, procedures in the event of an emergency, and the radiological and non-radiological consequences of nuclear accidents. All this was new for the actors, and after the visit they looked at the roles and the performance itself with completely different eyes. Above all, they understood ionizing radiation better and were less concerned about it."

Luka Snoj was not surprised that the theatre performance is about nuclear physics, as it is a topic that attracts and often causes emotions in people, both positive and negative.

"Science must come among people. It is necessary to talk about topics that divide, that are unclear, that are accompanied by myths and taboos, and that as openly as possible. It was wonderful to talk to non-experts in this field, who perceive things completely differently than we do. They opened up new perspectives on our work and it felt good to see the impact the reactor tour had on them."

Prof Snoj has already seen the show and is impressed by it. He experienced it completely differently than when reading the script. He completely immersed himself in it and experienced it very emotionally. The professional part was presented extremely correctly, also thanks to many conversations with the director.

"Collaborations are the key to building a better world, where people will understand each other better. Science and art have a lot in common, and I am surprised that there is not more cooperation between these extremely important areas for humanity. I

definitely support such collaborations. I highly recommend viewing. The play opens many important social issues, from the responsibility of ancestors to descendants, our relationship to the environment, energy use, energy resources and, last but not least, interpersonal relationships."



Based on results from the JSI, Adidas produces a completely new women's running shoe

Head of the Department of Knowledge Technologies of the JSI, Prof. Dr Sašo Džeroski and his colleagues Jure Žabkar and Aleš Jurca published the results of research in which they analysed data on 3D scans of men's and women's feet collected in North America, Europe and Asia in 2019. The research confirmed the existence of many statistically significant differences in average foot measurements between regions and between genders, and a large spread of foot measurements within each group of people. As it turns out, it also set new standards for footwear-manufacturing methods and measurements.

Based on the results of the research, Adidas produced a completely new running shoe for women, and the JSI is mentioned on its website and in the promotional film.

The company Lululemon, which generates \$6 billion in annual turnover from the sale of sportswear and leisurewear and has 574 stores worldwide, also produced its first running shoe this March, also based on the findings of research by JSI researchers.



Young researcher at the Department of Thin Films and Surfaces, Žan Gostenčnik, wins major prize in TV quiz

Žan Gostenčnik is pursuing a doctorate in the field of high-entropy thin layers applied by the magnetron sputtering at Department of Thin Films and Surfaces of the JSI, and on 22 October 2022, he won the highest prize €20,000 in the television quiz Joker on TV Slovenija. He didn't expect success, because he took it all as fun and didn't even think about the prize.

"I didn't have any nervousness, I was relaxed all the time. I was sure of certain answers, I was lucky with certain ones. I also took quite a few risks. Everything came together to achieve this success."

And why did he apply? "Actually, I signed up by mistake. In the winter during the quarantine, I occasionally watched some Joker shows. Viewers can also participate in the shows, by answering the same questions as the contestant during the show itself. Since I wanted to participate as a viewer, I visited the show's website where I found some application form that I started putting my information in. It wasn't until later that I realized that this application form was for an actual appearance on the show. Of course the fact that I'm a researcher helped me succeed, but the reason for the success is the same as the reason that I became a scientist, namely my curiosity and desire to discover new knowledge and the pleasure of research. Research improves me, gives me drive and motivation and brings me the income I live on. But it can also be very tiring, so it is necessary to find the right balance between science and private life. In addition, it is necessary to be very patient, because research is a long-distance race and often takes very long time to achieve something important in the field of science, if at all!"



Dr Gašper Tavčar helps the author of the exhibition *Scratching with Gold*

Between 10 June and 28 August 2022, a solo exhibition by Meta Grgurevič called *Scratching with Gold* took place in Cukrarna. This time, the author presented her main interest, in which she combines knowledge from the fields of mechanics and electrical engineering with the field of contemporary art, in a half-millimetre grain of gold. A piece of gold is the result of a months-long process and the demanding work of many people. As we have read many times in adventure books and seen in many westerns, every good story about the search for gold has to contain dramatic twists, ups and downs, wins and, last but not least, losses. Even the extraction of this small grain forms a story, in which the JSI also played its role.

Dr Gašper Tavčar, how did the collaboration between the author of the exhibition and the institute come about?

Ms Meta Grgurevič started asking the JSI who would be able to help her with her future project of extracting gold from used mobile phones. Based on the technological research we are dealing with in the section, she was referred to me. The idea and approach were also interesting to me. After a short conversation, we decided to help her with her artistic creation. After all, we have already worked on research in the field of recycling electronic components.

Who was involved in the project, what was your work like and how did it go?

Two of us were involved from the JSI side - Peter Frkal and me. Peter carried out experiments according to a preliminary plan that we made together.

Given that you were helping an artist, was your work very different from your everyday work?

It will probably come as a surprise that my answer will be no. We have already worked in the field of gold leaching, with just such a chemical approach. The only difference was the recording between the preparations for the reactions and the explanation of the individual stages. So far, we have also met several times with cooperation in various film projects where they used chemistry or filmed various chemical reactions, so filming was not problematic either.

How did you experience such cooperation between science and art? Did you also learn something new? Do you think such cooperation is important and why?

Our section with the School of Experimental Chemistry has been working on the popularization of science in Slovenia for many years and, among other things, presents more interesting chemical experiments at various events and schools. From the reaction there, it is easy to see that the presentation of science to the public is lacking. Especially the work that could easily influence the public. After all, a large part of our funding comes from the taxes of the people of Slovenia, and it is right that we try to bring our knowledge and experience closer to them, and help them, whether it is for children or for adults - in the artistic sphere. On the other hand, I learned quite a bit about art. For example, I have never before heard of an art direction that uses systems that move or uses lighting effects to create the illusion of movement. The interplay of science and art is certainly interesting. Last but not least, during the course of the project, everyone involved certainly learned something new and exchanged different points of view.

