BPU11 CONGRESS
The Book of Abstracts

Editors:

Antun Balaž
Goran Djordjević
Jugoslav Karamarković
Nenad Lazarević

Belgrade, 2022

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28 August 2022 - 1 September 2022

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The 11th International Conference of the Balkan Physical Union
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- The European Physical Journal (EPJ)

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Preface

Dear colleagues and readers,

The Abstract book of the BPU11 Congress, which you are holding in your hands, aims to provide you with more information regarding the scientific program and the scientific contributions that are going to be presented at the Congress, as well as at the parallel and satellite events.

The BPU11 Congress is part of the series of general conferences of the Balkan Physical Union (BPU) which were firstly organized in Thessaloniki, Greece in 1991. Due to the COVID-19 pandemic, BPU11 is held now, in 2022, in a hybrid format with more than 450 registered participants, instead of being held in 2021 as it was primarily scheduled.

The scientific program is comprised out of 15 different scientific sections, 13 plenary lectures, 21 invited talks, a special FRONTIER session, 5 round tables and 2 workshops for teachers.

There will be more than 300 presentations in total. There are 109 oral presentation and 159 poster presentations which were accepted by the International Scientific Committee (ISC) for presenting.

We wish to express our sincerest gratitude to the International Advisory Committee (IAC) with 60 confirmed members, which is co-chaired by the academician Zoran Popović and professor Radu Constantinescu, the ISC with 151 members, which is co-chaired by professors Antun Balaž, Jugoslav Karamarković, and Nenad Lazarević. We would also like to thank the International Organizing Committee (IOC), country coordinators and last but not least, the Local Organizing Committee (LOC) chaired by professor Dragoljub D. Dimitrijević.

I would personally like to thank professor Luc Berge, the president of the European Physics Society (EPS) and the cochairmen of the BPU11 IOC. Additionally, I would like to express my gratitude to Mr. David Lee, Secretary General of EPS, for his continuous support of the BPU and other regional associations in the Balkans.

The BPU11 Congress would not have been made possible without the great support of our institutional co-organizers:

The main host, the Serbian Academy of Science and Arts (SASA), Faculty of Sciences and Mathematics-University of Niš, Faculty of Physics-University of Belgrade, Mathematical Institute of Serbian Academy of Sciences and Arts (National Institute of the Republic of Serbia), which are also the co-hosts of the Congress; Faculty of Mathematics-University of Belgrade, Faculty of Sciences-University of Novi Sad, Faculty of Science-University of Kragujevac, Faculty of Sciences and Mathematics-University of Pristina in Kosovska Mitrovica, the

SEENET-MTP Centre, and last but not least, Vinča Institute of Nuclear Science (National Institute of the Republic of Serbia).

We would also like to thank the Institute of Physics Belgrade, National Institute of the Republic of Serbia, for their great scientific contribution that attributed to the success of the Congress.

Furthermore, it is important to note the EPS has greatly contributed to the organization of the BPU11 Congress, as well as the previous congresses, and helped to support it financially.

The Congress, its parallel, and satellite events are internationally broadcast and financially supported by: The International Center for Theoretical Physics (ICTP) Trieste, the Central European Initiative (CEI) Trieste, Conseil Européen pour la Recherche Nucléaire (CERN) in Geneva.

We are also very much indebted to the European Physics Journal (EPJ) for the sponsorship that will provide the awards for the best the poster presentations awards at the BPU11 Congress.

We would also like to thank the Ministry of Education, Science and Technological Development of the Republic of Serbia and the Provincial Secretariat for Higher Education and Scientific Research, Autonomous Province of Vojvodina, Republic of Serbia, for the valued financial support they have provided us with so far.

Finally, we would like to share with you the brief history of the BPU and to say a few words regarding its future: The BPU was firstly initiated by professors Aleksandar Milojević and Djordje Bek-Uzarov, in 1985, and established two years later in Bucharest, Romania, in 1987. BPU is a regional Union of 10 Physics societies. I am more than pleased to say that the BPU was recently, institutionally lifted to a higher level, and that it became a legal entity in June 2022, with its Headquarters at the Department of Physics, Aristotle University, Thessaloniki, Greece. The 4th edition of the Balkan Physics Olympiad which will take place in Cyprus, this October, proves that the BPU has established a strong foundation, and that there is an excellent reason to optimistically look forward towards the future of the BPU and its cooperation with its numerous partners from Europe and all over the world.

Niš, Serbia, 18 August 2022
Prof. Dr. Goran S. Djordjević
President of the Balkan Physical Union

Plenary Talks

PT-01 / **Plenary talk**

Structures of networks and application to models of disease spreading

Author: Panos Argyrakis[1]

[1] *Department of Physics, University of Thessaloniki, 54124 Thessaloniki, Greece*

Presenter: P. Argyrakis (panos@auth.gr)

In the last twenty years Statistical Physics has contributed immensely to other scientific fields, mainly by the introduction of networks. The main reason has been the creation of the internet, which has been ubiquitous in daily life. The different structures of networks will be shown, together with their characteristics, with several different applications from real situations, which help us to understand dynamic phenomena in many different fields, such as social networks, economic networks, linguistics, etc.

One important application is the spreading of diseases, such as the recent Covid-19 in a population in the form of a pandemic. In fact, predicting how fast an infection is spreading could be a major factor in deciding on the severity, extent and strictness of the applied mitigation measures, such as the recent lockdowns. Even though modelling epidemics is a wellstudied subject, usually models do not include quarantine or other social measures, such as those imposed in the recent pandemic. The current work builds upon a recent paper by Maier and Brockmann (2020), where a compartmental SIRX model was implemented. That model included social or individual behavioral changes during quarantine, by introducing state X, in which symptomatic quarantined individuals are not transmitting the infection anymore, and described well the transmission in the initial stages of the infection. The results of the model were applied to real data from several provinces in China, quite successfully. In our approach we use a Monte-Carlo simulation model on networks. Individuals are network nodes and the links are their contacts. We use a spreading mechanism from the initially infected nodes to their nearest neighbors, as has been done previously. Initially, we find the values of the rate constants (parameters) the same way as in Maier and Brockmann (2020) for the confirmed cases of a country, on a daily basis, as published by the Johns Hopkins University. We then use different types of networks (random Erdős-Rényi, Small World, and Barabási-Albert Scale-Free) with various characteristics in an effort to find the best fit with the real data for the same geographical regions as reported in Maier and Brockmann (2020). Our simulations show that the best fit comes with the Erdős-Rényi random networks. We then apply this method to several other countries, both for large size countries, and small size ones. In all cases investigated we find the same result, i.e. best agreement for the evolution of the pandemic with time is for the Erdős-Rényi networks. Furthermore, our results indicate that the best fit occurs for a random network with an average degree of the order of $<k> \sim 10$-25, for all countries tested. Scale Free and Small World networks fail to fit the real data convincingly.

PT-02 / **Plenary talk**

THz waves generated by laser-plasma interactions

Author: Luc Bergé[1]

[1] *CEA, DAM, DIF, Arpajon, France*

Presenter: L. Bergé (luc.berge@eps.org)

This talk will review different physical mechanisms involved in the emission of secondary radiations, with emphasis on terahertz waves, by laser-gas interactions. At moderate laser intensity, photocurrents can be exploited to perform a coherent terahertz spectroscopy of various crystals from air plasmas or to image tunneling electron wave packets from probing the polarization state of secondary Brunel radiations. With ultra-intense lasers, the possibility of generating high-field (close to 0.5 TV/m) THz pulses from relativistic gas plasmas embedded in strong (> 100 T) magnetic fields will be demonstrated.

PT-03 / **Plenary talk**

Verification of quantum technologies

Author: Borivoje Dakić[1]

[1] *University of Vienna, Austria*

Presenter: B. Dakić (borivoje.dakic@univie.ac.at)

As quantum technologies advance, the ability to engineer increasingly large quantum devices has experienced rapid development. In this context, the verification of large entangled systems represents one of the main challenges in the employment of such systems for reliable quantum information processing. Though the most complete technique is undoubtedly full tomography, the inherent exponential increase of experimental and post-processing resources with system size makes this approach infeasible at even moderate scales. For this reason, there is currently an urgent need to develop novel methods that surpass these limitations. In this talk I will review novel techniques [1] focusing on a fixed number of resources (sampling complexity), and thus prove suitable for systems of arbitrary dimension. Specifically, a probabilistic framework requiring at best only a single copy for entanglement detection is reviewed, together with the concept of selective quantum state tomography, which enables the estimation of arbitrary elements of an unknown state with a number of copies that is low and independent of the system's size. These hyper-efficient techniques define a dimension demarcation for partial tomography and open a path for novel applications.

References

1. J. Morris, V. Saggio, A. Gočanin and B. Dakić, Quantum Verification and Estimation with Few Copies, Adv. Quantum Technol. 2100118 (2022), https://doi.org/10.1002/qute.202100118.

PT-04 / **Plenary talk**

The Nobel Prizes awarded to Marie Curie and the one not awarded to Lise Meitner

Author: Karl Grandin[1]

[1] *Royal Swedish Academy of Sciences*

Presenter: K. Grandin (karl.grandin@kva.se)

The history of scientists that have been awarded a Nobel Prize is by now rather extensive, the history of scientists that have been awarded more than one Nobel Prize is (for that very reason?) also rather large. The list of scientists that have not been awarded Nobel Prizes is longer still. In this talk a 101 lesson on how the Nobel Prize institution works will be given by studying the prominent examples of Marie Curie (1867–1934) and Lise Meitner (1878–1968). Curie is famous for being awarded two Nobel Prizes, whereas Meitner is known for not being awarded one (though many people think she should have been). How were these two scientists nominated and how were they evaluated by the Nobel Institution, and what can we learn from this? By taking a close look at the original documents we will also discuss how the established historiography (Crawford, 1984; Quinn, 1995; Sime 1997; Rife, 1999) of these two scientists have overlooked some important sources and thus have partly constructed a misleading story of these two Nobel tales. Some of it is corrected in (Grandin, 2020).

References

1. Crawford, Elisabeth (1984), *The beginnings of the Nobel institution: The science prizes, 1901–1915* (Cambridge University Press, 1984).
2. Grandin, Karl (2020), "Marie Skłodowska Curie – between physics and chemistry and two Nobel Prizes," *Historia Scientiarum*, vol. 30–1 (2020), 3–18.
3. Quinn, Susan (1995), *Marie Curie: A life* (Heinemann, 1995).
4. Rife, Patricia (1999), *Lise Meitner and the dawn of the nuclear age* (Birkhäuser, 1999).
5. Sime, Ruth Lewin (1996), Lise Meitner: A life in physics (University of California Press, 1996).

PT-05 / **Plenary talk**

LISA: A gravitational wave observatory in space

Author: Philippe Jetzer[1]

[1] *University of Zurich*

Presenter: P. Jetzer (jetzer@physik.uzh.ch)

The LISA (Laser Interferometric Space Antenna) is an ESA/NASA space mission with the aim to observe gravitational waves in space at lower frequencies than it is possible with Earth bounded detectors.

It will thus be able to observe, e.g., the coalescence of supermassive black holes, which are present in the galactic centres.

I will describe the scientific objectives of the mission and the some technical issues, some of which have been already tested with the very successful LISA Pathfinder mission, which started in 2015. LISA should be launched in the mid '30.

PT-06 / **Plenary talk (virtual)**

Promising research results on a few potential applications of non-thermal plasma

Author: Monica Magureanu[1]

[1] *National Institute for Lasers, Plasma and Radiation Physics, INFLPR, Magurele, Romania*

Presenter: M. Magureanu (monimag@infim.ro)

Due to its non-equilibrium character, non-thermal plasma is able to promote a large variety of chemical reactions and to produce numerous highly reactive species, and thus shows great potential for a number of applications.

This talk will present experimental results on some of these possible applications: (i) the degradation of organic compounds in water, in view of wastewater treatment; (ii) plasma treatment of seeds for agricultural applications; (iii) material synthesis and processing.

The first part will focus on the degradation of pharmaceuticals, especially on antibiotics, a class of emerging water pollutants of high concern due to their contribution to the spread of antimicrobial resistance. Recent progress on the use of non-thermal plasma for removing these contaminants will be described. The discussion will address the ways to improve process efficiency associated with the discharge configuration and the main experimental parameters, as well as fundamental findings related to degradation pathways and mechanisms of various classes of antibiotics under plasma conditions.

Plasma agriculture is a novel and rapidly developing research field, aimed at enhancing plant vigor and improving yield while reducing the environmental footprint of conventional agricultural methods. The talk will address pre-sowing seed treatment by non-thermal plasma, which was generally found to improve germination, enhance plant growth, as well as to decontaminate seeds and to enhance stress tolerance and plants resistance to diseases. A few examples will illustrate these findings, both under laboratory conditions and in field trials.

The last section of the talk will be dedicated to the effects induced by the exposure of graphene materials to non-thermal plasma, as a part of the large interest in developing metal-free catalysts. It was found that plasma treatment produces various types of defects, which act as catalytic centers, and thus considerably improve the catalytic activity. Finally, the use of non-thermal plasma for the stabilizer-free synthesis of nanoparticles will be briefly addressed.

PT-07 / **Plenary talk**

Quantum-Orbit Theory in Strong-Laser-Field Physics

Author: Dejan Milosevic[1]

[1] *University of Sarajevo, Faculty of Science; Academy of Sciences and Arts of Bosnia and Herzegovina*

Presenter: D. Milosevic (milo@bih.net.ba)

The quantum-mechanical amplitude for the transition from an initial state i to a final state f can be represented in terms of Feynman's path integral. This integral includes all histories of the transition i -> f, i.e. the sum over all paths in space with fixed end points. In the classical limit this sum reduces to a sum over all classical paths for which the action S is stationary. In quantum mechanics the summation over all paths is equivalent to the exact solution of the time-dependent Schrödinger equation. For atomic processes in strong fields the sum over all paths can be substantially reduced. These relevant paths are complex due to the tunnelling nature of the quantum-mechanical ionization process. The quantum nature of these paths is also expressed through the interference of the contributions of different paths. Such paths, in analogy with classical orbits, are called quantum orbits. In our contribution we present quantum-orbit theory and apply it to various processes in strong laser fields. In particular, multi-step high-order processes, such as high-order harmonic generation and above-threshold ionization in tailored laser fields have recently attracted a lot of attention.

PT-08 / **Plenary talk**

HEP: current perspectives and future challenges

Author: Paris Sphicas[1]

[1] *CERN & NKUA*

Presenter: P. Sphicas (paraskevas.sphicas@cern.ch)

Over the past 40 years, the Standard Model (SM) of elementary particles and their interactions has been providing an unfailing and remarkably accurate description of all experiments with and without high-energy accelerators. With the discovery of the Higgs boson at the Large Hadron Collider in 2012, the SM is now complete, and we believe that we understand the physics of the very small up to energy scales of O(100) GeV. Nevertheless, the very existence of the Higgs boson, a particle like no other, gives rise to several new pressing questions that range from its true nature to its couplings to all other particles and the potential existence of New Physics. Along with the ever-present mystery of the nature of Dark Matter and the puzzles presented by the existence of particle flavors, there is fertile ground for new discoveries, both by theory and by experiment. The talk will present a broad-brush picture of how we have arrived at the current state of the field, followed by an overview of current and upcoming work, as well as some longer-term prospects for pushing the current frontier of knowledge in particle physics.

PT-09 / **Plenary talk**

Nature-inspired novel nanomaterials for multifunctional applications

Author: Ion Tiginyanu[1]

[1] *Technical University of Moldova; Academy of Sciences of Moldova*

Presenter: I. Tiginyanu (tiginyanu@asm.md)

The modern market requires new multifunctional materials which should be compatible with both electronics and living organisms. In this presentation, we report on novel bio-inspired hybrid nanomaterials – the so called aero-materials based on semiconductor compounds [1-4]. In particular, we report on a novel bio-inspired 3D nanoarchitecture of GaN, called aero-GaN or Aerogalnite, which represents the first artificial material exhibiting dual hydrophobic-hydrophilic behaviour (see [1] and physicsworld.com/a/hydrophobic-or-hydrophilic-aero-gallium-nitride-is-both) and has similar properties to a biological cell membrane. The 3D nanoarchitecture is based on GaN micro-tubular structures with nanoscopic thin walls, the inner surface being covered by an ultrathin film of ZnO. The micro-tubular structures are shown to self-organize when interacting with water, forming self-healing waterproof rafts with impressive cargo capabilities. The physical properties of aero-GaN will be presented in the context of prospects for microfluidic and biomedical applications [5]. Along with this, the novel material is shown to exhibit shielding capabilities against electromagnetic radiation in both the X-band (8-12 GHz) and Terahertz regions [6,7]. The shielding effectiveness in the frequency range from 0.25 to 1.37 THz exceeds 40 dB, thus placing aero-GaN among the best Terahertz shields known today [7].

Results of characterization of other aero-materials including aero-ZnS and aero-Ga2O3 are presented and possibilities of their applications in various fields are elucidated. The support from the European Commission under the Grant #810652 "NanoMedTwin" is acknowledged.

References

1. I. Tiginyanu, T. Braniste, D. Smazna, M. Deng, F. Schütt, A. Schuchardt, M. A. Stevens-Kalceff, S. Raevschi, L. Kienle, N. Pugno, Y. K. Mishra, R. Adelung. Self-organized and self-propelled aero-GaN with dual hydrophilic-hydrophobic behavior. Nano Energy, Vol. 56, 759-769 (2019).
2. Irina Plesco, Tudor Braniste, Niklas Wolff, Leonid Gorceac, Violla Duppel, Boris Cinic, Yogendra Kumar Mishra, Andrei Sarua, Rainer Adelung, Lorenz Kienle, Ion Tiginyanu Aero-ZnS architectures with dual hydrophilic-hydrophobic properties for microfluidic applications. AIP Materials, Vol. 8, 061105 (2020).
3. Irina Plesco, Vladimir Ciobanu, Tudor Braniste, Veaceslav Ursaki, Florian Rasch, Andrei Sarua, Simion Raevschi, Rainer Adelung, Joydeep Dutta, Ion Tiginyanu. Highly-Porous and Ultra-Lightweight Aero-Ga2O3: Enhancement of Photocatalytic Activity by Noble Metals. Materials, Vol. 14, 1985 (2021).
4. Tudor Braniste, Mircea Dragoman, Sergey Zhukov, Martino Aldrigo, Vladimir Ciobanu, Sergiu Iordanescu, Liudmila Alyabyeva, Francesco Fumagalli, Giacomo Ceccone, Fabian Schütt, Rainer Adelung, Pascal Colpo, Boris Gorshunov and Ion

Tiginyanu. Aero-Ga2O3 nanomaterial electromagnetically transparent from microwaves to terahertz for the internet of things applications. Nanomaterials, Vol. 10, 1047 (2020).
5. Tudor Braniste, Vladimir Ciobanu, Fabian Schütt, Hidenori Mimura, Simion Raevschi, Rainer Adelung, Nicola Pugno, Ion Tiginyanu. Self-propelled aero-GaN based liquid marbles exhibiting pulsed rotation on the water surface. Materials, Vol. 14, 5086 (2021).
6. M. Dragoman, T. Braniste, S. Iordanescu, M. Aldrigo, S. Raevschi, S. Shree, R. Adelung, I. Tiginyanu. Electromagnetic interference shielding in X-band with aero-GaN. Nanotechnology, Vol. 30, 34LT01 (2019).
7. T. Braniste, S. Zhukov, M. Dragoman, L. Alyabyeva, V. Ciobanu, M. Aldrigo, D. Dragoman, S. Iordanescu, S. Shree, S. Raevschi, R. Adelung, B. Gorshunov, I. Tiginyanu. Terahertz shielding properties of aero-GaN, Semicond. Sci. Technol., Vol. 34, 12LT02 (2019).

PT-10 / **Plenary talk (virtual)**

Nuclear Power in the XXI Century

Author: Jasmina Vujic[1]

[1] *University of California at Berkeley, Department of Nuclear Engineering*

Presenter: J. Vujic (vujic@berkeley.edu)

Nuclear power, which accounts for about 10 percent of the world's electricity supply, is currently the only technology with a secure base-load electricity supply and no greenhouse gas emissions that has the potential to expand at a large scale and effectively replace fossil fuels. However, after the 2011 Fukushima accident some countries, particularly in Europe, decided to slow down further expansion of nuclear power or even to shut down existing nuclear power plants, pointing out to potential safety risks, unresolved issues with nuclear spent fuel disposal, high construction prices, and public/political opposition. More "desirable" renewable solar and wind or other non-nuclear/non-fossil power sources are on the table. Will this approach work - having in mind that about one-third of the world's population still does not have access to electricity, and that underdeveloped and developing countries mostly use fossil fuels as the major source of energy? This presentation analyzes the current situation in the world, with examples of the countries that decided to phase out nuclear power, as well as the countries that decided to rapidly increase nuclear power. The presentation will also cover recent innovations in reactor designs, and advantages of small modular reactors and floating nuclear platforms. The last part of the presentation will focus on the challenges facing countries in the Balkans that would like to have nuclear power, but do not have required regulatory framework, nuclear infrastructure, financial support and expertise.

`PT-11` / **Plenary talk (virtual)**

Quantitative Scanning-Free Confocal Microscopy with Single-Molecule Sensitivity and Fluorescence Lifetime Imaging for the Study of Fast Dynamic Processes in Live Cells

Authors: Stanko N. Nikolic[1]; Aleksandar J. Krmpot[1]; Sho Oasa[2]; Andrew H. A. Clayton[3]; Lars Terenius[2]; Milivoj R. Belić[4]; Rudolf Rigler[5]; Vladana Vukojevic[2]

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[3] *Swinburne University of Technology, School of Science, Department of Physics and Astronomy*

[4] *Texas A&M University at Qatar*

[5] *Karolinska Institute, Department of Medical Biochemistry and Biophysics (MBB)*

Presenter: V. Vukojevic (`vladana.vukojevic@ki.se`)

Timing is everything in biology – biological systems exchange information by controlling the spatio-temporal behavior of biological molecules, using dynamics to encode and decode information. Dynamic changes in the concentration of biological molecules are therefore an integral part of biological networks' function and inadequate spatial distribution and temporal dynamics are characteristic of disease states.

Living cells control the concentration, spatial distribution, and temporal dynamics of biological molecules through molecular interactions and transporting processes, most notably diffusion. Through reaction-diffusion processes biomolecules are integrated in specific dynamical networks and perform specialized biological functions in the cell, such as gene expression. These networks are complex – they are made up of many constituents (different interacting molecules); they are tightly intertwined – products of one reaction are reactants in another one; and they are dynamically controlled – the rates at which biochemical transformations occur are autocatalytically regulated by molecules produced in the same biological network. Consequently, these complex networks may acquire a new quality – the capacity to self-adjust their essential variables to control their biological functions.

To understand how these dynamical networks are controlled and self-regulated, the concentration and mobility of interacting molecules – which are in addition to chemical reactivity the determinants of chemical kinetics, need to be quantitatively characterized in live cells.

To this aim, we have developed quantitative scanning-free confocal microscopy with single-molecule sensitivity, high temporal resolution (~10 μs/frame), and fluorescence lifetime imaging by integrating massively parallel fluorescence correlation spectroscopy [1] with fluorescence lifetime imaging microscopy (mpFCS/FLIM)[2].

The capacity of this method to characterize in live cells compartmentalization of molecular processes by measuring local excited-state decay *via* FLIM, and their dynamic integration by measuring diffusion/active transport using mpFCS will be discussed.

Acknowledgments: This work was supported by grants from the Swedish Research Council (2018-05337); Olle Engkvists Foundation (199-0480); Magnus Bergvall Foundation (2019- 03381, 2020-04043); Karolinska Institutet's Research Foundation Grants (2020-02325); Swedish Foundation for Strategic Research (SBE13-0115); NIH/NIAAA (R01AA028549); Nakatani Foundation for Advancement of Measuring Technologies in Biomedical Engineering; Strategic Research Program in Neuroscience (StratNeuro); Yoshida Foundation for Science and Technology; ERASMUS+: European Union Programme for Education, Training, Youth, and Sport; Qatar National Research Foundation (PPM 04-0131-200019); and Science Fund of the Republic of Serbia (call PROMIS, Grant no. 6066079).

References

1. A.J. Krmpot *et al.*, Anal. Chem. **91(17)**, 11129 (2019).
2. S. Oasa, A.J. Krmpot, S.N. Nikolić *et al.* Anal. Chem. **93(35)**, 12011 (2021).

PT-12 / **Plenary talk**

Quantum Simulation and Computation with Neutral Atoms

Author: Vladan Vuletić[1]

[1] *Department of Physics, Massachusetts Institute of Technology, USA*

Presenter: V. Vuletić (vuletic@mit.edu)

The last few years have seen a remarkable development in our ability to control many neutral atoms individually, and induce controlled interactions between them on demand. This progress ushers in a new era where one can create highly entangled states, or study quantum phase transitions. I will present results on atomic arrays containing more than 250 atoms, including transport of entangled states, and the generation of topological surface- and toric-code states. Finally, I will discuss prospects for near- and medium-term quantum computers with full quantum error correction.

PT-13 / **Plenary talk (virtual)**

Quantum gravity predictions for particle physics and cosmology

Author: Christof Wetterich[1]

[1] *Heidelberg University, Institute for Theoretical Physics, Germany*

Presenter: C. Wetterich (c.wetterich@thphys.uni-heidelberg.de)

Contrary to general belief, quantum gravity can have important consequences for observations in present day experiments. It can predict parameters of the standard model of particle physics. Functional renormalisation permits the computation of fluctuation effects of the metric. Quantum gravity can be formulated as a non-perturbatively renormalisable quantum field theory, in close analogy to the other fundamental interactions. The quantum scale symmetry associated to the ultraviolet fixed point has far reaching implications for particle physics and cosmology.

Quantum fluctuations of the metric determine the quartic self-interaction of the Higgs-scalar at an energy scale close to the Planck mass. Extrapolating the running couplings to the electroweak scale, the mass of the Higgs boson has been predicted in the range found later by experiment.

The scaling solution of quantum gravity for scalar potentials in cosmology has a form that can account both for the inflationary Universe and for dynamical dark energy.

S01-NPNE
Nuclear Physics and Nuclear Energy

S01-NPNE-001 / **Invited talk**

Applications of Geant4 simulation methods in studies of nuclear processes

Author: Dejan Joković[1]

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Presenter: D. Joković (yokovic@ipb.ac.rs)

Geant4 is a toolkit for Monte Carlo simulations of the particle transport through matter. It has a complete set of routines for modelling particle trajectories and interactions: geometry and materials, physical processes, event generation, detector response and analysis and visualisation. It has been used in wide range of applications in high energy, nuclear and accelerator physics, as well as in studies in medical and space science.

The low-background underground laboratory at the Institute of Physics Belgrade is a facility for gamma-ray spectroscopy measurements and for measurements of the cosmic-ray muon intensity. Related to the two research objectives, studies of the cosmic-ray muon induced background in gamma-ray spectroscopy is of particular interest. In these experiments various Monte Carlo based simulations (Geant4, CORSIKA) have been extensively used.

Continuous measurements of the cosmic-ray muon intensity at the ground and the underground levels have been done since 2002, by means of plastic scintillation detectors. The detector response, interpretation of the experimental spectra and their calibration have been done and verified using Geant4 based simulation. The results of the simulations were used for calculation of the muon fluxes at the ground and the underground levels [1].

The scintillation detector in the underground laboratory can operate in coincidence with HPGe gamma-ray detector. A simulation of the coincident response of the two detectors to the cosmic-ray muons has been made in order to determine the muon contribution to the background spectrum of the HPGe detector [2]. The cosmic-ray muons contribute to the background through production of particles in detector surroundings. In low-level gamma spectroscopy, neutrons are produced in the lead shielding of an HPGe detector. The Geant4 simulation of the muon induced neutron production in lead has been developed. It can also be used for the simulation of production of nuclei in rock or soil.

The Geant4 toolkit has been widely applied in efficiency calibration of HPGe detectors in gamma-ray spectroscopy measurements. The main problem with this method is an imprecise detector description; the detector parameters initially are not well defined and certain parameters deteriorate with time. Therefore the simulation models need to be optimised in order to obtain the best possible agreement with experimental results. Several studies on uses of the Geant4 based simulations in calculation of efficiency of HPGe detectors have been performed, applied to different detector assemblies [3,4].

References
1. A.Dragić et al. Measurement of cosmic ray muon flux in the Belgrade ground level and underground laboratories, Nucl. Instrum. Meth. A 591 (2008) 470
2. D.R.Joković et al. Monte Carlo simulations of the response of a plastic scintillator and an HPGe spectrometer in coincidence, Appl. Radiat. Isotopes 67 (2009) 719
3. J.Nikolić et al. Calculation of HPGe efficiency for environmental samples: comparison of EFFTRAN and GEANT4, Nucl. Instrum. Meth. A 763 (2014) 347
4. M.Krmar et al. A method to estimate a contribution of Ge(n,n‘) reaction to the low-energy part of gamma spectra of HPGe detectors, Nucl. Instrum. Meth. A 709 (2013) 8

`S01-NPNE-100` / **Oral presentation**

Neutron-Gamma Emission Tomography for radioactive waste characterization and nuclear security

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Presenter: B. Cederwall (`bc@kth.se`)

A project for non-destructive assay (NDA) of radioactive waste at the Studsvik nuclear decommissioning site is presented. The concept is based on a novel 3D radiation imaging modality for special nuclear materials (SNM) - neutron-gamma emission tomography (NGET) that was first demonstrated for nuclear security applications [1,2]. NGET has been recognized by the Royal Swedish Academy of Engineering Sciences (IVA) as one among the top 100 most important Swedish innovative research projects 2021 aiming at a sustainable preparedness for future societal crises [3].

More recently, the technique has been applied to localization and imaging of SNM inside shielded waste containers, adding to the array of existing techniques used for passive and active NDA in radioactive waste characterization. This project is aimed initially at the class of mixed, long-lived radioactive waste that is commonly called “legacy” or “historic waste” which has special safety, security and safeguards concerns due to its mixed composition, commonly poor documentation, and the frequent presence of SNM. However, a detection system featuring the NGET imaging modality might be applied to radioactive waste characterization in general, potentially including verification of spent nuclear fuel and other types of high-level waste suspected of containing SNM. The invention behind this novel radioactive waste characterization technique was recognized by awarded the Euratom Innovation Prize 2022 [4]. A major aim of this project is to enable a high degree of automation and high throughput capabilities. This would make it possible to quickly scan large radioactive waste inventories for the presence of special nuclear materials with minimal manual intervention.

References
1. Jana Petrović, Alf Göök, and Bo Cederwall, "*Rapid imaging of special nuclear materials for nuclear nonproliferation and terrorism prevention*", Science Advances, Vol. 7, No. 21, eabg3032 (2021). https://doi.org/10.1126/sciadv.abg3032
2. R. Stone, "*New type of imager could help spot smuggled nuclear materials*", Science, 19 May 2021 https://doi.org/10.1126/science.abj5464
3. www.iva.se/en/published/new-100-list-research-for-sustainable-emergency-preparedness-with-commercial-potential/
4. ec.europa.eu/info/news/nuclear-innovation-prize-seven-applications-awarded--2022-may-31_en

`S01-NPNE-101` / **Oral presentation**

An alternative approach within the CDFM for studies of nuclear symmetry energy components and their ratio

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A different alternative approach to calculate the ratio of the surface to volume components of the nuclear symmetry energy is proposed in the framework of the coherent density fluctuation model (CDFM). An alternate expression (scheme II) for the ratio is derived consistently within the model. This expression appears in a form more direct and physically motivated than the expression (scheme I) that was used in our previous works within the CDFM and avoids preliminary assumptions and mathematical ambiguities in scheme I. The calculations are based on the Skyrme and Brueckner energy-density functionals for nuclear matter and on the nonrelativistic Brueckner-Hartree-Fock method with realistic Bonn B and Bonn CD nucleon-nucleon potentials. The approach is applied to isotopic chains of Ni, Sn, and Pb nuclei using nuclear densities obtained in self-consistent Hartree-Fock+BCS calculations with the SLy4 Skyrme effective interaction. The applicability of both schemes within the CDFM is demonstrated by a comparison of the results with the available empirical data and with results of other theoretical studies of the considered quantities. Although in some instances the results obtained for the studied ratio and the symmetry energy components are rather close in both schemes, the proposed scheme II leads to more realistic values that agree better with the empirical data and exhibits conceptual and operational advantages.

S01-NPNE-102 / **Oral presentation (virtual)**

Application of the ASTECV2.2b Severe Accident Computer Code and Sunset Computational Tool for Uncertainty and Sensitivity Analyses on IVMR VVER1000 Test Case

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This article concerns an uncertainty and sensitivity investigation of certain parameters in the In-Vessel Melt Retention (IVMR) test case for VVER-1000/v320. It has been used the ICARE and CESAR modules of ASTECv2.2b severe accident computer code to describe the basic parameters behaviour and the main phenomena arising during the IVMR in VVER1000 reactor design. The external vessel water cooling has been chosen for IVMR strategy. First, one stand-alone calculation have been done to account the most heat loaded segment from the vessel.

After, the uncertainties in two parameters in the deterministic calculation have been investigated additionally to account their influence on the heat flux on this segment. An opportunity for an uncertainty and sensitivity analyses gives SUNSET (Statistical UNcertainty and Sensitivity Evaluation Tool) software which is a part of ASTEC computer code. The SUNSET computational tool developed by IRSN, is a statistical tool designed for uncertainty and sensitivity analysis of mathematical or physical models like computer codes.

It have been investigated an influence of the different pressure values inside the vessel and influence of the different temperature values of outside cooling water on the two basic output parameters: heat flux on the most heat loaded segment of the vessel and the minimal vessel wall thickness of this segment. It was found out to what extent each one of the both input parameters effect on the studied output parameters.

S01-NPNE-103 / **Oral presentation**

Neutral current quasielastic (anti)neutrino scattering beyond the Fermi gas model at MiniBooNE and BNL kinematics

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Presenter: M. Ivanov (`martin@inrne.bas.bg`)

Neutral current quasielastic (anti)neutrino scattering cross sections on a ^{12}C target are analyzed using a realistic spectral function $S(p, E)$ that gives a scaling function in accordance with the (e, e') scattering data. The spectral function accounts for the nucleon-nucleon (NN) correlations by using natural orbitals from the Jastrow correlation method and has a realistic energy dependence. The standard value of the axial mass $M_A = 1.032$ GeV is used in all calculations. The role of the final-state interaction on the spectral and scaling functions, as well as on the cross sections is accounted for. A comparison of the calculations with the empirical data of the MiniBooNE and BNL experiments is performed. Our results are analyzed in comparison with those when NN correlations are not included, and also with results from other theoretical approaches, such as the relativistic Fermi gas, the relativistic mean field, the relativistic Green's function, as well as with the SuperScaling Approach based on the analysis of quasielastic electron scattering.

`S01-NPNE-104` / **Oral presentation**

Characterization of thermoluminescence properties of eye glasses for applications in retrospective / accidental dosimetry

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Presenter: M. Karampiperi (`karampiperi.maria@gmail.com`)

Introduction
Retrospective/accidental dosimetry, seeks for materials that can be used as probes for the dose assessment, when there is no other available data, from personal or environmental monitoring, during nuclear accidents. When there is uncontrollable release of radiation, it is important to determine the dose of the exposed population, in order to take the corresponding measures to reduce the health risk.

Several methods can be employed for retrospective dosimetry, such as Electron Paramagnetic Resonance (EPR), Thermoluminescence (TL) and Optically Stimulated Luminescence (OSL). TL exhibits unique characteristics, since it can provide additional information for the materials examined, revealing properties that could not have been studied with another technique. However, TL can only be applied to heat-resistant materials. Thus, common heat-resistant objects would constitute an optimal choice for their potential use as accidental dosimeters.

In this context, a large variety of ubiquitous materials has been investigated with TL. Among them, glass displays of mobile phones [1,2], watch glasses [3] and window glasses [4] have been investigated, exhibiting promising properties. Recently, glass containers of pharmaceuticals have been studied, for post-sterilization purposes [5].

Materials and Methods
The scope of this study is to investigate the potential use of eye glasses as probes for retrospective dosimetry. Based on the heat resistance of the glasses, the study is conducted with TL, using a Risø TL/OSL reader (model TL/OSL DA-15). All measurements were performed in a nitrogen atmosphere with a low constant heating rate of 2 oC/s, to avoid significant temperature lag, while the applied doses varied between 100 mGy and 16 Gy.

Results
The main luminescence properties have been explored in the present study, such as sensitization, dose response and fading. In addition, a dose recovery test has been conducted. During this test, an "unknown" dose was delivered to the samples and TL was used in order to recover the value of the dose. It is evident, that eye glasses exhibit excellent TL properties, and the exposure dose can be successful recovered, after an accident.

An intrinsic background signal is often present in the glass samples even without the exposure of the material in radiation, and usually originates from the fabrication process. As suggested in previous studies [2], this signal can be erased or reduced by chemical etching of the glass surface. Therefore, a chemical pre-treatment protocol is also investigated in the present study.

Conclusions and Future work
The exhibited TL properties of the eye glasses confirm their potential application for dosimetric purposes. Further investigation is necessary regarding the complete bleaching of the intrinsic background signal. Moreover, OSL may also be studied.

References
1. M. Discher et al., Radiat. Meas., 53, 12 (2013)
2. M. Discher, M. et al., Radiat. Meas. 56, 240 (2013)
3. C. Aydaş et al., Radiat. Meas. 85, 78 (2016)
4. C. Bootjomchai et al., Nucl. Instrum. Methods Phys. Res. B: Beam Interact. Mater. At. 323, 42 (2014)
5. N. A. Kazakis, J. Lumin., 196, 347 (2018)

S01-NPNE-105 / **Oral presentation**

Lifetime measurements in Zn, Ga and Ge isotopes around N=40

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Presenter: T. Milanović (tmilanovic@vin.bg.ac.rs)

The interplay between single-particle and collective degrees of freedom is one of the most important and debated features in the study of the nuclear structure of medium mass nuclei. For neutron-rich nuclei with protons in the *fp* shell, nuclear structure observables indicate an onset of collectivity for neutron number N $\sim$40. Adding just a few particles/holes to the ^{68}Ni core leads to rapid structural changes.

This research mainly focuses on gallium isotopes, with three protons outside the ^{68}Ni core, while ^{73}Ga is of particular interest as in this isotope states 1/2 $^{-}$ and 3/2 $^{-}$ form a ground state doublet, unlike other neighbouring gallium isotopes which have a 3/2 $^{-}$ ground state [1,2]. Direct lifetime measurement of the first excited state can give information on the nature of the transition to the ground state and give additional proof for the existence of the doublet. Another point of interest are ^{70,72,74}Zn isotopes where we try to investigate systematic discrepancies appearing between B(E2;4 $^{+} \rightarrow$ 2 $^{+}$) values measured by Coulomb excitation [4] and plunger technique [3,5]. Lifetimes of low-lying states in germanium isotopes populated by the same reaction were also determined.

The experiment was performed in GANIL, Caen, France. The nuclei of interest were produced in deep-inelastic reaction in inverse kinematics with a ^{208}Pb beam at 6.63 MeV/A impinging on a 0.95 mg/cm ^{2} thick ^{76}Ge target deposited on a 1.2 mg/cm ^{2} Cu backing. Emitted gamma-rays were detected using the AGATA tracking array,

consisting of 29 HPGe crystals, in coincidence with recoils identified by VAMOS++ spectrometer. The lifetimes were measured using the plunger technique with the Recoil-Distance Doppler-Shift (RDDS) method.

We have measured lifetimes of low-lying states in ^{73,75}Ga, ^{70,72,74}Zn and $^{75-79}$Ge using γ singles data. Measured lifetime and deduced transition probabilities of the 5/2 $^{-}$ $_{1}$ state in ^{73}Ga support the argument of M1 dominant nature of the 5/2 $^{-}_{1}$ $\rightarrow$1/2 $^{-}$ transition and further confirm the existence of a ground state doublet. Determined lifetimes and B(E2;4 $^{+}$ $\rightarrow$2 $^{+}$) values in ^{70,72,74}Zn are in agreement with those of previous plunger experiments.

In $^{75-79}$Ge total of 28 lifetimes of low-lying states were determined, 23 of them being measured for the first time.

References
1. B. Cheal *et al.*, Phys. Rev. Lett. **104** (2010) 252502 .
2. J. Diriken *et al.*, Phys. Rev. C **82**, (2010) 064309.
3. C. Louchart *et al.*, Phys. Rev. C **87**, (2013) 054302.
4. J. Van de Walle *et al.*, Phys. Rev. C **79**, (2009) 014309.
5. I. Čeliković *et al.*, Act. Phys. Pol. **44**, (2013) 375.

S01-NPNE-106 / **Oral presentation (virtual)**

Structure of low-lying quadrupole states of polonium isotopes in the vicinity of ^{208}Pb

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Presenter: G. Rainovski (rig@phys.uni-sofia.bg)

The nuclei with few proton and neutron particles (holes) away from doubly-magic nuclei are the simplest nuclear systems in which both nuclear collectivity and the two-fluid nature of the nuclear matter can simultaneous be manifested. The relatively small number of valence particles (holes) allows the low-lying collective states in these nuclei to be described in the shell-model framework. The comparison of shell-model results with experimental data reveals the microscopic structure of these states and allows one to identify and, eventually, adjust the two-body matrix elements of the effective shell-model interaction which give rise to the configuration mixing responsible for the observed properties of the collective states.

The nuclei in the vicinity of the doubly magic nucleus ^{208}Pb have attracted significant interest in last several years. In the present contribution I will present the results from several lifetime measurements aimed to the properties of low-lying quadrupole states of 208, 210, 212Po. The results will be discussed in the shell-model framework with a focus on the onset of quadrupole collectivity and on the properties of low-lying quadrupole isovector excitations.

S01-NPNE-107 / **Oral presentation (virtual)**

Determination of Radioactivity in Soil Samples and Evaluation of Excess Lifetime Cancer Risk in Albania

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Presenter: E. Spahiu (erjon.spahiu@fshn.edu.al)

The aim of this study was determination of natural (^{226}Ra, ^{232}Th, ^{40}K) and artificial (^{137}Cs) radioactivity levels in thirty soil samples collected from different locations in Albania. The obtained results provides essential information concerning reference baseline concentrations of natural and artificial radioactive isotopes and environmental pollution. The main contributors of natural radioactivity in soil are ^{226}Ra, ^{232}Th and ^{40}K. Artificial radionuclides can be also present such as ^{137}Cs, resulting from fallout from weapons testing or nuclear accidents. For determination of natural and artificial radionuclides concentration in the environment non-destructive measurement technique with High Pure Germanium detectors (HPGe) is used. The soil samples were collected at maximum depth of 10 cm. The average activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were found to be 22.18 $\pm$ 0.73 Bq kg^{-1}, 23.53 $\pm$ 0.97 Bq kg^{-1}, 325.79 $\pm$ 15.30 Bq kg^{-1} and 6.29 $\pm$ 0.45 Bq kg^{-1} in soil samples, respectively. In order to evaluate the radiological hazard of radioactivity the total absorbed dose rate (D), the annual effective dose equivalent (AEDE) and excess lifetime cancer risk (ELCR) have been calculated. The average absorbed dose rate D (nGy h^{-1}) in air at 1 m above ground level due to the ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs in the soil samples was 38.23 nGy h^{-1}. The calculated values of annual effective dose (AEDE) for the all soil samples ranged from 3.59 to 94.94 μSv y^{-1} with a mean of 46.89 μSv y^{-1}, which is lower than the world average value of 70 μSv y^{-1}. The average of excess lifetime cancer risk (ELCR) value was calculated to be $0.16 \cdot 10^{-3}$. Moreover compared to the World's average of $0.29 \cdot 10^{-3}$, the lifetime risk of cancer result lower almost for all localities. Therefore, the all mean values of radiological hazard for all soil samples, were lower than the world average, it is safe for population living or other human activities without any radiological risk.

S01-NPNE-108 / **Oral presentation**

Anisotropy of the QGP droplet explored through high $p_\perp$ data

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Through analytical arguments, numerical calculations and comparison with experimental data, we show that the ratio of high $p_\perp$ observables $v_2/(1-R_{AA})$ reaches a well-defined saturation value at high $p_\perp$, which depends on the spatial anisotropy of quark-gluon plasma formed in ultrarelativistic heavy ion collisions. By using our recently developed DREENA framework, which can accommodate any temperature profile, we calculate this ratio for various temperature evolutions and demonstrate that it is robustly related to the time-averaged anisotropy of the evolving QGP, as seen by jets. With the future reduction of experimental errors, our method will provide a way to constrain an important bulk property of the medium – spatial anisotropy of QGP – directly from high pt experimental data.

`S01-NPNE-109` / **Oral presentation**

HPGe detector characterisation by means of Monte Carlo simulation through application of Geant4 toolkit

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Over the years High Purity Germanium (HPGe) detectors proved to be an excellent practical tool and as such have established their todays wide use in low background γ-spectrometry. One of the advantages of gamma ray spectrometry is its easy sample preparation as chemical processing and separation of the studied subject in not required. Thus, with a single measurement one can simultaneously perform both qualitative and quantitative analysis. One of the most prominent features of HPGe detectors, besides their excellent efficiency is their superior resolution. This feature virtually allows researcher to perform a thorough analysis by discriminating photons of similar energies in the studied spectra where otherwise they would superimpose within a single-energy peak and as such could potentially scathe analysis and produce wrongly assessed results. Naturally, this feature is of great importance when identification of radionuclides, as well as their activity concentrations, is being practiced where high precision comes as a necessity. In measurements of this nature, in order to be able to reproduce good and trustworthy results, one has to have intially performed an adequate full energy peak (FEP) efficiency callibration of the used equipement. However, experimental determination of the response i.e. efficiency curves for a given detector-sample configuration and its geometry is not

always easy and requires a certain set of reference callibration sources in order to account for and cover broader energy ranges of interest. With the goal of overcoming these difficulties, a lot of researches turned towards the application of different software toolkits that implement Monte Carlo method (e.g. MCNP, FLUKA, PENELOPE, Geant4, etc.), as it has proven time and time again to be a very powerful tool. In the process of creating a reliable model, one has to have a well-established and described specifications of the detector. Unfortunately, the documentation that manufacturers provide alongside of the equipment are rarely sufficient enough for this purpose. Furthermore, certain parameters tend to evolve and change over time, especially with older equipement. Deterioration of these parameters consequently decrease the active volume of the crystal and can thus affect the efficiencies by a large marginbif they're not properly taken into account. In this study, the optimisation method of two HPGe detectors through implementation of Geant4 toolkit developed by CERN is described, with the goal of further improving simulation accuracy in calculations of FEP efficiencies by investigating the influence of certain detector variables (e.g. crystal-to-window distance, dead layer thicknesses, inner crystal's void dimensions, etc.). Detectors on which the optimisation procedures were carried out were a standard traditional co-axial extended range detector (XtRa HPGe, CANBERRA) and a broad energy range planar detector (BEGe, CANBERRA). Optimised models were verified through comparison with experimentally obtained data from measurements of a set of point-like radioactive sources. Acquired results of both detectors displayed good agreement with exeperimental data that falls under an average statistical uncertainty of ~ 4.6% for XtRa and ~ 1.8% for BEGe detector within the energy range of 59.4–1836.1 [keV] and 59.4–1212.9 [keV], respectively.

`S01-NPNE-200` / **Poster presentation (virtual)**

Uncertainty estimation in Individual Monitoring – Part I

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Presenter: I. Bërdufi (`irmaberdufi@gmail.com`)

To achieve a good determination of the equivalent dose for occupational exposure workers from the whole body dosimeter an overall uncertainty associated with the measurement needs to be estimated. The work reported here is focused to estimate the absolute standard uncertainty that arises for Reader Calibration Factor (RFC), Element Correction Coefficient (ECC), and Zero Dose Reading. In this study, the thermoluminescence dosimeters are used and measured with Harshaw4500 Reader at Personal Dosimetry Laboratory in the Institute of Applied Nuclear Physics, Tirana, Albania and irradiated in the Secondary Standard Dosimetry Laboratory (SSDL) in place. In this study we estimated the uncertainties coming from the measurements, and didn't take into consideration those which might arise from the users. The method used in this study is based on Guide to the Expression of Uncertainty in

Measurement and ISO TR 62461 standard. The absolute standard uncertainty estimation for the RCF is found to be 0.0013nC/μSv, for the ECC is 0.028 and the Zero Dose Reading is 0.1324nC. This study will be expanded to include other important sources of uncertainties that influence the measurement, such as linearity correction factor, energy and angular correction factor, fading factor, temperature, environmental conditions, etc., in order to estimate the overall uncertainty that arises from all these sources and to find which of the input quantities have the largest contribution on it.

S01-NPNE-201 / **Poster presentation (virtual)**

Uncertainty estimation in Individual Monitoring – Part II

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Presenter: I. Bërdufi (irmaberdufi@gmail.com)

For an individual monitoring service is really important to provide accurate reports of the dose and to what extent the reported value is a good estimate of the true one. The process of determined the uncertainty which produces the best estimate of the quantity to be measured and may differ from the same quantity given by the instrument is an important one. This process can improve the result of the measurement by using different information beyond the indication of the instrument. The work reported here is focused to estimate the absolute standard uncertainty arises for the non-linearity, radiation energy and direction of radiation incidence and for measured value in order to achieve a good estimation of the overall uncertainty for better determination of the equivalent dose for occupational exposure workers from the whole body dosimeter. In this study the thermoluminescence dosimeters are used and measured with Harshaw4500 Reader at Personal Dosimetry Laboratory in the Institute of Applied Nuclear Physics and irradiated in Secondary Standard Dosimetry Laboratory (SSDL) in the Dosimetry Department of Greek Atomic Energy Commission. The method used in this study is based on Guide to the Expression of Uncertainty in Measurement and ISO TR 62461 standard. The absolute standard uncertainty estimation from the non-linearity is found to be 0.069, from the radiation energy and direction of radiation incidence is 0.0838 and from the measured value is 2.5473nC.

S01-NPNE-202 / **Poster presentation (virtual)**

Seasonal Measurements of Indoor Radon Concentration Level in the Period of Summer at Technical College of Applied Sciences in Zrenjanin

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Presenter: I. Borjanovic (iris@ipb.ac.rs)

Radon concentration measurements were performed at Technical College of Applied Sciences (TCAS) in Zrenjanin during summer, as part of the „Radon level measurements“ studies financed by the Provincial Secretariat for Higher Education and Scientific Research (the project is currently going on). The two lowest level rooms of the College building were examined, the basement and the groundfloor. We worked with the active type radon detector (brand Airthings) which is capable of both long-term (up to 1 year) and short-term continuous monitoring. It is an alpha type particle detector and contains passive diffusion chamber. Its precision for short-term measurements that were perfomed is 10%. The detector measured radon for 48h in each of the rooms. Doors and windows were closed during this period and rooms were not ventilated for at least 12h prior to the procedure. The results are discussed and also compared with the results obtained in the course of spring measurements. The maximum measured radon gas concentration at TCAS is below the National Reference Levels limits.

S01-NPNE-203 / **Poster presentation**

Detection of ionizing particles with monolith scintillator and segmented photodetector

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A simple framework for obtaining simultaneous energy and interaction position measurements from gamma particle interactions was developed in simulation and in hardware. The framework provides a method for obtaining the time of arrival and three methods for obtaining the interaction position, centroid, multiple maxima and an ML algorithm trained by simulation. Results of the simulations and the prototype performance are presented.

S01-NPNE-204 / **Poster presentation**

Radiation dosimetry applications based on silicate minerals extracted from dried oregano

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Introduction
The European Standard EN1788 (2001) [1] defines the procedure of silicate minerals' extraction from food products and their use to distinguish irradiated from non-irradiated food products, based on Thermoluminescence (TL). The extraction of the minerals is important since most of the food products, such as dried oregano, are not heat-resistant, thus TL cannot be applied to them directly. Additionally, the isolation of the minerals leads to samples with higher ratio of luminescent materials in the overall mass, making the detection of lower doses more efficient.

Calculation of the applied sterilization dose for the irradiated products is important, since there are certain pre-defined dose limits. Exceeding these limits during food sterilization may compromise of the public health [2].

Moreover, researchers seek for materials that could be used in retrospective/accidental dosimetry, in the cases that there is no available data from personal dosimeters. Everyday objects can be used, including commonly used pharmaceuticals [3] or even biological materials, such as chicken bones [4].

Materials and Methods
Considering that dried oregano is a common herb in variant cuisines, it is chosen as the material under-study. The goal of the present study is twofold; to examine if the extracted minerals can be used for the estimation of the sterilization dose and to calculate the dose released in case of an accident. Therefore, the TL properties of the material are investigated, for two dose regimes, namely between 50 Gy to 4 kGy and between 1 to 20 Gy.

Measurements were carried out using a Risø TL/OSL reader (model TL/OSL DA-15) and a 9635QA photomultiplier tube for light detection. Measurements were performed in nitrogen atmosphere with a low constant heating rate of 2^{o}C/s, to avoid significant temperature lag.

Results
Results reveal that the glow curve of the silicate minerals has at least three overlapping peaks in the dosimetric spectrum. The material exhibits strong sensitization, which can be corrected by normalizing the measured signal with the signal for a fixed test dose after each TL measurement. All three peaks demonstrate linear dose response for doses up to 1000 Gy, while for higher doses, saturation seems imminent.

An "unknown" delivered dose can successfully be recovered. The stability of the signal with respect to the storage time differs for the three peaks. However, the

remaining signal is appreciable for 1 month post irradiation, for most of them.
Conclusion and Future work

The findings of the present study support the potential use of the silicate minerals, for accidental/retrospective dosimetric applications and for the estimation of the irradiation dose for sterilization purposes. Further investigation will focus on studying the response of the sample with Optically Stimulated Luminescence (OSL).

References
1. European Standard EN 1788. European Committee for Standardization, Brussels, Belgium, (2001).
2. E. Kurzeja et al. Ital J Food Sci. 24(3), 254 (2012)
3. M. Karampiperi et al. Appl Radiat Isot., 166, 109364 (2020)
4. N. A. Kazakis et al. Appl Radiat Isot., 154, 108899 (2019)

S01-NPNE-205 / **Poster presentation**

Determination of ^{226}Ra and ^{222}Rn content in thermo-mineral water and assessment of radiation risk

Authors: Jovana Knezevic Radic[1]; Sofija Forkapic[1]; Kristina Bikit[1]; Dusan Mrdja[1]; Danijel Velimirovic[1]; Jan Hansman[1]; Predrag Kuzmanovic[1]; Istvan Bikit[1]

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Presenter: J. Knezevic Radic (jovana.knezevic@df.uns.ac.rs)

Determination of ^{226}Ra and ^{222}Rn activity concentration in water has been recognized as one of the most important tasks in the preservation of public health, since increased content of these radionuclides in drinking water may lead to increased health risk. Generally, the presence of ^{226}Ra in water samples is potentially dangerous due to its radiotoxicity and has been related to the cancer of bones [1]. On the other hand, its decay product ^{222}Rn is recognized as a potential cause for the development of lung cancer. Over the decays, several techniques have been developed for the determination of ^{226}Ra and ^{222}Rn in water−γ spectrometry, α spectrometry, and liquid scintillation counting.

The concentration of ^{226}Ra in water depends mostly on the geology of the area and may be elevated if water passes through rocks with elevated content of ^{238}U. Thus, it is especially important to measure the content of ^{226}Ra and ^{222}Rn in thermal and mineral water, since these waters are groundwater and a high concentration of ^{226}Ra is expected to be found [2]. At the same time, thermal and mineral water is used for different kinds of treatment [3], such as musculoskeletal diseases, arterial hypertension, bone fracture, post-traumatic conditions, neurological disorders, sports injury, etc, which may lead to increased doses due to inhalation and ingestion.

In this work, the activity concentration of ^{226}Ra and ^{222}Rn in thermomineral water samples was determined by using the liquid scintillation counting (LSC) technique. The samples were collected from spa Niska Banja [4] located in the southern part of Serbia. A comparison between two methods of sample preparation–one phase and two phases, for ^{226}Ra determination, was made. At the same time, the ^{222}Rn content was measured with the active radon device RAD7 and a comparison with the LSC result was conducted. Furthermore, the doses from ingestion and inhalation of ^{222}Rn, as well as from ingestion of ^{226}Ra were calculated. The annual effective doses were estimated for patients and tourists and compared with levels for the public imposed by the legislation of the Republic of Serbia.

References:
1. M. Villa, H.P. Moreno, G. Manjón, Radiat. Meas. 39, 543–550 (2005).
2. J. Mazur et al., Nukleonika 65(2), 77–81 (2020).
3. G. Marović, J. Senčar, Z. Franić, N. Kokobauer, J. Environ. Radioactivity 33(3), 309–317 (1996)
4. J. Nikolov et al., Radiat. Meas. 47, 443–450 (2012).

S01-NPNE-206 / **Poster presentation**

Radioactivity Measurements of Ceramic Tiles Produced in Serbia

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Presenter: P. Kuzmanović (predrag.kuzmanovic@df.uns.ac.rs)

Building materials may contain to some extent naturally occurring radioisotopes ^{226}Ra, ^{232}Th (from uranium and thorium decay chain) and primordial radioisotope ^{40}K. Those materials are often referred to as NORM (Naturally Occurring Radioactive Materials) [1, 2]. Owing to the presence of radioisotopes, using NORM in buildings can present a potential health risk to the population, due to the gamma radiation and indoor radon (^{222}Rn). For the purpose of radiological protection, monitoring of used building materials is necessary [3]. Averaged values of the activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in building materials worldwide are 50 Bq kg^{-1}, 50 Bq kg^{-1}, and 500 Bq kg^{-1}, respectively [4]. Ceramic tiles in Serbia are mainly used for covering floor and wall surfaces in domestics, as well in residential places. Regarding the frequent use of ceramic tiles as building materials, the measurements of the level of radioactivity are necessary in order to estimate potential health hazard for the population.

The main goals of the paper are measuring the level of radioactivity of some ceramic tiles produced in Serbia and determination of radiological risk, in order to estimate health risk originated from mentioned materials in domestic and residential spaces.

This paper presents the results of gamma spectrometry measurements of natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in some floor and wall ceramic tiles produced in Serbia and used in homes and business premises. The level of radioactivity of some ceramic tiles produced in Serbia by two major manufacturers – Zorka Keramika and Toza Markovic was examined. The measured mean value of the activity concentration of ^{226}Ra, ^{232}Th, and ^{40}K exceed the average values in the world for building materials with values of 67.2 $\pm$ 6.9 Bq kg^{-1} for ^{226}Ra, 57.4 $\pm$ 4.7 Bq kg^{-1} for ^{232}Th and 808 $\pm$ 48 Bq kg^{-1} for ^{40}K. Based on these calculated values, the representative level index – gamma index, associated with gamma radiation, whose average value is 0.78 $\pm$ 0.06 and annual effective dose, whose average value is 0.117 $\pm$ 0.009 mSv y^{-1} for homes and 0.034 $\pm$ 0.002 mSv y^{-1} for business premises were obtained. Estimated values fulfill all the recommendations of the European Commission for building materials, thus analyzed materials are considered not to be a health hazard for the public.

References
1. Joshua E.O., et al. Natural radionuclides and hazards of rock samples collected from Southeastern Nigeria, Radiat. Meas. 44, 2009: 401–404.
2. Alali E., et al. Radioactivity measurement and radiological hazard assessment of the commonly used granite and marble in Jordan. Radiat Prot Dosim 182, 2018: 386-393
3. Abdullahi S., et al. Determination of indoor doses and excess lifetime cancer risks caused by building materials containing natural radionuclides in Malaysia. Nucl Eng and Technol 51, 2018: 325-336.
4. UNSCEAR, Sources, Effects, and risks of ionizing radiation. United Nations Scientific Committee on the Effects of Atomic Radiation, United Nations, 1993, New York, USA.

S01-NPNE-207 / **Poster presentation (virtual)**

Thermoluminescence study on materials used in restorative dentistry for personal dosimetry applications

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Presenter: P. Taiganidis (ptaigani@physics.auth.gr)

The environment presents a plethora of radiation sources, both of natural, but mainly of human origin. The need to evaluate the dose threshold for biological effects has led to the development of the area of dosimetry. Accidental dosimetry deals with the quantification of the dose absorbed after an accident. Studies focus on materials in the immediate vicinity of human. Materials which meet this requirement are restorative dentistry materials that present the advantage that sampling does not require irreversible surgery.

The aim of the present study, which is included in the area of ionizing radiation, is of a dual nature. It aims on establishing the materials used in restorative dentistry as objects of personal accidental dosimetry, but also to establish luminescence techniques as innovative methods for the discrimination between materials with different stabilizers. The study is performed on two materials with different composition. Both of them are monolithic zirconia, but they differ in the amount of stabilizer in their synthesis, which is used to maintain high toughness. The applied methodology starts with the preparation of specimens. As a second step, the structural characterization studies are carried out in all specimens. Finally, the dosimetric study is performed with thermoluminescence (TL) measurements, in order to check the luminescence stability of the materials after successive cycles of irradiation and heating, the dose response and the lower detectable limit, since these are the most important aspects that should be studied for a potential personal accidental dosimeter.

The results seem promising, and they are also compared to existing studies on similar materials [1,2]. They aim to the establishment of dental restorative materials as personal passive/accidental dosimeters. The goal of this general project is to study all restorative dental materials in the same direction, for a complete data base.

References

1. I.K. Sfampa et al., Appl. Radiat. Isot. 157, 109024 (2020).
2. I.K. Sfampa et al., Radiat. Meas. 125, 7 (2019).

S01-NPNE-208 / **Poster presentation**

Cosmic-ray induced background of shielded HPGe detector

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Presenter: D. Velimirovic (danijel.velimirovic@df.uns.ac.rs)

In experiments searching for rare nuclear events (neutrinoless double beta decay,

dark matter, etc.) detailed knowledge of background is necessary in order to achieve reliable analysis and interpretation of experimental data [1]. In the ground-based laboratories, the significant contribution to the background of the detector spectrum originates from the interaction of cosmic rays with materials in the vicinity of the detector and detector itself [2]. In order to achieve reliable interpretation of data, it is necessary to understand and properly analyze background of the HPGe spectrum. One way to investigate background of the HPGe spectrum is to use Monte Carlo simulation [3]. In this paper, GEANT4 software package is used to perform simulation of HPGe detector system, consisting of detector relative efficiency of 100%. Muon and neutron components were simulated separately in order to achieve simpler separation of obtained data. Simulated spectra were merged and compared with experimental one. Furthermore, cosmic-ray induced processes in the Ge crystal itself, as well as in the detector shielding were investigated and spectra corresponding to certain processes induced from cosmic muons and neutrons were obtained. Contributions from each component were quantified.

References:
1. J. Knezevic et al., Nucl. Instrum. Methods Phys. Res. A 1032, 166624 (2022).
2. G. Heusser, Nucl. Instrum. Methods Phys. Res. A 369, 539–543 (1996).
3. N. Qouc Hung, V. Hong Hai, M. Nomachi, Appl. Radiat. Isot. 121, 87–90 (2017).

S02-AA Astronomy and Astrophysics

S02-AA-001 / **Invited talk**

Diffusive Shock Acceleration of Cosmic Rays - Quasi-thermal and Non-thermal Particle Distributions

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Presenter: B. Arbutina (arbo@matf.bg.ac.rs)

A well-known paradigm about the origin of Galactic cosmic rays (CRs) is that these high-energy particles are accelerated in the process of diffusive shock acceleration (DSA) at collisionless shocks (at least up to the so-called "knee" energy of 10^{15} eV). Knowing the details of injection of electrons, protons and heavier nuclei into the DSA, their initial and the resulting spectrum, is extremely important in many "practical" applications of the CR astrophysics, e.g. in modelling of the gamma or synchrotron radio emission of astrophysical sources. In this lecture I we will give an overview of the DSA theory and the results of observations and kinetic Particle-In-Cell (PIC) simulations that support basic theoretical concepts. PIC simulations of quasi-parallel collisionless shocks show that thermal and supra-thermal proton distribution functions at the shock can be represented by a single quasi-thermal distribution – the κ-distribution that is commonly observed in out-of-equilibrium space plasmas. Farther downstream, index κ increases and the low-energy spectrum tends to Maxwell distribution. On the other hand, higher-energy particles continue through the acceleration process and the non-thermal particle spectrum takes a characteristic power-law form predicted by the linear DSA theory. At the end, I will show what modification of the spectra is expected in the non-linear DSA, when CR back-reaction to the shock is taken into account.

S02-AA-002 / **Invited talk (virtual)**

New Technologies and HI Mapping Results from CRAFTS

Author: Marko Krco[1]

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Presenter: M. Krco (marko@mkastro.net)

The Commensal Radio Astronomy FAST Telescope Survey (CRAFTS) is underway. With over 2,000 hours complete (out of 11,000 planned) we have mapped significant sections of the sky visible from the Five Hundred Meter Spherical Aperture Telescope (FAST) located in Guizhou, China. The Survey itself represents a technological leap forward in radio telescope observation techniques which allows for multiple science objectives to be achieved simultaneously. In the case of CRAFTS this includes simultaneous Galactic HI Mapping, HI Galaxy Search, Continuum Imaging, Pulsar Search, and FRB Search projects. In this talk we will discuss some of the

new technologies that have made these commensal observations possible. We will also show the latest HI imaging results from selected regions of interest including the Taurus and Orion Molecular Cloud Complexes and the Lockman Hole.

`S02-AA-100` / **Oral presentation (virtual)**

Changes introduced by Cooling Flow (CF) effect, on Sunyaev-Zaldovich (S-Z) inverse Compton effect, profiling the hot electronic plasma on Clusters of Galaxies.

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Presenter: E. Çaça (`cenkelejd@yahoo.it`)

S-Z is an effect, which consists in the inverse Compton effect of the hot electronic gas interacting with Cosmic Microwave Background (CMB) photons passing through Intra Cluster Medium (ICM). Building more accurate profiles for temperature and density of hot electronic gas, concentrated in the center of clusters of galaxies, is a constant problem in survey of Sunyeav Zel'dovich effect (SZ). So far, the Isothermal model is used for temperature profiling in the calculation of the inverse Compton effect, but based on the recent improved observations from satellites, which showed in some clusters the hot electronic gas presents a feature, called Cooling Flow (CF), temperatures in this model differs towards the edges of the Clusters of Galaxies, leading to a change on the Compton parameter in comparison with Isothermal model. In this paper are processed data, provided by 3 Xray satellites (Chandra, XMM-Newton, ASCA). The X-ray analysis is based on two models for the electron density and temperature profile. A sample clusters of galaxies are analyzed, more than half of them show this feature, and by building the temperature profiles using CF model, the differences on the Compton parameter, are 10-50% in comparison with Isothermal model. Therefore to increase the accuracy of evaluation of the Compton parameter, we should take into account the change of the electronic gas temperature, change that affect changes in both, CMB spectrum and temperature, from SZ effect

S02-AA-101 / **Oral presentation (virtual)**

Updated BBN cosmological constraints on Beyond Standard Model physics

Authors: Daniela Kirilova[1]; Mariana Panayotova[1]; Emmanuil Chizhov[1]

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Presenter: D. Kirilova (dani@astro.bas.bg)

Big Bang Nucleosynthesis (BBN) is one of the most reliable tests of Beyond Standard Model (BSM) physics due to the remarkable concordance between the theoretically predicted and the derived from observations abundances of light elements produced primordially. Recently the primordial light elements D and He-4 were determined with higher accuracy. This allows to update and strengthen the Big Bang Nucleosynthesis constraints on physics beyond Standard Model.

We consider several models representing BSM physics. We derived updated more stringent BBN constraints on electron-sterile neutrino oscillations parameters corresponding to 1% accuracy of the determination of the primordial produced Helium-4. We present new cosmological constraints on the number of the effective degrees of freedom of light particles during the BBN epoch and updated the BBN constraints on the freezing temperature of the light sterile neutrinos.

S02-AA-102 / **Oral presentation**

The new 1.5-meter robotic telescope for the Rozhen Observatory

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Presenter: E. Semkov (esemkov@astro.bas.bg)

Bulgarian National Astronomical Observatory Rozhen is located in the Rhodope Mountains at about 1750 m above sea level. The astronomical observatory is the biggest one-time Bulgarian investment in scientific infrastructure and a leading astronomical center in the South-East Europe. So far, the observatory has four telescopes: 2-m RCC multipurpose telescope equipped with four new professional CCD cameras, coudé and éshelle spectrographs, 50/70 cm Schmidt telescope, 60 cm Cassegrain telescope and 15 cm Lyot-coronagraph.

In order to expand the capability for astronomical observations and to increase the efficiency of the Observatory, in 2020 a contract was signed with the company ASA Astrosysteme GmbH for the supply and installation of a new 1.5 m telescope in NAO Rozhen. The telescope will be installed in a new dome with a diameter of 6 m and

a height of 8 m and will be fully robotic. The main objects for observation will be: small bodies from the Solar system, various types of variable stars, blazars and active galactic nuclei. The telescope will initially work only in photometric mode, but in the future the delivery of a low-dispersion spectrograph is also planned.

The new 1.5 m robotic telescope has already been produced and the delivery and installation is expected to take place in July-August. We hope to start the first test observations in September this year, after which it will be put into regular operation.

`S02-AA-103` / **Oral presentation**

Wavelet analysis of the near-surface air temperature in Bulgaria

Authors: Grozdan Shirov[1]; Tsvetan Tsvetkov[1]; Nikola Petrov[1]; Ashkhen Karakhanyan[2]

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Presenter: G. Shirov (`gshirov@astro.bas.bg`)

One of the current problems of our contemporary time is related to changes in the climate of local, as well as global scope. We offer an analysis of long-term time series of meteorological data from different weather stations in Bulgaria. The main portion of the analyzed data are monthly average values of temperature, precipitation, atmospheric pressure, and they can be related to different factors influencing climate change – geological, cosmical, anthropological (generated by human activity)Based on data from Bulgarian meteorological stations, we detected a periodicity in long-term variations of the near-surface air temperature, using wavelet analysis. Bulgaria has a continental climate. Therefore, we compared the results obtained in Bulgaria with the wavelet analysis results obtained in Eastern Siberia. Observational data for Siberia are provided by RIHMI-WDC (http://meteo.ru/data).

`S02-AA-104` / **Oral presentation**

Flares of Solar Cycle 24 Related to Active Regions

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Presenter: T. Tsvetkov (`tstsvetkov@astro.bas.bg`)

Analyzing our catalog of active-region-related activity events of solar cycle 24, we pay special attention to solar flares. In addition to Geostationary Operational Environmental Satellite (GOES) soft X-ray flare listing data that we investigated to associate solar flares with active regions, we added microwave flare observations by the Badary Broadband Microwave Spectropolarimeter (BBMS). Used spectral microwave parameters are the flux value of spectrum maximum and the frequency of spectral maximum, the presence of the polarization, and it signs, and the frequency of the maximum polarization value. We note that the flare list was limited within the period 2011-2019 and by the daily time range of BBMS observations.

`S02-AA-105` / **Oral presentation**

Variability of massive stars in IC342 galaxy

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Presenter: A. Valcheva (`valcheva@phys.uni-sofia.bg`)

We report BR-bands monitoring of 6 massive star candidates selected in a 10x10 sq. arcmin field in north-east quarter of the IC342 galaxy on the base of our B+H α images obtained with the 2m RCC telescope at NAO Rozhen, Bulgaria. We analyzed 2.3 yr BR-light curves of the objects. The candidates demonstrate photometric variations smaller than 0.2 mag, and no overall brightness changes has been detected. We supplement our photometry with BV HST magnitudes, obtained by us using the DOLPHOT 2 package and gr magnitudes from the Pan-STARRS catalogue DR1 in order to expand the light curve coverage and to check for a blending effect of neighboring stars on our PSF ground-based photometry.

Acknowledgements: This work is a part of the two years bilateral project between Bulgarian and Russian astronomers granted in 2019 by the National Science Fund of Bulgaria, KP-06-Russia-9/2019.

S02-AA-106 / **Oral presentation**

Lightcurve analysis on asteroids from BNAO Rozhen observations in 2021

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Presenter: E. Vchkova Bebekovska (elenavckova@gmail.com)

In the last two decades, part of the observational time at Bulgarian National Astronomical Observatory (BNAO) Rozhen was dedicated to asteroid observations. Even though we had limited time, we collected enough information to proceed with differential photometry on many asteroids. Using a combination of lightcurves of an asteroid, gained from observations at several oppositions, we were able to determine precise synodic periods, and through an analysis of the different lightcurves, we can give predictions about their preliminary shape.

In this work, we will present the process for synodic period determination for several asteroids. Moreover, using the characteristics of the lightcurves, we will calculate the ratio between the axis of the asteroid and give first assumptions about its shape.

S02-AA-107 / **Oral presentation**

Polarization of the Daytime Sky

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Co-authors: Tsvetan Tsvetkov [1]; Nikola Petrov [1]; Ruslan Zlatev [2]

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Presenter: Y. Zinkova (yovelina.zinkova@gmail.com)

Polarization is a property of light widely used as a source of additional information in astronomy. The primary source of polarization in the atmosphere is the scattering by gas molecules although meteorological conditions, sky pattern, underlying surface reflectance, etc. may influence the observed sky polarization. In order to explicate polarization measurements correctly, it is important to understand how partially polarized skylight varies. We present results for the daytime sky degree of polarization. Our equipment includes linear polarization filter attached to a photo

camera as well as digital polarization camera. We determine the dependence of polarized daylight on the peculiarities of the landscape, altitude of the observer and the season.

S02-AA-200 / **Poster presentation**

Lightcurve Analysis of Asteroids at the Astronomical Station Vidojevica for the first half of 2022

Authors: Gordana Apostolovska[1]; Nataša Todorović[2]; Vchkova Bebekovska Elena[3]

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Presenter: G. Apostolovska (gordanaapostolovska@gmail.com)

We present one part of our long-term photometry program, targeted at studying the shape and spin state of asteroids. The CCD photometric observations were carried out in the first half of 2022 with two telescopes at the Astronomical Station Vidojevica (Serbia): 1.4m Ritchey-Chrétien-Coude "Milanković" and the 60cm Cassegrain "Nedeljković" telescope.

In this work, lightcurves, the synodical periods of rotation, ellipsoid shape ratios a/b, and first assumptions about the shape of several main-belt asteroids are presented. Obtained results contribute to the database of rotational characteristics of the asteroids, enhancing the understanding of the creation of our planetary system.

S02-AA-201 / **Poster presentation**

Characteristic Emission of Star-Forming High Redshift Galaxies: Testing the IR Template

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Presenter: J. Bogdanoska (janabogdanoska@pmf.ukim.mk)

In anticipation of JWST data, today's study of early Universe galaxies focuses on preparations for efficient data handling. For that reason, in our previous work (Burgarella et al. 2021, in press), we constructed an IR template which is based mainly

on the ALPINE data sample with an addition of a few other well-studied galaxies, which includes galaxies in the redshift range $4.5 < z < 6.2$. To build the IR template, a sample of galaxies with a well-sampled SED was chosen and SED fitting was performed on the entire sample using the flux data of all available filters. This mainly served to constrain the UV part of the SED, give an idea about the type of IR SED that we might expect, and have a best-fit model of the entire SED. Then, by normalising the SEDs of each individual galaxy at the rest-frame 200 μm flux, a composite IR SED was constructed from the normalised ALMA Band 6 or 7 fluxes of all galaxies, this time in the observer frame. When shifted to the observer frame, the flux of the ALMA Bands is at a different wavelength for each galaxy, due to the difference in redshift. We call this technique "using the Universe as a spectrograph". Finally, these data points were fitted to create a SED template representative of the entire studied sample. The IR template is expressed through the parameters of three different dust emission models that are required as input in the SED fitting code CIGALE which we consistently use in our work. By using these values of the parameters, the number of models needed to fit the SED is greatly reduced. In this work, we use older data from Bouwens et al. (2016) to test the IR template. Three of the objects from this dataset were already used in building the IR template, however, the majority of them did not meet the required minimum of 5 data points in the UV-optical and the S/N $>$1.5 criteria. The SED fitting with CIGALE is first carried out by using a grid of models for the dust emission. In a second fitting run, the parameters of the IR template are used. We compare the main output parameters of the models, i.e. the characteristics of the galaxies, as well as the typical diagnostic diagrams for this kind of sample, such as the SFR-M_star, IRX-M_star and IRX-beta diagrams. We also compare our results to the original findings of Bouwens et al. (2016).

`S02-AA-202` / **Poster presentation**

Flux densities and spectral indices of Relaxed Double radio galaxy 3C 84

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Presenter: V. Borka Jovanovic (`vborka@vinca.rs`)

Here we study the flux densities at 1380, 4908 and 15365 MHz, as well as the radio spectral index distribution of 3C 84, a Double Radio source Associated with Galactic Nucleus (DRAGN). 3C 84 is the dominant giant elliptical galaxy in the Perseus cluster, and thus very interesting for our research. This famous radio galaxy Perseus A has Relaxed Double classification because it has the large halo, with the lack of its compact structure. We calculated the radio spectral index distribution over the whole area of the source, which we then also used to investigate the nature and mechanisms of its radiation.

S02-AA-203 / **Poster presentation**

Milankovitch cycles, eighty years later

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Presenter: G. Jovanovic (gocaj@t-com.me)

Milutin Milankovitch published his influential research "Canon of Insolation and the Ice-age Problem" in Belgrade, Serbia, 1941. His work is important nowadays in terms of studying climate changes. In this paper we consider new scientific knowledge about solar insolation. Periodic solar activities such as sunspots and the magnetic field cycle or grand solar minimum/maximum affect the Earth's atmosphere. These periodic natural factors, together with Milankovitch cycles, are important for regional and for global climate.

S02-AA-204 / **Poster presentation (virtual)**

Methods for detecting NEO-type celestial bodies, possibly NEA asteroids

Author: Afrodita Liliana Boldea[1]

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Presenter: A. Boldea (liliana.boldea@nipne.ro)

For the detection of celestial bodies near the Earth, called NEO bodies, Near Earth Object, among which are NEA asteroids, Near Earth Asteroids, several types of software and utilities have been created. This paper includes the way in which the image packets were processed, taken from the telescope, highlighting the characteristics of NEO bodies and how they were used in Astronomy, to obtain a body with physical significance, namely an asteroid, possibly NEA type. The images were obtained using the Isaac Newton Telescope, INT, from the Canary Islands, La Palma. Thus, the data for the celestial bodies, from the E227 image pack, were recorded between October 6-9, 2020. These data for the identified bodies were included in the Minor Planet Center database. The software packages used were Astrometrica and Nearby, respectively. The determinations made with the help of students, University of Craiova, Faculty of Sciences, within the existing Research Project, were materialized in the composition of teaching-learning didactic projects, in the disciplines of Pedagogical Practice, respectively in Didactics of Natural Sciences, using the methods interactive teaching - learning, such as research investigation and e-learning teaching method. The utilities accessed after identifying significant celestial bodies were Asteroids Identifications, Find Orb Project Pluto-MPC, from the Minor Planet Center, Astrocheck, Nea Checker, and Neo Checker-MPC.

S03-GC
Gravitation and Cosmology

S03-GC-001 / **Invited talk**

Theoretical and experimental challenges in quantum gravity phenomenology

Author: Jose Manuel Carmona[1]

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Presenter: J. Carmona (jcarmona@unizar.es)

The experimental search of non-conventional effects predicted by bottom-up approaches and theoretical models of quantum gravity is a quite recent field of research. Generically, it requires to consider probes of very high-energy and amplification mechanisms, conditions which are fulfilled by the propagation of the cosmic messengers. Advances in multi-messenger astronomy during the last decade has driven progress in the field, but a number of theoretical and experimental challenges still lie ahead. We will review them, making emphasis in two complementary lines of research: the study of time delays and the modification of interactions which appear in quantum-gravity motivated extensions of special relativity.

S03-GC-002 / **Invited talk (virtual)**

The Hubble Tension

Author: Dragan Huterer[1]

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Presenter: D. Huterer (huterer@umich.edu)

Over the past several years, a foremost development in cosmology has been the rise of the so-called Hubble tension. This refers to the disagreement between the measurements of the expansion rate of the universe - the Hubble constant (H0). Direct measurements of H0 using the astronomical "distance ladder" find H0 of about 67 km/s/Mpc, while the analysis of the cosmic microwave background anisotropies finds 74 km/s/Mpc, with both measurement errors small enough to make the discrepancy highly statistically significant. I will explain the ingredients that go into the two measurements, and the difficulty of explaining the tension with unaccounted-for systematic errors.

S03-GC-100 / **Oral presentation**

Thin-Shell wormhole in gravity coupled with nonlinear electrodynamics

Authors: S. Habib Mazharimousavi[1]; Zahra Amirabi[1]

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Presenter: Z. Amirabi (zahra.amirabi@emu.edu.tr)

In the context of the spontaneously broken scale-invariant nonlinear electrodynamic introduced by Guendlmann et al with a magnetic dominance feature, we construct a thin-shell wormhole. The surface tension of the TSW is zero in static configuration implying the exotic matter present at the throat is a cloud of exotic dust. We apply the small-velocity perturbation as well as the radial linear perturbation to investigate its mechanical stability. In the former case, the equation of state of the fluid on the shell is kept unchanged and upon our calculation the TSW is unstable. For the latter case, we consider a variable equation of state for the dynamic phase of the wormhole and with detailed analysis, it is shown that the TSW may be stable.

S03-GC-101 / **Oral presentation**

Hidden Symmetries, Rapid Turns and Cosmic Acceleration

Author: Lilia Anguelova[1]

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Presenter: L. Anguelova (anguelova74@gmail.com)

Hidden symmetries provide a powerful tool for finding exact solutions in multifield cosmological models. I will show how, using such symmetries, one can find inflationary solutions in two-field models, which lead to the generation of primordial black holes. I will also discuss an exact solution in a two-field cosmological model, which describes dark energy. This solution is obtained with the use of a hidden symmetry, although the latter is broken by a constant term in the scalar potential. All of the above solutions are characterized by field-space trajectories with rapid turns.

S03-GC-102 / **Oral presentation**

Infrared behavior of two-field cosmological models

Authors: Calin-Iuliu Lazaroiu[1]; Elena Mirela Babalic[1]

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Presenter: E. Babalic (mbabalic@theory.nipne.ro)

We study the first order infrared behavior of “tame” hyperbolizable two-field cosmological models, defined as those classical two-field models whose scalar manifold is a connected, oriented and topologically finite hyperbolizable Riemann surface and whose scalar potential admits a positive and Morse extension to its end compactification. We achieve this by determining the universal forms of the asymptotic gradient flow of the classical effective potential with respect to the uniformizing metric near all interior critical points and ends of that Riemann surface.

S03-GC-103 / **Oral presentation**

Nonlocal Gravity Model and its Cosmological Solutions

Author: Ivan Dimitrijević[1]

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Presenter: I. Dimitrijević (ivand@matf.bg.ac.rs)

A nonlocal gravity model

$S = \frac{1}{16\pi G} \int (R - 2\Lambda + (R - 4\Lambda)\mathcal{F}(\Box)(R - 4\Lambda))\sqrt{-g}\mathrm{d}^4x$

was recently introduced, and two exact cosmological solutions in flat space were presented.

One solution has similar properties to an interplay between the radiation and the dark energy, while the other one is a nonsingular time symmetric bounce. In this talk we investigate other possible exact cosmological solutions and find some new ones in nonflat space. Used nonlocal gravity dynamics can change background topology. To solve the corresponding equations of motion, we first look for a solution of the eigenvalue problem $\Box(R - 4\Lambda) = q(R - 4\Lambda)$. We also discuss possible extension of this model with nonlocal operator symmetric under $\Box \longleftrightarrow \Box^{-1}$ and its connection with another interesting nonlocal gravity model.

This talk is based on joint work with Branko Dragovich, Zoran Rakić and Jelena Stanković.

S03-GC-104 / **Oral presentation**

Spontaneously broken scale-invariant nonlinear electrodynamics and thin shell wormholes

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Presenters: S. Mazharimousavi (habib.mazhari@emu.edu.tr),
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Maxwell's action in vacua is scale-invariant. This causes singularity in the fields and infinite self-energy. By breaking this symmetry one may remove the singularity as well as make the self-energy finite. In the context of the spontaneously broken scale-invariant nonlinear electrodynamic with a magnetic dominance, we introduce black a hole solution.

We study the physical properties of the solution and particularly investigate its thermal stability.

Furthermore, we construct a thin-shell wormhole (TSW) in this bulk spacetime. We show that the surface tension of the TSW constructed TSW becomes zero with a fine-tuned parameter in a static configuration. This in turn implies the exotic matter present at the throat is a cloud of exotic dust. The dynamics of the TSW powered by the exotic dust are also analyzed in detail. We present a mechanical stability analysis to show that the TSW is stable against a radial linear perturbation.

S03-GC-105 / **Oral presentation**

Analytical Quasinormal modes of charged fermions in Einstein-Born-Infeld dilaton black hole spacetime

Author: İzzet Sakallı[1]

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Presenter: İ. Sakallı (izzet.sakalli@emu.edu.tr)

We consider the charged massless Dirac fields in the background of 4-dimensional Einstein-Born-Infeld dilaton black hole spacetime. We derive the analytical spin-half quasinormal modes, whose Dirac equations are obtained in terms of the hypergeometric functions. The stability analysis of those black holes under the charged Dirac perturbations is also discussed. Obtained results are highlighted with graphs and tables.

S03-GC-106 / **Oral presentation**

Nonlocal de Sitter Gravity

Authors: Branko Dragovich[1]; Ivan Dimitrijević[1]; Jelena Stankovic[1]; Zoran Rakic[1]

[1] *University of Belgrade*

Presenter: J. Stankovic (jelenagg@gmail.com)

General relativity (GR), i.e. Einstein theory of gravity, is recognized as one of the best physical theories – with nice theoretical properties and significant phenomenological confirmations. Nevertheless, GR is not a complete theory of gravity and there are many attempts to modify it. One of the actual approaches towards more complete theory is nonlocal modified gravity. Nonlocal gravity model, which we consider here without matter, is given by the action $S = \frac{1}{16\pi G}\int\sqrt{-g}\big(R - 2\Lambda + \sqrt{R-2\Lambda}\ \mathcal{F}(\Box)\ \sqrt{R-2\Lambda}\big)d^4x$, where R is scalar curvature and Λ – cosmological constant. $\mathcal{F}(\Box) = 1 + \sum_{n=1}^{+\infty}\left(f_n\Box^n + f_{-n}\Box^{-n}\right)$ is an analytic function of the d'Alembert-Beltrami operator $\Box$ and its inverse $\Box^{-1}$. Derivation of equations of motion for gravitational field $g_{\mu\nu}$ is presented in [2]. To solve the corresponding equations of motion, we first solve equation $\Box\sqrt{R-2\Lambda} = q\sqrt{R-2\Lambda}$, where $q = \zeta\Lambda \quad (\zeta \in \mathbb{R})$ is an eigenvalue and $\sqrt{R-2\Lambda}$ is an eigenfunction of operator $\Box$. We presented several exact cosmological solutions for homogeneous and isotropic universe. One of these solutions mimics effects that are usually assigned to dark matter and dark energy, see [1]. Some other solutions are examples of the nonsingular bounce ones in flat, closed and open universe. There are also singular and cyclic solutions. All these cosmological solutions are a result of nonlocality and do not exist in the local de Sitter theory of gravity.

References

1. I. Dimitrijevic, B. Dragovich, A. S. Koshelev, Z. Rakic and J. Stankovic, *Cosmological solutions of a nonlocal square root gravity*, Phys. Lett. B 797 (2019) 134848, arXiv:1906.07560 [gr-qc].
2. I. Dimitrijevic, B. Dragovich, Z. Rakic and J. Stankovic, *Variations of infinite derivative modified gravity*, Springer Proc. in Mathematics & Statistics {\bf 263} (2018) 91–111.

S03-GC-107 / **Oral presentation**

On some analytical solutions of inflationary models with DBI tachyon field

Authors: Marko Stojanovic[1]; Goran S. Djordjević[2]; Milan Milošević[2]; Dragoljub D. Dimitrijević[2]

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Presenter: M. Stojanovic (marko.stojanovic@pmf.edu.rs)

Cosmological inflation provides solutions to some problems in standard cosmology. Many different scenarios of inflation have been proposed. The generally accepted and the most commonly used approach is that the inflationary phase can be described by a single scalar field. One of the interesting possible mechanisms for inflation is based on the dynamics driven by the tachyon field θ [1, 2]. The dynamics in this model can be described by an effective Dirac-Born-Infeld (DBI) type Lagrangian. A specific property of different models is determined by choice of the potential associated to the tachyon field, motivated by the string theory.

The usual manner of analyzing inflationary dynamics (in both tachyon and canonical scalar field cases) is based on slow-roll regime/approximation. Although the slow-roll approximation can simplify the system of equations, the numerical procedure is still necessary for finding its solution [3]. Also, the properties and predictions of the model greatly depend on a type of potential.

In this work, we consider some specific criteria which can provide analytical solutions of the dynamical equations. Having in mind that the Hubble parameter (H) is a decreasing function of a tachyon field, we find the analytical solutions of the exact dynamical equations (without slow-roll approximation) for some specific cases ($H(\theta) \propto \theta^{-2}$, $H(\theta) \propto \sin^{-2}\theta$, etc.), which have not been considered so far. In addition, we calculate the Hubble hierarchy slow-roll parameters. In order to compare predictions of the model with observational data we calculate the values of the most important observational parameters for inflation, in the slow-roll regime, i.e. the scalar spectral index (n_{s}) and the tensor to scalar ratio (r). We compare the obtained results with the Planck 2018 data [4]. Parameterization of observational parameters, via the number of e-folds (N), is introduced [5] for some specific cases of $H(\theta)$.

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References

1. D.A. Steer and F. Vernizzi, Phys. Rev.D 70, 043527 (2004).
2. N. Bilic, D. D. Dimitrijevic, G. S. Djordjevic, M. Milosevic and M. Stojanovic, JCAP 08, 034 (2019).
3. M. Milošević, N. Bilić, D. D. Dimitrijević, G. S. Djordjević and M. Stojanović, Numerical Calculation of Hubble Hierarchy Parameters and Observational Parameters of Inflation, AIP Conf. Proc, 2075, 090009 (2019); M. Milosevic, D. D. Dimitrijevic, G. S. Djordjevic and M. Stojanovic, Serb. Astron. J. 192, 1–8 (2016).
4. Planck 2018 results - X. Constraints on inflation, A&A 641, A10 (2020).
5. V. Mukhanov, Eur. Phys. J. C. 73 (2013).

S03-GC-108 / **Oral presentation**

Thermodynamic Equilibrium, Nambu Brackets and Induced Hessians

Author: Tsvetan Vetsov[1]

Co-authors: Radoslav Rashkov [2]; Hristo Dimov [2]; Miroslav Radomirov [2]

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Presenter: T. Vetsov (c.vecov@gmail.com)

We introduce the notion of global and local thermodynamic equilibrium for any thermal system with well-defined first law. Our approach relies only on few key concepts, namely: Legendre transformation, Hessian matrices, Nambu brackets and thermodynamic curvature. In the extremal point, every convex (concave) potential must be in its global minimum (maximum). This allows one to impose standard conditions on the second derivatives (the elements of the Hessian) of the potential to fully determine the global equilibrium of the system. When turning to a different thermodynamic potential via a Legendre transformation, it may not be fully convex (concave) in its natural parameters. In this case, to translate the condition for global thermodynamic equilibrium, one must relate the components of the new Hessian to the previous one. The relation turns out to be a non-trivial mapping (a generalized pushforward/pullback) from one thermodynamic space to another involving curvature terms. We show that the components of the new induced Hessians can be equivalently calculated within the Nambu Bracket formalism. The latter is in the core description of the local thermodynamic equilibrium.

S03-GC-200 / **Poster presentation**

The production of particles with well determined angular momentum in external Coulomb field on de Sitter expanding universe

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Presenter: M. Baloi (mihaela.baloi@e-uvt.ro)

We study pair production processes from vacuum of scalar particles and fermions in the presence of an external Coulomb field on de Sitter expanding universe assuming that, the quantum fields are minimally coupled with gravity. Our study is done in the chart with spherical space coordinates and the produced particles are described by the spherical wave solutions of the field equations. In this chart we define the transition amplitude in the first order of perturbation theory and we obtain for the first time the dependence of the probability on the angular quantum numbers. Our

analytical results show that, the angular momentum of the produced particles is conserved in the sense that the quantum numbers are related trough the following relations: l= l' and m= -m'. Our graphical results show that, the most probable transitions are those that generate particles with small angular momentum. We obtain that, this process is significant when the Hubble's constant is large and vanishes in the Minkowski limit.

S03-GC-201 / **Poster presentation (virtual)**

An analysis of oscillations in fuzzy dark matter cores

Authors: Milos Indjin[1]; I-Kang (Gary) Liu[1]; Nick P. Proukakis[1]; Gerasimos Rigopoulos[1]

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Presenter: M. Indjin (m.indjin@newcastle.ac.uk)

Fuzzy dark matter (FDM) is a rapidly growing area of research which aims to alleviate the shortcomings of the current leading cold dark matter (CDM) model. On large cosmic scales, FDM recreates the large scale structure generated by CDM simulations; the two diverge on smaller scales, where CDM suffers the most. Where CDM requires the addition of baryonic feedback and other physics, one of the main attractive aspects of FDM is the inherent existence of a soliton core at the centre of the parent halo, which agrees with astronomical data of dwarf galaxy surveys. Given that the existence of the core is one of the foundational and fundamentally important aspects of FDM, it is of paramount importance that we understand the relevant dynamics and properties. Greater understanding and more accurate predictions of these dynamical behaviours will significantly assist in the search of smoking gun signals of FDM's existence, and may also constrain the properties of FDM, such as the boson mass.[1]

Simulations show that the soliton core exhibits dynamical behaviours in the form of a random walk within the potential well of the halo, as well as fixed period oscillations. We study the latter by performing a perturbative analysis of a generalised ground state soliton core using the empirical formula from [2], and compute an analytical expression for the oscillation frequency as a function of the soliton core's fundamental properties, inspired by the approach taken in [3]. We also numerically solve the Gross-Pitaevskii Poisson system of equations in 3D and separately using a spherically symmetric solver, to simulate the dynamical behaviour of a FDM soliton core. Our analytical study finds qualitative agreement with results from [3]—where instead of an accurate empirical formula, a Gaussian ansatz is used to model the core—with clear identifiable corrections and an improvement on agreement with our numerical simulations.

We henceforth generalise this analysis further to account for the possibility of self-interaction between the bosons through the use of the adjusted empirical formula

from [4], and thus lay the foundations for further work to be done on self-interacting FDM.

References

1. D. J. Marsh and J. C. Niemeyer, Phys. Rev. Lett., 123, 051103 (2019)
2. H. Y. Schive, T. Chiueh, and T. Broadhurst, Nat. Phys. 10, 496 (2014)
3. P.-H. Chavanis, Phys. Rev. D - Part. Fields, Gravit. Cosmol. 84, 1 (2011)
4. J. Chen, X. Du, E. W. Lentz, D. J. Marsh, and J. C. Niemeyer, Phys. Rev. D 104, 083022 (2021)

S03-GC-202 / **Poster presentation**

On Various Aspects of DBI Lagrangian Dynamics and its Mechanical and Cosmological Realization

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Presenter: M. Popović (milan.popovic@pmf.unibl.org)

The DBI Langrangian (or a family of DBI Lagrangians) has been known and widely considered in many different fields of physics.

For instance, classical and quantum dynamics of tachyon systems have been examined, describing spatially homogeneous scalar fields, in the limit of classical and quantum mechanics.

Understanding and modelling of these systems are of particular importance in the development of field and string theory. We review its application in modern cosmology and in the theory of inflation. The focus is on the study of the dynamics of a scalar tachyonic field with a non-standard Lagrangian of a DBI type, or a Lagrangian used in the so-called effective field theories, with various potentials.

It is suitable to use lower-dimensional models, including a zero-dimensional classical-mechanical analogue.

The original calculations for several specific and important (tachyon) potentials are presented.

Those potentials are also exactly solvable in the framework of Friedmann cosmology, and they have physical motivation in inflationary cosmology.

In addition, the so-called locally-equivalent Lagrangians of the standard type are considered. The classical and quantum formalism for a harmonic oscillator with time-dependent frequency is given as an example.

S03-GC-203 / **Poster presentation**

On a gauge invariant variable for scalar perturbations during inflation

Author: Nenad Vesić[1]

Co-authors: Dragoljub D. Dimitrijević [2]; Goran S. Djordjević [2]; Milan Milošević [2]; Marko Stojanovic [3]

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Presenter: N. Vesić (n.o.vesic@outlook.com)

We discuss cosmological perturbations of the scalar type in the spatially flat FRWL background during inflation. There are five independent scalar perturbations. Four of them are perturbations of the FRWL metric and the fifth one represents perturbations of a scalar field. As usual, a scalar field is used to describe dominant (perfect) cosmological fluid responsible for inflation [1].

These five scalar perturbations are not gauge invariant, i.e. their values strongly depend on coordinate system we use and are not physical. In order to obtain physical quantities, gauge invariant variables are introduced. Their values will not depend on a choice of coordinate system we use and will not change under general coordinate transformations.

Frequently used gauge invariant scalar perturbations in the literature are two Bardeen's potentials, the gauge invariant perturbations of a scalar field and the Mukhanov-Sasaki variable [2,3,4]. The main idea is to construct a general gauge invariant variable, that will contain all four mentioned gauge variables. It can be done by looking at a set of expressions defining explained in details in this work. At the end, we discuss about dynamical equation and its solution for a general gauge invariant variable.

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References
1. S. Weinberg, Cosmology, Oxford University Press (2008).
2. J. M. Bardeen, Phys.Rev. D, 22, 1882 (1980).
3. H. Kodoma and M. Sasaki, Prog. Theor. Suppl., 78, 1 (1984).
4. V. Mukhanov, H. Feldman and R. Brandenberger, Phys. Rep., 215, 203 (1992).

S04-AMP
Atomic and Molecular Physics

`S04-AMP-001` / **Invited talk**

Quantum Computing Challenges for Transition Dynamics in Atomic and Molecular Systems

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Presenter: P. Krstic (`krsticps@gmail.com`)

Quantum computing (QC), based on principles of superposition, entanglement, and measurement of qubits, promises the advantage to surpass the performance of classical computing in cryptography, communication, and optimization problems, as well as in simulations of complex quantum system in physics and computation chemistry. Despite decades in development, fully coherent, fault-free universal quantum Turing machine with large number of qubits is not yet accessible. The decoherence and quantum noise in the so called near-term, noisy, intermediate-scale quantum (NISQ) computers impair the performance and accuracy of many applications [1]. This is partially mitigated by development of hybrid quantum-classical algorithms which reduce the depth of the quantum circuits, lessening sources of the noise [2].

We will present development of new family of quantum algorithms and relevant computational tools for simulating transition dynamics in time-dependent quantum systems on a quantum computer at NISQ era. These aim to answer two questions: (1) How to simulate the transition dynamics, accurately and efficiently, between many states of an atomic system perturbed by strong time-dependent perturbation? (2) How to compute the collisional S-matrix for the vibrational dynamics of the $+_2$ system, including dissociative processes?

To answer 1), a QC schemes were developed utilizing McLachlan variational principle in a hybrid quantum-classical algorithm, using both unary and qubit efficient encoding to accurately calculate the transition dynamics between excited states of a closed quantum system, an one electron atom, subject to a strong, attosecond laser pulses [3]. A systematic approach for optimal construction of a general N-state ansatz with unary N-qubit encoding is refined. The qubit efficient encoding reduces the number of qubits to $\log_2 N$, simultaneously diminishing depth of a quantum circuit.

Building an algorithm and a relevant system of quantum circuits [4] to calculate evolution operator in Trotter approximation for simulating the collisional $H + H_2$ system, answers question 2). The full S-matrix of the system is obtained, which describes transitions between all bound vibrational states and the discretized vibrational continuum of the ground electronic surface of H_3. Obtaining the cross sections for vibrational transitions coupled to the dissociative continuum paw a road for the QC description of the dynamic of the open quantum systems.

References:
1. Y. Wang and P. Krstic, Phys. Rev. A 102, 042609 (2020), arXiv:2006.10037 [quant-ph]

2. H. Patil, Y. Wang, and P. Krstic, Phys. Rev. A 105, 012423 (2022), arXiv:2107.08606 [quant-ph]
3. Y. Wang and P. Krstic, arXiv:2112.06365 [quant-ph] (Phys. Rev. A, 2022)
4. Y. Wang and P. Krstic, arXiv:2205.14201 [quant-ph] (New J. Phys, 2022)

S04-AMP-002 / **Invited talk (virtual)**

Experimental Quantum Control with the IBM Quantum Computers

Author: Nikolay Vitanov[1]

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Presenter: N. Vitanov (vitanov@phys.uni-sofia.bg)

In this talk I will review the very recent experiments conducted by my group on various quantum control techniques at some of the open-access IBM quantum processors. I particular, I will show results on quantum control by composite pulses, quantum control by polychromatic pulse trains, quantum sensing of small frequency shifts, tuning the parameters of the quantum computer, dynamical decoupling from noise, power narrowing, and others. Our results demonstrate an excellent agreement between theory and experiment, which indicates both the power of the quantum control technique and the high quality of the superconducting qubits in use at IBM Quantum.

S04-AMP-100 / **Oral presentation**

Tribological Properties of Selected Vanadium Oxide Stoichiometries Studied with Reactive Molecular Dynamics

Author: Miljan Dašić[1]

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Presenter: M. Dašić (mdasic@ipb.ac.rs)

Providing effective lubrication at high temperatures/pressures and in oxidative environments is relevant for various industrial applications, such as turbomachin-

ery and cutting tools [1,2]. Promising solutions for such conditions are oxidation-resistant hard coatings consisting of binary or ternary films (Cr-N, Ti-N, Cr-Al-N, Ti-Al-N) doped with an additional element which can diffuse to the surface of the coating and form an oxide layer that serves as a lubricant. Vanadium became a popular dopant since its oxides melt at considerably low temperatures, hence providing liquid lubrication.

The amount of oxygen present in an oxidative environment can be taken as a study parameter, leading to the consideration of different vanadium oxide stoichiometries. This study aims to explore the tribological performance of under-oxidized vanadium lubricants, selected in accordance with available experimental studies [3].

We present a reactive molecular dynamics study on the tribological properties of five vanadium oxide stoichiometries $\{ V_2O_3, V_3O_5, V_8O_{15}, V_9O_{17}, VO_2\}$ at elevated temperatures $\{ 600, 800, 1000\}$ [K] and pressures $\{ 1, 2, 3, 4\}$ [GPa]. Our tribological system consists of two rigid V_2O_5 layers, modeling two solid surfaces in a tribocontact, and a vanadium oxide with stoichiometry labeled as V_xO_y, confined between them. Under the imposed working conditions, all studied vanadium oxides were amorphous.

We have employed an atomistic model within the *ReaxFF* (reactive force field) potential to describe the interactions of vanadium and oxygen atoms. Sliding simulations were implemented in the *reax/c* package of the *LAMMPS* code [4].

By applying a linear fit on the dependence of the sliding force F_x on the normal load F_z:

$$F_x = COF \cdot F_z + F_x^0,$$

we extracted the coefficient of friction COF and the sliding force at zero load F_x^0 (adhesion component of the friction force). At a fixed temperature, we did not notice significant changes of the friction coefficient with stoichiometry. The values which we obtained for the COF (~0.2 at 600 K, ~0.15 at 800 K and ~0.1 at 1000 K) are in good agreement with the previously determined results for amorphous V_2O_5 lubricant at the same temperatures [5]. We concluded that all considered V_xO_y stoichiometries (i.e., under-oxidized vanadium) are going to be an effective lubricant. The friction coefficient COF decreases with the increase of the temperature. We observed the increasing trend of the adhesion-related offset of the friction force F_x^0 with the decrease of the oxygen content in V_xO_y lubricants and explained it by the more-pronounced tendency of vanadium atoms from V_xO_y to bond with oxygen atoms from V_2O_5 in oxygen-poorer environments.

Our study on vanadium oxide lubricants provides a reference which is relevant for the design of vanadium doped oxidation-resistant hard coatings.

References

1. P. A. Papi, C. Mulligan, and D. Gall, Thin Solid Films **524**, 211 (2012)
2. A. A. Voevodin, C. Muratore, and S. M. Aouadi, Surf. Coat. Technol. **257**, 247 (2014)
3. F. Fernandes, J. Morgiel, T. Polcar, and A. Cavaleiro, Surf. Coat. Technol. **275**, 120 (2015)
4. S. Plimpton, J. Comput. Phys. **117**, 1 (1995)
5. I. Ponomarev, T. Polcar, and P. Nicolini, Tribol. Int. **154**, 106750 (2021)

S04-AMP-101 / **Oral presentation**

NS super-excited molecular states in the collision of electrons with NS+ cation

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Presenter: F. Iacob (`felix.iacob@e-uvt.ro`)

The recent discovery of the NS+ cation in the interstellar medium1 triggered the interest in the study of its collision with electrons. In this complex process, the electron can be captured into NS Rydberg-bound states predissociated by Feshbach resonances of this latter molecule. These both types of states have been calculated within the Born-Oppenheimer approximation using a variationa ab-initio method based on the the R-matrix theory. The electronically-excited Rydberg states form series converging either to the ground or to the excited states of the cation. We will focus on the Rydberg series of 2Σ+ symmetry converging to the ground X1Σ+ state of the ion, conveniently characterized by their quantum defects or effective quantum numbers.

S04-AMP-102 / **Oral presentation**

Compound-state model for non-sequential double ionization

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Presenter: N. Simonović (`simonovic@ipb.ac.rs`)

Non-sequential double ionization (NSDI) is a strong-field atomic process in which two electrons simultaneously leave atom irradiated by an intense laser pulse. [1] This process has been described successfully by the three-step (TS) model. The first step of this model is the process of tunneling an atomic electron through the barrier which is formed by combining the atomic potential with the electric component of laser field in the maximum phase. The second step is the acceleration of the tunneled electron in the field during the next half of the optical cycle. In the third step the electron reverse direction, as the electric field changes, and returns with increased

energy back towards the parent ion. A possible result of this process is the electron-ion recombination and the formation of a highly excited atomic state, which can be further deexcited to the ground state by emitting radiation, the so-called high harmonic generation, or decomposed by NSDI. In numerical simulations of the NSDI the tunneling dynamics (the first step) is treated quantum mechanically or semi-classically, but the electron's motion in the second and the third step is treated fully classically. In order to collect a sufficient amount of data for quantitative analysis, simulations of this kind of collision processes are usually performed using the classical trajectory Monte Carlo (CTMC) method.

For the field intensities close to the threshold for NSDI the so-called compound-state (CS) model [2] might be a valid alternative to the TS model. Both models assume that the NSDI goes via formation of a doubly excited intermediate state in the recollision process. However, the CS model assumes that, due to strong electron-electron interactions during recollision, the excited state has lost almost the complete memory of its formation dynamics [3,4] such that a compound state is prepared. This state determines initial conditions for the rest of the NSDI process. In numerical simulations we start with a compound state of a given energy $E_{\rm CS}$ formed at the moment of recollision $t_{\rm rec}$ and consider its decay in the laser field. The possibility for double ionization strongly depends on the phase of the field at $t_{\rm rec}$. Fixing the carrier envelope phase (CEP) of the laser pulse the parameters $E_{\rm CS}$ and $t_{\rm rec}$ become well-defined functions of the time t_0 when the recolliding electron leaves the barrier after tunneling. Using the CTMC method the NSDI can be simulated by varying randomly the time t_0 and the compound state parameters (except the energy $E_{\rm CS}$ which is a function of t_0). In this way one reduces the full-collision calculations, used in the TS model, to half-collision ones. The later significantly simplifies and speeds up the simulation of NSDI and might be extended easily to non-sequential multiple ionization (NSMI) processes.

References
1. C. Joachain, N. Kylstra and R. Potvliege, *Atoms in intense laser fields* (Cambridge University Press, 2012).
2. K. Sacha and B. Eckhardt, Phys. Rev. A **63**, 043414 (2001).
3. M. Weckenbrock *et al*, Phys. Rev. Lett. **91**, 123004 (2003).
4. N. Camus *et al*, Phys. Rev. Lett. **108**, 073003 (2012).

`S04-AMP-200` / **Poster presentation**

Experimental determination of the energy dependence of the rate of negative muon transfer reaction $\mu^- p + O \rightarrow p + \mu^- O$

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Presenter: D. Bakalov (dimitarbakalov2011@gmail.com)

We are reporting the results of the first experimental determination of the collision-energy dependence of the muon transfer rate from the ground state of muonic hydrogen to oxygen in the energy range below 100 meV. These results shed new light on the kinematics of the processes involving exotic atoms, and may serve as benchmark for the full-scale quantum-mechanical calculations of low-energy non-elastic scattering of atoms, including charge transfer. In the meantime, the accurate quantitative knowledge of the characteristics of the process of muon transfer to oxygen, which is used by the FAMU collaboration as signature of the resonance laser-induced excitations of the triplet spin state of the $\mu^- p$ atom, allows the precise modelling and fine-tuning of the ongoing FAMU experiment for the measurement of the hyperfine splitting in the ground state of muonic hydrogen and the determination of the electromagnetic Zemach radius of the proton.

S04-AMP-201 / **Poster presentation**

Nonrelativistic energy spectra of three-particle systems calculated in the adiabatic approach by using finite difference method

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Presenter: P. Danev (petar_danev@abv.bg)

Precise spectroscopy of light atomic and molecular systems gives us new insides in the fundamental laws and physical constants of nature [1]. In particular, exotic atoms like antihydrogen and antiprotonic helium could also allow comparison between matter and antimatter characteristics and test of CPT symmetry [2]. From theoretical point of view, development of very accurate techniques like adiabatic and variational methods give us the tools to compute different atomic quantities with high precision [3].

Here, we present accurate calculations of nonrelativistic energy levels of three-particle systems, like for example $\bar{p}He^+$, in adiabatic approximation. In our approach, the electronic wavefunctions are computed by using two-dimensional finite difference method (FDM) and the radial wavefunctions are obtained by solving a system of eigenvalue problems [4] by iterative application of one-dimensional FDM. We analyze the results of using the method with Cartesian and logarithmic stencils and different number of node points. We show that the level of precision allows our results to be used in computations of leading relativistic corrections to transition spectra of these systems and accurately determining the effects of interactions with external fields. A comparison with other computations of light atomic systems' energy spectra has been made and the advantages and disadvantages have been assessed.

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References

1. I.V. Kortunov et. al., Proton–electron mass ratio by high-resolution optical spectroscopy of ion ensembles in the resolved-carrier regime, Nature Physics 17, 569–573 (2021).
2. The ALPHA Collaboration, Investigation of the fine structure of antihydrogen, Nature, 578, 375–380 (2020).
3. P. Danev, D. Bakalov, V.I. Korobov, S. Schiller, Hyperfine structure and electric quadrupole transitions in the deuterium molecular ion, Phys. Rev. A 103 (1), 012805 (2021).
4. S.I. Vinitskij, L.I. Ponomarev, Adiabatic representation of three-body problem with the Coulomb interaction, J. Phys. B. (1978).

S04-AMP-202 / **Poster presentation**

Muonium formation in collisions of positively charged muons with hydrogen and helium atoms

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Presenter: N. Milojević (nenad.milojevic@pmf.edu.rs)

Muonium formation in muon-hydrogen ($\mu^+ - \mathrm{H}(1\mathrm{s}^1)$) and muon-helium ($\mu^+ - \mathrm{He}(1\mathrm{s}^2)$) charge-exchange collisions is considered at intermediate and high impact energies, from 10 keV to 1 MeV. The prior form of the three-body boundary-corrected first Born approximation (CB1-3B) [1] is used for calculations of the state-selective total cross sections Q_{nl} for single-electron capture into $1s$, $2s$ and $2p$ final states of the (μ^+, e) systems. In the helium targets case, the frozen-core approximation and the independent particles model were used. In the frozen-core approximation the non-captured (passive) electron is assumed to occupy the same orbital before and after capture of the active electron, while in the independent particles model the passive electron is included only through a shielding of the original nuclear charge of the target. The state-summed total cross sections Q_Σ for electron capture into all the final states are obtained by applying the Oppenheimer (n^{-3}) scaling law [2]:

$Q_\Sigma = Q_{1s} + 1.616(Q_{2s} + Q_{2p})$.

Unfortunately, no measurements are available, so that the calculated results are compared with the theoretical results which were obtained by applying the three-body continuum distorted wave (CDW-3B) method [3].

References

1. Dž. Belkić and H. S. Taylor, Phys. Rev. A 35, 1991 (1987).
2. J. R. Oppenheimer, Phys. Rev. 31, 349 (1928).
3. Dž. Belkić and R. Janev, J. Phys. B 6, 2613 (1973).

S04-AMP-203 / **Poster presentation**

Shannon Entropy for Ground State of Harmonium in Spherically Confined Plasma

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Co-authors: Ljiljana Stevanović [1]; Nikola Filipović [1]; Vladan Pavlović [1]; Nikola Andrejić [1]

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Harmonium is a system of two electrons whose Coulomb interaction with the nucleus is replaced with harmonic potential. Such a theoretical system is widely used for studying density functional theory, electron correlation, entanglement and black body entropy. It is of great importance to examine spherically confined harmonium in plasma environment, since the results can be useful for nanoelectronics as this system is similar to quantum dots under different confinements. It is well known that plasma environment provides screening effect, and it can be described using two potentials, Debye and Exponentially Cosine Screened Coulomb (ECSC) potential. Debye potential has the form $V(r) = \frac{1}{r} exp(-\frac{r}{\lambda})$, while ECSC potential has the form $V(r) = \frac{1}{r}\ exp(-\frac{r}{\lambda})\ cos(\frac{r}{\lambda})$, where λ is Debye radius and r is distance.

Shannon entropy is often used to quantify the degree of electron localization, structural characteristics, electron correlations, to name but a few. Shannon entropy is an information theory measure, and is defined as $S = -\int \rho(\mathbf{r})\ ln\rho(\mathbf{r})\ d\mathbf{r}$, where $\rho(\mathbf{r})$ is probability density for many-electron system. The smaller Shannon entropy is, the more concentrated the wave function of the state is and the accuracy in predicting the localization of electron is higher.

The goal of this study is to calculate Shannon entropy for the ground state of harmonium in spherically confined plasma and examine how it depends on relevant parameters. The relevant parameters that are varied are - Debye radius (λ), confinement radius of sphere (a) and force constant (ω). Shannon entropy is calculated for both potentials and the results are compared. In order to better examine the system, Shannon entropy is calculated for relative and center of mass motion separately, as well as the total entropy, for the ground state. All numerical calculations are performed by using the 2 nd order finite difference method.

It is shown that Shannon entropy for both potentials monotonically decreases to the value for the corresponding free system. It can be also noted that Shannon entropy for ECSC potential has slightly smaller values. On the contrary, it is observed that Shannon entropy increases with an increase of the radius of spherically confined plasma. Finally, it is demonstrated that Shannon entropy for both potentials gradually decreases with an increase of the force parameter (ω).

S04-AMP-204 / **Poster presentation**

Fitting Potential Energy Curves (PEC) For Diatomic Molecules

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Presenter: A. Sinanaj (alketasinanaj@hotmail.com)

Fitting potential energy curves (PEC) for diatomic molecules becomes a well-established routine confirmed empirically with numerous examples in the literature. One of the questions, which remains still open concerns the extrapolation properties of the potential functions. The experimental PECs virtually always are determined from a limited set of experimental data and this in turns limits the range of internuclear distances where the shape of the potential is unambiguously fixed. Extrapolations are usually unreliable because there is no universal analytic form which parametrizes all possible potentials. Exception is the long-range form of the potential, where the inverse-power expansion De-Cn/Rn- Cm/Rm-… is valid with powers n, m etc., which depend on the atomic asymptote.

The Morse-Long-Range (MLR) potential (Mol. Phys. 105, 663 (2007)) has been reported to have a built in long-range asymptotic behavior and therefore it is plausible to expect that one can expect good extrapolation properties and even possibility to determine important molecular parameters like De or/and Cn from limited set of experimental data.

In this contribution we will study the extrapolation properties of the MLR potential and the uncertainty of De and Cn. The studies will be based on Monte-Carlo approach and will be based on real experimental data.

S04-AMP-205 / **Poster presentation**

Drift velocity of the electron transport in RF elelectromagnetic field in N_2 gas

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Presenter: V. Stanković (violeta.stankovic@ff.bg.ac.rs)

The research topic is calculation of the drift velocity of electron transport in N_2 gas under the influence of an external crossed electromagnetic field, E x B. A Monte

Carlo simulation code has been used to obtain non-equilibrium electron energy distribution function within one oscillation of external crossed fields. In simulation, E is aligned with the z-axis, while B is parallel with y-axis.

In order to test our simulation code validity under the condition of crossed RF electric and RF magnetic fields, we compared drift velocity components of electron transport in Reid's model gas with the available literature data. The results shows the transversal drift velocity (Vx, in E×B direction) obtained by our simulation and obtained by Petrovic et al., with their Monte Carlo code. The calculation was performed for the frequency of 50 MHz, reduced electric field of 14 Td while the reduced magnetic field value was 500 Hx. One can clearly see the excellent matching of the compared velocities which proves the validity of our code.

According to the results of that comparison, we have been encouraged to research and calculate the drift velocity components of electron transport in real N_2 gas. These results have been obtained under the condition of reduced electric field, E/N, of 100 Td, frequency of 100 MHz and reduced magnetic field, B/N, of 1000 Hx.

References

1. Z. LJ. Petrović, Z.M. Raspopović, S. Dujko, T. Makabe, Applied Surface Science, 192 (2002) 1-25

`S04-AMP-206` / **Poster presentation (virtual)**

Investigation of the hyperfine structure of the $c^3\Sigma^+$ state in KRb

Authors: Asen Pashov; Velizar Stoyanov

Presenter: V. Stoyanov (`vstoyanov38@gmail.com`)

The study of the hyperfine structure (HFS) in electronic transitions in diatomic molecules is a challenging task due to its experimental and theoretical complexity. We want to study the HFS of one of the $c^3\Sigma^+$ excited states of the KRb molecule, because previous studies indicated that the splitting may be much larger than in similar alkali metal diatomics [1]. Another motivation is that the $c^3\Sigma^+$ state serves as an intermediate state for transferring cold Feshbach molecules from the $a^3\Sigma^+$ state to the ground $X^1\Sigma^+$ state [2]. Due to the proximity of the $B^1\Pi$ state, perturbations caused by the spin-orbit interaction are observed. This makes possible to observe transition to the mixed pair of states from the singlet $X^1\Sigma^+$ state.

We report on the experimental setup for observation of hyperfine structure of the $X^1\Sigma^+$ - ($c^3\Sigma^+$, $B^1\Pi$) transition. Single laser saturation and polarization spectroscopy and also optical-optical double resonance saturation spectroscopy in V configuration is used. The obtained experimental results will be presented at the conference.

References

1. A. Pashov et. al Phys. Rev. A 76, 022511 (2007)
2. Ni et al., Science 322, 231 (2008)

S05-HEP
High Energy Physics
(Particles and Fields)

S05-HEP-001 / **Invited talk**

Flavour anomalies and status of indirect probes of the Standard Model

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Presenter: V. Gligorov (vgligoro@lpnhe.in2p3.fr)

The Standard Model of particle physics is a remarkably successful and self-consistent theory of the microscopic universe. Nevertheless, profound contradictions between this microscopic world of the Standard Model and astrophysical and cosmological theories describing the macroscopic universe point to a need for a more complete theory. While we have so far failed to directly observe any particles beyond the Standard Model directly in the lab, such particles can be searched for indirectly by precisely measuring Standard Model processes and looking for tell-tale deviations from theoretical predictions induced by new particles and processes. In this talk I will summarise the motivation for, and status of, such indirect tests in quark mixing. As well as a general overview I will describe in detail the so-called "flavour anomalies", a series of measurements in beauty hadron decays which appear to coherently deviate from Standard Model predictions, and discuss prospects for further indirect probes of the Standard Model in the coming decades.

S05-HEP-100 / **Oral presentation**

Inclusive vector bosons results in CMS

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Presenter: I. Bubanja (itana.bubanja@cern.ch)

Recent results on inclusive W and Z boson productions obtained with CMS proton collision data at 13 TeV are presented. Results include total cross sections and decay properties of W and Z bosons. Recent differential results on Drell-Yan dilepton productions in a wide range of invariant masses are also included.

S05-HEP-101 / **Oral presentation**

First Prototype of a Machine Learning Trigger Algorithm on FPGA for Micromegas detectors

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Presenter: A. Chirosca (alecsandru.chirosca@unibuc.ro)

High Energy Particle Physics is constantly evolving towards increasing the complexity of the detectors and the amount of experimental data. Micromegas-type detectors offer great resolution and are able to operate reliably at high data-taking rates. We trained a convolutional neural network using simulated muons to identify their tracks and determine if they originate from the supposed interaction point. The main goal of this study is to investigate the feasibility of using machine learning models on FPGA for online trigger algorithm implementations.

This approach provides an automated, high speed trigger processor that shows increased adaptability by being more resilient to electronic noises and background radiation, thus providing an error tolerant solution. Our results show this method to be suitable for an assembly of Micromegas detectors both in terms of trigger efficiency and the very good precision offered.

S05-HEP-102 / **Oral presentation**

K_S^0 production in *p+p* interactions measured by NA61/SHINE

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Presenter: M. Cirkovic (marjan.cirkovic@cern.ch)

NA61/SHINE (SPS Heavy Ion and Neutrino Experiment) is a fixed-target experiment at the CERN Super Proton Synchrotron. One of its research projects is the systematic measurement of hadron production in proton+proton, proton+nucleus and nucleus+nucleus interactions. These studies are performed in particular to study the predicted signals of the onset of deconfinement and search for the critical point of strongly interacting matter. For this investigation, a two-dimensional scan in beam momentum (13 A -150 A GeV/ c) and nuclear mass number of colliding nuclei was performed.

K_S^0 are detected and measured by NA61/SHINE by means of their weak decays into $\pi^+ + \pi^-$ with a branching ratio of 69.2\%. This contribution reviews recent results on the production of K_S^0 in *p+p* interactions measured by NA61/SHINE. The rapidity and transverse momentum distributions of K_S^0 will be presented and compared to transport model predictions. The mean multiplicity of studied K_S^0 mesons will be compared with the available data in the range $\sqrt{s_{NN}} = 3 - 32$ GeV.

S05-HEP-103 / **Oral presentation (virtual)**

Analysis of the Radiation Monitoring System's Initial Data from the GEM Detectors at the CMS Experiment

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Presenter: M. Hristova Misheva (milena.hristova.misheva@cern.ch)

Compact Muon Solenoid (CMS) is one of the two general purpose detectors at the Large Hadron Collider (LHC). It underwent several upgrades in preparation for LHC RUN-3. Among them is the installation of 144 new muon detectors based on Gas Electron Multiplier (GEM) technology at Station 1 in the endcap region. In each endcap, there are integrated RadMon (active radiation sensor) units that are integrated on six GEM detectors to measure the total dose and particle flux. Every RadMon contains Radiation-sensitive Field Effect Transistors (RadFETs) and p-i-n diodes for estimation of the absorbed dose and 1MeV neutron equivalent (neq) fluence respectively. This paper describes the radiation readout system structure and the analysis and visualization of the data collected before the start of LHC RUN-3.

S05-HEP-104 / **Oral presentation**

The PADME experiment at LNF-INFN

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Presenter: V. Kozhuharov (venelin@phys.uni-sofia.bg)

Despite the impressive success of the Standard model (SM) in describing nature it still fails in finding the answers for a few astrophysics phenomena, including the lack of antimatter in the Universe and what Dark Matter is made of. Recently, models proposing the existence of a whole new world of particles, the so-called Dark sector (DS), regained interest. The PADME experiment at LNF-INFN aims to search for new light states, which may act as a portal between the SM and the DS, employing positron-on-target annihilation technique. Operating since autumn 2018, PADME accomplished successfully its first two periods of data taking at the DAΦNE Linac, corresponding to O(10^{13}) positrons on target. The sensitivity to new light states depends on the reliable reconstruction of the events in a high instantaneous rate environment, precise knowledge of the background processes, and detailed Monte Carlo simulation of the experimental setup. The design and the construction of the PADME experiment will be described and the first physics results using part of the collected data will be presented.

S05-HEP-105 / **Oral presentation**

Absolute Luminosity calibration in pp collisions at $\sqrt{s} = 900$ GeV in the ATLAS experiment

Author: Veljko Maksimovic[1]

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Presenter: V. Maksimovic (veljko.maksimovic@cern.ch)

At the LHC, the absolute accuracy of the luminosity scale and its precision can be a limiting factor in terms of systematic uncertainty for some measurements such as that of the total proton-proton scattering cross-section. This report presents the calibration of the ATLAS luminometers by the van der Meer method in pp collisions at $\sqrt{s} = 900$ GeV, during dedicated data-taking periods in late 2018 devoted to elastic and total cross-section measurements at that center-of-mass energy. After outlining the overall luminosity-calibration methodology and detailing the fitting procedure of the luminosity-scan curves, the presentation focuses on the characterization and the mitigation of the potential systematic biases that may affect this calibration. The resulting preliminary uncertainty on the absolute luminosity scale during these running periods lies in the 1-2 % range.

S05-HEP-106 / **Oral presentation**

Vector boson associated with jets in CMS

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Presenter: J. Mijuskovic (jelena.mijuskovic@cern.ch)

The study of the associated production of vector bosons and jets constitutes an excellent environment to check numerous QCD predictions. Total and differential cross sections of vector bosons produced in association with jets have been studied in pp collisions using CMS data. Differential distributions as a function of a broad range of kinematical observables are measured and compared with theoretical predictions.

S05-HEP-107 / **Oral presentation**

Higgs to invisible searches

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Although the observed 125 GeV boson is so far compatible with the SM Higgs boson, non-SM properties cannot be ruled out. Assuming particle DM, invisible Higgs decays can be realized in models having interactions between the Higgs boson and dark matter, as for example, "Higgs-portal" models. This talk summarizes recent results from the CMS collaboration on invisible Higgs decays and outlines future prospects.

S05-HEP-108 / **Oral presentation**

Probing hydrodynamics in PbPb collisions at $\sqrt{s_{\mathrm{NN}}} =$ 5.02 TeV using higher-order cumulants, $v_2\{2k\}$ ($k = 1, ..., 5$)

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Presenter: J. Milosevic (jovan.milosevic@cern.ch)

The elliptic flow harmonic $v_2\{2k\}$ is determined using Q-cumulants of different orders, with $k = 1, ..., 5$, for 5.02 TeV PbPb collisions. The results were obtained using data from the CMS experiment at the LHC. The $v_2\{2k\}$ values show an ordering, with $v_2\{2\} > v_2\{4\} >\approx v_2\{6\} >\approx v_2\{8\} >\approx v_2\{10\}$. The hydrodynamics behavior of the medium can be probed with high precision using the higher order moments of the cumulant expansion. It is found that both hydrodynamics probes $\frac{v_2\{6\}-v_2\{8\}}{v_2\{4\}-v_2\{6\}}$ and $\frac{v_2\{8\}-v_2\{10\}}{v_2\{6\}-v_2\{8\}}$ are centrality dependent. This dependence is explained by introducing previously ignored higher order moments in the Taylor expansion of the corresponding generating function of the cumulants. The higher order moments, skewness, kurtosis and the new 5^{th} moment are expressed through the $v_2\{2k\}$ ($k = 1, ..., 5$) harmonics and measured as a function of centrality. The results bring new precision to probes sensitive to initial-state fluctuations.

S05-HEP-109 / **Oral presentation**

Tensor interactions of dark bosons with Standard model leptons

Authors: Momchil Naydenov[1]; Venelin Kozhuharov[1]

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Presenter: M. Naydenov (mnaydenov@phys.uni-sofia.bg)

A phenomenological lagrangian is proposed to include dark sector mesons interacting through tensor currents with Standard Model leptons. For certain values of the interaction constant, the model has the potential of providing an explanation for the discrepancy between theory and experiment, regarding the anomalous magnetic moment of the muon, the Be-8 anomaly, and others, manifesting lepton universality violation. In addition, the new terms lead to a contribution to the total decay width of $\pi^0 \to \gamma e^+ e^-$, where the electron-positron pair is produced through a decay of a dark meson. The implication of the presented model on the present and future searches for new dark particles is also discussed.

S05-HEP-110 / **Oral presentation**

Physicochemical study of electrode aging in CSC longevity tests using eco-friendly gas mixture Ar/CO2/HFO1234ze

Authors: Aleksandra Radulovic[1]; Andrey Korytov; Armando Lanaro; Boris Rajcic; Dubravka Milovanovic[1]; Gennady Gavrilov; Guenakh Mitselmakher; Katerina Kuznetsova; Nebojsa Begovic[1]; Petar Adzic[2]; Predrag Milenovic[2]

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Presenter: A. Radulovic (aleksandra.radulovic@cern.ch)

Finding eco-friendly replacement for CF4 while preserving performance and long-term operation of gas discharge detectors is of the high environmental and economic importance. Tetrafluoropropene (C3H2F4) with the trade name HFO1234ze appeared as promising candidate with low GWP. Using gas mixture of 40% Ar, 58% CO2 and 2% HFO1234ze, longevity tests were performed with β-source 90Sr and accumulated charge 1.2 C cm−1. Deterioration of the electrode surfaces was studied using scanning electron and atomic force microscopy techniques. Structural and elemental chemical analysis of deposit formed on the electrodes was analyzed using X-ray diffraction, vibrational and energy dispersive spectroscopy.

S05-HEP-111 / **Oral presentation**

Shaping the quark-gluon plasma using measurements of anisotropic flow in Pb–Pb and Xe–Xe collisions with ALICE

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Presenter: C. Ristea (catalin.ristea@cern.ch)

Measurements of azimuthal anisotropic flow provide valuable information on the properties of the quark-gluon plasma created in relativistic collisions of heavy ions. In addition, strong fluctuations of the anisotropic flow allow for an efficient selection of the events corresponding to a specific initial geometry. This selection technique, Event Shape Engineering, has been used to measure the elliptic and triangular flow of inclusive and identified particles (π, K, p, $\mathrm{K^0_S}$, Λ, Ξ) in Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV recorded by the ALICE detector. The measurements are reported for a wide range of particle transverse momenta, $p_{\rm T}$, within the pseudorapidity region $|\eta| < 0.8$. The effect of the event-shape selection is within uncertainties independent of particle species up to $p_{\rm T} \sim 8$ GeV/ c, and the origin of this observation is discussed. Strong constraints on the initial conditions of a collision and hydrodynamic medium response are placed comparing these results to those from Xe–Xe collisions at $\sqrt{s_{\rm NN}} = 5.44$ TeV.

S05-HEP-112 / **Oral presentation**

Systematic uncertainties in integrated luminosity measurement at CEPC

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Presenter: I. Smiljanić (i.smiljanic@vin.bg.ac.rs)

The very forward region is one of the most challenging regions to instrument at a future e+e- collider. Machine-detector interface at CEPC will include a calorimeter dedicated for precision measurement of the integrated luminosity at a permill level or better. We discuss a feasibility of such precision from the point of view of systematic effects arising from luminometer mechanical precision and positioning, beam-related requirements and physics background. Additionally, a method of the beam energy spread determination, initially proposed for FCC, is discussed for the CEPC beams, as well as the impact of beam energy spread on integrated luminosity

determination and the precision of electroweak observables measurement at the Z0 pole.

S05-HEP-113 / **Oral presentation**

Value of event-by-event fluctuations and v4 puzzle for QGP tomography

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Co-authors: Jussi Auvinen [1]; Igor Salom [1]; Magdalena Djordjevic [1]; Pasi Huovinen [2]

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Presenter: D. Zigic (`zigic@ipb.ac.rs`)

We present a novel framework ebe-DREENA, based on a state-of-the-art dynamical energy loss model, which can include any temperature profile from bulk medium simulations. The framework is fully optimized to exploit different state-of-the-art medium evolutions - both event-by-event hydrodynamics and kinetic transport theory. It does not use fitting parameters within the energy loss model, allowing it to fully exploit differences in temperature profiles, as the only input in the framework. The framework applies to both light and heavy flavor observables, and both large (A+A) and small (e.g. p+A) systems. We calculate high-pt harmonics up to 6th order and exploit how the differences in the temperature profiles affect them, which will be especially useful with the upcoming high-luminosity measurements at RHIC and LHC. These comparisons of predictions and data are done within the same formalism and parameter set. We, therefore, propose ebe-DREENA as a unique tomography tool, which allows systematic and comprehensive mapping of QGP properties.

S05-HEP-200 / **Poster presentation**

Upgrade and extensive hardware and software tests of the CMS ECAL detector for the upcoming LS3

Author: Lazar Cokic[1]

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Presenters: L. Cokic (`lazar.cokic@cern.ch`), P. Milenovic (`predrag.milenovic@cern.ch`)

As part of the Compact Muon Solenoid (CMS) experiment, the Electromagnetic CALorimeter (ECAL) detector control system (DCS) is preparing for major tests and upgrades of both software and hardware for the next long shutdown 3 (LS3). Interlocks of Cooling system, High Voltage (HV) and Low Voltage (LV) by the PLC system will be tested, as well as lowering the temperature at which the detector is currently operating (from 18 ℃ to 9 ℃), as well as the impact of changing the temperature sensor type (our goal is to move from the NTC type to the PT1000 type which is much easier to read and integrate into the Siemens PLC system, and on the other hand has the necessary accuracy and reliability). The existence of a real test system (identical system is currently in operation inside the detector at P5) in one of our laboratories provides a unique opportunity to perform all these tests and many others, in order to improve safety and robustness during the operation and achieve new control features. All these tests and results will help us choose the best hardware and we should be able to understand the limits of the control system and how to overcome them until the next LS3 (foreseen in 2025).

`S05-HEP-201` / **Poster presentation (virtual)**

Robust and Non-destructive Readout Card Installation Algorithm for MicroMegas Modules Cosmic Ray Tests

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Presenter: M. Demichev (`mdemichev@jinr.ru`)

The ATLAS Muon Spectrometer upgrade [1] is designed to cope with expected increase of LHC luminosity and to include the advanced particle detector technologies. The MicroMesh Gaseous Structure detectors - the MicroMegas are used now as a large area tracking detector in the endcap parts of ATLAS Muon Spectrometer. The whole construction is built from sectors subdivided into detector modules. MicroMegas modules of type LM2 were assembled and tested in Dubna, JINR [2]. The tests included geometry verification, high voltage and gas leakage tests and physical test at the cosmic stand. The final test included installation of multichannel readout cards with 8xVMM3 ASICs [3]. The goals of cosmic test were to fix the problems with electronics installation, to observe a longterm high-voltage stability of the module and to measure the module's efficiency map.

The voltage operation point of gaseous particle detector is close to the discharge region so that occasional discharges are possible. Discharge duration is limited inside the detector by integrated resistive strip coating but even with that the ROC channel

will eventually stop working if its individual discharge protection circuits are mechanically damaged. The most damaged part of the ROC used to be the signal edge with contact density ~0.4 strip/mm and densely populated with SMD components of 0.5x1.0mm size.

At each installation a good electric contact between ROC and detector readout strips must be established. The contact is provided by so called Zebra-connectors: the soft rubber bands with aligned conductive microwires inside. The ROC with Zebra-connector is pressed against detector strips with a compression bar fixed on detector frame. The compression bar (CB) has 6 eccentric cams with a stepped helical surface so that pressure is transfered to the ROC by applying a certain torque to the cams.

It was found out that ROC damage was the result of not only having insufficient clearance between CBs and ROCs but also of repetitive trials and errors during connection tests, including ROC PCB deformation due to cams overpressure and PCB edge fixation with a plastic clip. A 3D mechanical engineering model was studied for better understanding of ROC and Zebra deformation. An algorithm was developed to clearly distinguish between different installation problems with solutions to fix each of them. This allowed us to switch from personal experience to a regular procedure so that other people can be trained thus reducing installation time. The number of available ROCs was limited not allowing to test the whole module in a single step. As a consequence in the end of production each of the ROCs was installed and removed >100 times. It was essential to keep electronics from electrostatic and mechanical damage.

The examples of module cosmic test results will be presented.

References
1. The ATLAS Collaboration, ATLAS NSW TDR: CERN-LHCC-2013-006, ATLAS-TDR-20-2013 (2013)
2. Developing Production Technology and Control Methods for Micromegas Detectors, Balykina et.al, PEPAN Letters, Vol. 18, No. 3, pp. 323–337 (2021)
3. VMM3, an ASIC for Micropattern Detectors, George Iakovidis for ATLAS Muon Collaboration, PoS MPGD2017 (2019)

`S05-HEP-202` / **Poster presentation**

Hardware and Physics Studies at KAHVELab

Authors: Aytül Adıgüzel[1]; Berare Göktürk[2]; Erkcan Özcan[2]; Gökhan Ünel[3]

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Presenter: B. Göktürk (`berare.gokturk@cern.ch`)

The emphasis of the talk will be related to the physics studies at the KAHVELab, and on top of that I will be mentioning current status of hardware development at our laboratory.

The analysis focuses on FCNC decay channel $pp \to DD \to XjZj \to 4j2\updownarrow$ where X represents a boson that decays hadronically and Z boson which decays leptonically. The D quarks are predicted by universal gauge theory based on $E6$ Model that suggests unification of strong, electromagnetic and weak forces where more detail can be found at https://inspirehep.net/literature/100124 . The analysis is currently conducted with data gathered by ATLAS detector between 2015 and 2018, but preliminary version will be presented with our signal studies via Delphes.

Furthermore, we have been developing proton and electron beam machines at MeV energies with the aim of using the p-machine for PIXE spectroscopy and e-machine for industrial applications. Both machines are designed and produced with local resources. The proton machine will be part of RFQ linac that operates at 800 MHz which aims to be smallest and most energetic one of its kind. These machines will also be used to develop particle detectors and educate next generation of accelerator physicists.

S05-HEP-203 / **Poster presentation**

Study of mass hierarchy in heavy flavor suppression

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Presenter: B. Ilic (Blagojevic) (bojanab@ipb.ac.rs)

The forthcoming measurements at RHIC and LHC will generate heavy flavor data with unprecedented precision, providing an opportunity to utilize high- p_T heavy flavor data to analyze the interaction mechanisms in the quark-gluon plasma. Experimentally observed suppression mass hierarchy, and investigation of the dead-cone effect in radiative energy loss, inspired us to study the mass hierarchy in heavy flavor suppression more thoroughly.

To this end, we employ the recently developed DREENA framework, which is based on our dynamical energy loss formalism. Thus [1] we present 1) How to distinguish between different interaction mechanisms (i.e., radiative and collisional energy losses) at the same dataset. 2) A novel observable, which is sensitive only to the collisional energy loss, that is robust to collision energy, system (size), and centrality. 3) Analytical derivation of a direct relation between collisional suppression/energy loss and heavy quark mass; 3) Analytical and numerical extraction of the mass ordering in collisional energy loss through this observable.

References
1. Bojana Ilic and Magdalena Djordjevic, arXiv:2203.06646 [hep-ph] (under review in Phys. Rev. C).

S05-HEP-204 / **Poster presentation**

Measurements of rare B meson decays properties with CMS Run2 data

Author: CMS Collaboration

Presenter: T. Ivanov (todor.trendafilov.ivanov@cern.ch)

Rare B meson decays provide important input for studies of anomalies in $b \to sl^+l^-$ transitions. The $B_s^0 \to \mu^+\mu^-$ is an example of a process with theoretically clean predictions and a clear experimental signature making it a perfect match for BSM physics searches. Here we present a measurement of $B_s^0 \to \mu^+\mu^-$ branching fraction and effective lifetime in proton-proton collisions at $\sqrt{s} = 13TeV$ using data collected with the CMS detector through years 2016-2018, corresponding to an integrated luminosity of $140fb^{-1}$. The measurement results are found to be consistent with the SM predictions.

S05-HEP-205 / **Poster presentation**

Measurement of the Higgs to γγ branching fraction at 3 TeV CLIC

Author: Goran Kacarevic[1]

Co-authors: Ivanka Bozovic-Jelisavcic [1]; Natasa Vukasinovic [1]

[1] *Vinca Institute of Nuclear Sciences, University of Belgrade*

Presenter: G. Kacarevic (kacarevicgoran@vinca.rs)

In this talk we address a full simulation of experimental measurement of the Standard Model Higgs boson decaying to two photons at 3 TeV center-of-mass energy at Compact Linear Collider (CLIC). Since photons are massless, they are not coupled to Higgs boson at the tree level, but rather are created in a loop exchange of heavy particles either from the Standard Model or beyond. Any deviation of the Higgs to γγ branching fraction and consequently of the Higgs to photon coupling may indicate a New Physics. It is shown that the product of the Higgs production cross section in W+W− fusion and BR (H ⟶ γγ) as the observable for determination of the Higgs to photon coupling, can be measured with a relative statistical precision of 5.5%, assuming the integrated luminosity of 5 ab^{-1} and unpolarized beams.

S05-HEP-206 / **Poster presentation**

Collective modes of gluon in an anisotropic thermomagnetic medium

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Presenter: B. Karmakar (karmakarbithika.93@gmail.com)

It is found from viscous hydrodynamics that the QGP created in ultra relativistic heavy-ion collisions has different longitudinal and transverse pressures at early times. This occurs due to the large momentum space anisotropy in the p_T-p_L plane. This momentum space anisotropy can cause plasma instabilities that are largely responsible for the thermalization and isotropization of the system. Additionally, the production of a very strong magnetic field created in the non-central heavy-ion collisions naturally motivates one to ask if the dynamics of the anisotropic QGP gets affected by the magnetic field. We systematically study the collective modes of gluon using the generalized 'Romatschke-Strickland' form of the distribution functions in the presence of a magnetic field. Studying the behavior of the unstable modes, We may conclude that the magnetic field and the anisotropy behave in an opposite manner which is contrary to one's intuition.

S05-HEP-207 / **Poster presentation**

The way we succeed in our research within LGAD R&D enabling real time and 4D tracking for LHC-HL, by designing the scientific tools and performing the experiments at the European Research Infrastructures: The case of Montenegro RD50 group

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Presenter: G. Lastovicka-Medin (gordana.medin@gmail.com)

In this paper we present our three different research activities set at the different EU labs. Due to lack of scientific tools at the premises of the University of Montenegro this was the way that allows us to be successful in taking role and responsibility towards addressing the questions of high priority within LGAD Research and Design activities as a member of RD50 CERN Collaboration.
Firstly, we will overview our research at the EU laser facility ELI Beamlines in Prague, where we built an unique femtosecond laser based experimental station and state-of-the-art scientific tool, based on technique of transient currents with

two modalities: Single Photon and Two Photon Absorption (TCT-SPA/TPA), for characterization of the state-of-the-art timing detector LGAD that is needed for ATLAS and CMS upgrade (LHC-HL). Single Event Burnout was systematically studied during a few comprehensive campaigns (LGAD's fatalities has been firstly observed in Fermilab's beam tests with protons). A new research target, utilization of TPA for the interpad distance study in TI-LGAD (more advanced version of segmented LGAD) will be briefly overviewed as well.

The second case we will be overviewing in this article is our ion microbeam studies of charge transport in semiconductor radiation detectors with three-dimensional structures. In this study a few LGADs have been tested using the Tandem accelerator and low-energy ions (carbons and H+) at the Rudjer Boskovic Institute in Zagreb. The method of Ion Beam Induced Charge (IBIC) and ions with different energies (and thus with the different position of Brag peaks) were used to probe the different detector depths in order to study LGAD's response. The gain suppression has been observed and systematically studied.

The third case we will be discussing is devoted to our future goal that is now in the preparation phase. Our aim is to utilize 30 MeV proton from Cyclotron in Prague in order to study the LGAD's response; the 30 MeV protons are not minimum ionizing particles (MIP) and extended knowledge on effects of charge screening (covering large energy region for non-MIP particles) in LGADs is of significant importance From the application point such studies are needed as the energy of 30 MeV are close to protons energies encountered in proton-CT therapy.

`S05-HEP-208` / **Poster presentation**

Progress on characterizatin of LGAD sensors for the ETL

Authors: Lazar Markovic[1]; Nicolo Cartiglia; Predrag Milenovic; Roberta Arcidiacono; Roberto Covarelli

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Presenter: L. Markovic (`lazar.markovic@cern.ch`)

Installation of a MIP Timing Detector (MTD) to the CMS detector will introduce new capabilities and will allow precise timestamp assignemnt to traversing charged particle up to pseudorapitidy of |eta|=3. Targeted timing resolution is 40 ps per track, which will help reduce the pile-up conditions expected at the High-Luminosity LHC. The endcap region of the MTD, Endcap Timing Layer (ETL), will be instrumented with silicon Low Gain Avalanche Diods (LGADs), covering the pseudorapidity range 1.6<|eta|<3.0. Progress on characterisation of LGAD sensors for the ETL will be presented.

S05-HEP-209 / **Poster presentation**

Analysis of deposit accumulated on electrode samples in the course of CSC longevity tests using 40% Ar, 50% CO2 and 10%CF4 gas mixture

Authors: Aleksandra Radulovic [1]; Dubravka Milovanovic[1]; Andrey Korytov; Armando Lanaro; Boris Rajcic[1]; Gennady Gavrilov; Guenakh Mitselmakher; Janez Kovac[2]; Katerina Kuznetsova; Nebojsa Begovic[1]; Petar Adzic[3]; Predrag Milenovic[3]

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Presenter: D. Milovanovic (dmilovanovic@iofh.bg.ac.rs)

Chemical reactions in the avalanche plasma lead to formation of deposit on the electrode surfaces thus causing degradation of operating characteristics of gaseous detectors and limiting their long-term use in particle physics experiments. Various surface non-destructive complementary techniques were employed for detailed characterization of deposit accumulated on the surface of electrodes subjected to a long-term exposure of β-source 90Sr in the gas mixture of 40% Ar, 50% CO2 and 10%CF4, in the course of CSC longevity tests. Chemical composition, morphology, crystal and amorphous structure of phases constituting deposit were studied.

S05-HEP-210 / **Poster presentation**

Measurement of the σ x BR(H→ZZ*) at 350 GeV and 3 TeV center-of-mass energies CLIC

Author: Gordana Milutinovic Dumbelovic[1]

Co-authors: Ivanka Bozovic-Jelisavcic [1]; Natasa Vukasinovic [1]; Goran Kacarevic [1]; Mirko Radulovic [2]; Jasna Stevanovic [2]

[1] *Vinca Institute of Nuclear Sciences, University of Belgrade, Serbia*

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Presenter: G. Milutinovic Dumbelovic (gordanamd@vinca.rs)

CLIC is a mature option for a staged linear electron-positron collider that could run from 350 GeV up to 3 TeV center-of-mass energy. Measurements of the product of a Higgs production cross-section and branching ratio of the Higgs boson, serve as input to a global fit of Higgs properties (couplings and width) in a model-independent or model-dependent way. In this talk we present the full simulation of σ x BR(H→ZZ*→qq¯l+ l-,l= e±,μ±) measurement, at 350 GeV and 3 TeV center-of-mass energies.

S05-HEP-212 / **Poster presentation (virtual)**

Lattice QCD simulations using Borici - Creutz fermions

Authors: Rudina Osmanaj (Zeqirllari)[1]; Dafina Xhako[2]; Enkelejd Caca[2]

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Presenter: R. Osmanaj (Zeqirllari) (rudina.zeqirllari@fshn.edu.al)

Minimally doubled fermions are a class of lattice fermions, which preserve exact chiral symmetry and are strictly local, details that make them very suitable for lattice simulations. Borici - Creutz fermions are one kind of minimally doubled fermions that have certain properties adaptable for lattice studies and simulations. In this work we present some of the lattice simulations made by using this kind of fermions, in light hadrons spectrum and spontaneous chiral symmetry breaking. We study and analyze the properties which make them desirable and the problems they show in lattice simulations.

S05-HEP-213 / **Poster presentation**

The ATLAS New Small Wheels for LHC Run3

Author: Maria Perganti

Presenter: M. Perganti (maria.perganti@cern.ch)

ATLAS, the largest particle detector at the Large Hadron Collider (LHC), had undergone a massive upgrade during the Long Shutdown 2, for proper operation under the high rates expected from High-Luminosity LHC (HL-LHC) era. Two New Small Wheels (NSW) have been constructed and installed, replacing the old SWs, at the most forward region of the ATLAS muon spectrometer and they are the first new detectors in the experiment specifically designed to handle High Luminosity. The NSW detectors are at the forefront of detector design, using two innovative gaseous detector technologies: Micromegas (MM) and small-strip thin-gap chambers (sTGC), and they provide both fast and precise muon-tracking capabilities.

This presentation will summarize the motivation of the NSW upgrade and the steps from the validation of the electronics for a system with more than 2.1 M electronic channels to the preliminary results for early detector operation and data-taking in 2022 for Run3 with the new Muons System.

S05-HEP-214 / **Poster presentation**

Analysis of the strange particle transverse flow in relativistic heavy-ion collisions

Authors: Catalin Ristea[1]; Oana Ristea[2]; Alexandru Jipa[2]; Marius Calin[2]; Tiberiu Esanu[3]

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Presenter: O. Ristea (oana.ristea@unibuc.ro)

Heavy-ion collisions at relativistic energies offer an unique opportunity to investigate the properties of highly excited dense nuclear matter in the laboratory. Strange hadron production in nucleus-nucleus collisions is believed to be an important tool to study the dynamics of the produced QCD matter. Transverse momentum spectra of strange particles (K^0_S, Λ, $\overline{\Lambda}$, Ξ^-, $\overline{\Xi}^+$, ϕ, Ω^-, and $\overline{\Omega}^+$) produced in relativistic nuclear collisions at various collision energies are studied using different parametrizations. The centrality, energy and hadron mass dependence of the average transverse momentum and the effective temperature of strange particles will be presented. These results will be compared with previous results from AGS, SPS and RHIC experiments.

S05-HEP-215 / **Poster presentation**

On the quarks transverse momenta in SIDIS experiments

Author: Michail Stoilov[1]

[1] *INRNE - BAS*

Presenter: M. Stoilov (mstoilov@inrne.bas.bg)

In a series of recent papers we have suggested to use the information on the so-called difference asymmetries (i.e. the difference between the asymmetries in the production of particles and their anti-particles) in Semi-inclusive deep inelastic scattering (SIDIS) in order to determine the Boer-Mulders functions. Here we comment on how our analysis can be used to find the mean value of the quark and hadron transverse momenta.

S05-HEP-216 / **Poster presentation**

Neural network distributed training and optimization library (NNLO)

Author: Irena Veljanovic[1]

Co-authors: Maurizio Pierini [1]; Vladimir Loncar ; Jean-Roch Vlimant

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Presenter: I. Veljanovic (irena.veljanovic@cern.ch)

With deep learning becoming very popular among LHC experiments, it is expected that speeding up the network training and optimization will soon be an issue. To this purpose, we are developing a dedicated tool at CMS, Neural Network Learning and Optimization library (NNLO). NNLO aims to support both widely known deep learning libraries Tensorflow and PyTorch. It should help engineers and scientists to easier scale neural network learning and hyperparameter optimization. Supported training configurations are a single GPU, a single node with multiple GPUs and multiple nodes with multiple GPUs. One of the advantages of the NNLO library is the seamless transition between resources, enabling researchers to quickly scale up from workstations to HPC and cloud resources. Compared to manual distributed training, NNLO facilitates the transition from a single to multiple GPUs without losing performance.

S05-HEP-217 / **Poster presentation**

Application of Multivariate Analysis in Separation of Higgs Boson Signal at future e+e- colliders

Author: Ivana Vidakovic[1]

Co-author: Goran Kacarevic [1]

[1] *Vinca Institute of Nuclear Sciences*

Presenter: M. Radulovic (mirko.radulovic@pmf.kg.ac.rs)

Even the environment at future e+e- colliders is practically QCD background free, there is a large number of processes with high cross-sections and/or similar topology as the Higgs signal. Minimization of the statistical uncertainty calls for optimized event selection w.r.t. the statistical significance. This is where the Multivariate Analysis (MVA) is employed, separating the signal from multiple backgrounds on the basis of their kinematical and event shape properties. In this poster we discuss the concept of MVA, its application and evaluation of the performance, on example of a Higgs two-photon decay at CLIC.

S05-HEP-218 / **Poster presentation**

Determination of CPV Higgs mixing angle in ZZ-fusion at 1.4 TeV CLIC

Author: Natasa Vukasinovic[1]

Co-authors: Ivanka Bozovic-Jelisavcic [1]; Goran Kacarevic [1]; Tatjana Agatonovic-Jovin [1]; Mirko Radulovic [2]; Jasna Stevanovic [2]

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Presenter: N. Vukasinovic (nvukasinovic@vin.bg.ac.rs)

In this talk we discuss the CP violation in the Higgs sector under assumption that Higgs is a mixture of CP even and odd states. Study is done in ZZ-fusion, at the intermediate energy stage of CLIC, in full simulation of a detector for CLIC and machine and physics related backgrounds. By measuring the properties of electron and positron in the final state, selecting the Higgs dominant decay to b $\bar{b}$ to reduce backgrounds, we discuss the statistical precision of CP-violating mixing angle measurement with 2.5 ab $^{-1}$ of data.

S06-CMPSP
Condensed Matter Physics and Statistical Physics

`S06-CMPSP-001` / **Invited talk**

Metal-coated microsphere arrays: versatile nanofabrication platforms for plasmon-enhanced optical spectroscopy

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Presenter: C. Farcău (`cfarcau@itim-cj.ro`)

Metal-coated microsphere arrays (MCMA), consisting of metal films deposited over dielectric (polymer, SiO_2) colloidal microspheres, represent a class of plasmonic crystals with proven capabilities as substrates for surface enhanced optical spectroscopy (Surface Enhanced Raman Scattering - SERS, Surface/Metal-Enhanced Fluorescence - SEF/MEF) or sensing based on Localized Surface Plasmon Resonance (LSPR) [1,2]. Their ability to amplify the intensity of Raman scattering or fluorescence emission of molecules relies on excitation of both localized and propagative surface plasmons. By physical/chemical processing of the underlying polymer microsphere arrays various variations of the nano/microstructured metal films can be achieved, which in turn allow to modulate the plasmonic response [3]. Due to their relatively easy fabrication and tunable optical response [4], MCMA are versatile candidates for many practical applications as optical molecular sensors.

Here, some of our recent results concerning fabrication of nanostructured plasmonic surfaces, based on colloidal microsphere arrays are presented: metal-coated microspheres, metal-coated plasma-etched microspheres, linear metal-coated microsphere arrays, patterned polymer films obtained by etching through the colloidal microsphere mask. Optical reflectance/transmittance measurements, together with Finite-Difference Time-Domain (FDTD) simulations are employed for understanding the optical behaviour of these structures, and its dependence on structural parameters. Specifically, we evidence the impact of sphere size, metal films thickness and fine morphology on the transmittance, reflectance and absorbance of MCMA, or polarization-sensitive behaviour of linear MCMA. Then, the SERS efficiency of these MCMA is analyzed and correlated to the optical response, highlighting the routes towards optimizing SERS. Moreover, we use MCMA to develop plasmonic electrodes, for use in Electrochemical SERS (EC-SERS) applications, or integrate them in microfluidic devices for in-flow SERS detection. The use of MCMA as substrates for more specialized spectroscopic techniques such as Surface-Enhanced Coherent Anti-Stokes Raman Scattering (SECARS) is also explored. These results demonstrate the utility of MCMA as platforms for fundamental plasmonics studies, but also for developing practical applications in optical molecular sensing.

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References

1. C. Farcau, Sci. Rep. 9(1), 3683 (2019).
2. C. Farcau, A.-M. Craciun, R. A. L. Vallée, J. Chem. Phys. 153(16), 164701 (2020).

3. C. A. Tira, I. Ly, R. A. L. Vallee, S. Astilean, C. Farcau, Opt. Mater. Express 7(8), 2847–2859 (2017).
4. N. Nechita, C. Farcău, Opt. Express 29(25), 42238–42250 (2021).

S06-CMPSP-002 / **Invited talk**

Domains of scaling in the three-dimensional random field Ising model

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Presenter: D. Spasojevic (`djordjes@ff.bg.ac.rs`)

Random field Ising model, in particular its nonequilibrium version, has been extensively used for modeling the behavior of disordered ferromagnetic materials driven by external magnetic field. To this point, for systems of finite size, two domains of disorder were identified based on the occurrence of spanning avalanches in the system.

Here we present new results clearly demonstrating the existence of the third domain of disorder, the transitional one. Applying scrutinized analyses we found that the first domain, comprising the range of disorders that are below the critical, is characterized by the onset of only the avalanches spanning all three spatial dimensions. In the second one, in which the disorders are above the effective, size-dependent, critical value, the behavior of the system is not affected by its size and all avalanches are finite and nonspanning. The third, transitional domain, spreading in between these two, is encompassing the range of disorders within which all kinds of spanning avalanches are generated in the system.

We found that each of the domains has different scaling behavior and, provided that the system parameters are tuned so that the finite-size scaling conditions are met, the data collapsing is achievable, characterized by universal scaling functions different for each domain. Our results, obtained in extensive numerical simulations of finite systems covering the wide range of sizes, could be of relevance for studies on other types of finite systems and also for experimental studies conducted on mesoscopic scale.

References

1. S. Janićević, D. Knežević, S. Mijatović and D. Spasojević, J. Stat. Mech. 2021, 013202 (2021).

S06-CMPSP-003 / **Invited talk**

Transport in Strongly Correlated Systems: the Hubbard Model Perspective

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Understanding the behavior of strongly correlated electronic systems is one of the central challenges in condensed matter theory. In the focus of these efforts are the cuprate superconductors: They exhibit a highly universal strange metallic behavior, from the superconducting critical temperature, up to the highest accessible temperature. The nature of the strange metallic state, its universality and its apparent connection with superconductivity are not well understood. In this talk we will review some of the recent theoretical results, based on numerical simulations of the Hubbard model, that shed light on these matters. There are several universal behaviors that arise at high temperatures, and that seem to connect large classes of systems. In particular, a quantum critical scaling law of resistivity puts kappa-organics and the cuprates on the same phase diagram [1,2]. Also, doping-independent Brown-Zak magnetic quantum oscillations observed in moire lattices are now understood as a universal feature of incoherent regimes [3]. At the longest wavelengths and lowest frequencies, one finds that an emergent hydrodynamics underlies transport: the temperature dependence of dc resistivity is ruled by the effective diffusion constant; this is now supported by both the optical-lattice and numerical simulations of the Hubbard model [4]. In the end we will discuss recent developments [5] in quantum many-body methodology that are expected to allow further insights in the correlated-electron dynamics at low temperature.

References:

1. H. Terletska, J. Vučičević, D. Tanasković, and V. Dobrosavljević, Phys. Rev. Lett 107, 026401 (2011)
2. J. Vučičević, D. Tanasković, M. Rozenberg, and V. Dobrosavljević, Phys. Rev. Lett 114, 246402 (2015)
3. J. Vučičević and R. Žitko, Phys. Rev. Lett. 127, 196601 (2021)
4. J. Vučičević, J. Kokalj, R. Žitko, N. Wentzell, D. Tanasković, and J. Mravlje, Phys. Rev. Lett 123, 036601 (2019); J. Vučičević and M. Ferrero, soon to be published
5. J. Vučičević, P. Stipsić, and M. Ferrero, Phys. Rev. Research 3, 023082 (2021)

S06-CMPSP-100 / **Oral presentation**

Synthesis and characterization of some C-Ti based multilayer and composite nanostructures

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Using TVA technology, multilayer and composite C-Ti layers were deposited on silicon substrates. The C-Ti multilayers were constructed from the silicon substrate as follows: 100nm of carbon, followed by alternant 17nm Ti and 40 nm C three times, covered by one last 17 nm Ti layer, resulting a seven multilayer structure. For the composite layer, after the pre 100nm carbon one, we varied quasi continuously the Ti:C atomic ratio, from 1:9 and reaching 9:1 at the top of the 119 nm. For both composite and multilayer structures, several batches were obtained for comparison. We varied the substrate temperatures during the deposition (R. T.,100, 200, 300 and 400oC) and one deposition batch was obtained at 300oC with a -700V polarisation voltage on the substrates, in order to increase the ions energy reaching the layer, during the coating process.

Characterization of structural properties of films was achieved by Electron Microscopy technique (TEM) and GIXRD techniques. The measurements show that increase of the substrate temperature reveal changes in TixCy lattice parameters. Thus, according to GIXRD analysis it was found out that the Ti:C atomic ratio changes with increase of synthesis temperature. Also, in the case of composite films an increase of amount and sizes of TiC nanocrystals with the increase of energy of Ti ions determined by increase of polarisation voltage was observed. The tribological measurements were performed using a ball-on-disk system with normal forces of 0.5, 1, 2, 3N respectively. Was found that the coefficient of friction depends on the synthesis temperature and on the polarisation voltage. It is also noted that the friction coefficient depends on the pure C content, Ti content and amount of TiC nanocrystallites. These results are due to atomic diffusion at Ti/C interfaces and also are associated with amount of TiC nanocrystallites. Using Bruker Hysitron TI980 Triboindenter System, global hardness of the coating, in depth hardness and SPM imaging analysis were performed. By Nanoscratch Analysis, global and depth Young modulus was measured. To characterize the electrical conductive properties, the electrical surface resistance versus temperature have been measured, and then the electrical conductivity is calculated. Using the Wiedemann-Frantz law was obtained the thermal conductivity.

S06-CMPSP-101 / **Oral presentation**

Linear dispersions in two-dimensional materials: a crystal with symmetry pbma1' as an example

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Symmetry determines forms of band structures in the vicinity of special points in the reciprocal space of one-, two- and three-dimensional materials. After short introduction to the complete classification of linear dispersions in 2D materials, [1] we will focus on a particular example. A tight binding model on a crystal with four sites per primitive cell that belongs to grey layer single group $pbma$ (45.2.315 or $pbma1$' in the magnetic layer groups notation of Ref. [2]) is calculated. Fortune teller states are obtained in the Brillouin zone corners, as predicted [3,1] by group theory for non-magnetic materials with negligible spin-orbit coupling. We will discuss possible realizations of this model in realistic and hypothetical materials.

References

1. N. Lazić, V. Damljanović and M. Damnjanović, *arXiv*: 2108.11733 (2021).
2. D. B. Litvin, Acta Cryst. A **61**, 382 (2005).
3. V. Damljanović, I. Popov and R. Gajić, Nanoscale **9**, 19337 (2017).

`S06-CMPSP-102` / **Oral presentation**

Influence of the Size of Cation on the Structure and Tribological Properties of Ionic Liquids Studied with Molecular Dynamics

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Ionic liquids (ILs) are two-component systems composed of large asymmetric and irregularly shaped organic cations and anions. Physical properties of ILs like negligible vapour pressure, high-temperature stability, high ionic conductivity and also a great variety of ILs and their mixtures highlight them as potentially relevant to lubrication [1, 2]. A large number of variations in IL composition is possible, estimated at the order of magnitude of 10^{18} different ILs. From their variety stems the possibility of tuning their physicochemical properties which can affect lubrication, such as viscosity, polarity, surface reactivity. Hence, it would be advantageous to figure out general relations between the molecular structure and tribological properties of ILs.

In this study, we investigate a generic tailed-model (TM) of ILs which includes: an asymmetric cation consisting of a positively charged head ($\sigma_C = 5$Å) and a neutral tail of variable size ($\sigma_T = 3, 5, 9$Å) and a large spherical negatively charged anion ($\sigma_A = 10$Å). It represents a more realistic model compared to the simplest one, the so called Salt Model (SM) [3, 4]. We figured that, although simple, TM model results in striking differences in equilibrium bulk structure of IL governed by the tail size relative to cationic head: (i) simple cubic lattice for the small tail, (ii) liquid-like state for symmetric cation-tail dimer, and (iii) molecular layer structure for the large tail. A mutual feature of all investigated model ILs is a formation of the fixed (stable) layer of cations along solid plates.

We have investigated the influence of the size of the cationic tail on the response of three ILs to confinement and mechanical strain, using molecular dynamics simulations in the *LAMMPS* code [5]. Tribological properties of three IL models are compared in and out of equilibrium. We have related the evolution of normal force with inter-plate distance to the changes in the number and structure of confined IL layers. A mutual feature of all investigated model ILs is a formation of the fixed (stable) layer of cations along the solid plates. The fixed layer formation is a result of strong Lennard-Jones interaction between the plates and ions. A consequence of the fixed layer stability is a steep rise of the normal force at small interplate gaps. The steep rise of the normal force is an effect useful for preventing solid-solid contact and accompanying wear.

Understanding the interplay between different processes in thin lubricant films is important due to the conflicting demands imposed on how IL lubricant should behave in dynamic confinement: high load-carrying capability requires strong adsorption to the surface, while low friction requires low viscosity.

References
1. F. Zhou, Y. Liang and W. Liu, Chem. Soc. Rev. **38**, 2590 (2009)
2. R. Hayes, G. G. Warr and R. Atkin, Phys. Chem. Chem. Phys. **12**, 1709 (2010)
3. R. Capozza, A. Vanossi, A. Benassi and E. Tosatti, J. Chem. Phys. **142**, 064707 (2015)
4. M. Dašić, I. Stanković and K. Gkagkas, EPJ E **41** (11), 130 (2018)
5. S. Plimpton, J. Comput. Phys. **117**, 1 (1995)

`S06-CMPSP-103` / **Oral presentation**

Anomalous Josephson effect in $d_{x^2-y^2}/F/I/F/d_{xy}$ junctions

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Presenter: S. Djurdjević (`stevandj@ucg.ac.me`)

We study a quasi two-dimensional Josephson junction of d-wave superconductors through two ferromagnetic layers in between. Ferromagnets are separated by isolator barrier. In the frame of Bogoliubov – de Gennes formalism we solve scattering problem to find current-phase relations in the case of $d_{x^2-y^2}$/ferromagnetic barrier/ d_{xy}-wave superconductor junctions. We find that current-phase relation is anomalous, $I(\varphi = 0)$ 0, with $I(\varphi) = -I(-\varphi + \pi)$, and has 2π periodicity. Also the net Josephson current can be separated in two series which are proportional to $\sin\ (2n\varphi)$, and $\cos\ ((2n-1)\varphi)$, for n 1. These two components of Josephson current exhibit phase transition from coegsistence of 0 and π states to $\pi/2$ state of junction and vice versa with increasing of ferromagnetic layer thickness but for different values of thicknesses. We observed nonmonotonous temperature dependence of critical current through this junction with finite interface transparency between ferromagnets. This result gave a possibility of junction phase transition with changing a temperature. Influence of $\cos$ part of Josephson current is significant on higher temperatures.

References:
1. Stevan Djurdjević and Zorica Popović, Prog. Theor. Exp. Phys. **2021**, 083I02 (2021).
2. B. Lu, K. Yada, A. A. Golubov, and Y. Tanaka, Phys. Rev. B **92**, 100503(R) (2015).

`S06-CMPSP-104` / **Oral presentation**

Raman Spectroscopy Study of magnetic Quasi-two-dimensional materials

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Presenter: S. Djurdjić Mijin (`sanja.djurdjic.mijin@ipb.ac.rs`)

Quasi-two-dimensional materials, known for their easy exfoliation to a monolayer and unique optical and transport properties are promising candidates for nanospinctronics and nanoelectronics. Experimental confirmation of magnetic ordering persisting to a monolayer in these complex systems in 2017 did not only widen up the area of their potential application, but also opened up a completely new experimental field in condensed matter physics. Considering that previously widely accepted theories forbid magnetic ordering in 2D systems, it is no surprise that magnetic quasi-2D materials have only recently become an area of extensive study. Aiming to provide much needed insight into these systems, we have performed Raman spectroscopy studies of CrI3 and VI3 single crystals. Polarization dependent Raman spectra of CrI3 single crystals were analyzed in accordance with suggested low-temperature and high-temperature structures, confirming the existence of phase transition between the low-temperature rhombohedral and the high-temperature monoclinic structure [1]. In the temperature dependence of phonon energies and line widths a clear splitting of the Eg rhombohedral modes into the Ag and Bg monoclinic modes can be observed at 180 K, contrary to the previously reported 220 K. No phase co-existence can be tracked within our spectra. Polarization dependent Raman spectra, together with DFT calculations and PDF analysis of synchrotron XRD patterns, provided an answer to the on-going debate regarding the crystal structure of VI3 [2]. Our results point to two possible scenarios: the coexistence of two phases, short range ordered $P\bar{3}1c$ and long range ordered $R\bar{3}$ as two segregated phases and/or randomly distributed short range ordered $P\bar{3}1c$ domains in the long-range ordered $R\bar{3}$ lattice. Observed phonon line asymmetry of the most pronounced peak indicates strong spin-phonon coupling in this quasi-two-dimensional material.

References
1. S. Djurdjić Mijin, A. Šolajić, J. Pešić, M. Šćepanović, Y. Liu, A. Baum, C. Petrovic, N. Lazarević, and Z. V. Popović, Lattice dynamics and phase transition in CrI3 single crystals, Phys. Rev. B 98, 104307 (2018)
2. S. Djurdjić Mijin, A.M. Milinda Abeykoon, A. Šolajić, A. Milosavljević, J. Pešić, Yu Liu, C. Petrovic, Z. V. Popović, N. Lazarević, Short-range order in VI3, Inorg Chem. 59 (22):16265-16271 (2020)

`S06-CMPSP-105` / **Oral presentation**

Quantum Transport Through a magnetic molecule in constant and time-varying magnetic fields

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We study charge and spin transport through a molecular level connected to two Fermi leads and coupled to a magnetic molecule via exchange interaction, in a time-dependent magnetic field. In a constant external magnetic field the molecular spin is considered as a classical variable and is assumed to precess around the field axis with Larmor frequency. The expressions for charge and spin currents [1] are derived by means of the Keldysh nonequilibrium Green's functions technique [2]. The coupling between the electronic spins and the magnetization dynamics of the molecule leads to inelastic tunnel processes which contribute to the spin currents. The inelastic spin currents as a back action exert a spin transfer torque [3,4] acting on the molecular spin, including a contribution to the Gilbert damping [5], which can be controlled by changing the bias and gate voltages, and a change of the precession frequency. We derive and analyse the properties of the charge and spin-dependent tunneling currents in the presence of time-varying magnetic fields, with the magnetization dynamics of the molecular spin depending on these fields.

References
1. M. Filipović, C. Holmqvist, F. Haupt and W. Belzig, Phys. Rev. B 87, 045426 (2013); 88, 119901(E) (2013).
2. A. P. Jauho, N. S. Wingreen and Y. Meir, Phys. Rev. B 50, 5228 (1994).
3. J. C. Slonczewski, Phys. Rev. B 71, 024411 (2005).
4. Y. Tserkovnyak, A. Brataas, G. E. W. Bauer and B. I. Halperin, Rev. Mod. Phys. 77, 1375 (2005).
5. T. Gilbert, IEEE Trans. Magn. 40, 3443 (2004).

S06-CMPSP-106 / **Oral presentation**

Synthesis and characterization of nanosized ZnFe2O4 powders obtained by sonochemistry

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Zink ferrite powders are widely studied due to their application in many fields, such as anode materials for lithium-ion batteries, gas sensors, magnetic materials, catalytic materials, and antibacterial materials in water treatment. We present the structural and magnetic properties of nanosized $ZnFe_2$O $_4$ powders synthesized by sonochemistry and discuss their dependence on the synthesis conditions. The XRD spectra of the as-prepared samples reveal the presence of both an amorphous and a crystalline $ZnFe_2$O $_4$ phase. In the spectrum of the sample annealed at 500 ^oC, the peaks are considerably narrower and of higher intensity, proving the sample's higher degree of crystallinity. The room temperature Mössbauer spectra of the as-prepared and annealed $ZnFe_2$O $_4$ samples showed a superparamagnetic doublet spectrum. Both kinds of samples exhibited paramagnetic behavior at room temperature, which is typical of the normal spinel structure. A very narrow hysteresis curve at 4.2 K was recorded, which could be expected for superparamagnetic particles in the ferrimagnetic state at low temperatures.

Acknowledgments: The work was supported by the Bulgarian National Science Fund under contract KP-06-N48/5 "Multifunctional composite structures based on ferrites (including magneto electrics) and carbon materials" and by the Bulgarian National Science Fund under contract KP-06-India-2 "Usage of thin $ZnFe_2O_4$ films for various spintronic devices". This work was also supported by a joint research project between the Bulgarian Academy of Sciences and WBI, Belgium, and by a joint research project between the Bulgarian Academy of Sciences and the Institute of Low Temperature and Structure Research, Polish Academy of Sciences.

S06-CMPSP-107 / **Oral presentation**

Finite-Temperature Dynamical Properties of the Holstein Model: Hierarchical Equations of Motion Approach

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While ground-state properties of the Holstein model are well understood by now, the evaluation of its finite-temperature spectral properties has received more attention only recently [1, 2]. Here, we develop a hierarchical equations of motion (HEOM) approach to compute real-time single-particle correlation functions and thermodynamic quantities of the Holstein model at finite temperature [3]. We exploit the conservation of the total momentum of the system to formulate the momentum-space HEOM whose dynamical variables explicitly keep track of momentum and energy exchanges between the electron and phonons. Our symmetry-adapted HEOM enable us to overcome the numerical instabilities inherent to the commonly used real-space HEOM. The HEOM results for the electronic spectral function, obtained on chains containing up to ten sites, compare favorably to existing literature. To provide an independent assessment of the HEOM approach and to gain insight into the importance of finite-size effects, we devise a quantum Monte Carlo (QMC) procedure to evaluate finite-temperature single-particle correlation functions in imaginary time and apply it to chains containing up to twenty sites. QMC results reveal that finite-size effects are quite weak, so that the results on 5 to 10 site chains, depending on the parameter regime, are representative of larger systems.

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References

1. J. Bonča, S. A. Trugman, and M. Berciu, Phys. Rev. B **100**, 094307 (2019).
2. D. Jansen, J. Bonča, and F. Heidrich-Meisner, Phys. Rev. B **102**, 165155 (2020).
3. V. Janković and N. Vukmirović, Phys. Rev. B **105**, 054311 (2022).

S06-CMPSP-108 / **Oral presentation**

Ab-initio calculations of the temperature-dependent band gap of inorganic halide perovskites

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Inorganic metal-halide perovskites have drawn much attention as candidates for producing low cost high-performance solar cells having efficiency reported as high as 20% in single-junction architecture. Their electronic and structural properties have been the case of intense study in both experimental setups and computational simulations. Since solar cells are expected to perform outside of such laboratory conditions, it is important to have an understanding of how their performance will be affected by their surroundings. Temperature is the main parameter which governs both the crystal and the electronic structure of inorganic metal-halide perovskites. Theoretical approaches that rely on either Monte-Carlo sampling of vibrational states [1] or classical molecular dynamics [2] have been successful to some extent. However, quantum mechanical ab-initio studies that yield accurate temperature dependence of band gaps of inorganic halide perovskites are still lacking.

In this work, we perform such studies for $CsPbC_3$, $CsPbBr_3$ and $CsPbI_3$. First, we use the density functional theory (DFT) with PBEsol exchange-correlation functional to obtain a decent starting estimate at zero temperature. Such an approach has a well-known error of underestimating the band gap. To overcome this, we employ the PBE0 hybrid functional whose parameters are chosen to enforce Koopman's condition for localized defect states [3]. Second, we include the effects of electron-phonon interaction that depend on the temperature of the material using the Allen-Heine-Cardona (AHC) theory [4]. Phonon modes are obtained from density functional perturbation theory, that in the present case produces unphysical imaginary frequencies in the phonon spectrum due to the harmonic approximation. We overcome this issue by calculating the phonon spectrum using the self-consistent phonon method that accounts for the effects of anharmonicity [5]. We obtain the electronic band gaps for the cubic phase of $CsPbCl_3$, $CsPbBr_3$, and $CsPbI_3$, at temperatures of 320, 403, and 300 K, respectively, of 3.07, 2.30, and 1.70 eV. These results differ by no more than 0.25 eV from the experimental ones found in the literature.

References

1. W. A. Saidi et al, J. Phys. Chem. Lett. 2016, 7, 5247-5252
2. J. Wiktor et al, J. Phys. Chem. Lett. 2017, 8, 5507-5512
3. T. Bischoff et al, Phys. Rev. Mater. 2019, 3, 123802
4. S. Ponce et al, J. Chem. Phys. 2015, 143, 102813
5. Y.N. Wu et al, J. Phys. Chem. Lett. 2020, 11, 2518–2523

S06-CMPSP-109 / **Oral presentation**

The magnetothermopower of organic superconductor $\kappa-(\mathrm{ET})_2\mathrm{Cu}(\mathrm{NCS})_2$: possible charge density wave scenario

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The interlayer magnetothermopower of the organic superconductor $\kappa-(\mathrm{ET})_2\mathrm{Cu}(\mathrm{NCS})_2$ is studied at temperatures down to 0.5 K and fields up to 32 T. Analysis of the background magnetothermopower show that at low temperatures it is negative and exhibits an upturn at higher field, producing a dip at a field close to the upper critical field B_{c2}. There are clear magnetothermopower quantum oscillations visible above 5 T. The obtained oscillation frequencies are in a good agreement with those previously reported on the magnetoresistance and magnetization quantum oscillations. According to our results, the magnetothermopower in $\kappa-(\mathrm{ET})_2\mathrm{Cu}(\mathrm{NCS})_2$ presents features which have already been detected in YBCO and other high- T_c cuprates indicating that some kind of a charge density wave order is also present in the normal state of $\kappa-(\mathrm{ET})_2\mathrm{Cu}(\mathrm{NCS})_2$. Most strikingly, our measurements show that there is another dip, again followed by an upturn, in the magnetothermopower of $\kappa-(\mathrm{ET})_2\mathrm{Cu}(\mathrm{NCS})_2$ occurring at much higher fields than B_{c2}, around the magnetic breakdown field of ~ 21 T that is not present in YBCO. We propose that the two induced successive phase transitions, consisting of two similarly ordered states each restricted to a finite magnetic field window are in fact charge density wave ordered states arising as a result of the layer-stacking mechanism in the interlayer direction. Our results support and advance some of the previous findings that the superconductivity in the organic superconductor $\kappa-(\mathrm{ET})_2\mathrm{Cu}(\mathrm{NCS})_2$ is mediated by a charge density wave order rather than antiferromagnetic fluctuation.

S06-CMPSP-110 / **Oral presentation**

Exciton-phonon effects in the spectra of microcavity polaritons

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The coupling of Frenkel excitons (FEs) and intramolecular vibrations in an organic layer as a part of microcavity has been studied in the paper. Two cases are treated: a) uniaxial layer of point group 4 (optical axis is supposed perpendicular to the layer); b) monoclinic anthracene-like layer with monoclinic axis b perpendicular to the layer. The exciton-phonon coupling produces the vibronic wings with complex spectra which can contain bound exciton-phonon states and many-particle (unbound) bands. Consequently in those regions the absorption lines and the resonance members in dielectric tensor appear. We treat theoretically their effects on the polaritons in the microcavity and illustrate using numerical calculations the peculiarities of the polaritonic spectra in the vibronic wings of Frenkel excitons.

S06-CMPSP-111 / **Oral presentation**

Spectral functions of the Holstein polaron: exact and approximate solutions

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It is generally accepted that the dynamical mean field theory (DMFT) gives a good solution of the Holstein model [1], but only in dimensions greater than two. Here we show that the DMFT, which becomes exact in the weak coupling and in the atomic limit, provides an excellent numerically cheap approximate solution for the spectral function of the Holstein model in the whole range of parameters even in one dimension. To establish this, we made a detailed comparison with the spectral functions that we obtained using newly developed momentum-space numerically exact hierarchical equations of motion method, which yields electronic correlation functions directly in real time [2]. We crosschecked these conclusions with our path integral quantum Monte Carlo and exact diagonalization results, as well as with the available numerically exact results from the literature [3].

References:

1. S. Ciuchi, F. de Pasquale, S. Fratini, and D. Feinberg, Phys. Rev. B **56**, 4494 (1997).
2. V. Janković and N. Vukmirović, Phys. Rev. B **105**, 054311 (2022).
3. D. Jansen, J. Bonča, and F. Heidrich-Meisner, Phys. Rev. B **102**, 165155 (2020).

S06-CMPSP-112 / **Oral presentation**

Effects of structural disorder on phonon spectra of $2H$-TaSe $_{2-x}$S $_{x}$ $(0 \leq x \leq 2)$ single crystals

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Transition metal dichalcogenides, as a well studied family of quasi-2D materials, have attracted considerable attention in recent years due to rich phase diagrams, thickness-dependent transport, unique optical properties and collective electron phenomena which occur at experimentally accessible temperatures. Additionally, it was recently shown that in the metallic single crystal alloys of $2H$-TaSe $_{2-x}$S $_{x}$ the crystalline disorder promotes superconductivity, while suppressing charge density wave (CDW) order. In this work, the lattice dynamics of TaSe $_{2-x}$S $_{x}$ $(0 \leq x \leq 2)$ alloys was probed using Raman spectroscopy and results were compared to density functional theory (DFT) calculations. In order to investigate whether crystallographic disorder affects the phonons, spectra of doped materials were compared to the ones belonging to the end alloys. The Raman spectra of the end compounds ($x = 0$ and $x = 2$) host two out of three symmetry-expected Raman active modes for backscattering configuration. Calculated phonon energies agree well with the experimental ones. In Raman spectra of the doped samples additional peaks, though of low intensity, can be easily identified. These additional peaks most likely arise from the crystalline disorder. Dependence of phonon energies and linewidths on sulfur content x also reveals a clear fingerprint of crystallographic disorder.

S06-CMPSP-113 / **Oral presentation**

DFT study of AlF3 intercalated in HOPG: a rechargeable battery application

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Currently, rechargeable ion batteries are attracting more attention than others due to their advantages as recycling charging devices with high energy capacity, high performance, and easy adaptation to industry [1,2]. Lithium-ion batteries (LIBs) are currently the best performing batteries mainly due to their relatively high energy densities, good stability, and low self-discharge. Their main deficiencies are the limited resources of lithium and the poor distribution of its raw materials throughout the world [3]. This concern has prompted research into alternative systems based on different types of metal-ion batteries, such as aluminum (Al), sodium (Na), magnesium (Mg), and Zinc (Zn), whose applications range from personal electronics to grid storage. Batteries employing metallic Al as the anode material show considerable promise due to their low cost, ease of handling under ambient conditions, and high theoretical capacities (with energy densities of 30-70 Wh kg-1). On the other hand, graphite is the material mostly used as a cathode in ion batteries, mainly due to its ability to capture ions, atoms, or molecules inside [4]. Several theoretical and experimental studies have focused on the appropriate combination of host species and graphite cathodes to improve the recharging performance of aluminum batteries. In this talk, a theoretical study in the density functional theory (DFT) formalism is reported to explain surface intercalation experiments of neutral AlF3 on highly oriented pyrolytic graphite (HOPG) [5,6].

References

1. X. Gu, T. Tang, X. Liu, Y. Hou "Rechargeable metal batteries based on selenium cathode: progress, challenges and perspectives", J. Mater. Chem. A, vol. 7, p. 11566-11583, 2019.
2. Z. Yang, J. Zhang, M. Kintner, X. Lu, D. Choi, J. Lemmon, J. Liu "Electrochemical energy storage for green grid", Chem. Rev., vol. 5, p. 3577-3613, 2011.
3. S. Wang, S. Jiao, D. Tian, H. Chen, H. Jiao, J. Tu, Y. Liu, D. Fang "A novel ultrafast rechargeable multi-ions battery" Adv. Mater., vol. 29, p. 1606349, 2017.
4. M.-C. Lin, M. Gong, B. Lu, Y. Wu, D. Wang, M. Guan, M. Angell, C. Chen, J. Yang, B. Hwang, H. Dai "An ultrafast rechargeable aluminium-ion battery", Nature, vol. 520, p. 325-32, 2015.
5. S.J. Rodríguez, A. Candia, M. Passeggi Jr., E. Albanesi, G. Ruano, "A theoretical study on the intercalation and diffusion of AlF3 in graphite: its application in rechargeable batteries", Phys. Chem. Chem. Phys., vol. 23, p. 19579-19589, 2021.
6. A.E. Candia, S.J. Rodríguez, E.A. Albanesi, G. Bernardi, D. Fregenal, G.E. Zampieri, M.C.G. Passeggi, G. Ruano, "Aluminum fluoride intercalation in graphite for rechargeable batteries design", Carbon, vol 186, p. 724-736, 2022.

S06-CMPSP-114 / **Oral presentation**

Indium Antimonide Nanostrucutres: Synthesis and Properties

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Presenter: I. Stanescu (iuliana.stanescu@365.univ-ovidius.ro)

This article summarizes some of the features of pure indium antimonide nanostructures growth through TVA method and their potential applications in the industry. To obtain the expression of geometric magnetoresistance at low magnetic fields and the expression for resistance in intermediate magnetic fields, the current density equation was examined. For the particular case of the sandwich structure approximation of spherical constant energy surfaces was used.

S06-CMPSP-115 / **Oral presentation**

Graphene's striped moire acting as a switchman for metal adatoms

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Presenter: S. Stavrić (srdjan.stavric@spin.cnr.it)

Graphene (G) grown on Ni(100) forms the stripped moiré pattern that can be described as an alternate arrangement of valleys, where G is close to the nickel substrate and interacts with it rather strongly, and ridges, where G is far away from the substrate and is almost free-standing [1]. When metal adatoms are deposited on G/Ni(100), the structural differences between the valleys and the ridges reflect in the adsorbate's behavior as well. The scanning-tunneling microscopy (STM) measurements of cobalt (Co) deposited on G/Ni(100) revealed an abundance of Co on ridges and almost no Co on valleys. With the additional manipulation by the STM tip, Co clusters on ridges were able to move but only in a direction parallel to the stripes. Puzzled by this strong preference for ridges, we employed density functional theory (DFT) to model the different Co structures on G/Ni(100) [2]. From the

DFT charge analysis we found that Co upon adsorption donates electrons to G and becomes positively charged both on valleys and ridges. Given that nickel substrate donates electrons to G as well, the charge redistribution in the system results in the Co-Ni repulsion modulated by G's corrugation - the farther is the Co adatom from Ni the weaker is the repulsion and thus the higher is the binding energy of Co on G. Moreover, the same repulsion increases the Co mobility, as the calculated barrier for the Co diffusion along the ridge is the lowest of all possible directions on the G's surface. This explains why the Co adatoms and small clusters remain on the ridge even after being kicked by STM tip. On the other hand, gold (Au) adatoms display the opposite behavior as they adsorb on G's valleys. Again here, the adsorbate-substrate electrostatic interaction explains the preference for valleys: unlike Co, Au adatoms take the electrons from G, resulting in the Au-Ni attraction that drives Au adatoms to the valleys as regions that are closest to the substrate. This leads us to the simple law: metal adatoms that donate electrons to G will adsorb on ridges whereas those that take electrons from G will adsorb on valleys, revealing the switchman's role of G's striped moiré for the positively/negatively charged adsorbates. This law is quite general as our DFT calculations show that it holds for many different elements from the periodic table. Our findings expand the possibilities in efforts for creating the self-assembled and well-ordered superlattices of metallic nanostructures using moiré graphene as template [3,4], as they reveal the preferred clusterisation sites and directions of diffusion for different types of atoms on stripe moiré graphene.

References

1. Z. Zou et al., Carbon **130**, 441-447 (2018)
2. S. Stavrić et al, in preparation.
3. A. T. N'Diaye et al, Phys. Rev. Lett. **97**, 215501 (2006).
4. M. Pivetta et al, Phys. Rev. B **98**, 115417 (2018).

S06-CMPSP-116 / **Oral presentation**

Exact solutions for Ising models with triplet interactions and external field

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Presenter: V. Urumov (v.urumov@gmail.com)

Ising model on honeycomb, decorated honeycomb and diced lattices, and other planar lattices with single decoration on each bond, is solved exactly in the presence of pair and triplet interactions with additional external magnetic field acting on specific sites. Field induced transition is observed when triplet interactions are present. Reentrance phenomenon is found in the decorated triangular lattice. With particular value of the magnetic field, exact critical temperature is obtained also when the field acts on all lattice sites.

S06-CMPSP-200 / **Poster presentation**

The dwell time of electron tunneling through a multi-barrier quantum structure based on graphene

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Presenter: D. Bălțățeanu (doru.baltateanu@e-uvt.ro)

Here we consider a model in which the dwell time of the tunneling on a multi-barrier quantum structure based on monolayer graphene is computed. This quantum system is composed by N barriers and $N-1$ wells, at zero temperature, in which the spin-orbit effects and the carrier-phonon interactions are absent. In addition, one assumes that the dimensions of the system in the $x-y$ plane are large enough to neglect the edge effects. The transmission coefficient is calculated and the connection between it and dwell time is established, for different values of the parameters associated with the quantum structure. The results show that the dwell time is sensitive to the variation of some parameters such as the angle of incidence or the system geometry and could be used in the field of optoelectronic devices based on graphene.

References

1. M.I. Katsnelson et al, Nat. Phys. 2, 620 (2006)
2. C. Bai et al, App. Phys. Lett., 96 (2010)
3. Y. Gong and Y. Guo, J. Appl. Phys. 106, 064317 (2009)
4. Z Wu et al., J. Appl. Phys. 105, 043702 (2009)
5. F. Sattari and E. Faizabadi, AIP Advances 2, 012123 (2012)

S06-CMPSP-201 / **Poster presentation (virtual)**

On the Potential of Electric Impedance Spectroscopy and Refractive Index Dispersion Measurements to Monitor the Sunflower Seed Oil Oxidation

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Presenters: G. Exner (ginka.exner@gmail.com), I. Bodurov (bodurov@uni-plovdiv.bg)

Refined sunflower seed oil, prepared according to a national standard [1] is the most commonly employed vegetable oil in Bulgaria. In our traditional cuisine it is

applied either fresh - for salads, as an ingredient of doughs for cookies and bread, or in the process of backing and frying. Its wide everyday use demands some reliable and fast methods for quality control. At present, the chemical methods are preferred but even being reliable they require long processing times and often include volatile solvents. On the contrary, many physical methods are fast and the samples do not require any pre-treatment.

In the present study, four different trademarks of refined sunflower oils were purchased from local stores. The initial oil properties were systematically modified by thermal treatment, so that as a result of thermal reactions of oxidation, from unsaturated fatty acids, such as linoleic acid, dimers, trimers, and polymers are formed [2].

For the experiments, 700 ml oil was heated to 160oC and portions of 50 g of red potatoes were consecutively fried for 6 minutes each. After every two portions, 50 ml oil was removed. After cooling to room temperature, the samples were paper filtered and stored at room temperature. The total treatment time was 2 hours.

Electric impedance spectroscopy, EIS, (1910 Inductance Analyser, Quad Tech, USA, 100 Hz – 1 MHz frequency range used) and refractive index measurements (dispersion curves), RId, by the method of the disappearing diffraction pattern [3] for three laser wavelengths – 405, 532, and 635 nm were employed in the present study. The RId curves were calibrated by means of the standard method (Abbe refractometer measurement at a fixed wavelength, according to ASTM D1218; distilled water and iso-octane as standards). The dispersion curves were approximated using one-term Sellmeier model with total uncertainty of ± 0.00015.

The results of both methods were compared with those from standard UV spectroscopy [4], performed on a Metertech UV/VIS Spectrophotometer SP-8001 (absorption at 232 and 268 nm, due to conjugated diene and triene formation, respectively, 1 % (m/V) of iso-octan (2,2,4 trimethylpentane) solution, quartz cuvette with an optical path-length 10 mm).

A linear dependence between the extinction coefficients, at 268 nm, and the real part of the dielectric constant (capacity measurements) was established. The results show that the RId method is also very sensitive to the thermally introduced changes providing additional information about the quality of the oil not only by the absolute value of the refractive index but also by the slope of the dispersive curve. These findings prove the potential of EIS and RId for quality monitoring (oxidation) of sunflower seed oils.

References

1. https://www.bfsa.bg/bg/Page/sun-oil/index/sun-oil /Браншови%20с
2. A. Gouveia de Souza et al., Braz. J. Chem. Eng. 21(2), 265 (2004)
3. S Sainov, Rev. Sci. Instrum. 62(12), 3106 (1991).
4. International olive council, COI/T.20/Doc. No 19/Rev. 5 2019 www.internationaloliveoil.org/wp-content/uploads/2019/11/Method-COI-T.20-Doc.-No-19-Rev.-5-2019-2.pdf

S06-CMPSP-202 / **Poster presentation (virtual)**

Characterization of advanced technological material using X-ray techniques and SEM

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Presenter: E. Delli (evdelli@physics.auth.gr)

The constantly increasing demand for advanced products with improved performance and minimum thermal/energy/material waste alongside the fast emerging environmental challenges and the limited reliability and narrow life-cycle performance of old material systems greatly effect several areas of everyday life and economy. Thus, developing of advanced technological materials which satisfy the newly established technological standards is of great importance. The experimental procedure of optimizing and tuning the performance of a pre-existing or newly created material requires thorough testing of its properties to certify its usage and large scale production capability. In depth knowledge of the structural and chemical properties is considered the first step towards the understanding of the physical characteristics of a material and its potential usage. X-rays diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS) and Scanning Electron Microscopy (SEM) are among the most used material characterization techniques enabling surface imaging, composition identification, elemental analysis, chemical state characterization, structural quality and homogeneity investigation, failure analysis, etc. In this work we present the XRD, XPS, EDX and SEM results obtained [1] for a wide range of advanced technological materials, such as polymer nanocomposites, thermoelectrics, zeolites, biomaterials, etc. Results analysis indicated the importance of these complementary techniques in the thorough characterization of the material properties and failure points making them a useful tool in the research process and manufacturing.

References

1. http://amdelab.physics.auth.gr/char-structure-en.htm

S06-CMPSP-203 / **Poster presentation**

Slow and fast relaxation times of quantum lattice model with local multi-well potentials: Phenomenological dynamics for $Sn_2P_2S_6$ ferroelectric crystals

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Presenter: R. Erdem (rerdem@akdeniz.edu.tr)

A phenomenological framework for the relaxation dynamics of quantum lattice model with multi-well potentials is given in the case of deformed $Sn_2P_2S_6$ ferroelectric lattice. The framework is based on the combination of statistical equilibrium theory and irreversible thermodynamics. In order to study these dynamics in a connected way we assume that the dipole ordering or polarization (η) and volume deformation (u) can be treated as fluxes and forces in the sense of Onsager theory. From the linear relations between the forces and fluxes the rate equations are derived and characterized by two relaxation times (τ_S, τ_F) which describe the irreversible process near the equilibrium states. The behaviors of τ_S and τ_F in the vicinity of ferroelectric phase transitions are studied.

S06-CMPSP-204 / **Poster presentation (virtual)**

Composite With Improved Dispersion Of Single Walled Carbon Nanotubes In Liquid Crystalline Molecules

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Since their discovery in 1991, carbon nanotubes (CNTs) attract tremendous scientific interest. CNTs are nanodimensional objects, possessing excellent electrical, optical and thermal properties, large area, and a broad temperature range of thermal stability, making them promising for environmental, electrical, optical, biomedical, and etc. applications [1].

The main challenge to realize a successful CNT application is to achieve a homogeneous dispersion, since due to their very strong attraction they tend to re-aggregate and re-bundle [2]. Hence the stability of the CNT suspension is of great concern.

Different approaches have been adopted in resolving this issue. One pathway is to functionalize the CNTs2 improving their solubility in liquid media. Unfortunately, introducing functional groups attached to the CNT surface leads to a change in some of the CNT excellent native properties. Another important issue is to find an appropriate solvent, taking into account the CNT hydrophobicity. Previous results

show that polar organic molecules, such as DMF and NMP [3,4] are the best candidates but it still depends on the synthesis method and type of the CNTs. In addition, homogeneous dispersions are possible only at very low concentrations. Successful dispersing of CNTs has been claimed by polymer assistance.

A new one promising concept is using liquid crystals (LCs). The main advantage of employing LCs is related to their long range orientational order that may help to disperse more effectively and even align the CNTs. Additionally, the properties of LC may enhance or modify those of the CNTs.

In the present study, a composite of single walled carbon nanotubes, SWCNTs (Meijo, Japan) and newly synthesized thermotropic liquid crystalline ((R,E)-4-(4-((3,7-dimethyloctyl) oxy) styryl) phenyl 4-(undecyloxy) benzoate) [5], SB(3R)-11 was prepared from an ultrasonicated solution of NMP. As a result, the composite, after solvent evaporation, contained 1 wt. % SWCNTs. Differential scanning calorimetry, Raman spectroscopy, and Polarised optical microscopy were employed to investigate the composite. The results showed that the composite still exhibit LC states but the thermal stability and number of phase transitions were strongly affected by the SWCNTs presence. The results indicate improved dispersion of the SWCNTs in the composite.

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References

1. N. Jain et al., Smart Sci. 10, 1 (2021)
2. D. Rajendran et al., J. Compos. Sci. 6(1), 26 (2022)
3. T. Premkumar et al., Small 8(9), 1299 (2012)
4. T. Hasan et al., J. Phys. Chem. C 112(51) 20227 (2008)
5. B. N. Veerabhadraswamy et al., New J. Chem. 39(3), 2011 (2015)

S06-CMPSP-205 / **Poster presentation**

Long-ranged Cu-based order at cuprate/manganite interface

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We present a resonant inelastic and elastic X-ray scattering (RIXS/REXS) study of epitaxial YBa2Cu3O7/Nd1-x(Ca1-ySry)xMnO3 heterostructures (NYN). We show that the Copper charge density wave (Cu-CDW) order of the near optimally doped YBa2Cu3O7 layers can be strongly modified via the hole doping and tolerance factor of Nd1-x(Ca1-ySry)xMnO3, i.e. by changing x and y.

At x=0.35 we observe a quasi-2D Cu-CDW order with dx2-y2 orbital character that resembles the one that is commonly found in strongly underdoped bulk YBCO. The strength of the corresponding Bragg peak at Q||=0.3 r.l.u. gets strongly enhanced as the tolerance factor of the manganite layers[1] is decreased and its CE-type antiferromagnetic and charge/orbital ordered (COO) is reinforced[1].

Upon increasing the hole doping of the manganite layers to x=0.5, we observe a new kind of Cu-CDW order which has a much smaller wave vector of Q||=0.1 r.l.u., a larger correlation length of about 40nm, and a different orbital character, i.e. dz2 rather than dx2-y2, than the one commonly found in the bulk cuprates[2].

The origin of this new Cu-dz2 charge order is presently not understood, but seems to be rooted in the particular properties of the cuprate/manganite interface. The RIXS and additional x-ray absorption spectroscopy (XAS) data provide evidence for an important role of the orbital reconstruction of the Cu-ions at the interface with the manganite and a related transfer of electrons from the manganite to the cuprate. In particular, they show that the Cu-dz2 orbital of the interfacial Cu ions is strongly shifted up in energy and lies close to the Fermi-level such that it contains a significant part of the hole carriers, which usually mainly reside in the Cu-dx2-y2 orbital. This orbital reconstruction may well exhibit a lateral modulation along the interface that is linked with the anomalous dz2-type Cu-CDW order.

While further studies are required to fully understand the interfacial coupling mechanism(s), the possibility of tuning the Cu-CDW holds great prospects for studying its relationship with high temperature superconductors and hopefully, for future quantum devices.

References

1. E. Perret et al., Coupled Cu and Mn charge and orbital orders in YBa2Cu3O7/Nd0.65 (Ca1-ySry)0.35MnO3 multilayers, Communications Physics **1**, 45 (2018);
2. R. Gaina et al., Long-ranged Cu-based order with dz2 orbital character at a YBa2Cu3O7/ manganite interface. npj Quantum Materials **6**, 12 (2021);

S06-CMPSP-206 / **Poster presentation**

Superconductor in a weak time-dependent magnetic field

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Presenter: K. Ivanović (krstoivanovic@gmail.com)

Electromagnetic response of a superconductor subject to incident electromagnetic wave is studied phenomenologically and within nonequilibrium equations of superconductivity.

S06-CMPSP-207 / **Poster presentation**

Terahertz Radiation from the BSCCO Single Crystal in resonance region

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Since the intrinsic Josephson effects in high-temperature superconductors were first investigated by R. Kleiner and P. Muller, various kinds of new phenomena related to the ¨effects have been found [1-5]. In this work, the emission of terahertz electromagnetic waves from an intrinsic Josephson junction array (IJJA) embedded in an LCR resonant circuit is studied theoretically. A bias current is applied to the electrodes at the top and bottom of the array. In the voltage state, the ac Josephson current generates a displacement current in the IJJA, and both the currents induce an oscillating current in the electrodes. The whole system, including the array and the environment around it, has been described in terms of an LCR resonant circuit. When the Josephson frequency is in the resonance frequency region of the LCR circuit, the amplitudes of the displacement current in the Josephson junction array and the oscillating current in the electrodes both are strongly enhanced by a feedback process. The emission power and the current-voltage (I-V) characteristic curve for the system has been calculated. Inside the frequency region of the LCR circuit resonance, stable and intense emission occurs in both the increasing and decreasing processes of the high-bias current. In the emission region the I-V characteristic curve has a dip structure. These results are consistent with those of the emission observed in a high-bias current region by using mesa-shaped samples of BSCCO.

References:

1. R. Kleiner et al., ¨ Phys. Rev.Lett. 68, 2394 (1992).
2. K. Lee et al., Phys. Rev. B 61, 3616 (2000).
3. M. Tachiki et al., Phys. Rev. B 71, 134515 (2005).
4. S.Lin, *Annual Report on Numerical Study of Strong and Coherent Radiation of Terahertz Electromagnetic Waves from High-Tc Superconductors*, 2014
5. T.Benseman et al., APS March Meeting Abstracts 2021, S47. 001 (2021).

S06-CMPSP-208 / **Poster presentation**

Effect of Yttrium Substitution on Structural Properties of nanopowder nickel ferrites: X-Ray and Raman studies

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Presenter: S. Jankov (stevan.jankov@df.uns.ac.rs)

Among various ferrites, nanosized nickel ferrite is one of the most frequently employed materials for production of electronic materials due to a set of outstanding physical and chemical properties. Doping with various atoms is a common choice when it comes to the development of new materials with target properties. Rare-earth elements have been frequently used in different research areas in order to improve various physical and chemical properties of materials. Nanocrystalline ferrites with chemical formula NiFe2−xYxO4 (x = 0.20, 0.30) have been synthesized by the co-precipitation method and further annealed at 750 ℃ . The details of the synthesis are given in [1]. X-Ray diffraction analysis (XRD) were carried out using Rigaky MiniFlex 600 diffractometer. Raman spectra were collected using a Thermo Scientific DXR Raman Microscope at room temperature with DPSS (Diode Pumped Solid State) laser using λ = 532.2 nm excitation. CCD camera has been used as detector.

Spinel ferrites crystallize in cubic spinel structure belonging to space group O7h (Fd3m). The recorded XRD patterns have confirmed the formation of spinel ferrite phase in the samples. No peaks corresponding to any precursor/impurity were recorded in the patterns implying that the samples are single phase. With the substitution of Y3+ in NFO, the whole diffraction pattern is shifted towards lower 2θ angle, which is a signature of an increase in lattice parameter of the substituted samples.

Group theory predicts the five Raman active modes, i.e. A1g + Eg + 3T2g. The measured spectra have been fitted and it is deconvoluted into individual Lorentzian component in order to determine the peak position. The spectra consists of band around ~ 450, ~ 560, ~ 640, ~ 680, ~ 695 cm^{-1}. The modes at above 600 cm^{-1} are related to the T-site mode that reflects the local lattice strain effect in the tetrahedral sublattice. The Raman modes below than 600 cm^{-1} corresponds to the O-site mode reflecting the local lattice strain effect in octahedral sublattice.

S06-CMPSP-209 / **Poster presentation**

Alternating-Basis Quantum Monte Carlo Method for Strongly Correlated Electrons

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Ultracold-atom simulators have provided important insights into charge and spin transport in the two-dimensional Hubbard model [1, 2]. However, theoretical tools to compute quantities directly measured in experiments, such as space- and time-resolved charge/spin densities following a quench of an external density-modulating field, are still scarce. Here, we devise the alternating-basis quantum Monte Carlo (ABQMC) method for interacting electrons on a lattice, which is uniquely suited to compute such quantities. Apart from out-of-equilibrium setups, the formalism is equally applicable in thermal equilibrium described by either canonical or grand-canonical ensemble. The method relies on the Suzuki–Trotter decomposition (STD) and owes flexibility to the representation of the kinetic and interaction terms in the many-body bases in which they are diagonal. We formulate a Monte Carlo update scheme that respects both the momentum and particle-number conservation laws, to restrict the configuration space. The sampling efficiency is further enhanced by ensuring that the ABQMC algorithm manifestly respects several symmetries of the Hubbard model [3, 4]. We find that the method's performance is heavily plagued by the fermionic sign problem, whose extent is primarily related to the number of time-slices in the STD. Nevertheless, the ABQMC equation of state (density vs. chemical potential curve) computed on square-lattice clusters containing up to 48 sites agrees remarkably well with reference methods. We also discuss how the (real-time) dynamics of the survival probability of pure density-wave-like states on 4x4 clusters depends on the filling and the initial density pattern.

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References

1. P. T. Brown et al., Science **363**, 379 (2019).
2. M. A. Nichols et al., Science **363**, 383 (2019).
3. J. Yu et al., Phys. Rev. Lett. **119**, 225302 (2017).
4. H. Zhai et al., New J. Phys. **21**, 015003 (2019).

`S06-CMPSP-210` / **Poster presentation**

Magnetic Hyperthermia Potential of Colloidal Zinc-substituted Iron Oxide Nanoparticles and TiO2@Zinc Ferrite Hybrids

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Iron oxide based magnetic nanoparticles (Fe3O4, *gamma*-Fe2O3), are widely investigated in biomedicine, especially as diagnostic and therapeutic agents. They can be used as imaging contrast agent, drug-delivery nanocarriers, intracellular hyperthermia mediators, etc. If their size is in the range of 4-28 nm, they show *superparamagnetic* behavior, with magnetic saturation comparable to that of a ferromagnet but with zero coercivity and remanence.

A suspension of superparamagnetic nanoparticles (SPIONs) has ability to generate heat when they are exposed to an externally applied alternating (AC) magnetic field, what has been explored for *magnetic fluid hyperthermia* treatment of a malignant tissue [1]. Local increase of tissue temperature (previously loaded with SPIONs) can cause irreversible damage of a pathologic object. There are several physical processes which govern the transformation of magnetic to thermal energy. For SPIONs losses are mainly induced by Brownian and Néel processes. The amount of generated heat power, expressed by the *specific absorption rate* (*SAR*) value [1], depends on the chemical composition, size, shape anisotropy in nanoparticles, as well as on aggregation and coating of SPIONs.

In this work we studied magnetic hyperthermia potential of two samples consisting of nanosized, oleic acid (OA)-coated zinc ferrite particles with pronounced shape anisotropy [2]. The samples were synthesized by thermal decomposition method. The heating ability of octahedral 18nm-sized Zn0.13Fe2.87O4 NPs and pebbles-like in shape Zn0.6Fe2.4O4 NPs with size ranging from 7 to 30 nm, were studied in a medium with low viscosity. The *SAR* values were evaluated for frequency, f−range (252-808) kHz and the AC magnetic field amplitude, H0-range (100-300) Oe. Hydrophobic Zn0.6Fe2.4O4 nanoparticles underwent a double-treated procedure with titania dioxide, when hybrid structures composed of magnetic nanoparticles homogeneously dispersed inside photocatalytic TiO2 phase (amorphous or crystalline), were obtained. TEM, XRD, ATR-FTIR and Mössbauer spectroscopy, as well as magnetic measurements by SQUID, were used to characterize samples.

References

1. S. Laurent, S. Dutz, U. O. Häfeli, M. Mahmoudi, Magnetic fluid hyperthermia: Focus on superparamagnetic iron oxide nanoparticles, *Adv. Colloidal Interface Sci.***166** (2011) 8-23.
2. N. Jović Orsini, M. M. Milić and T. E. Torres, Zn- and (Mn, Zn)-substituted versus unsubstituted magnetite nanoparticles: structural, magnetic and hyperthermic properties, *Nanotechnology* **31** (2020) 225707

S06-CMPSP-211 / **Poster presentation (virtual)**

Experimental and computational study of heteroepitaxial thin Fe/Pt spintronic bilayers

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Fe/Pt thin bilayers constitute a spintronic system for the prominence of the next generation of data processing, transfer, and storage devices 1–3. These magnetic heterostructures exhibit the ability to inject spin current through the interfaces via the spin pumping (SP) effect 4. However, only a few efforts investigate the magnetic properties of the systems through the interfacial morphology, purity, and surface symmetry, even if the spin pumping, the spin mixing conductance, and the magnetic proximity effects are pure interfacial mechanisms.

In the specific study, Fe (12 nm)/Pt (6 nm) thin bilayers were epitaxially grown by the electron beam evaporation method in ultra-high vacuum conditions, using different substrate temperatures of 30oC, 150oC, 300oC, and 450oC. The epitaxial model was studied by Molecular Dynamics with Monte Carlo simulations. The simulations were experimentally confirmed by X-ray photoelectron spectroscopy, resolving the interfacial and the chemical state of the interfaces. We confirmed that, during the deposition and because of the kinetics, the atoms of the different layers are diffused through the interface. The Pt heteroepitaxy on Fe, sputters the Fe atoms of the deposited surface, resulting in its local deformation. The diffused Fe atoms inside the Pt lattice, after an annealing process, tend to return to the interface, resulting in increased interfacial roughness. The short-range interdiffusion/interfacial roughness of ≈ 2 nm which was confirmed both from the simulations and the XPS depth profiling, creates free energy stairs at the interface, that affect the magnetization reversal 5. The magnetic anisotropy and static magnetic properties of the different samples were compared by magneto-optical Kerr effect microscopy in the longitudinal alignment (L-MOKE) and magnetic hysteresis loops were recorded in the longitudinal geometry for all the crystallographic in-plane axis of the samples. Combining the overall findings, we reported the Fe/Pt epitaxial model that could serve as a useful “tool” for a deeper comprehension of the origin of the magnetic properties in nanoscale and the potential interfacial induced phenomena in magnetism.

References

1. J.H. Van Vleck, Physica 17, 234 (1951).
2. S. Umesh and S. Mittal, Journal of Systems Architecture 97, 349 (2019).
3. A. Barman and J. Sinha, Spin Dynamics and Damping in Ferromagnetic Thin Films and Nanostructures (Springer International Publishing, Cham, 2018).
4. K. Ando, S. Takahashi, J. Ieda, Y. Kajiwara, H. Nakayama, T. Yoshino, K. Harii, Y. Fujikawa, M. Matsuo, S. Maekawa, and E. Saitoh, Journal of Applied Physics 109, 103913 (2011).
5. D. Karfaridis, L. Mihalceanu, S. Keller, K. Simeonidis, G.P. Dimitrakopulos, T.

Kehagias, E.T. Papaioannou, and G. Vourlias, Thin Solid Films 694, 137716 (2020).

S06-CMPSP-212 / **Poster presentation (virtual)**

Structural and Optical properties of PEO/PVP-I blended polymer electrolyte membranes

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In the process of replacement of solid electrolytes, polymer electrolyte membranes have been gaining substantial attention in view of safety, non-toxic and economically viable. It is well acquaint that, till today lithium ion batteries are exhibiting reliable characteristic output properties. However, the continuous decrease of lithium resources lead to the development of better rechargeable electrochemical energy storage systems complementing Li-ion batteries [1]. Magnesium is one of the lightest multivalent metals identified for battery applications and magnesium is the most abundant element in earth's crust, seawater, and geographically prevalent than lithium. Polyethylene oxide (PEO) is non-toxic in nature, economically viable, and find in various industrial applications. Nevertheless, pure elastomeric PEO polymer-based electrolytes demonstrate lower ionic conductivities at room temperature due to the existence of a dominant semi-crystalline portion in the matrix of PEO [2, 3]. It is worth mentioning that, metal ion conduction is predominant in the amorphous portions. Most of the scientific literature is available on PEO polymer-based blend or composite electrolytes complexed with different lithium salts for lithium-ion battery (LIB) applications only [39, 40]. However, high cost, a decrease of abundance, environmental impact, and safety limitations are impeding the widespread implementation of LIBs in large-scale batteries for future generation technologies. It shows the impetus scope to search for better alternative energy storage systems capable of complementing the LIB technology. Different polymer host materials and fabrications procedures for lithium polymer electrolytes are widely investigated. Few researchers followed similar procedures and reported insignificant results on magnesium - ion-conducting polymer electrolytes [4]. The distinct differences between the magnesium and lithium systems, such as stronger interaction of the magnesium cation (Mg2+) with counter ions or polymer hosts, higher under/overpotentials for Mg electrodeposition/dissolution, and nature of the anode-electrolyte interface, mean that new materials and evaluation techniques are required for impactful advances in magnesium polymer electrolytes. Free-standing

and flexible blended electrolyte membranes of nanocomposite 'Poly (ethylene oxide) (PEO)/Polyvinylpyrrolidone, iodine complex (PVP-I) ' complexed with magneisum sulphate (MgSO4) at various concentrations (10, 20, 25 and 30 wt.%) were prepared using conventional solution casting technique. The microstructural and optical properties of the pure and MgSO4 salt complexed PEO/PVP-I membranes were characterized by means of Fourier transform infrared spectroscopy, Raman spectroscopy, differential scanning calorimetry and optical properties. The significant changes in nature of characteristic vibrational modes of PEO revealed the decrease of crystalline portion in the matrix of PEO/PVP-I blend electrolyte.

References

1. L. Long et al., J. Mater. Chem. A. 4, 10038 (2016).
2. B. Sun et al., Solid State Ionic. 262, 738 (2014).
3. Y – W. Park et al., J. Non Cryst. Solids. 351, 144 (2005).
4. M. Mahalakshmi et al., Ionics. 26, 4553 (2020).

`S06-CMPSP-213` / **Poster presentation**

Generalized Haldane Model and Molecular Excitons' Spectra

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Haldane model is devoted to explore the electron spectra of honeycomb hexagonal 2D lattice. In this paper we treat its connections with the excitonic spectra of two types of molecular excitations, Frenkel excitons (FEs) and Charge Transfer Excitons (CTEs) and study the generalized Haldane model in 2D Lattices of hexagonal symmetry. Excitations with transition dipole moment perpendicular to the lattice or in-line moments are consider in the following cases: a) FEs in honeycomb model with two identical nonequivalently positioned molecules in unit cell; b) FEs and CTEs coupling in Donor-Acceptor (DA) solids with two different molecules in unit cell; c) indirect coupling of FEs in DA solids vice their coupling with CTEs. The equations for the excitonic spectra, especially in case c, could be used in more precious interpretation of spectroscopic data or in other applications of Haldane model.

S06-CMPSP-214 / **Poster presentation (virtual)**

Investigating the degradation effects of a compartment fire protocol on wall-paintings

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Presenter: L. Malletzidou (labrinim@auth.gr)

Wall painting technique identification is an ongoing problem, as identification criteria are still a matter of discussion. The main purpose of this study is to examine the possibility of detecting organic binders as a function of the maximum developed temperature in the case of a fire. This is important in the case of wall paintings, as the presence or absence of organics is one of the criteria for the determination of the applied painting technique. Thus, the study of the characterization of a wall painting that has undergone such an incident may lead to erroneous conclusions about the presence or the absence of organic binders. In general, the effects of fire on artifacts vary and depend on the time of exposure to the event, but also on the temperatures developed during it. In the case of wall paintings, these effects range from the deposition of surface pollutants, to their total destruction due to the collapse of the substrate or masonry.

In the framework of this study, traditional recipes were applied for the preparation of wall painting mock-ups. Thus, using yellow ochre, the painting layer was applied on freshly prepared Ca(OH)2 ground using water (fresco technique), and on dried grounds using egg yolk, linseed oil, gum arabic, and casein as the organic binders (secco technique). After undergoing a fire protocol representative of temperatures/duration for compartment fires, the mock-ups were studied by Fourier transform infrared spectroscopy (FTIR), X-rays diffraction (XRD), thermogravimetry (TGA), UV-Vis spectrophotometry, X-rays photoelectron spectroscopy (XPS) and optical microscopy. The results showed that there are strong indications that a wall painting which has survived after a fire incident can carry information regarding the applied binder.

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S06-CMPSP-215 / **Poster presentation**

Semi-flexible interacting self-avoiding polygons on 3-simplex lattice

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Self-avoiding polygons with bending stiffness and attractive nearest-neighbor interactions, are studied on three simplex fractal lattice. Via an exact set of restricted generating functions, the number of contacts as a function of the Boltzmann weights associated with stiffness and interaction energies, is calculated numerically. Calculation reveals that the number of contacts is a non-monotonic function of stiffness, for each considered value of the interaction weight. Possible causes and implications of such a peculiar behavior are discussed.

S06-CMPSP-216 / **Poster presentation (virtual)**

Effect of polymer-coated gold nanoparticles on the flexoelectricity in planar thin films of pentylcyanobiphenyl (5CB) nematic liquid crystals

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The flexoelectricity1 providing linear coupling is a phenomenon that takes place in liquid crystal systems. If the nematic liquid crystals (NLCs) molecules are slightly pear shaped and exhibit a longitudinal permanent dipole, like the cyanobiphenyls, an applied field not only orients the nematic director along the field direction but also causes a slight splay distortion of the director field. The most important aspect of this effect is that positive and negative voltages cause opposite splays, creating a first harmonic electro-optic response2,3. The flexoelectric effects in NLCs-based composites have not been investigated systematically.

In this work, the flexoelectricity in planar thin films of NLCs pentylcyanobiphenyl (5CB) nanostructured by inclusion of gold nanoparticles (AuNPs) were studied. Polymer-coated nanospheres of AuNPs with a mean diameter of 20 nm were dispersed in 5CB at a concentration of 0.5 wt% 4. AuNPs/5CB nanocomposite films with a thickness of 25 μm were characterized by polarizing microscopy and flexoelectro-optic spectroscopy. The flexoelectric origin of the first harmonic spectra in AuNPs/5CB nanocomposite nematic system was discussed.

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References
1. A. Buka and N. Eber, Flexoelectricity in liquid crystals, (London, Imperial College Press, 2013), 290 pp.
2. A.G. Petrov et al., Liq. Cryst 19, 169 (1995).

3. A.G. Petrov et al., JOAM 9, 420 (2007).
4 G.B. Hadjichristov et al., J. Appl. Phys. 115, 083107 (2014).

S06-CMPSP-217 / **Poster presentation**

Mobility of Holstein polaron from real and imaginary time quantum Monte Carlo calculations

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Electron-phonon (e-ph) interaction is responsible for majority of transport phenomena in condensed matter. In this work, we consider the short-range (localized) e-ph interaction described by the Holstein Hamiltonian. We develop numerically exact path integral Monte Carlo (PIMC) methods to obtain current-current correlation functions (CFs) and polaron mobility of one-dimensional Holstein model.

Generally, several challenges need to be overcome to reliably calculate dynamical properties using the PIMC methods. First one is the dynamical sign-problem of real time CFs which can be eliminated by doing calculations in imaginary time and then analytically continuing to real time. The other challenge is that there is not a reliable method for analytic continuation of numerically obtained values. We overcome these limitations by combining real time and imaginary time calculations with singular value decomposition method for analytical continuation.

For weaker e-ph interaction strengths we were able to calculate CFs in real time for a range of temperatures by using a Monte Carlo algorithm derived from momentum representation of electronic degrees of freedom and coordinate representation of phonons. For stronger interactions such an algorithm leads to a significant sign-problem for longer times and better results are obtained by using a different algorithm. This algorithm is derived from site representation of electronic degrees of freedom and coordinate representation of phonons. The phonon coordinates are then integrated out analytically and Monte Carlo summation over electronic states is performed. In the case of stronger interactions, where real time calculations cannot be used to obtain CFs at longer times, doing analytic continuation of both real time and imaginary time data gives much better results. The methods described enabled us to calculate polaron mobility for a range of temperatures and e-ph interaction strengths.

S06-CMPSP-218 / **Poster presentation**

Crystallization of sodium chlorate crystals by evaporation in a magnetic field

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Slow evaporation as a crystallization technique can allow the growth of large oriented crystals. In the experiments performed, sodium chlorate crystals were obtained by evaporating microdroplets of a saturated aqueous solution both at ambient conditions and at a constant temperature of 31.5°C in a closed container. The solution was saturated at a temperature of (31.5±0.1)°C. A 5 µL drop of the solution was placed on silicon wafers to evaporate slowly. To determine the effect of magnetic field on crystallization, experiments were performed under zero-field conditions and in a static magnetic field of B=(390±5) mT. Preliminary research results show that larger and more regularly shaped macrocrystals are formed by slow evaporation in a closed system at constant temperature in the applied magnetic field.

S06-CMPSP-219 / **Poster presentation**

Midgap state in silicon carbide monolayer induced by atom adsorption

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The recent synthesis of two-dimensional (2D) silicon carbide (SiC) [1] experimentally proved the existence of 2D carbides, a new class of semiconducting materials with the honeycomb structure. Considering the point defects, one of the simplest structural deformations in 2D materials, we examined the prospect of employing them for the band-gap engineering of a SiC monolayer. Applying density functional theory, we found that in a free-standing SiC layer, out of the plane deformation of a single silicon atom creates a new midgap state otherwise not present in a perfectly flat sheet [2]. Additionally, upon a continuous displacement of the Si atom in the direction perpendicular to the layer, the midgap state shifts from the top of

conduction to the bottom of the valence band. A tight-binding model reproduces a qualitative understanding of midgap state energy shift. The inspected deformations can be realized by the adsorption of suitable metal atoms. We chose lithium (Li) [3] and calcium (Ca) atoms since they strongly bind to the SiC and donate one and two electrons, respectively. Furthermore, we found that the midgap state induced by atoms in SiC is filled by one electron in the case of Li and two electrons with opposite spin in the case of Ca adatoms. We demonstrated that the electronic charge transfer from the adsorbate to the SiC alters both its structural and electronic properties to a much greater extent than in other known 2D honeycomb crystals.

References
1. S. Chabi, et al., Nanomaterials 11, 1799 (2021).
2. M. Orozović, Ž. Šljivančanin, S. Stavrić, manuscript in preparation.
3. S. Stavrić, Z. S. Popović and Ž. Šljivančanin, Phys. Rev. Mater. 2, 114007 (2018).

S06-CMPSP-220 / **Poster presentation**

Monastery of the Ascension, Elassona, Mount Olympus, Greece: Characterization of Late Post-Byzantine Wall Paintings

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The Monastery of the Ascension is located in Sykea, a village of Elassona town near Mount Olympus, with a significant contribution in the area regarding charity and culture [1]. Its catholicon was constructed and painted in about the mid-17th century, while the iconographer remains unknown. The purpose of this study is the materials characterization of the catholicon's wall-paintings and the identification of the painting technique that was used, as post-Byzantine artistic period is characterized by the application of new painting materials and techniques. At the same time, many artistic guilds of ecclesiastical iconography remain faithful to traditional Old Masters' recipes.

The collected samples -including plaster and painting layers- were analyzed by means of optical microscopy, micro-Fourier transform infrared (micro-FTIR) spectroscopy, scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS), X-ray diffractometry (XRD) and thermogravimetry (TGA). This combination

of complementary spectroscopic, thermal and microstratigraphic techniques was applied to free specimens, and also to embedded cross-sections. The results indicate the use of fresco technique; calcite with quartz and fibers of plant origin were used for the plaster layer [2]. The artist's palette is quite simple, as the painting layers consist of red, yellow and brown ferrous pigments, malachite and carbon black. This study is a part of a general project concerning the documentation of the late post-Byzantine artistic workshops, which acted in Central and Northern Greece [3].

Acknowledgements The corresponding author acknowledges the Research Committee of Aristotle University of Thessaloniki (RC-AUTH) for the financial support of the participation in BPU11.

References

1. Monastery of the Ascension of Christ at Sykea (Diocese of Elassona, 2007)
2. L. Regazzoni et al., Stud. Conserv. 63, 326 (2018).
3. L. Malletzidou et al., Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 206, 328 (2019).

`S06-CMPSP-221` / **Poster presentation**

Bose-Einstein condensate - Tunneling

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Bose-Einstein condensate is state of matter that is the future of the quantum computers. One of the crucial properties of Bose-Einstein condensate is quantum tunneling. In this paper are listed previously achieved results by other authors considering the factors that affect tunneling in Bose-Einstein condensate, such as form of interaction between particles, shape of potential well and the form and the dimension of the system [1]. According to Meng *et al.* who studied two-dimensional honeycomb optical lattice, tunneling occurs in an atractive interaction regime if dipole gap solitons are in-fase and in repulsive interaction regime if dipole gap solitons are out of phase [2]. If the particle experiences gradual change of potential barrier the probability of the excitation is lower [3]. If the particle experiences sudden change of the potential barrier, probability increases. [3] The further study of the factors that affect tunneling in Bose-Einstein condensate may be conducted in exploring different systems and mixtures of aforementioned condensates.

References

1. X. Zhao *et al.*, Phys. Rev. A **96**, (2017).
2. H. Meng *et al.*, Physica A: Stat. Mech. Appl. **577**, 126087 (2021).
3. D. Lindberg *et al.*, arXiv:2110.15298v3 [cond-mat.quant-gas]

S06-CMPSP-222 / **Poster presentation**

Polymer nanocomposites filled with core-shell nanoparticles for nanodielectric application

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Polymer nanocomposites are prepared by a simple and environmentally friendly technique. First, sheets of isotactic polypropylene (iPP) and atactic polystyrene (aPS) were prepared by compression molding with Servitec Polystat Press 200 T at 473.15 K and 3.0 MPa pressure followed by quenching in water at room temperature. The polymer sheets thus prepared were then immersed separately in three saturated salt water solutions (MnCl2, FeCl2, and NiCl2), at two temperatures (23°C and 90°C), and under influence of two DC electrical potentials (+4 kV, and ground potential). Count profiles and generated images of TOF – SIMS records have shown that higher temperature treatment (90°C) and positive potential (+4kV) have given the highest count of iron ions and better distribution and dispersion of nanoparticles in polymer matrices. Also, the measured concentration of transition metals by ICP-OES confirmed higher concentrations of metals in nanocomposites obtained by these treatment conditions. It was stated that iron(II)-chloride had the highest concentration in iPP and aPS matrices in comparison to the other two transition salts. TEM micrographs showed spherically-shaped cores in the core-shell system and agglomerated particles of irregular shape. Encapsulation of iron cores prevented nanoparticles from agglomeration. The cores of the investigated particles were probably iron oxides and/or hydroxides that occurred during the hydrolysis of iron salts in deionized water solution. Dielectric properties of obtained nanodielectrics were investigated. Relative dielectric constant and loss tangent has been studied in the frequency range from 20 Hz to 9 MHz. It was shown that adding the small amount of core-shell nanoparticles (from 15 nm to 150 nm in diameter) in a very small amount (1.72E-8 mol/cm3 to 1.17E-5 mol/cm3) are resulted in significant improvement and stabilization of relative dielectric constant value and also lowering loss tangent in compare to starting polymer matrices.These dielectric properties were marked as suitable for nanodielectric application for high speed and high dencity microelectronic packaging.

S06-CMPSP-223 / **Poster presentation**

Josephson current in d-wave superconductor junctions with inhomogeneous ferromagnet

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We study Josephson effect in a junction with arbitrarily oriented d-wave superconducting electrodes connected through two ferromagnets with noncollinear magnetizations. We solve the scattering problem based on the Bogoliubov-de Gennes formalism, extended to the case of anisotropic superconductors and presence of spin flip scattering due to ferromagnet interlayer. We investigate mutual influence of crystal orientation of superconducting electrodes and angle α between magnetizations in ferromagnetic bilayer of thickness d by calculating critical value of Josephson current IC. For various orientation of superconducting electrodes, we calculate (d,α) phase diagram, and discuss the possibility to achieve except coexistence of two stable states 0 and π, also coexistence of three stable states 0, π and π/2, by varying the angle between magnetizations which can be much better for application compared to varying thickness of barrier or temperature. In the crossover point triply degenerate 0, π/2 and π equilibrium states occur, the fourth harmonic have dominant contribution and I~sin4φ, in the same way as in SFS junction where second harmonic have dominant contribution in 0-π crossover point. We observe also areas of coexistence of stable and metastable states.

Reference:

1. Stevan Djurdjević and Zorica Popović, Prog. Theor. Exp. Phys. 2021, 083I02 (2021).

S06-CMPSP-224 / **Poster presentation**

Towards the Discrimination between Natural and Synthetic Pigments: The Case of Ultramarine

Authors: Anastasia Pourliaka[1]; Lamprini Malletzidou[1]; Dimitrios Karfaridis[1]; Triantafyllia Zorba[1]; Konstantinos M. Paraskevopoulos[1]; George Vourlias[1]

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Ultramarine has been for centuries one of the most highly prized pigments of all traditional artists' materials, due to its durability, excellent color, and its intrinsic value. For the production of the blue pigment Ultramarine, the rare semiprecious stone Lapis Lazuli is used, which has been mined since ancient times in mines north-east of Afghanistan, making it difficult to transport to the Mediterranean region. This accounts for the pigment being named ultramarine blue, i.e. a blue pigment coming from beyond the sea. The production of a synthetic version by Guimet in 1828, which was obtained from the calcination of a mixture of metakaolin, sulfur, sodium carbonate, and a reducing agent, followed by an oxidation step, introduced an important change in artists' habits, in that a less expensive pigment was available for their palettes [1]. The verification of the natural or synthetic origin of the pigment is particularly important in a project, e.g. in authentication cases.

In this research work, ten samples of natural and synthetic Ultramarine pigments were used to investigate the possibility of their discrimination using characterization methods. In the first stage of the research, all samples were studied by Fourier transform infrared (FTIR) spectroscopy. The distinction between natural and synthetic ultramarine using FTIR -as proposed in previous studies- is difficult, as the FTIR bands of interest coincide with the peaks of atmospheric CO_2 ($2400 - 2300cm^{-1}$) [2,3]. For this reason, X-ray diffractometry (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM-EDS), and UV-Vis spectrophotometry were used for all samples to support the study [4,5]. The combination of elemental composition, morphological analysis, phase identification, chemical state, color calculation, and optical band gap estimation is studied, to propose an analytical protocol for the discrimination between samples of artificial and natural origin.

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References

1. J. Plesters, in Artists' pigments: a handbook of their history and characteristics, vol. 2, edited by R. Ashok (Oxford University Press, Washington, 1993).
2. V. Desnica et al., e-PS. 1, 15 (2004).
3. C. Miliani et al., Chem. Phys. Lett. 466, 148 (2008).
4. M. González-Cabrera et al., Dyes Pigm. 178, 108349 (2020).
5. A. Škvarlová et al., Micropor. Mesopor. Mater. 284, 283 (2019).

S06-CMPSP-225 / **Poster presentation**

Superconducting Quantum Interference Proximity Transistor (SQUIPT)

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Presenter: T. Prtenjak (tprtenjak@gmail.com)

The superconducting quantum interference proximity transistors, abbreviated SQUIPTs, are interferometers based on a Josephson junction (JJ) that use the superconducting proximity effect to achieve high sensitivity in the measurement of magnetic fields. SQUIPTs can provide phase control of the thermal conductivity at very low temperatures by modifying applied magnetic flux [1]. This article gives a general overview of the latest discoveries regarding the aforementioned transistors. Research in this field can be crucial for potential application in radiation sensing, thermal logic gates, and the next generation of electronic devices - quantum computers. Topological SQUIPT is especially interesting given its potential application in nano-electronics and spintronics [2]. ω-SQUIPT is a recently realized three-terminal Josephson interferometer where the normal metal is in a form of a T-shaped nanowire connecting two superconducting loops, which helped in further understanding of multi-terminal JJs [3]. Understanding characteristics of these devices is important for realizing their potential for application in different fields.

References:
1. E. Strambini, F. S. Bergeret, and F. Giazotto, Appl. Phys. Lett. **105**(8), 082601 (2014).
2. L. Bours, B. Sothmann, M. Carrega, E. Strambini, E. M. Hankiewicz, L. W. Molenkamp, and F. Giazotto, Phys. Rev. Appl. **10**(1), 014027 (2018).
3. F. Vischi, M. Carrega, E. Strambini, S. D'Ambrosio, F. S. Bergeret, Y. V. Nazarov, and F. Giazotto, Phys. Rev. B **95**(5), 054504 (2017).

S06-CMPSP-226 / **Poster presentation**

Synthesis, Structural and Electrical Properties of SWCNT Thin Film Electrodes - First Results

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Presenter: M. Siljegovic (mirjana.siljegovic@df.uns.ac.rs)

Due to growing demands for minituarization and small electronic devices, the production of novel composite material enhanced by the incorporation of nanomaterial fillers such as multiwall (MWCNT) and singlewall carbon nanotubes (SWCNT) is the subject of widespread research today. The investigations also shown that SWCNT explore better performance compared to MWCNT structures. One of the most promising aspects of SWCNTs applications, due their optical and electrical

properties, are transparent conductive thin films or electrodes. The thin film electrodes were prepared on Pt substrates using very simple Layer-by-layer (LbL) technique, by alternate deposition of polyethileneimine (PEI) and carboxylic single walled nanotubes (SWCNT-COOH). This attractive technique allows deposition of polyelectrolytes with opposite charges using electrostatic interaction forming a multilayered films in nanometer range. In this work we present the results of preparation of the samples on Pt with 4 and 10 bilayers (PEI+SWCNT-COOH) using layer-by-layer technique.

Raman measurements of synthetized samples were performed using confocal DXR Raman Microscope with CCD camera as a detector. Excitation is provided by diode pumped solid state (DPSS) laser $\lambda = 532nm$. The obtained results enabled structural characterization and study of interface interactions. Due to the presence of sp2 carbon in the nanotubes structure two G bands were noticed in Raman spectra of both samples. Their shape and ratio gives information about semiconductor type of SWCNTs.

In order to get the insight into the fundamental charge transport through single nanostructures, the electrical properties of SWCNT were characterized using current-voltage and Hall effect measurements. The I-V characteristics of both samples are linear, thus exhibiting the ohmic behavior. The lower resistance of the sample with 10 layers is also noticed. The Hall effect measurements revealed the higher values of mobility, sheet resistance, sheet concentration and conductivity of the sample with higher number of layers.

`S06-CMPSP-227` / **Poster presentation**

Non-equilibrium molecular dynamics investigation of a model ionic liquid lubricant for heavy-duty applications

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Presenter: I. Stanković (`igor.stankovic@ipb.ac.rs`)

In the current work, we present a modeling approach for simulating mesoscopic phenomena related to lubrication. Our geometry allows a variable confinement gap and a varying amount of lubricant in the gap. We have implemented and compared several coarse-grain molecular dynamics descriptions of an ionic liquid (spherical model and model with cation tail) as a lubricant that can expand into lateral reservoirs. The results have revealed two regimes of lubrication, and elastohydrodynamic one under low loads and one with low, velocity-independent specific friction, under high loads. The observed steep rise of normal forces at small plate-to-plate distances is an interesting behavior that could potentially be exploited for preventing solid-solid contact and wear.

S06-CMPSP-228 / **Poster presentation**

Tubular structures of magnetic particles: platform for curvilinear nanomagnetism

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Presenter: I. Stanković (igor.stankovic@ipb.ac.rs)

We review tubes [1,2] consisting of magnetic dipolar particles as a model for magnetic nanostructures and show, in particular, how to obtain anti-ferromagnetic states. The tubular assemblies of magnetic particles can be realized with different thickness, length, and lattice structures. The universality of dipolar interaction concerning the length scale allows the realization of these systems both at the macro scale as dipolar rotors and mesoscale using magnetic microspheres. Our system consists of tubes created by the assembly of dipolar spheres. The cylindrical topology results in the breakup of degeneracy observed in planar square and triangular packings. As far as the ground state is concerned, the tubes switch from circular to axial magnetization with increasing tube length. All magnetostatic properties found in magnetic nanotubes, in which the dipolar interaction is comparable to or dominant over the exchange interaction, are reproduced by the dipolar tubes including an intermediary helically magnetized state. Besides, we discuss the antiferromagnetic phase resulting from the square arrangement of the dipolar spheres and its interesting vortex state [2]. The proposed system should enable research of tubular magnetic nano-devices at scales that are more accessible for observation simultaneously avoiding material imperfections, existing in solid-state counterparts.

References

1. I. Stanković, M. Dašić, J.A. Otálora, C. García, "A platform for nanomagnetism–assembled ferromagnetic and antiferromagnetic dipolar tubes", Nanoscale vol. 11, p. 2521-2535, 2020.
2. R. Messina, L.A. Khalil, I. Stankovic, "Self-assembly of magnetic balls: From chains to tubes", Physical Review E vol. 89, 011202226, 2014.

S06-CMPSP-229 / **Poster presentation**

Planar surfaces of point dipoles as a platform for 2d magnetic structure research

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Presenter: S. Rodriguez Sotelo (`sindyjuliethr@gmail.com`)

Our system consists of planar magnetic structures created by the assembly of point dipoles. The departure point of this work is the known degeneracy of ground states in planar square and triangular packings. The square lattice has a particularly interesting antiferromagnetic ground state exhibiting a transformation from percolating antiferromagnetic chains of dipoles pointing head-tail to a remarkable magnetic vortex configuration [1]. We follow the breakup of degeneracy observed in planar square and triangular packings with a mismatch of the orientation of stacked lattices. We further investigate the ability of these surfaces to carry spin current and manifest the magnetoelectric effect [2].

References

1. I. Stanković, M. Dašić, J.A. Otálora, C. García A platform for nanomagnetism–assembled ferromagnetic and antiferromagnetic dipolar tubes, Nanoscale 11(5), 2521-2535 (2019).
2. H. Katsura, N. Nagaosa, and A. V. Balatsky, Phys. Rev. Lett. 95, 057205 (2005).

`S06-CMPSP-230` / **Poster presentation**

Computational study of lead selenide doped with group IIIA elements

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Presenter: E. Toth (`elvira.djurdjic@df.uns.ac.rs`)

Lead selenide (PbSe) is a semiconductor of the cubic structure whose bandgap is 0,27 eV. It belongs to a group of essential materials for developing uncooled mid-IR detectors. This material also proved to be an excellent thermoelectric, offering a few advantages compared to other materials. It is also worth mentioning that

doping can readily modify its properties. In this work, we have studied the structural and electronic properties of PbSe doped with IIIA group elements. Applying density functional theory calculations, we have investigated how the introduction of mentioned elements into the structure of PbSe influences characteristic bond lengths and cell parameters, band structure and density of states. Charge distribution of doped PbSe was also under consideration through calculations of electron density difference, while effective screening medium calculations were performed to understand the properties of PbSe surface upon incorporating mentioned elements.

S06-CMPSP-231 / **Poster presentation**

Influence of magnetic field on the growth mechanisms of sodium chlorate crystals

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The mechanisms of crystal growth depend on the temperature and supersaturation of the solution. As a result of their competition, different growth regimes may occur. The results of previous studies have shown that in the range of supersaturation of 0.66–1.56%, the {100} sodium chlorate crystal faces grow according to the model of spiral growth [1]. In order to determine the possible influence of the static magnetic field on the growth mechanisms of sodium chlorate crystals, two groups of experiments were performed in the supersaturation range of 0.89-1.56%. In the first group of experiments, crystals were nucleated and grown under zero-field conditions in a specific supersaturation range. In the second group of experiments, crystal growth was performed in the same supersaturation range, but at an applied magnetic field of 55±3 mT. The most common method for analyzing crystal growth mechanisms is to analyze the (R,σ) dependence, where R is the growth rate in <100> and σ is the supersaturation of the solution. Preliminary results of the analysis of this dependence for crystals grown under zero-field conditions show that the observed sodium chlorate crystals grew according to the Chernov's model of growth, i.e., growth by screw dislocations, while the crystals grew in the magnetic field according to the power law R~σ^n. The obtained results will be discussed in accordance with the theories of crystal growth.

References

1. Radiša, B. Z., Mitrović M. M., Misailović B. M., & Žekić A. A. (2016). Investigation of growth mechanisms of sodium chlorate crystals from aqueous solutions. Industrial & Engineering Chemistry Research, 55(39), 10436-10444.

S06-CMPSP-232 / **Poster presentation**

Simulations of phonon-limited electron mobility in II-VI semiconductors

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Presenter: N. Vukmirović (nenad.vukmirovic@ipb.ac.rs)

Mobility of charge carriers is a physical quantity that determines the performance of semiconductor electronic and optoelectronic devices. It is still a significant challenge to predict its value starting from the crystal structure of the material. To date, such calculations have been performed only for few semiconductor materials, such as Si, GaAs and GaN [1]. In this work, we study the mobility of conduction band electrons in II-VI semiconductors ZnSe, CdTe, ZnTe and CdSe [2].

Temperature dependence of mobility was calculated using an ab-initio methodology, where electronic bands, phonon bands and electron-phonon coupling constants were obtained from density functional theory calculations. Fourier-Wannier interpolation procedure [1] was performed to obtain these quantities on a dense momentum grid which is necessary to obtain reliable values of these quantities. Density functional theory calculations were performed using the ABINIT code, while Fourier-Wannier interpolation was performed using our in-house parallel code.

The results indicated that mobilities obtained from calculations within generalized gradient approximation to density functional theory overestimate the experimental mobility several times. Very good agreement with experiments was obtained when electronic band structure and high-frequency dielectric constants were obtained using the hybrid HSE06 functional [2]. Our results also showed that accurate mobility in these materials can be obtained if we only consider the long-ranged part of electron-phonon interaction, thus avoiding the need for demanding interpolation of electron-phonon coupling constants to a dense momentum grid. We find that even the simple Fröhlich model yields a reasonable estimate of the mobility around room temperature when the dominant scattering mechanism comes from longitudinal optical phonons.

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References

1. S. Poncé, W. Li, S. Reichardt, and F. Giustino, Rep. Prog. Phys. 83, 036501 (2020).
2. N. Vukmirović, Phys. Rev. B 104, 085203 (2021).

S07-OP
Optics and Photonics

S07-OP-001 / **Invited talk**

Net Heat Current at Zero Mean Temperature Gradient

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Thermal waves generated by the periodic fluctuations on time of a temperature field are widely used to determine thermal properties of macro-, micro-, and nanomaterials via standard photothermal techniques (thermoreflectance, radiometry, 3w, photoacoustics, and resonant cavity), and they usually do not carry a net heat flux in materials with constant thermal properties. By contrast, in materials whose thermal properties do depend strongly on temperature, the material thermal response is driven by the temperature values at each instant of time and therefore the thermal waves are expected to carry a net heat flux. However, this thermal wave heat current is not quantified yet.

In this work, we theoretically demonstrate the existence of the conductive heat shuttling, a net heat current generated by thermal waves that shows up even in the absence of a mean temperature gradient. This heat shuttling is generated by the temperature-dependent thermal conductivity of materials excited with a thermal excitation periodically modulated in time. We show that this modulation gives rise to a heat current superimposed on the one generated by the mean temperature gradient, which enhances the heat transport when the thermal conductivity increases with temperature. By contrast, if the thermal conductivity decreases as temperature increases, the thermal wave heat current inverts its direction and reduces the total heat flux. The reported shutting effect is sensitive to the amplitude of the periodic thermal excitation, which can facilitate its observation and application to harvest energy from the temperature variations of the environment.

S07-OP-100 / **Oral presentation**

The Gouy phase of long-range Gauss-Bessel beams

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One of the processes that is assumed to be well understood, is that any fundamental Gaussian light beam experiences an axial phase shift of radians with respect of a reference plane wave when passing through its focus. For a higher-order Hermite-Gaussian mode with mode indices (m, n) this phase is multiplied by a factor of ($1 + m + n$). For a higher-order Laguerre-Gaussian mode with mode indices (l, p) the corresponding multiplication factor is ($1+|l|+2p$). The modulus sign accounts for the fact that the azimuthal mode index l (i.e. the on-axis topological charge of the point phase dislocation known as an optical vortex) can be either positive or negative.

In our previous studies, we have demonstrated the possibility to generate long-range and quasi-non-diffracting Gauss-Bessel beams (GBBs) by creating and annihilating multi-charge optical vortices [1,2]. The method was demonstrated even to work for sub-7-femtosecond pulses [3]. Recall that the Gouy phase is measured relative to that of an infinite plane wave, and an infinite plane wave does not experience diffraction. One might think that quasi-nondiffracting GBBs have zero (or negligible) Gouy phase.

In the only two experimental works [4,5] we are aware of, the Gouy phase of GBBs is found to change linearly over short distances (up to 5 within 1 mm [5] and up to 6 within 6 μm [4]).

In this talk we will describe an analytical theoretical model for the Gouy phase of long-range GBBs accounting for the relevant experimental parameters. In particular, under relatively weak focusing of the initial hollow ring-shaped beam, the Gouy phase of the GBB is found to change linearly at a rate of some 0.2 /cm over a distance of 45 cm. Under moderate focusing, the slope can reach (1.0 /mm) over distances exceeding 4 millimeters. The theoretical results are found in a good quantitative agreement with the experimental data.

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References

1. L. Stoyanov, M. Zhekova, A. Stefanov, I. Stefanov, G. Paulus, and A. Dreischuh, Scientific Reports 10, 21981 (2020).
2. L. Stoyanov, M. Zhekova, A. Stefanov, B. Ivanov, I. Stefanov, G. G. Paulus, and A. Dreischuh, Optics Communications 480, 126510 (2021).
3. L. Stoyanov, Y. Zhang, A. Dreischuh, and G. G. Paulus, Optics Express 29, 10997-11008 (2021).
4. M.-S. Kim, T. Scharf, A. da Costa Assafrao, C. Rockstuhl, S. F. Pereira, H. P. Urbach, and H. P. Herzig, Optics Express 20, 28929- 28940 (2012).
5. M. Liebmann, A. Treffer, M. Bock, T. Elsaesser, and R. Grunwald, Optics Express 25, 26076-26088 (2017).

S07-OP-101 / **Oral presentation (virtual)**

ZnSe-based solar-blind ultraviolet photodetectors with hybrid Ag-nanowire and Ni/Au contacts

Authors: Vadim Sirkeli[1]; Oktay Yilmazoglu[2]; Ahid Hajo[2]; Natalia Nedeoglo[1]; Dmitrii Nedeoglo[1]; Sascha Preu[2]; Franko Küppers[3]; Hans Hartnagel[2]

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Presenter: V. Sirkeli (vadim.sirkeli@gmail.com)

Zinc selenide is a wide bandgap semiconductor which is attractive for the fabrication of many optoelectronic devices, including ultraviolet (UV) photodetectors, due to its large bandgap energy (2.67 eV at 300 K), high electric breakdown field strength (~ 1 MV/cm), as well as high resistance to intense UV and X-ray radiation. Most commercial UV-photodetectors are based on Si or GaAs semiconductors, which require a filter to eliminate visible and infrared light. To solve this issue, bulk high-resistivity ZnSe could be used for fabrication of a stable UV photodetectors with metal-semiconductor-metal (MSM) structures. In this work, we report on fabrication and characterization of ZnSe-based UV photodetectors with hybrid Ag-nanowire (Ag-NW) and Ni/Au contacts. High resistivity bulk ZnSe crystals grown were used as an active layer. ZnSe-based UV photodetectors with hybrid contacts have been fabricated: one of contacts is a conventional Ni/Au contact and the second one is Ag-nanowire contact. The Schottky contacts were fabricated by e-beam evaporation of 25 nm Ni followed by a thermally evaporating of 140 nm Au, and performing standard photolithographic and lift-off processes. A 500 nm dielectric SixNy passivation layer was placed above the metallic structure in order to prevent electric breakdown. A simple spin coating method was used to distribute a commercially available Ag-NWs with diameter of 120 nm over the ZnSe substrate. The alignment of the Ag-NWs has been performed using dielectrophoresis method. The current-voltage characteristics of fabricated UV photodetectors in the dark and under UV illumination were measured using a Keithley 2612 multimeter. The applied bias voltage was varied from 0 V to 15 V. The photocurrent was excited by a 325-nm Cd-He laser with output optical power of 56.5 mW. The current-voltage characteristics of the UV photodetectors with hybrid Ag-NW and Ni/Au contacts in the dark and under illumination with the UV laser were measured. It is found that the dependence of dark current increases exponentially with the increase of bias voltage up to 2.5 V, and then it increases practically linearly when the bias voltage is above 2.5 V. When a bias voltage of 15 V is applied, the maximum dark current is equal to 0.36 nA. Under UV illumination, the behavior of I-V characteristics shows significant changes and becomes non-linear indicating carrier multiplication effects. The responsivity of photodetector with hybrid contacts has a similar character to the photocurrent dependence of the respective device. A maximum value of responsivity of 0.58 A/W at bias voltage of 15 V for light with a wavelength of 325

nm is found for this device. A maximum values of detectivity of $5.49 \cdot 10^{10}$ cm $Hz^{1/2}$ W^{-1} and photocurrent on/off ratio of 5006 at bias voltage of 15 V were obtained for this device. Thus, the ZnSe-based UV photodetector with hybrid Ag-NW and Ni/Au contacts could be attractive for high-speed UV telecommunications and UV-Tomography applications.

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S07-OP-200 / **Poster presentation**

Optical spectroscopy of BaF2:Pb2+ crystals

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Presenter: G. Buse (gabriel.buse@e-uvt.ro)

The spectroscopic properties of ns^2 ions in alkaline halide crystals are old and well-studied [1]. Regarding the spectroscopic properties of ns2 ions doped in alkaline-earth fluorides, these are less investigated. Few authors [2,3,4] have studied the optical properties of $CaF_2:Pb^{2+}$ crystals and LuAG:Ce single crystalline films. Recently, the effect of gamma irradiation on the PbF_2 doped BaF_2 crystals was reported [5]. The main goal of this paper is to investigate the influence of Pb^{2+} ions on the spectroscopic properties of the BaF_2 crystals.

The various PbF_2-doped BaF_2 crystals were grown using the Bridgman method. The crystals are transparent, colorless, with no inclusions. The samples are cleaved slices along (111) crystallographic plane of about 10 mm in diameter.
Room-temperature UV-VIS absorption spectra were recorded by Shimadzu 1650PC spectrophotometer. Room temperature UV-VIS luminescence spectra and time resolved measurements were recorded using by FLS 980–Edinburgh Instruments spectrofluorimeter equipped with Xe lamp as excitation source.

The Pb^{2+} ions in BaF_2 lattice gives rise to absorption bands in UV domain [1, 2]. The absorption spectra of $BaF_2:Pb^{2+}$ crystals reveal the two absorption bands centered at 203 and 290 nm, respectively. As the concentration increases the shape and intensity of absorption band at 203 nm increases, while the band at 290 nm conserves their sharp shape and width. From the preliminary luminescence measurements, results the same UV-VIS emission spectra for all samples under excitation at 290 nm; the UV emission intensities at 304 and 321 nm depends on Pb^{2+} ions concentration. These bands are attributed to the $^3P_1 \rightarrow {}^1S_0$ transition of Pb^{2+} ion.

References

1. P. W. Jacobs, J. Phys. Chem Solids. 52, 35 (1991).

2. K. P. Oboth, F. J. Lohmeller and F. Fischer, phys. stat. sol. (b) 154, 789 (1989).
3. V. Babin, V. Gorbenko, A. Makhov, M. Nikl, S. Zazubovich and Y. Zorenko, phys. stat. sol. (c) 4, 797 (2007).
4. M. Stef, O.M. Bunoiu, M. Paraschiva, A. Pruna, I. Nicoara, AIP Conf. Proc. 1131, 131 (2009).
5. I. Nicoara, M. Stef, D. Vizman, Radiat. Phys. Chem. 168, 108565 (2020).

`S07-OP-201` / **Poster presentation (virtual)**

Generation Gauss-Bessel beams with vortex phase plates at formally inadequate wavelengths

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In the first studies of the generation of long-range quasi-non-diffracting Gauss-Bessel beams (GBBs) by creating and annihilating multi-charge optical vortices (OVs) [1-3], calibrated reflective liquid-crystal spatial light modulators are used. Because of their low damage threshold, they are not applicable with high-power laser beams. Vortex phase plates (VPs; phase plates which thickness is varying azimuthally) are an adequate solution of this problem. The limitation is, however, that each VP is designed to produce the desired integer topological charge (TC) at a specified wavelength. If the used wavelength is different, OVs with fractional TCs are created and the background beam becomes accordingly modulated.

In this work we report experimental results confirming that multiple optical vortices with fractional TCs can be successfully annihilated and zeroth- and first order GBBs can be successfully generated at even formally inadequate wavelengths.

We will report results on the generation of GBBs by using vortex plates (VPs) designed for 532nm, using laser beams at 445 nm, 532 nm, 633 nm, and 800 nm. The GBB propagation is followed from z=32cm behind the focus of the lens to 320 cm behind it. At each distance the experimental cross-section of the GBB is compared with a theoretical Bessel function. The close inspection of the data at z=32 cm shows best match between the experimental and numerical positions and relative intensities of the peaks for 532 nm and 800 nm. At 100 cm the best match can be seen at 532 nm and 633 nm. At 320 cm and at the largest distance 540 cm studied here, good agreement between the experimental and numerical data can be seen for 445 nm, 532 nm, and 633 nm. Summarizing these observations, one can conclude that the experimental and numerical radial profiles of the (Gauss-)Bessel beams match best for 532 nm – the wavelength for which the VPs are designed. Qualitatively

the same holds for the data obtained for first-order GBBs. The data show, however, that zeroth- and first order GBBs can be generated with a reasonable good quality at formally inadequate wavelengths. Another argument in support of this statement are the low divergences of the generated GBBs at the formally "inadequate" wavelengths (151 μrad and 125 μrad for zeroth and 1-st order GBBs at 800 nm, respectively; 123 μrad and 106 μrad for zeroth and 1-st order GBBs at 633 nm).

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References

1. L. Stoyanov et al., Scientific Reports 10, 21981 (2020).
2. L. Stoyanov et al., Optics Communications 480, 126510 (2021).
3. L. Stoyanov et al. Optics Express 29, 10997-11008 (2021).

`S07-OP-202` / **Poster presentation**

Evaluation of Thermophysical Properties of Semiconductors by Photoacoustic Phase Neural Network

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Presenter: K. Djordjevic (`katarina.djordjevic@vin.bg.ac.rs`)

The idea of this paper is to develop a method for determination thermal diffusivity, linear expansion coefficient and thickness of a semiconductor sample from photoacoustic phase measurement by using neural network. The neural network has been trained on a large basis of photoacoustic phases obtained from a theoretical Si n-type model in the range of 20Hz to 20kHz. The advantages of using a phase neural network with high accuracy and precision in prediction depending on the number of epochs are presented, as well as analyzes of the application of random Gaussian noise to the network in order to better predict the experimental photoacoustic signal. An analysis of a theoretical photoacoustic model with a phase neural network is demonstrated.

S07-OP-203 / **Poster presentation**

Compact localized modes in Dice lattice dressed by artificial flux

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Presenter: A. Mancic (anam@pmf.ni.ac.rs)

Flat-band (FB) photonic lattices are attracting substantial attention of researchers since they provide an excellent platform for studying various fundamental physical phenomena difficult to achieve in the condensed matter systems. In that regard, some of those phenomena demonstrated in the last two decade are discrete solitons, dynamical localization and Anderson localization in disordered lattices [1]. One of the advantages of photonic lattices is that they are easy to manipulate with. Maybe the most important property of FBs is that they can host a complete set of compact localized states (CLS), highly robust to environmental noise.

Here, we investigate the CLS in two-dimensional (2D) dice lattice dressed by artificial flux in the presence of nonlinearity. Due to the Aharonov-Bohm (AB) caging effect, this lattice can host a fully FB spectrum [2]. The FB eigenmodes are compact snowflake-like structures shared by a few unit cells [3]. The goal is to find suitable conditions for selecting the localized states with user-friendly characteristics. We do this by testing the dynamics of those snowflake-like CLS in the linear and nonlinear regime. We have found two types of dynamics of compact structures, one, the snowflake-like, robust in both linear and nonlinear regime, and the other one, breathing complexes, robust only in the presence of weak nonlinearity.

References

1. L. Tang et al., Nanophotonics 9, 1161 (2020).
2. J. Vidal, R. Mosseri, and B. Douçot, Phys. Rev. Lett.81, 5888 (1998).
3. S. M. Zhang and L. Jin, Phys. Rev. B 102, 054301 (2020).

S07-OP-204 / **Poster presentation**

Scattering and absorption of light by aerosol particles

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This work aimed to review the optical properties of aerosol particles and the approximations developed to describe them. Aerosol particles have a significant effect on the total radiation balance. During the interaction of light with matter, two main phenomena can be observed, scattering and absorption of light, depending on matter's wavelength and optical characteristics of aerosols.

The scattering and absorption processes determine the reduction of light intensity passing through particles. Many aerosol assessment techniques in the atmosphere are based on measuring the scattering of light by aerosol particles. The amount of scattered light depends not only on the wavelength of the light used and the scattering angle but also on the physical parameters of the particles, such as shape, size, and refractive index. Different theories describe the interaction of light with aerosols, depending on the size of the particles that scatter the light. Complex refractive index, scattering and absorption coefficient factors, and approaches describing optical properties of aerosol particles related to their microphysical parameters, among them Raleigh approximation, Mie theory, Raleigh-Debay-Gans, and Van de Hulst approximations, are presented here.

S07-OP-205 / **Poster presentation (virtual)**

Experimental Study of Microhardness and Wettability of Hard Multilayer Coatings of CR-39 Spectacle Lenses

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Presenter: G. Mihova (gerganamihova4@gmail.com)

The presented research aimed to study the microhardness, wettability as well as the surface roughness of organic spectacle lenses for everyday use, based on CR-39 (Poly(allyl diglycol carbonate) (PADC).

The modern spectacle lens's organic materials [1], like CR-39, are superior to the old mineral lenses in many aspects, but their major vulnerability to scratches and chemical substances requests applying special protective surface coatings [1,2]. The most widely used are Hard Multilayer Coatings (HMC). These advanced protective coatings provide not only mechanical durability, dust, and dirt-resistant layers, but also allow modification and improvement of the optical properties like anti-reflectiveness, UV protection, color filters, etc. Although the optical properties of the spectacle lenses are widely studied [3] the data about their surface coatings' mechanical properties are insufficient [4]. Due to this fact, our research is focused on the experimental study of three parameters of the lens surface: microhardness, roughness, and wetting properties. CR-39 lenses, from different manufacturers, were selected for the purpose of the experiments. Each manufacturer was

represented by one reference uncoated lens and other lenses with different functional types of protective coating. Each lens has been mechanically cut into multiple samples for easier characterization and better statistics. The microhardness, roughness, and wetting properties have been experimentally determined for each sample.

The results of this study provide systematic data about the studied mechanical properties of the most commonly used CR-39 spectacle lenses from different quality rates, and correspondingly manufactured with different classes of protective optical coatings.

Acknowledgments: This study is supported by the Bulgarian State Budget and Sofia University "St. Kliment Ohridski" under project 80-10-124/16.5.2022. The laboratory is supported by the project CoE "National center of mechatronics and clean technologies" BG05M2OP001-1.001-0008-C01.

References:

1. R. Pillay, R. Hansraj and N. Rampersad, Clin. Optom. **12**, 157 (2020).
2. F. Samson, Surf. Coat. Technol. **81**, 79 (1996).
3. M.F. Schubert et al., Appl. Phys. Express **3**, 082502 (2010).
4. J. Caro et al., Surf. Coat. Technol. **205**, 5040 (2011).

S07-OP-206 / **Poster presentation**

Control of group index in two level system by Kerr nonlinearity

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Presenter: M. Perić (milica.peric1@pmf.edu.rs)

Group velocity control of light is of fundamental as well as practical interest for the construction of various optical devices such as optical buffers and quantum memories. In recent decades, great attention has been paid to the study of conditions and techniques for obtaining subluminal and superluninal light. It is found that the presence of Kerr nonlinearity can be usefull tool for group index control.

In this paper, the interaction of a laser with a two-level system was studied and the Kerr coefficient was calculated using the density matrix formalism. By solving the optical Bloch equations, the expressions for the linear and nonlinear part of susceptibility were obtained, as well as the expression for the Kerr coefficient. The dependence of the group refractive index depending on the laser intensity and its detuning was studied. The contributions of linear and nonlinear parts were considered separatlly. It has been noticed that with the increase of laser intensity, the

type of dispersion changes from normal to anomalous. Also, the values of detuning, depending on laser intensity, where superluminal or subluminal light is observed, were found.

Our study consists of analytical approach and numerical simulations. For simulations we used the parameters of the real two level physical system in ^{87}Rb atoms: $5S_{1/2}(F=1, m_F=1) \rightarrow 5P_{1/2}(F=2, m_F=0)$.

S07-OP-207 / **Poster presentation**

Existence and dynamics of eigenmodes in linear flux dressed two-dimensional plus lattice

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Presenter: M. Stepić (`mstepic@vinca.rs`)

Flatband (FB) photonic systems have been in the spotlight of researchers since they represent an advantageous testbed for studying transport and localization properties at the linear level [1]. Among variety of platforms where flatbands have been realized photonic lattices have been established as the ideal ones, since working with them is very comfortable - they are easy to manipulate with and it is possible to directly observe the wave dynamics. Due to their geometry, it is possible to design artificial gauge field effects which are equivalent to the magnetic field flux, i. e. the spin-orbit interaction in atomic systems [2].

Here, we study a two-dimensional (2D) pluslike lattice [3], dressed by the artificial flux, which could be realized by experimental techniques based on the coupled-spring resonators [4] and wave-guide networks [5]. We investigate the influence of the artificial flux on the energy band spectrum and the idea is to find the compact localized modes (CLM).

The unit cell of the plus lattice consists of five sites, with real intra-cell hopping represented by the coupling coefficient. The flux of the artificial field modifies the coupling between different unit cell sites to t·exp(±iϕ/4), where tis the hopping parameter and ϕ is the artificial flux. In the absence of flux, in the uniform lattice, the energy spectrum has one fully degenerate FB, centered at zero, between two dispersive bands (DBs), each of which is being accompanied with the other mirror symmetric DB [3]. We have found that 2D plus lattice can be dressed by artificial flux to host the Aharonov-Bohm (AB) effect. This effect causes the appearance of flat zones in the energy spectrum of the lattice. Hence, when diamond plaquettes are dressed by artificial flux ϕ=π, this lattice spectrum is described by two momentum independent, fully degenerated FBs, and three DBs.

The dynamics of CLMs in 2D flux-dressed plus lattice can be analyzed numerically, adopting the Runge-Kutta procedure of the 6th order. In order to scan the dynamical properties of the CLMs we will calculate some of the following quantities: the participation number, which is a measure of the mode localization; the mode overlapping, which represents normalized magnitude of the field overlap; and total intensity distribution. The evolution of these quantities will show the efficiency of the mode compactness-localization.

References
1. D. Leykam, A. Andreanov, and S. Flach, Advances in Physics:X 3, 1 (2018).
2. S. Lisi et al., Nature Phys. 17, 189 (2021).
3. M. Stojanović Krasić et al., Phys. Rev. E 102, 032207(2020).
4. D. Leykam and L. Yuan, Nanophotonics, 9, 4473 (2020).
5. L. Morales-Inostroza and R. A. Vicencio, Phys. Rev. A, 94, 043831 (2016).

S07-OP-208 / **Poster presentation**

Experimental demonstration of coherent beam recombination after controllable beam break-up and filamentation by using optical vortex lattices

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Coherent beam combining (CBC) is denoting a group of methods developed for achieving higher power/energy and for enhancing the spectral brightness of laser emission at preserved beam quality by combining several high-power laser beams (or sub-beams) [1]. On the other hand, the spectral broadening of coherent optical pulses is inevitably necessary for their compression in time. The beam filamentation is a complex nonlinear process (see e.g. [2]), potentially promising for the subsequent pulse compression. This makes sense only if there is a reliable way to coherently recombine the sub-beams after their spectral broadening for following pulse compression prior entering the interaction zone in the experiment.

The controllable (and reversible) beam break-up of optical vortex lattices in the focal plane of a lens (i.e. in the artificial far field) to an ordered structure of well-formed

peaks, has been demonstrated with square-shaped [3] and with hexagonal OV lattices [4], as well as after mixing such OV lattices (formally - using the Convolution theorem for the Fourier-transformation) [5]. These beam reshaping techniques along with their reliability to controllably split the beam into sub-beams and later to recombine them is the key component of the present work.

Here, we essentially exploit this technique in order to coherently recombine the peaks from the focal region after a nonlinear process of filamentation in its vicinity, resulting in a spectral broadening of the involved femtosecond laser pulses. Results for the experimental realization of controllable beam break-up into six peaks, filamentation and coherent beam recombination using specific optical vortex lattices in ambient air and in a glass substrate (as nonlinear media) will be presented and discussed.

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References

1. Z. Liu, P. Zhou, X. Xu, et al. Sci. China Technol. Sci. 56, 1597–1606 (2013).
2. A. Braun, G. Korn, X. Liu, D. Du, J. Squier, and G. Mourou, Opt. Lett. 20, 73-75 (1995).
3. L. Stoyanov, G. Maleshkov, M. Zhekova, et al., J. Opt. Soc. Am. B 35, 402-409 (2018).
4. L. Stoyanov, G. Maleshkov, M. Zhekova, I. Stefanov, et al., J. of Optics 20, 095601 (2018).
5. L. Stoyanov, G. Maleshkov, I. Stefanov, et al., Opt. Quant. Electron. 54, 34 (2022).

S08-PGDP
Plasma and Gas-Discharge Physics

S08-PGDP-100 / **Oral presentation**

Electroerosion - a complex phenomenon of a physical-chemical nature

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A first description of this phenomenon, as well as its application in practice was made by acad. Boris Lazarenko. Based on what he and his colleagues presented, new processes for electro-physical processing of materials were developed. This paper, based on the analysis of the literature, as well as on our own experimental investigations and findings, shows that the proper erosion of metals is caused by thermal phenomena in the plasma of electric discharges and by the action of the three components (force of gravity, force of surface tension and electro-dynamic force) in a relationship. Their correlation determines the development of capillary waves, and these in turn annihilate or amplify the erosion.

Based on the graphite erosion, it is established that, in fact, it is subject to vaporization, oxidation, as well as to dissipation due to bombardment with highly energized particles (neutral atoms, ions and electrons), which causes intense cathodic dissipation of graphite. Thus, the authors propose a new vision on this phenomenon.

S08-PGDP-200 / **Poster presentation**

Experimental study of Ne II spectral lines shapes in the cathode sheath of an abnormal glow discharge

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We report results of an experimental study of shapes of Ne II 369.421 nm, Ne II 371.308 nm, and Ne II 372.711 nm lines in the cathode sheath (CS) region of an abnormal glow discharge in pure neon. The experimental profiles were studied using optical emission spectroscopy (OES). Several strong ionic neon lines from the near UV region exhibit extensively broadened wings of their spectral profiles. We used Ne I 520.390 nm spectral line to measure the strength of the electric field and

draw attention to the possibility of determining the electric field strength in CS from one particular parameter of the complex line profiles.

S08-PGDP-201 / **Poster presentation**

Determination Of The Temperature Distribution In The Cathode Sheath Region Of Hydrogen Glow Discharge Using R-Branch Of Fulcher-α Band

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Optical emission spectroscopy technique was used to measure rotational and gas temperature distribution in the cathode-sheath region of an abnormal glow discharge operated in hydrogen. The rotational temperature of excited electronic states of H2 was determined from the relative line intensities of the R-branch of the Fulcher-α diagonal band $d^3\Pi_u^+, \nu' = 0 \rightarrow a^3 \sum_g^+, \nu'' = 0$ and compared with published results for the Q-branch of the Fulcher-α diagonal band $d^3\Pi_u^-, \nu' = 0 \rightarrow a^3 \sum_g^+, \nu'' = 0$. The population of excited energy levels, determined from the relative line intensities, was used to derive the rotational temperature of the ground state of hydrogen molecule. The boundary between the cathode sheath and negative glow region is determined using Stark polarization spectroscopy of the hydrogen Balmer alpha line.

S08-PGDP-202 / **Poster presentation**

Influence of air and water vapor on EEDF and some active species in atmospheric pressure low temperature helium plasmas: investigation by global model

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Presenter: Ž. Mladenović (`zeljko.mladenovic@pmf.edu.rs`)

A numerical 0D global model is developed with an aim to study the influence of air and water vapour impurities on electron energy distribution function and chemical

composition of atmospheric pressure helium plasma, focusing on the main reactive oxygen and nitrogen species. Model includes 1488 reactions among 74 species, taken from the literature [1,2]. Rate coefficients for electron impact processes are calculated using two-term Boltzmann solver BOLSIG+ [3], with cross section data mainly taken from Quantemol-DB database [4]. The main channels for production and consumption of reactive species are examined for a constant electron concentration 10^{10}cm^{-3} and electron temperature 2eV. We have performed parametric study where mole fraction of air and water vapour were varied in the wide range, using data from the literature [5]. The calculations are done for 100ppm, 1000ppm and 10000ppm of air in plasma, and for each of these values the content of water vapour was 100ppm, 1000ppm, 2000ppm and 10000ppm. Through the influence of these contents on EEDF and appropriate rate coefficients, the variations of the most important production and consumption processes for O, OH, N and NO are analysed in detail. Results show that increasing of air and water vapour contents require higher E/N values to achieve given mean electron energy, rising the energy tail of EEDF and the values of rate coefficients for the electron impact processes with higher energy thresholds, such as dissociation of O_2, N_2 and H_2O, important for initial production of O, OH, N and NO. Thus, for the same amount of water vapour, increasing of air content in plasma leads to higher concentration of OH radical and consequently higher level of H_2O_2. For the same amount of air, higher content of water vapour generally leads to decrease of O and N concentrations through chemical reaction with OH radicals.

References

1. Mladenović Ž, Gocić S, Marić D and Petrović Z Lj 2018 Eur. Phys. J. Plus 133, 344.
2. Schroter S, Wijaikhum A, Gibson A R, West A, Davies H L, Minesi N, Dedrick J, Wagenaars E, de Oliveira N, Nahon L, Kushner M J, Paul Booth J, Niemi K, Gans T and O'Connell D 2018 Phys. Chem. Chem. Phys. 20, 24263.
3. Hagelaar G J M and Pitchford L C 2005 Plasma Sources Sci. Technol. 14, 722-733.
4. Jonathan Tennyson et al., 2017 Plasma Sources Sci. Technol. 26, 055014.
5. Sun B, Liu D, Wang X, Liu Z, Iza F, Yang A and Rong M 2019 Phys. Plasmas 26, 063514.

S08-PGDP-203 / **Poster presentation**

Stark shifts dependence on the upper level ionization potential and the rest core charge of the emitter within 3s-np transition arrays

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Presenter: M. Scepanovic (mara.scepanovic@gmail.com)

Stark width and shift simultaneous dependence on the upper level ionization potential and rest core charge of the emitter has been evaluated and discussed. It has been verified that the found relations, connecting Stark broadening parameters with upper level ionization potential and rest core charge of the emitters for particular electron temperature and density, can be used for prediction of Stark line width and shift data in case of ions for which observed data, or more detailed calculations, are not yet available. Stark widths and shifts published data are used to demonstrate the existence of other kinds of regularities within similar spectra of different elements and their ionization stages. The emphasis is on the Stark parameter dependence on the upper level ionization potential and on the rest core charge for the lines from similar spectra of multiply charged ions. The found relations connecting Stark widths and shift parameters with upper level ionization potential, rest core charge and electron temperature were used for a prediction of new Stark broadening data, thus avoiding much more complicated procedures.

S08-PGDP-204 / **Poster presentation**

Obtaining secondary light radiation under the action of that caused by plasma in the air environment

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Presenter: P. Topala (pavel.topala@gmail.com)

Light radiation is one of the phenomena that is constantly in the attention of researchers and practitioners. The laser has become a contemporary tool that is applied in physics, technology, medicine, etc. Today we can practically not imagine our life without it, but it is necessary to obtain monochrome radiation that can be focused and directed more easily, which in special situations have a much higher penetrating power through the environment compared to polychromatic light. The authors of the paper have got the experimental results for obtaining secondary monochrome radiation by using as a radiant body the optical filter glass, doped differently depending on the desired result. The important thing is that this radiation is obtained under the action of the plasma of the electric discharges under normal conditions.

S08-PGDP-205 / **Poster presentation**

Cathodes with increased thermoelectronic emission properties

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The phenomena of electronic emission, in general, and thermoelectronic emission, in particular, seems that have already been studied well enough and there is nothing left to do. The electron beam, as a tool in the processing of materials is very convenient, because it does not cause changes in chemical composition and ensures processing in micrometric and nanometric scales.

It is experimentally demonstrated in this paper that the intensity of thermoelectronic emission current can be increased up to 10 times by micrometric changes in the geometry of the cathode active surface. It was also found that the artificially created asperities on the active surfaces of the cathodes also serve as concentrators of the electric fields. At the same time, the extraction of nanometric asperities from the micrometric ones further increases the active area of the thermoelectronic emission surface, and as a result the efficiency of the process.

S09-TMCP
Theoretical, Mathematical and Computational Physics

S09-TMCP-001 / **Invited talk**

Fractional calculus in modelling hereditariness and nonlocality in transmission lines

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Transmission lines are traditionally modelled by considering Heaviside's elementary circuit that contains a resistor and inductor in the series branch, accounting for the energy losses and magnetic effects, while the shunt branch contains a resistor and a capacitor, accounting for the energy losses and capacitive phenomena. Classical telegrapher's equations, modelling the signal propagation in a transmission line, are obtained by assuming the infinitesimal length of the elementary circuit and by passing to a continuum.

The generalization of elementary circuit is two-fold: topological by adding the capacitor in the series branch in order to account for the charge accumulation effects along the line and constitutive in order to account for the memory effects that transmission line may display. The constitutive generalization is performed by changing the constitutive relation describing the capacitive and inductive material properties using the fractional calculus approach accounting for the short-tail memory.

On the other hand, the inclusion of nonlocal material properties of a transmission line is performed by considering the magnetic coupling of inductors in the series branch of Heaviside's elementary circuit, so that the magnetic flux is obtained as a superposition of local and constitutively given nonlocal magnetic flux through the cross-inductivity kernel. Signal propagation is studied in the case of power, exponential, and Gauss type cross-inductivity kernels.

The abstract accounts for the results obtained in collaboration with Stevan Cvetićanin and Milan Rapaić and published in [1, 2, 3].

References

1. S. M. Cvetićanin, D. Zorica, M. R. Rapaić, Generalized time-fractional telegrapher's equation in transmission line modeling, Nonlinear Dynamics, 88 (2017) 1453–1472.
2. S. Cvetićanin, D. Zorica, M. Rapaić, Non-local telegrapher's equation as a transmission line model, Applied Mathematics and Computation, 390 (2021) 125602–1–18.
3. D. Zorica, S. M. Cvetićanin, Transmission line modeling by fractional and topological generalization of the telegrapher's equation, in A. G. Radwan, F. A. Khanday, L. A. Said (Editors), Fractional-Order Modeling of Dynamic Systems with Applications in Optimization, Signal Processing, and Control, Elsevier – Academic Press, 2021, London.

S09-TMCP-100 / **Oral presentation**

Coupled discrete solitonic equations and the periodic reduction

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Presenter: C. Babalic (babalic.corina@ucv.ro)

Starting from a general completely integrable 'diagonal' equation in two dimensions and performing periodic reduction one can obtain coupled completely integrable equations. The idea is to consider that the independent discrete variable of the analyzed equation is in fact a diagonal in a two-dimensional (or d-dimensional) lattice. Imposing periodic reduction on the one such coordinate in that 2D-lattice, then we will obtain coupled integrable systems with branched disperssion. We will exemplify the technique on some integrable semidiscrete equations.

S09-TMCP-101 / **Oral presentation**

A weighted particle scheme for solving the Enskog-Vlasov equation in spherical geometry

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Presenter: S. Busuioc (sergiu.busuioc@e-uvt.ro)

The Enskog-Vlasov equation has proven successful in investigating fluids undergoing a phase change [1,2,3,4]. However, the numerical solution of this kinetic model is computationally demanding and, therefore, existing studies are restricted to one-dimensional planar flows or flows with cylindrical symmetry. In this work, a weighted particle scheme is developed for solving the Enskog–Vlasov equation in spherically symmetric geometry. It is shown how to cope with the non-local structure of the Enskog collision integral and a closed-form expression of the mean force field is determined using the shell theorem.

As an application, the growth rates of nano-droplets/bubbles in the bulk of a homogeneous metastable vapour/liquid are evaluated in a wide range of supersaturation ratios that was not possible until now due to the high computational cost required by alternate approaches.

The proposed scheme significantly broadens the range of problems that can be investigated via the Enskog-Vlasov equation, and it is thus a valuable tool for studying fluid flows with phase change.

References
1. A. Frezzotti, L. Gibelli, S. Lorenzani, 17, 012102 (2005).
2. M. Kon, K. Kobayashi, M. Watanabe, 26, 072003 (2014).
3. P. Barbante, A. Frezzotti, L. Gibelli, 8, 235–254 (2015).
4. E. Benilov, M. Benilov, 2019, 103205 (2019).

S09-TMCP-102 / **Oral presentation**

Dynamics of Entropy Production in Open Quantum Systems

Authors: Aurelian Isar[1]; Tatiana Mihaescu[1]

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Presenter: A. Isar (isar@theory.nipne.ro)

The Markovian time evolution of the entropy production rate is studied as a measure of irreversibility generated in a bipartite quantum system consisting of two coupled bosonic modes immersed in a common thermal environment. The dynamics of the system is described in the framework of the formalism of the theory of open quantum systems based on completely positive quantum dynamical semigroups, for initial two-mode squeezed thermal states, squeezed vacuum states, thermal states and coherent states. We show that the rate of the entropy production of the initial state and nonequilibrium stationary state, and the time evolution of the rate of entropy production, strongly depend on the parameters of the initial Gaussian state (squeezing parameter and average thermal photon numbers), frequencies of modes, parameters characterising the thermal environment (temperature and dissipation coefficient), and the strength of coupling between the two modes. We also provide a comparison of the behaviour of entropy production rate and Rényi-2 mutual information present in the considered system.

S09-TMCP-103 / **Oral presentation**

The Role of Size and Shape in the Stability of the Quantum Brownian Rotator

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Presenter: I. Petrović (igorpetrovicsb@gmail.com)

Shape and size are the basic characteristics of macroscopic, classical systems, and as such represent a special challenge within the fundamental problem of "transition from quantum to classical", but also the problem of quantum measurement. Propeller-shaped molecules are excellent candidates for analyzing the effects of size and shape because of the linear dependence of both the moment of inertia and the damping factor on the number of propeller blades. Also, such research can be useful for their practical application within molecular machines technology [1,2].

The propeller-shaped large-molecules rotators can be modeled by a single (rotational) degree of freedom as a rigid system that is open to the environmental influence using the so-called Caldeira-Leggett master equation [3]. The use of this equation is motivated by both, the well-defined classical limit as well as by the explicit quantummechanical corrections in the weak-coupling limit, although it was used phenomenologically. Two methods for investigating stability are used, a quantum-mechanical counterpart of the so-called "first passage time" method, and investigation of time dependence of the standard deviation of the rotator for both the angle and angular momentum quantum observables. The analysis was performed for three different cases of external potential, the free, harmonic and weakly non-harmonic rotator [4,5].

The analysis of the dynamics of molecular propellers showed the presence of quantum corrections that are not negligible, especially in short initial time intervals. It was concluded that in the transition from quantum to classical dynamics in the case of molecular propellers, contrary to expectations, quantum decoherence is not the dominant process [4,5].

A number of interesting theoretical predictions regarding stability of rotation are obtained: for certain parameter regimes the time decrease of the standard deviations and also nonmonotonic dependence on the rotator size are observed for the standard deviations and for the damping of the oscillation amplitude, which is contrary to the classical expectation that the size of the rotator can be reduced to the inertia of the rotator [4,5].

The sensitivity of rotation to details of the model and the parameter regimes emphasizes that utilizing the propeller rotations stability is an optimization problem that requires a separate careful analysis.

References

1. R. A. L. Jones, Soft Machines. Nanotechnology and Life, Oxford Univ. Press, Oxford, 2004.
2. G. S. Kottas, L. I. Clarke, D. Horinek, J. Michl, Artificial Molecular Rotors, J. Chem. Rev. 105, 1281 (2005).
3. H.-P. Breuer, F. Petruccione, The Theory of Open Quantum Systems, Oxford University Press, 2002.
4. J. Jeknić-Dugić,I. Petrović, M. Arsenijević, M. Dugić, Dynamical stability of the one-dimensional rigid Brownian rotator: the role of the rotator's spatial size and shape, J. Phys.: Condens. Matter 30, 195304 (2018).
5. I. Petrović, J. Jeknić-Dugić, M. Arsenijević, M. Dugić, Dynamical stability of the weakly nonharmonic propeller-shaped planar Brownian rotator PhysRevE. 101. 012105 (2020).

S09-TMCP-104 / **Oral presentation**

Sasaki–Ricci flow and on Sasaki-Einstein spaces $T^{1,1}$ and $Y^{p,q}$

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Presenter: M. Visinescu (mvisin@gmail.com)

We are concerned with completely integrable Hamiltonian systems and generalized action-angle coordinates in the setting of contact geometry. We investigate the deformations of the Sasaki–Einstein structures, keeping the Reeb vector field fixed, but changing the contact form. We examine the modifications of the action-angle coordinates by the Sasaki–Ricci flow. We then pass to the particular cases of the contact structures of the five-dimensional Sasaki–Einstein manifolds $T^{1,1}$ and $Y^{p,q}$.

S09-TMCP-200 / **Poster presentation**

The Magnetic Properties of Bilayer Ising Model in External Magnetic Field

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Presenter: C. Ekiz (cekiz@adu.edu.tr)

The magnetic properties of a ferromagnetic bilayer Ising system consisting of two monolayers with different spins 1/2 - 1 and different interaction constants coupled together with an interlayer interaction are studied by using the lowest approximation of the cluster variation method. The temperature dependences of the layer and total magnetizations are investigated extensively and observed only second-order in phase transition in the case of layer spin values 1/2. On the other hand, both the first and second-order phase transitions are observed for the spin values and on the monolayers. The effect of single-ion anisotropy (D) on the only B monolayer is also studied. The phase transitions of monolayer magnetizations are studied and the phase diagrams of the system are given in different planes. The temperature dependence of the total magnetization and the effect of the external magnetic field on all system is also examined. We find interesting magnetic properties in the system, such as tricritical point and compensation behavior, depending on the competition between the interlayer interactions and single-ion anisotropy parameter.

S09-TMCP-201 / **Poster presentation (virtual)**

Application Of Numerical Methods of Solving Time Delay Differential Equations Using Python

Author: Joan Jani[1]

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Presenter: J. Jani (j.jani@fimif.edu.al)

In this paper we are presenting the numerical integration techniques applied in solving time delayed system. These systems are described by a type of differential equation in which the derivative of the unknown function at a certain time is given in terms of the values of the function at previous times. For the solution we are using the JiTCDDE package, a standalone Python implementation of the DDE integration method proposed by Shampine and Thompson. As an application, we have implemented the proposed technique in the Lang-Kobayashi equations which describe a solid state laser with optical feedback.

S09-TMCP-202 / **Poster presentation**

Steering witnesses for Gaussian quantum states

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Presenter: T. Mihaescu (mihaescu.tatiana@theory.nipne.ro)

We define and fully characterize the witnesses based on second moments detecting steering in Gaussian states by means of Gaussian measurements. All such tests, which arise from linear combination of variances or second moments of canonical operators, are easily implemented in experiments. We propose also a set of linear constraints characterizing steering witnesses. Given an unknown quantum state we implement a semidefinite program providing the optimal steering test with respect to the number of random measurements performed. We study the efficiency of steering detection for squeezed vacuum states and for general unknown covariance matrices. In addition, we discuss the robustness of this method to statistical errors.

S09-TMCP-203 / **Poster presentation**

High robustness discrete time quantum random walk search algorithm without marking coin

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[2] *Institute for Nuclear Research and Nuclear Energy, Bulgarian Academy of Sciences*

Presenter: H. Tonchev (htonchev@issp.bas.bg)

Discrete Time Quantum Random Walk Search (DTQRWS) is quantum search algorithm that is quadratically faster than its classical counterpart. It can be used to search on graphs with arbitrary topology. Some structures, like Hypercube offer potential for practical applications. This quantum algorithm is very sensitive to the precision of constructing the operators of both mark and traversing coins. However, a walk coin consisting of generalized Householder reflection and additional phase multiplier allows DTQRWS algorithm to become more robust against inaccuracies in phases. To achieve such stability, a certain relation between coin parameters should be maintained. However, this method only treats the problem of constructing the walk coin, but not the marking coin.

Here, we present a simplification of the DTQRWS with high robustness. Namely, removing the need of marking coin in such way, that preserves all advantages that come from walk coin build by Generalized Householder reflection and additional phase multiplier. This simplifies the quantum circuit.

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S09-TMCP-204 / **Poster presentation**

A Parallelized Soft for Lattice QCD Simulations

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Presenter: D. Xhako (dafinaxhako@yahoo.com)

Lattice Quantum Chromodynamics (LQCD) is the lattice discretization of QCD theory, the mathematically formulation that describes the strong interactions between elementary particles. It is based on complex numerical algorithms that comes from a similarity one by one among the path integral in statistical mechanics and the Markov chain in the Monte Carlo algorithm. Solving QCD theory with Monte Carlo simulations it has a large computational cost and often these kinds of simulations have to be done in supercomputer with high computation speed and power. In addition to the complexity of formulating the theory in lattice, the computational cost is increased by the fact that in order to be as close as possible to the continuous limit we have to do simulations in as large lattices as possible. For these purposes we bring in this paper a study that present the efficacity of FermiQCD software when it is used in parallel cores. This paper gives a very good start point for lattice QCD community that a very optimal way to win time and computational cost it is to use parallel simulations using the most appropriate software for such kind of calculations such as FermiQCD. In our paper, FermiQCD software testing was done with quenched quantum chromodynamics simulations, in SU(3) gauge calibrations. One of the main advantages of FermiQCD over other libraries is the fact that it is based on a simple object-oriented programming structure as opposed to a "procedural" design. The results shows that this software is on of the optimal parallelized soft as for now in the research field of lattice QCD community. We found out that this software has a very good scaling for number of cores up to five. The computing time of the computation decreases exponentially with the increase of the number of processors used for a node, for a fixed lattice volume. All parallel simulations are done under High Performance Computing Project for South East European countries.

S10-MG
Meteorology and Geophysics

S10-MG-001 / **Invited talk**

Physical processes of desert dust in the atmosphere

Author: Stavros Solomos[1]

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Presenter: S. Solomos (ssolomos@academyofathens.gr)

Mineral dust is one of the most important aerosol types in terms of mass and optical depth. It affects radiation and alters liquid and ice cloud properties, as well as precipitation processes. Once dust particles are deposited at the surface, they provide micronutrients to the ocean or to land ecosystems, affecting fishery and agriculture activities. Moreover, very high concentrations of dust are often transported away from Sahara Desert towards Europe. Under such conditions, the smaller PM2.5 particles can be easily inhaled and deposited on the lungs and are related to human health disorders. Furthermore, under certain circumstances cloud icing by mineral dust may impact aviation safety. For these reasons, mineral dust and the associated uncertainties in climate projections are key topics for atmospheric physics research. This is particularly true for the highly dust-affected area of Eastern Mediterranean where the largest climate change effects are also expected in the decades to come. Early theoretical and modeling studies have defined the primary physical processes that lead to dust mobilization, long range transfer and deposition processes. These atmospheric models are being constantly improved with the inclusion of more detailed physical schemes and with the assimilation of in-situ and remote sensing data. This effort results in more detailed representations of the atmospheric physical processes, in accordance with the in-situ (surface stations and airborne) and remote sensing (surface and satellite observations). In general, the most crucial parameter for the emission of dust is the near-surface wind. Increased wind speeds may occur due to synoptic wind forcing, topographic effects (e.g., valley channeling), low-level jets (LLJ) squall lines and storm downdrafts. Most of the above processes result in detached elevated dust plumes over the Mediterranean. Most dust layers in the area are observed at heights of 4–5 km in the troposphere and are associated either with Mediterranean low-pressure systems or with the summer anticyclonic circulation over north Africa. When the plumes reach mainland, their transport over complex terrain can be strongly affected by local wind patterns (e.g., Foehn flows). The description of surface dust emissions also plays a major role in mineral dust research. The development of assimilation methods for including satellite observations in model fields replaces the earlier static dust source maps with dynamic satellite-based emissions maps, allowing a physically based representation of seasonal and annual variations of dust-source strength. Hyperspectral retrievals of soil mineralogy are also implemented in dust models for the description of different types of dust minerals. Additionally, 3D-Var assimilation of dust Aerosol Optical Depth from satellite retrievals is also used for nudging the simulated fields towards the observational satellite values. An overview of the aforementioned physical processes and associated theoretical model developments, as well as the current status of knowledge regarding dust physics in the atmosphere will be discussed.

Acknowledgment Stavros Solomos acknowledges support by the Hellenic Foundation for Research and Innovation project MegDeth (HFRI no.703)

References

1. Nickovic, S., Kallos, G., Papadopoulos, A., and Kakaliagou, O.: A model for prediction of desert dust cycle in the atmosphere, J. Geophys. Res., 106, 18113–18129, 2001.
2. Solomos, S., Kallos, G., Kushta, J., Astitha, M., Tremback, C., Nenes, A., Levin, Z.: An integrated modeling study on the effects of mineral dust and sea salt particles on clouds and precipitation, Atmos. Chem. Phys., 11, 873–892, doi:10.5194/acp-11-873-2011, 2011
3. Solomos, S., Kallos, G., Mavromatidis, E., Kushta, J.: "Density Currents as a Desert Dust Mobilization Mechanism", Atmos. Chem. Phys., 12, 11199–11211, doi:10.5194/acp-12-11199-2012, 2012
4. Solomos, S., Kalivitis, N., Mihalopoulos, N., Amiridis, V., Kouvarakis, G., Gkikas, A., Binietoglou, I., Tsekeri, A., Kazadzis, S., Kottas, M., Pradhan, Y., Proestakis, E., Nastos, P.T., Marenco, F. From Tropospheric Folding to Khamsin and Foehn Winds: How Atmospheric Dynamics Advanced a Record-Breaking Dust Episode in Crete. Atmosphere 2018, 9, 240., 2018
5. Spyrou, C.; Solomos, S.; Bartsotas, N.S.; Douvis, K.C.; Nickovic, S. Development of a Dust Source Map for WRF-Chem Model Based on MODIS NDVI. Atmosphere 2022, 13, 868. https://doi.org/10.3390/atmos13060868

`S10-MG-100` / **Oral presentation**

Studying the Natural and Anthropogenic Factors of Climate Change

Authors: Ekaterina Batchvarova[1]; Yavor Chapanov[1]; Natalia Kilifarska[1]; Katya Georgieva[1]; Vesselin Alexandrov[1]; Damyan Barantiev[1]; Tsvetelina Velichkova[1]

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Presenter: E. Batchvarova (`ekbatch@gmail.com`)

A project titled "Natural and anthropogenic factors of climate change – analyzes of global and local periodical components and long-term forecasts" funded by the Bulgarian National Science Fund allows us to review and stream studies of Bulgarian scientists in order to identify the role of natural and anthropogenic factors causing climate change in global or regional scale. The Natural factors act in long time and show long-term periodicity, while the anthropogenic influence records are only of hundred or tens of years duration. Traditionally, the paleoclimates are field of geological research, solar-terrestrial relations are field of physicists and anthropogenic records of meteorological and atmospheric composition parameters are field of variety of professions. In this project we look for links and analogies among these different fields of research, but also perform studies in the different fields. A model of Kilifarska et al relates the near surface temperatures with ozone content

in the lower troposphere, which depends on the penetration of cosmic rays and solar winds. Chapanov is studying climate and solar parameters records spectra and founds common periodicity. Alexandrov et al perform research on the climatological data available in Bulgaria and on some climate projections data. Barantiev et al study local coastal climates of the wind and turbulence vertical profiles.

Acknowledgement National Science Fund of Bulgaria, Contract KP-06-N34/1, Natural and anthropogenic factors of climate change - analyzes of global and local periodical components and long-term forecasts.

References

1. Alexandrov, V.A., Slavov, N.. in Drought in Bulgaria: A Contemporary Analog for Climate Change, Drought impacts on crops Book Chapter. Published August 23, 2018 by Routledge, 2018, ISBN:9781138622074, 157-170.
2. Barantiev, D., Batchvarova, E.. Wind Speed Profile Statistics from Acoustic Soundings at a Black Sea Coastal Site. Atmosphere, 12, 9, Multidisciplinary Digital Publishing Institute (MDPI), 2021, ISSN:2073-4433,
DOI:https://doi.org/10.3390/atmos12091122, 1122.
3. Barantiev, D., Batchvarova, E., Hristina Kirova, Orlin Gueorguiev. Climatological Study of Extreme Wind Events in a Coastal Area. In: Dobrinkova N., Gadzhev G. (eds) Environmental Protection and Disaster Risks. EnviroRISK 2020. Studies in Systems, Decision and Control, 361, Springer, Cham., 2021, ISBN:978-3-030-70189-5, DOI:https://doi.org/10.1007/978-3-030-70190-1_5,
Chapanov Y.. Anthropogenic and Solar Influence on Temperature over Bulgaria. Studies in Systems, Decision and Control, 361, Springer, 2021, ISBN:978-3-030-70190-1, DOI:https://doi.org/10.1007/978-3-030-70190-1_6, 75-89.
4. Kilifarska, N, Velichkova, T, Batchvarova, E. From phase transition to interdecadal changes of ENSO, altered by the lower stratospheric ozone. Remoth Sensing, 13, MDPI, 2022, ISSN:2072-4292.
Shiokawa, K., Georgieva, K.. A review of the SCOSTEP's 5-year scientific program VarSITI—Variability of the Sun and Its Terrestrial Impact. Progress in Earth and Planetary Science, 8, 1, Springer Open, 2021, ISSN:21974284, DOI:0.1186/s40645-021-00410-1.
5. Velichkova, Tsvetelina, Kilifarska, Natalya Obridko, V. N., Abunin, A.A., Georgieva, K., Kirov, B., Shelting, B.D., Livshits, I.M.. Some Features of the Present-day Transition Period in Solar Activity. Geomagnetism and Aeronomy, 60, 8, Pleiades Publishing, Ltd, 2020, ISSN:0016-7932, DOI:10.1134/S0016793220080186, 1007-1016.

`S10-MG-101` / **Oral presentation**

Preliminary results of the radioactive debris dispersion investigation after a hypothetical nuclear accident at Akkuyu Nuclear Power Plant

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Presenter: I. Christodoulakis (`physjohn@yahoo.gr`)

One of the most important difficulties in the fight against the environmental pollution and its consequences (burden on human health, climate change and others) is the development of alternative electric power sources in the place of the polluting electric power plants consuming fossil fuels. Nuclear power and nuclear plants are one of these alternatives which present a lot of advantages like they do not produce air pollutants nor greenhouse gases, the power production is controlled so it can be synchronized to power needs and is affordable. The main disadvantage is the damage which can be caused by a nuclear accident. According to nuclear accident's conditions the damage may be distributed to areas far enough from the place of the accident. A main precaution against such an accident is the ability to predict which areas will be affected by the radioactive debris exposed by the nuclear accident. At Akkuyu, Turkey, it is constructed the first Turkish nuclear power plant which will cover around 10% of country's electric power needs. In the framework of this study, they are investigated different scenarios about the dispersion of the radioactive debris which will be exposed in the atmosphere after an explosion. The investigation is based on the SNAP (Severe Nuclear Accident Program) model and meteorological conditions met at the specific area. The last version of the SNAP model has been developed so it can be applied for simulating dispersion of radioactive debris from nuclear accident as well as to simulate movement of the radioactive cloud from nuclear explosion. In addition, the model can be used for estimating three-dimensional trajectories from arbitrary point in the model domain. The obtained results for different cases of nuclear accidents and meteorological conditions is going to be presented.

`S10-MG-102` / **Oral presentation**

Probability seismic hazard analysis (PSHA) for Eastern Macedonian Seismogenic zone

Author: Ljubcho Jovanov[1]

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Presenter: L. Jovanov (`ljubco.jovanov@hotmail.com`)

The aim of this research was to analyze the earthquake hazard of the Eastern Macedonian seismogenic zone by determining the a and b values in Gutenberg-Richter law. For this purpose, the previously known division of the zone to six epicentral areas was used. The b and a values were calculated for the epicentral areas where the seismic data permits, using the least square method. Using these values, the mean return period, the most probable maximum magnitude in t year time period and the probability for an earthquake occurrence with magnitude $\geq M$ within time span of t years were estimated too. Furthermore, maps with spatial variations of the parameters will be provided.

S10-MG-103 / **Oral presentation**

A preliminary analysis regarding the impact of rainfall erosivity on arable irrigated and non-irrigated lands in Romania

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Presenter: B. Kobulniczky (bela.kobulniczky@ubbcluj.ro)

The rainfall affects the condition of arable land and its agricultural productivity. This study aims to analyze the impact of rainfall erosivity on irrigated and non-irrigated arable land and to create relevant statistics on the differences observed over specific periods in Romania. The database is made up of historical data on rainfall erosivity from the European Soil Data Center in conjunction with land use data from Land Copernicus.

S10-MG-104 / **Oral presentation**

A Correct Parameter for Climate Change Estimation

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Presenter: S. Mijović (smijovic@yahoo.com)

Although the Intergovernmental Panel on Climate Change (IPCC), the United Nations body for assessing the science related to climate change, gives clear quantitative pictures about climate change and increasing the mean Earth's temperature due to increasing greenhouse gas concentration, the general public concern and scientific debate still continue [1]. A clear identification of the antropgenic signal in climate observations reduces the present scientific uncertainities regarding magnitude and form of anticipated climate change and provides a more reliable quantitative basis for development of rational political abatement and adaptation strategy [2]. But as K. Hasselman, Nobel Laureate for physics in 2021, said, the detection problem is often viewed as a task of identifying the most sensitive climate index, from a large set of potentialy available indices, for which the anticipated antropogenic climate signal can be most readily distingwished from the natural climate noise. Global or regional mean surface temperature, vertical temperature differences, sea ice extent, sea level change, and integrated deep ocean temperatures are examples of indices.

In this work is shown that, the mean Earth's surface temperature as the key variable for estimation the climate change has actually small significance in estimation of the global change. The reason for that is because of high non-linearity dependences of Earth's cooling on local Earth's temperature and the linear way of calculating the mean Earth's temperature. So, the local temperature to power fourth will be more reliable parameter for climate change estimation.

References

1. IPCC Global Warming of 1.5 °C, Special Report, 2018 https://www.ipcc.ch/sr15/
2. Scientific Background on the Nobel Prize in Physics 2021 "FOR GROUNDBREAKING CONTRIBUTIONS TO OUR UNDERSTANDING OF COMPLEX PHYSICAL SYSTEMS" https://www.nobelprize.org/uploads/2021/10/sciback_fy_en_21.pdf

S10-MG-105 / **Oral presentation**

Response of geomagnetic field related to atmospheric composition

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Presenter: K. Peqini (klaudio.peqini@fshn.edu.al)

There is a growing amount of evidence of possible connections between the geomagnetic field and ozone production in the lower stratosphere. They emphasize the control the geomagnetic field can exercise on production and distribution of ozone, thus inflicting minor changes in climate patterns. In the present study we investigate such connection for other atmospheric gases, namely water vapor. The last gas is related to near-surface temperatures; here we investigate if the possible connections with the near-surface geomagnetic field. We have used the CHAOS field model producing internal magnetic field at different altitudes, covering the whole of Earth's surface. The important implications are discussed.

S10-MG-106 / **Oral presentation**

Long term analyses of the Tirana's extreme daily precipitation

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Presenter: T. Porja (tanjaporja@meteoalb.com)

Urban flooding in Albanian are mostly consequence of extreme daily precipitation that very often causes a huge economical and social impact. Events of extreme daily precipitation, mainly their frequency and severity play an important role and also control the long-term variation of the seasonal and annual precipitation amounts. To have a long term trend of the phenomenon and to point out the variation of some important precipitation indices, a multi annual analyses of this phenomenon is needed. There are many methods to classify a daily precipitation event as an extreme phenomenon but, it would be more objective to analyze the longest possible data series of the daily precipitation, for a given area. A good method may be the estimation of an extreme precipitation threshold or building the sub-series of the annual maximum 1-day precipitation and the monthly maximum 1-day precipitation for the longest possible period of the area of the interest. In this study, analyses of the annual total precipitation (PRCPTOT); annual maximum of 1-day precipitation (Rx1-Y) and the monthly maximum of 1-day precipitation (Rx1-M) were done for Tirana, the capital city of Albania. Analyses cover a period of 72-years and the results present some important indicators of the extreme precipitation in Tirana regarding their multi annual behavior. These indicators may be used as objective tools to develop new strategies on flood risk reducing of many similar urban areas in Albania.

`S10-MG-107` / **Oral presentation**

Evaluation of NOTHAS performance in assessing initiation and evolution of a various scale convective systems

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The predictability of mesoscale convective phenomena is limited by the rapid transfer of energy between the large-scale and microscale as the result of the initial conditions, the natural constraints imposed by synoptic-scale forcing, and physical processes. Uncertainties are the greatest challenge when predicting the initiation of convection as the most difficult aspects of convection, due to the complexity of small-scale atmospheric processes. To reduce and minimize the possible errors and forecast uncertainties, the NOvel THunderstorm Alert System (NOTHAS) is developed as a dynamic and diagnostic tool for predicting local-scale phenomena across the specified region up to 72 hours in advance such that it combines various microphysical parametrizations, schemes, and convective parameters by taking the maximum hourly-based local scale signal driven from the NCEP-GFS (or ECMWF)

forecasting model and utilizing the WRF model configuration to produce the model hourly outputs. It is adapted to the algorithm based on the probability concepts of the multivariate distribution to estimate the uncertainties under the sharpest threshold criteria and afterward integrated into the main function to obtain the expected output. The flexibility of applying different schemes, and parametrizations, and adapting them to the WRF system implies the NOTHAS capability to run different domains under a single or nested domain under the different horizontal grid lengths. The NOTHAS has been heavily tested over the last three years with the several severe mid-latitude and tropical storm case scenarios, producing a high level of accuracy and being in alignment with the observed thunderstorm activity hours ahead. The excellent model performance of the model is verified under the statistical and scientific guidelines of the World Meteorological Organization.

S10-MG-200 / **Poster presentation**

Evaluation of low-cost air quality measuring devices - Klimerko

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Presenter: N. Aleksandrov (nedaaleksandrov@yahoo.com)

The problem of pollution in Serbia is severe. In winter, concentrations of PM2.5 and PM10 often exceed the permitted values. In addition to official automatic stations for measuring air quality, it is useful to have low-cost sensors that are available to everyone. The benefit of this type of measurement lies in the fact that in addition to understanding the overall problem of pollution, low-cost sensors allow citizens to know at any time how polluted the air in their environment is. Klimerko is a low-cost sensor that measures air quality data, such as the concentration of PM1, PM2.5, and PM10 every 15 minutes. It also measures meteorological parameters like Temperature, Humidity, and Pressure. PMS7003 Sensor is used for air quality measurements whereas BME280 Sensor is used for meteorological measurements. In this research, the goal was to detect how well Klimerko devices measure the concentration of pollutants compared to official automatic stations. Klimerko devices installed in Bor and Nis were observed. Klimerko data in the period from February 1 to February 28, 2022, were analyzed. Measurements from Klimerko stations were compared with measurements from the nearest official station. The data from official stations were provided by the Serbian Environmental Protection Agency (SEPA). The initial step in data analysis was to prepare the data. That includes filtering the data - making decisions on how to treat missing or invalid values. The next step was determining data completeness for every device and its distance to the official station. Devices that had over 90% of valid data for the observed period and were at a distance of up to 1 km in relation to the SEPA station were taken into consideration. Then, the daily mean, maximum, and minimum values of PM2.5 and PM10 between Klimerko devices and official stations were compared. It was concluded that there is a qualitative agreement in the measured data with Klimerko

and the nearest SEPA station. Also, it was found that Klimerko devices measure a slightly higher daily concentration of PM2.5 and PM10 compared to the SEPA station.We also calculated the correlation coefficients for PM2.5 and PM10 particles between Klimerko and SEPA stations. It was found that there is a significant correlation between Klimerko and SEPA stations in Bor and Nis for both pollutants. The coefficient values ranged from 0.62-0.95 for PM2.5 and 0.48-0.91 for PM10.

S10-MG-201 / **Poster presentation**

Investigation of the Dst variations in X component at mid latitudes during geomagnetic storm in 3 February 2022

Author: Rumiana Bojilova[1]

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Presenter: R. Bojilova (rbojilova@geophys.bas.bg)

The main idea of this study is to investigate the Dst variations in the X component of the Earth's magnetic field and their latitudinal distribution in the conditions of geomagnetic disturbance in February 3, 2022. For this purpose, data from the world database of geomagnetic observatories INTERMAGNET were used. Three sectors have been selected: (i) East Europe, (ii) West Europe, (iii) East Asia, which meet the requirement for a sufficient number of stations close in longitude and magnetic longitude. For each sector, changes in the X component were considered and Sq variations were previously removed, based on data for 5 quite days determined by the Helmholtz Center Potsdam, GFZ German Research Center for Geosciences. The results allow to propose a methodology for filtering Dst variations in the X component for the considered geomagnetic observatories. In the concluding part of this work, an analysis of the relationship between variations in the X component and the equatorial ring current represented by Dst is proposed. The obtained linear regression coefficients for each of the sectors show the well-known dependence, expressed in the reduction of the influence of Dst on the changes in the X component as it moves from the equator to higher northern latitudes.

S10-MG-202 / **Poster presentation (virtual)**

Tsunami Numerical Modelling in the Eastern Ionian Sea

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Presenter: L. Dimova (`lyuba_dimova@phys.uni-sofia.bg`)

This study is an attempt to identify several tsunamigenic sources located offshore in the vicinity of Peloponnese Peninsula, Kefalonia and Lefkada. Ionian Sea is surrounded by major geological structures, like the Hellenic and the Calabrian subduction zones and in addition its lithosphere is submerging beneath Eurasian tectonic plate. These tectonic features are the main cause for devastating earthquakes and tsunami waves. In the seismic history of the Ionian Sea there are several strong earthquakes that generated tsunami waves in the southern Peloponnese 1867 (Ms7.1), Ithaca Island 1915 (Ms6.7), north of Kefalonia 1948 (Mw6.5) and Lefkada 2015 (Mw6.5). Considering several seismic sources located in the eastern Ionian Sea in agreement with the European Database of Seismogenic Faults we present results of numerical simulations of the tsunami generation and propagation using the model UBO-TSUFD (Tinti and Tonini, 2013). The code is based on the nonlinear shallow-water equations of Navier-Stock. Okada‘s method (1985) is used to compute the initial tsunami elevations. Known focal mechanisms associated with recent earthquakes are selected for the hypothetical tsunamigenic scenarios. Tsunami simulations results are shown as maximum water elevations and propagation fields. The contribution of all scenarios along the Peloponnese, Kefalonia and Lefkada is studied via synthetic mareograms. The water column on the coastline is computed and presented as simplified colored map.

Acknowledgements: The first author would like to thank the Tsunami Research Team from University of Bologna for the opportunity to work with UBO-TSUFD. This paper was supported by the project CP-06-COST-7/24.09.2020 "Tsunami Hazard Assessment in the Southeastern European region", funded by BNSF. The first author (LD) contributed to the European Cooperation in Science and Technology COST project "AGITHAR-Accelerating Global science In Tsunami HAzard and Risk analysis".

`S10-MG-203` / **Poster presentation**

Determination of maximal expected magnitude of the main neotectonic zones in North Macedonia

Author: Katerina Drogreshka[1]

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Presenter: K. Drogreshka (`katerinadrogreska@yahoo.com`)

Determination of the maximal expected magnitude (*Mmax*) of future earthquakes is one of the most important part of seismic hazard and risk assessment. In this

research, an attempt for determining the *Mmax* of the three neotectonic zones in North Macedonia was made, based on available seismological data for last 42 years. Two approaches were used: first one determining *Mmax* using the magnitude-frequency relationship (Gutenberg-Richter law) and the second one using the sum of energy released by earthquakes (Benioff diagram).

S10-MG-204 / **Poster presentation**

Spatial distribution of the magnetic disturbances at European midlatitudes during substorms: case study

Authors: Veneta Guineva[1]; Rolf Werner[1]; Rumiana Bojilova[2]; Atanas Atanassov[1]; Lyubomira Raykova[1]; Dimitar Valev[1]

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Presenter: V. Guineva (v_guineva@yahoo.com)

This work is aimed to study the spatial distribution of the magnetic field components variations during substorms. In this purpose, two isolated substorms, the substorm on 22 March 2013 at ~23:12 UT and the one on 14 January 2016, with central meridian over Europe have been chosen. Magnetic field data from INTERMAGNET, SuperMAG and IMAGE databases have been used. The X and Y variations due to the substorms were computed for 50 stations based on the developed programs. Maps of the spatial distribution of the magnetic variations have been created and some characteristics as the line of sign conversion latitude, the central meridian, the longitudinal and latitudinal extent of the positive bays and the latitudinal and longitudinal dependence of the variations at the time of the midlatitude positive bay maximum at Panagjurishte (PAG) and some other basic moments of the substorm development have been estimated. The midlatitude local time profiles for these events have been constructed. The European midlatitude positive bay (MPB) index has been computed.

Acknowledgements: This study was supported by the National Science Fund of Bulgaria (NSFB) (project number КП-06-Русия/15) and by the RFBR (project number 20-55-18003).

S10-MG-205 / **Poster presentation (virtual)**

A case study of high PM concentration despite the low anthropogenic pollution in March 2020 during the first COVID-19 lockdown in Sofia

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Presenter: N. Kolev (`nic_k@abv.bg`)

The aim of this study is to investigate the atmospheric air quality in Sofia during a 2-week period in the beginning of the first COVID-19 lockdown in March 2020. Observations of the aerosol distribution measured with two laser particle counters for PM2.5 and PM10 on clear sunny days (7 a.m. to 2 p.m.) at a site inside the built area near the bus stop Pliska on the Tsarigradsko shose during 16-31 March 2020 are presented. Mass and particle number concentrations of PM with high temporal resolution are compared with the data reported by Executive Environmental Agency monitoring network. In the beginning of the period the concentrations of PM10 vary between 20 and 80 μg/m3 with a peak around 9 - 10 a.m and PM2.5 concentrations reach 30 μg/m3. On 28 March at 9 a.m. the PM10 and PM2.5 concentration raise up to 250 μg/m3 and 175 (μg/m3), correspondingly. This abrupt change in the aerosol content in the atmosphere is explained not with anthropogenic load, but with long range dust transport from the Karakum desert region (located between the eastern coast of the Caspian Sea and the steppes near the central Asian mountain ranges), which is a very rare event of intrusion compared to the typical in spring Sahara dust transport. The HYSPLIT back trajectory model is used as additional source of information in the selected days, showing transport in the layer 1000 m – 3000 m from North-West until 26 March and from East on 27-29 March. The GDAS boundary-layer depth at 12 UTC is between 1000 m and 1600 m which suggest intrusion from above during the period. These model data are compared to local meteorological and aerological observations. This study shows the importance of detailed in time laser particle counter observations of PM10, PM2.5 and finer particles for better explanation of causes for the low air quality in urban atmosphere.

`S10-MG-206` / **Poster presentation**

Verification of EBU-POM regional climate model using E-OBS and ERA5-Land dataset over Pannonian Basin

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Presenter: I. Lazic (`irida.lazic@ff.bg.ac.rs`)

The direct approach to model evaluation is to compare regional climate model (RCM) output with observations and analyze the resulting difference in order to identify deficiencies in the model itself which can be reduced by its improvement or taken into

account for understanding and interpretation projections of future climate change. In previous studies, it was noticed that most of EURO-CORDEX RCMs tend to overestimate the mean near surface air temperature and underestimate the precipitation in the Pannonian Basin during summer [1], leading to so-called summer drying problem [2]. Our intention for this study is to check does dry and warm bias is also present in the results of fully coupled atmospheric-ocean RCM EBU-POM [3]. The gridded observational dataset of E-OBS for the daily mean near surface air temperature and daily precipitation with horizontal resolution 0.11 degree (approximately 12 km) is used in the evaluation of the model for time period 2000-2010. Also, in order to further investigate the reason of warm and dry bias in EBU-POM model, we verified soil moisture content, heat fluxes, evaporation and runoff against gridded ERA5-Land dataset for selected time period.

Model skill for selected time period was expressed in term of three verification scores: BIAS, root mean square error (RMSE) and spatial correlation coefficient. Finally the calculated scores are averaged over Pannonian valley. From wider Pannonian Basin region bounded by longitudes, 14°E and 27°E, and latitudes, 43.5°N and 50°N we elect the sub-domain in the centre of this longitude-latitude box, in which topography elevation is below 200 m, and it is introduced to eliminate impact of scores obtained over surrounding mountains on average score value for Pannonian valley. To create compact sub-domain, few exceptions from elevation constrain was made. Visualization of the verification results was done using Taylor diagram.

According to the results, in summer season during evaluation period, warm and dry bias exists. To better understand the sources and reasons for summer drying problem further research is needed such as testing the hypothesis that the biases are related to a false representation of soil properties in this region.

References

1. Lazić, I., Tošić, M., & Djurdjević, V. (2021). Verification of the EURO-CORDEX RCM Historical Run Results over the Pannonian Basin for the Summer Season. Atmosphere, 12(6), 714.
2. Kotlarski S. et al., (2014): Regional climate modelling on European scales: a joint standard evaluation of the EURO-CORDEX RCM ensemble. Geoscientific Model Development 7:1297–1333, doi: 10.5194/gmd-7-1297-2014
3. Djurdjevic, V. and Rajkovic, B. (2010), Development of the EBU-POM coupled regional climate model and results from climate change experiments, In: Advances in Environmental Modeling and Measurements, Editors: T. D. Mihajlovic and Lalic B., Nova Publishers.

S10-MG-207 / **Poster presentation**

Seasonal distribution of lightning over Bulgaria and Black Sea and its relationship with sea surface temperature

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Presenter: R. Mitzeva (`rumypm@phys.uni-sofia.bg`)

In this work the seasonal – diurnal variations of lightning over two different areas: continental (Bulgaria) and maritime (Black Sea) are analyzed based on a 10 year long dataset (March 2005-February 2015) provided by the ZEUS lightning detection network operated by the National Observatory of Athens. The number of recorded flashes and the flash density at time intervals (annual, seasonal, monthly and 3-hours) in grid boxes of 0.25x0.25 degrees over land and sea are determined. Analysis of the spatio-temporal distribution of the number of flashes and of the flash density highlights the locations and moments with maximum lightning activity over Bulgaria and the Black Sea for each season. The results show that during autumn (September, October and November) the flash density is higher over the Black Sea than over the land surfaces of Bulgaria, while during the other seasons the situation is inverted. These results lead to the next task in the present work: to investigate if there is a relationship between lightning activity and sea-surface temperature (SST) on the Black sea during autumn. For the analysis sea surface temperature (SST) retrieved from the ERA5 reanalysis of the European Centre for Medium-Range Weather Forecasts, for the autumn days in the period 2005-2014, valid at 0000UTC, 0600UTC, 1200UTC, 1800UTC, are used. The analysis reveals that the mean and median of SST over the Black Sea in autumn are higher for the cases when lightning occurred than when it was absent.

`S10-MG-208` / **Poster presentation (virtual)**

Advanced Broadband DIAL Sounder of Methane

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Methane is a powerful greenhouse biogas that plays a key role in several atmospheric environmental domains affecting the current enhancement of the greenhouse effect. It has been the cause of about 20% of the increased trapping of atmospheric infrared radiation during the past 200 years. In addition, it affects the oxidizing capacity of the atmosphere and, therefore, the lifetimes of other strong greenhouse gases. The trends of growing emissions from industrial zones and the rapidly melting permafrost of Northern America, Europe and Asia nowadays raise great concern. The development of remote sensors of methane, especially over facilities of peak concentrations, such as sewage treatment and biogas production plants is highly demanded.

The optical remote sensing has the advantage of obtaining selective analytical information unaffected by systematic external influence, e.g., disturbing electric fields, moisture, heat, multi- component gas mixtures, etc. We advanced pioneering studies in this research area to realize an effective differential absorption lidar (DIAL), which operates with broadband lasers thus replacing their narrowband counterparts [1-3]. DIAL is also advantageous in retrieving range-resolved data about the atmospheric content of methane unattainable by in-situ analysers.

The DIAL technique developed in our study utilizes the spectral properties of powerful broadband laser diodes matching the strong molecular vibration-rotational absorption bands of methane around 1.65 μm. The conventional scheme of differential absorption on dual wavelengths "On" and "Off" an absorption line is replaced with the ratio of confined segments of the integral absorption spectrum. The detected signal is a function of the absorption line strengths instead of the amplitude of the separate line subjected to pressure-broadening. Since the absorption spectra of methane are generally mixed with interfering spectra of water vapor, an optimal approach to DIAL measurement is needed that is insensitive to atmospheric humidity.

A solution based on multiplexation of the radiation of a single powerful laser diode in complementary spectral channels is proposed equalizing the absorption by water vapor in the range of the broad laser line. The high-resolution spectra of methane and water vapor are derived from HITRAN database of molecular absorption. Such lidar of compact design, reliable operation, low energy consumption and great dynamic range of sensitive measurement is promising for uses in mobile and airborne ecological surveillance of methane emissions, particularly over hardly-accessible regions, as well as, for gas pipeline control and reconnaissance of energy resources.

Acknowledgments: This research was funded by the Ministry of Education and Science of Bulgaria (support for ACTRIS BG, part of the Bulgarian National Roadmap for Research Infrastructure).

References:
1. S. Penchev et al., Comptes rendus de l'Académie bulgare des Sciences. 65 (5), 669 (2012).
2. B. Thomas et al., App. Phys. B. 113, 265 (2013).
3. B. Thomas et al., J. Mol. Spec. 291, 3 (2013).

S10-MG-209 / **Poster presentation**

Preliminary results on the multifractal nature of the main geomagnetic field

Authors: Dod Prenga[1]; Klaudio Peqini[1]; Rudina Osmanaj[1]

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Presenter: K. Peqini (klaudio.peqini@fshn.edu.al)

The external geomagnetic field is known to exhibit multifractal behavior as deduced by analyzing the extensive magnetic field time series. Usually the internal magnetic field is not discussed because its changes occur with a much longer time scale. However, one can make use of the existing palaeomagnetic measurements of the dipolar (internal) field that offer a broad view on the geological past. We have analyzed two series that offer a view of the magnetic dipole for the last 4 million and 2 million years respectively. The multifractal nature is determined by analyzing the Hurst exponent through the Multi Fractal - Detrended Fluctuation Analysis method. Also, we have studied the time evolution of the Hurst exponent for each series. The respective discussions are made for each case.

`S10-MG-210` / **Poster presentation**

Autumn - diurnal variation of lightning over Black Sea and Bulgaria

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Presenter: S. Petrova (`asavita@phys.uni-sofia.bg`)

Studies of the global distribution of lightning show that the annual number of lightning over land is higher than over the sea. However some research reveals that lightning activity is different over various geographical locations and highly variable on timescales (annual, seasonal, monthly and daily). It is of interest to analyze the spatial and temporal distribution of lightning for specific geographical areas with different surfaces: land and sea. According to the results of our previous work summer-time flash density for each of the analyzed years (from 2005 to 2014) is higher over Bulgaria than over the Black Sea, while diurnal variation of flash density shows that during the night and morning hours lightning activity is higher over the Black Sea. The aim of present work is to analyze the land-sea contrast in the lightning activity over Bulgaria and the Black Sea in the autumn. The lightning data during autumn period (September, October and November) for 10 years will be used. Data for the time and the position of lightning are provided by the ZEUS network (operating at the National Observatory of Athens - NOA). The work will reveal for the **autumn** period: i) the difference in monthly and diurnal variations of flash density over land (Bulgaria) and over maritime area (Black Sea), ii) locations and moments with maximum lightning activity over the studied areas.

S10-MG-211 / **Poster presentation**

Three decades of heat waves and extreme precipitation in Albania

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A few change in the global mean temperature and noticeable changes were observed in some elements of the climate around the world. One of the most popular derivatives of the global warming is the increase of the frequency of extreme weather phenomena. The most popular extreme weather events observed in the Albanian territory during the last three decades are the days of high precipitation intensity and the summer heat waves events. Very often, each one of the phenomenon and/or one after another, have caused a significant impact in the economy and life activity of the Albanian society. With the aim to better manage the negative impact any time the extreme weather events happen and to minimize the losses, a better knowledge of each phenomenon is needed. More concrete, during the three last decades there are signals of an increasing tendency of the extreme weather in general and to have a clear trend of both the phenomena, a long-term analyses should be performed for both of them. To determine a phenomenon as an extreme weather event, different authors have used many methods. A good method may be the estimation of some important indicators as the trend and the frequency in long-term periods of the heat waves and daily intense precipitation. For this reason, this study is based on the estimation and analyses of some extreme indices of heat waves as the HWF, HWD, HWS, HWI and HWP while for the extreme daily rainfall, estimated and analyzed indices are the SDII, CWD, PRCPTOT, RX1day, R100mm and R150mm during the last 30 yrs period. Daily data of both air temperatures and precipitation were used to estimate the above indices and their analysis reveal some useful information that may be used as an important tool to improve the strategies of risk reduction of the flooding and heat waves in the urban areas.

S10-MG-212 / **Poster presentation**

Evolution in the Semantics of the Term 'Climate'

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Presenter: N. Takuchev (nnnppptttt@gmail.com)

Introduction. Trying to find out what should be understood by 'climate', the inquisitive reader is surprised by the lack of sufficient clarity about the content of this concept even today, although the term was used in antiquity and literally translated from Greek means "slope" (of the Sun's rays relative to the Earth's surface). The purpose of the study is to trace the formation of the content included in the concept of climate from antiquity to the present day. Results. Concepts underlying the understanding of the concept of climate, such as a phenomenon, property, weather, regime, and their characteristics as an element, climatic norm, course of the element, state and statistical ensemble, are clarified. Examples are given from antiquity (staring with Hippocrates) to the present day (WMO, NASA, IPCC) of the content included in the concept of climate. The suitability of the examples is critically discussed in light of the previously clarified concepts. Conclusions. According to the author, the problem with the shortcomings of the notions of climate cited in the work is the lack of explicit clarification of the role of the observer. When 'climate' is considered a four-dimensional space-time phenomenon, an appropriate climate description is: "Multiannual weather regime". As the weather is a local phenomenon, it is understood that this description applies to local climates. The description does not imply the presence of an observer, i.e. it is suitable both for the Earth's climate – from the distant past, through the present to the distant future, and for those on other planets. If it is implied presence of an observer examining the environment by measurement, the climate is considered as a characteristic of the weather conditions, and in this case, an appropriate notion of climate as a characteristic may be proposed as "a set of climatic norms calculated over a multiannual interval, for example, 30 years, on the measured values of the elements characterizing the weather".

References

1. Hippocrates, On air, water, and places, written around 400 BC. http://classics.mit.edu/Hippocrates/airwatpl.mb.txt, visited May 2022
2. WMO, GLOBAL ATMOSPHERIC RESEARCH PROGRAMME (GARP), Publications Series No.16, 1975. Global Atmospheric Research Program, the Physical Basis of Climate and Climate Modeling, https://library.wmo.int/doc_num.php?explnum_id=7112 visited May 2022
3. IPCC, 2013: Annex III: Glossary [Planton, S. (ed.)]. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
4. NASA, www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html, visited May 2022

S10-MG-213 / **Poster presentation**

The evaluation of vulnerability to extreme climate events over Balkan Peninsula using modified Climate Extremes Index

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Co-authors: Neda Aleksandrov [1]; Vladimir Djurdjevic [1]; Irida Lazic [1]; Darko Savic [1]

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Presenter: M. Tosic (milica.tosic@ff.bg.ac.rs)

Assessing the variability of climate extremes in changing climate is one of the greatest and most important challenges in climate science, not only because these events are rare, but also because they can be accompanied by devastating consequences. Climate change in the future could lead to an increase in the frequency, intensity and duration of extreme events and the greatest impact on the global ecosystem will be manifested through extreme weather events.

A climate index is defined as a calculated value that can be used to describe the state and the changes in the climate system. By using such climate indices, we are able to perform statistical analyses of variations of the dependent climatological aspects, such as analysis and comparison of time series, means, extremes and trends and to better understand current and future exposure to combined extreme climate conditions.

Previous studies mostly focused on single extreme events, but in order to explain the combined impacts and future exposures to have comprehensive knowledge, we also need to examine the concept of combining extreme events. The aim of this study is to estimate exposure to the aggregated climate extremes in historical and future climate.

In this study we used the modified Climate Extremes Index (mCEI) which was developed by Kelebek et al. (Kelebek et al. 2021) for spatiotemporal analyses of climate extremes. The domain of our study is focused on the Balkan peninsula, because this area is marked as one of the major hotspots for the combined extremes. For the calculation of the annual and seasonal values of mCEI we first calculated ten different percentile based climate indices, including temperature and precipitation indices of extremes and drought indicator (scPDSI). Each of the percentile values is calculated using the 1961–1990 standard reference period. We used E − OBS observational gridded dataset with horizontal resolution 0.1 degree, for historical period, and EURO-CORDEX Project database, for future projections. For the annual and seasonal time series, the trend of the index was computed and tested for statistical significance using the nonparametric Man-Kendall test and the Sen's slope estimator. The individual change of each index integrated in mCEI was analysed to better understand the drivers of the final mCEI.

We conclude that mCEI is a very useful tool because it assimilates the effects of different extreme climate conditions in one combined index. We found that our re-

search area has experienced an increase in extremes in recent decades and, according to scenario RCP8.5 for climate projections, an upcoming change that exposure to these extremes is expected to exceed in the future and become more vulnerable to climate extremes.

Kelebek, M.B., Batibeniz, F. and Önol, B., 2021. Exposure assessment of climate extremes over the Europe–mediterranean region. Atmosphere, 12(5), p.633.

S11-EPASE
Environmental Physics – Alternative Sources of Energy

S11-EPASE-100 / **Oral presentation**

Mineral Dust Single Scattering Albedo and Radiative Effects Based on DREAM Model

Author: Maja Kuzmanoski[1]

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Presenter: M. Kuzmanoski (maja.kuzmanoski@ipb.ac.rs)

Mineral dust is the most abundant aerosol, with the largest contribution to global aerosol mass load and significant aerosol optical depth [1]. Dust affects the Earth's radiative balance directly, through interaction with solar and terrestrial radiation, and indirectly, altering the optical properties and lifetime of clouds. There are still uncertainties in model estimates of dust radiative effects, partly due to variability in its mineral composition and shape of its particles, which are not accounted for in models [2]. Single scattering albedo is one of key properties determining dust direct radiative effects, therefore its accurate representation in models is important. Dust single scattering albedo depends on its mineral composition, particularly on the content of iron oxide minerals (hematite and goethite).

In this study we present dust single scattering albedo values based on Dust Regional Atmospheric Model (DREAM) with incorporated particle mineral composition [3,4]. The domain of the model covers Northern Africa, Middle East and the European continent, with horizontal resolution of 1/5 °. It uses eight particle size bins, in the radius range of 0.1-10 μm. DREAM model simulations of a dust episode that affected Mediterranean and part of Eastern Europe in June 2010 are performed to obtain total dust and hematite mass concentrations. Single scattering albedo is calculated using total dust and hematite concentration in each size bin from the model output. We analyze the spatial variability of the resulting dust single scattering albedo over the model domain. The results are evaluated using Aerosol Robotic Network (AERONET) [5] inversion products. Furthermore, the resulting direct radiative effects of dust are discussed.

Acknowledgement: We would like to thank the AERONET network and the principal investigators, as well as their staff, for establishing and maintaining the AERONET sites used in this work.

References

1. S. Kinne et al., Atmos. Chem. Phys. 6, 1815 (2006).
2. C. Di Biagio et al., Geophys. Res. Lett. 47, e2019GL086186 (2020).
3. S. Ničković, G. Kallos, A. Papadopoulos, and O. Kakaliagou, J. Geophys. Res. 106, 18113 (2001).
4. S. Ničković et al., Atmos. Chem. Phys. 12, 845 (2012).
5. B. N. Holben et al., Remote Sens. Environ. 66, 1 (1998).

S11-EPASE-101 / **Oral presentation**

Analysis of the pollen phenology distributions and their impact on the modeled concentrations in Thessaloniki, Greece

Authors: Sofia Papadogiannaki[1]; Serafeim Kontos[1]; Daphne Parliari[1]; Dimitrios Melas[1]

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Presenter: S. Papadogiannaki (spapadog@physics.auth.gr)

This study aims on the analysis of the pollens' phenological distributions in the greater area of Thessaloniki, over the years 2016-2020. The main pollen season of the most contributable taxa of pollen spectrum is presented and its beginning, end and duration are compared with similar European studies. Regularity tests and probability plots revealed the absence of trend in timeseries. Exponential distribution proved to describe pollen concentrations with a small deviation in contrast with the Gaussian, which was used of its simplicity in pollen data analysis. The effect of the exponential distribution, relative to the common Gaussian approach, on the diagnosis of the pollen concentrations is tested for Quercus taxa with the WRF-NEMO-CAMx modeling system. The modeling system consists of three models in series, the Weather Research and Forecasting (WRF) meteorological model, the Natural Emissions Model NEMO and the chemistry – transport model CAMx. The overall performance for both approaches is found satisfactory, with the exponential distribution producing slight better results. Significant spatial differences were found in remote areas of the modeling domain, mainly outside of the city of Thessaloniki.

S11-EPASE-102 / **Oral presentation**

The influence of different polyaniline polymer and carbon material morphologies on electrical properties

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Presenter: T. Şuteu (tudor.suteu2001@gmail.com)

Polyaniline powders are prepared using two different reaction routes in order to obtain different morphologies. Using ammonium persulfate (APS) as a dopant and in a solution of ethanol and acetic acid, the polymerisation of aniline gave rise to tubular like nanostructures, thus the sample was named PANI-T. Similarly, PANI-R (polyaniline with a "round" morphology of nanostructures), was synthesized in a sulphuric acid solution and with APS as a dopant. The different morphologies of the polymer species were confirmed using scanning electron microscopy (SEM). In order to obtain the carbonic materials, the polymers were raised to 900℃ under N2 constant flow. X-Ray Diffraction (XRD) was used to confirm the transition from polymers to nitrogen containing carbon nanostructures, which were labelled PANI-T-900 and PANI-R-900. The study of the electrical conductivities was done by two approaches: I-V characteristics, and electrochemical impedance spectroscopy (EIS) on a broad range of frequencies. The polymers PANI-R and PANI-T exhibit a typical semiconductor behaviour of their I-V curve, but the electrical conductance of PANI-R is a few orders of magnitude above the one of PANI-T. The measured values for the carbonic materials far exceed the ones of the polymers, entering the range of conductors. Out of the samples examined, PANI-T was the only one that exhibited a capacitive behaviour of the EIS Nyquist plot, while the other three showed an inductive one.

S11-EPASE-200 / **Poster presentation (virtual)**

Optimal design of hybrid PV-Wind-Battery systems for supply of microgrids

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Presenter: U. Buzra (u.buzra@fimif.edu.al)

Abstract. Power supply issues are more acute in isolated areas. Hybrid systems are becoming one of the most promising ways to meet the energy needs of microgrids. The proposed PV-wind- battery system consists of a PV system, a wind energy converter system and a battery system, which stores surplus energy from the PV and wind power systems, and uses this energy accumulated latter when the PV system and wind turbines do not generate enough power to fulfil the load. The main aim of the study is to model total renewable energy systems that meet the electric load of microgrids. The HOMER software is used as a tool for simulation and optimization of the proposed system. The Net Present Cost (NPC) method is used to determine the optimal combination of the system.

S11-EPASE-201 / **Poster presentation (virtual)**

Solar Water and Air Heating Systems: Technical Aspects, Their Current and Future State

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Presenters: U. Buzra (rimibuzra@yahoo.com), D. Mitrushi (driadamitrushi@yahoo.com)

Electricity is essential for human life, but growing demands for energy, high cost, limited fossil fuel resources, environmental pollution, and global warming through the greenhouse effect are the reason why renewable energy technologies, over about three recent decades, are seen as cost-effective and environmentally sustainable energy sources. Investments in the development of capacities of renewable energy sources have exceeded the investments in increasing the capacities of fossil energy sources in the last ten years. Solar heating systems are replacing the use of electricity or gas almost all over the world in order to have a high standard of living for all users of solar energy or other renewable energies. The overview aims to present the technical aspects of solar water and air heating systems, economical methods and ways of production, use and energy conservation, their current states, and scientific developments to improve their use in the future. A particular analysis is dedicated to the actual state of renewable energies in Albania.

S11-EPASE-202 / **Poster presentation**

Lidar Investigation and Mapping of Aerosol Loadings above Sofia, Bulgaria

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Presenter: T. Dreischuh (tanjad@ie.bas.bg)

Atmospheric aerosols, both natural and anthropogenic, have strong direct or indirect effects on the regional and global climate, air quality and human health. Their impacts depend mainly on the aerosol composition, particle size, and chemical-physical properties. The lidar technique is an effective instrument for near real-time observations of the aerosol mass stratification and optical parameters with high spatial and temporal resolutions over long distances and large areas.

The Sofia lidar station (located at the Institute of Electronics, Bulgarian Academy of Sciences) has participated in coordinated measurements of the European Aerosol Research Lidar Network (EARLINET) since 2002, and is currently part of the Aerosols, Clouds, and Trace gases Research InfraStructure (ACTRIS). The station's lidar systems perform systematic vertical monitoring of various type of aerosols (Saharan dust, volcanic ash, fire smoke, as well as marine, anthropogenic and mixed aerosols) in the atmosphere above Sofia, as well as near-ground aerosol mapping over urban areas.

In this work, we report results of studies of different types of atmospheric aerosols present above Sofia by using a Nd:YAG-laser-based lidar emitting at 1064 nm and 532 nm. The results are presented in terms of vertical profiles of the atmospheric backscatter coefficient and color maps of range-corrected lidar signals in height-time coordinates, which illustrate the aerosol density spatial distribution and temporal evolution. The retrieved backscatter profiles at the two lidar wavelengths are used to calculate the corresponding profiles of the backscatter-related Ångström exponent as a qualitative indicator of the dominant particle-size fractions in the aerosol fields observed.

Results are reported on lidar observations of extraordinary in altitude (up to 15 km) aerosol layers above Sofia that consisted predominantly of Saharan mineral dust partly mixed with other aerosol types, as well as of a wintertime Saharan dust intrusion, the latter a rare and atypical until recently for the region. Data are also presented from lidar monitoring of atmospheric smoke aerosols resulting from a local fire burning forest areas close to Sofia. Finally, results of near-surface atmospheric measurements and aerosol lidar mapping over broad urban and sub-urban areas of Sofia City are displayed and discussed. To identify the type and origin of the aerosols in the layers registered by the lidar, modeling and forecasting data from online accessible resources are used, such as the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model and the dust forecast models provided by the SDS-WAS (Sand and Dust Storm Warning Advisory and Assessment System) Regional Node for Northern Africa, Middle East and Europe. Conclusions are drawn confirming the high efficiency of the lidar technology for rapid and reliable monitoring of airborne aerosol pollutions of different type and assessing their environmental and social impacts.

Acknowledgments: This research was supported by the Bulgarian Ministry of Education and Science in the framework of the National Science Program "Environmental Protection and Reduction of Risks of Adverse Events and Natural Disasters" (Agreement No. D01-279/2021) and by the Bulgarian National Science Fund (Grant No. KP-06-N28/10/2018). The equipment used is of ACTRIS BG, part of the Bulgarian National Roadmap for Research Infrastructure.

`S11-EPASE-203` / **Poster presentation (virtual)**

Characterization by AERONET Sun Photometer of Aerosol Events with High Aerosol Optical Depth and Ångström Exponent over Sofia, Bulgaria

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The aerosol particles in the atmosphere strongly influence the energy exchange between the Sun and the Earth's atmosphere and surface. Thus, they could significantly impact multiple atmospheric phenomena, the climate, and the living conditions on the Earth. Also, the fine (submicron) fraction of the aerosol ensembles, the so called fine dust particles (FDP), may be especially harmful to the human health. The anthropogenic and biomass-burning (BB) smoke FDP are characterized as well by high light absorptivity and take an active part in the solar energy redistribution. The permanent monitoring and studying of the aerosol properties and dynamics contribute to the better understanding of many atmospheric processes, including the climate change, and assist the authorities in urban areas in being timely informed of dangerous FDP concentration rise above the permissible levels.

The main purpose of the present work is to describe and analyze the results of two-year passive optical remote sensing of the atmospheric aerosol field over Sofia, Bulgaria, and characterize mainly the aerosol situations by a strongly prevailing fine particle fraction of a relatively high concentration.

The analysis of aerosol situations over Sofia is based on a wide set of columnar aerosol characteristics evaluated automatically by AErosol RObotic NETwork (AERONET) algorithms using results of specific automatic procedures of measuring the direct sun/moon irradiance and the sky radiance by a Cimel CE318-TS9 sun/sky/lunar photometer. The sun photometer has been functioning since 5 May 2020 in the Sofia Site in the Institute of Electronics, Bulgarian Academy of Sciences that is contributing to AERONET and is involved in European Aerosol Research Lidar Network (EARLINET) and Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) activities.

The main aerosol characteristics employed in the analysis are the aerosol optical depth (AOD) and the Ångström exponent (AE), the volume size distribution (VSD) and the single-scattering albedo (SSA) of the aerosol particles. The particle sphericity factor (SF), depolarization ratio (DR) and the real part of the refractive index n_r are also considered.

The analysis performed shows that aerosol situations with a strongly prevailing fine particle fraction (around 100 nm in size) with a relatively high concentration (AOD > 0.3), sphericity factor (SF ~ 99%) and low depolarization ratio (DR ~ 0.002) take place mainly in the summer and early autumn, when the wildfire activity is maximum. Because of their small sizes, the scattering from such particles decreases rapidly with the light wavelength, λ, and faster than the absorption.

Correspondingly, the AE is large > 1.6-1.7 and the SSA is sharply decreasing with λ, beginning from 0.85 − 0.95 at λ = 440 nm. The relative occurrence of BB aerosol situations is estimated to be 9.1%.

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S11-EPASE-204 / **Poster presentation (virtual)**

Coastal vs continental heatwave-induced mortality: the Piraeus and Athens cases

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Presenter: S. Geronikolou (sgeronik@bioacademy.gr)

Background: Climate change is intertwined with excessive ambient temperatures. Humans' adaptation to wide temperature changes varies greatly for unknown reasons. Methods: This study profits from a long-lasting heatwave event of the South-eastern Mediterranean: the july 1987 event. We studied a coastal (Piraeus) and a continental city (Athens). Mortality data were collected from the Piraeus Municipality Registry, whereas Athens data were obtained from literature retrieved from PUBMED. As for Athens, we also found studies providing data for 1988 and 1992 heatwave events. Ambient temperature characteristics were obtained from the Geronikolou 1991 thesis and the National Organizations. Thom's formula was applied so as to calculate the Discomfort index for each city and event. From the death events the odds ratio and relative risk in Athens compared to the Piraeus 1987 event, were calculated. Results: the 1987 heatwave was more lethal (seven fold) in Athens than in Piraeus. The ensuing 1988 and 1992 heatwaves were less lethal, because the population learned to conform to the authorities advices while the 1992 observed increase may be imputed to population heterogeneity due to a recent large immigration. Conclusions: The odds of dying due to a heatwave is highly dependent on lifestyle (body watering, buildings cooling, prudent circulation and walking within the city, etc), population sensitization to preventive measures and Public health policy, as well as locality and land use planning.

References

1. Geronikolou, S. Public Health in Piraeus 1985-1989, Public Hygene, TIE, Athens 1991

2. Baccini, M.; Biggeri, A.; Accetta, G.; Kosatsky, T.; Katsouyanni, K.; Analitis, A.; Anderson, H.R.; Bisanti, L.; D'Ippoliti, D.; Danova, J.; et al. Heat effects on mortality in 15 European cities. Epidemiology 2008, 19, 711-719

3. Katsouyanni, K.; Trichopoulos, D.; Zavitsanos, X.; Touloumi, G. The 1987 Athens heatwave. Lancet 1988, 2, 573.

4. Kiraly, A.; Bartos, I.; Janosi, I.M. Correlation properties of daily temperature anomalies over land. Tellus A 2006, 58, 593–600.

5. Giles, B.D.; Balafoutis, C. The Greek heatwaves of 1987 and 1988. Int J Climatol 1990, 10, 505-5017.

S11-EPASE-205 / **Poster presentation**

Tailoring the photocatalytic properties of anatase TiO_2 by B - TM (TM = Pt, Ta, V) co-doping

Authors: Valentin N. Ivanovski[1]; Jelena Belošević-Čavor[1]; Vasil Koteski[1]; Ana Umićević[1]

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Presenter: V. Ivanovski (valiva@vin.bg.ac.rs)

In the present work, the electronic and optical properties of (B, TM) co-doped (TM = Pt, Ta, V) anatase TiO $_2$ were investigated using modified density functional theory (DFT) calculations, in order to provide insight into the synergistic effect of co-doping with various elements on the photoactivity of TiO $_2$. We considered two combinations for each co-doped sample, with TM atom replacing Ti atom and B atom either replacing O atom or embedding interstitially into TiO $_2$ lattice. The calculations showed that for all studied transition metals, the co-doping is more favorable in the case of interstitially doped boron than for the substitutional one and under the O-rich conditions. For the co-doped systems with B atom substitutionally replacing O atom, a small reduction of the band gap is observed in all the investigated cases. In contrast, the results obtained for the co-doped systems with boron embedded interstitially into TiO $_2$ lattice, exhibited no band gap narrowing. However, in these systems, the doping induced localized states within the band gap, which could enhance visible light absorption through a two step optical transition from the valence to conduction band.

S11-EPASE-206 / **Poster presentation (virtual)**

Critical overview of renewable energy resources in Albania: Potentials, technologies and costs

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Presenter: D. Mitrushi (d.mitrushi@fimif.edu.al)

Successive energy crises necessitate the use of renewable energy sources such as solar and wind, they can be properly complementary with other sources. We have presented solar and wind energies and their importance in the current status, their future in Albania, from the statistical point of view, including in terms of representative generation parameters.

It will be discussed for the assessment of wind and solar potential, feasibility analysis for different regions in Albania. Statistical evaluation in terms of technical parameters, capacity for power installation, generation and generalization on economic parameters. The originality of this study is to present a comprehensive basis for assessing future growth and the potential development of wind and solar power in Albanian electricity supply mix.

S11-EPASE-207 / **Poster presentation (virtual)**

The assessment of the tilt angle for optimal solar energy utilization, case southern Albania

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This study assesses the specific optimal tilt angle of a plane surface facing south to collect the maximal potential of solar energy. The study focuses on 5 different regions of Albania using several years of hourly solar radiation intensity data. The analysis shows the monthly variation of optimal tilt angle. The optimum tilt angle of the plain surface with horizon gradually increased from summer to winter, having a minimum in June-July and a maximum in December -January.

S11-EPASE-208 / **Poster presentation**

Development of a Monitoring and Forecasting Air Quality Modelling System

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Presenter: S. Papadogiannaki (spapadog@physics.auth.gr)

The present study focuses on the description of a versatile and flexible air quality monitoring and forecasting system. The system provides environmental information and advice to stakeholders and citizens via proper hardware & software infrastructure, scientific expertise and computational excellence. It is a combination of three-dimensional air quality models (WRF/CAMx), innovative models for anthropogenic and natural emissions (MOSESS/NEMO), satellite data for updating emissions, air quality low-cost sensor networks, and computational intelligence and data fussion methodologies. The system has been implemented in two pilot areas in Greece, Thessaloniki and Heraklion and provides information concerning air pollutant concentrations and relevant indicators.

This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness,Entrepreneurship and Innovation (call RESEARCH-CREATE-INNOVATE, project code T1EDK-01697).

`S11-EPASE-209` / **Poster presentation**

Developing an integrated Urban Heat Island Forecasting and Heat Health Warning System for selected Mediterranean urban areas

Authors: Dimitris Melas[1]; Stavros Keppas[1]; Serafim Kontos[1]; Sofia Papadogiannaki[1]; Daphne Parliari[1]; Thanasis Natsis[1]; Francesca de'Donato[2]; Giampietro Casasanta[3]; Stefania Argentini[3]

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The aim of the present study is the description of the implementation and operation of an integrated modeling system that focuses on the Urban Heat Island and its impact on human health. The modeling system, used for both short-term prediction and future projection, was developed on two levels:
a. The UHI forecasting system which produces high-resolution (250 m) UHI-related products, including thermal bioclimate indices (UTCI, DI, Tapp) and Heating/Cooling Degree Days (HDD/CDD).
b. Heat Health Warning Systems that provide differential alerts within each involved city and the potential effects on health at high spatiotemporal resolution.

The above endeavor is being realized by a coupled modeling system, consisting of the Weather Research and Forecasting model (WRF) and the Urban Canopy Model (UCM) in high horizontal resolution (2 km). The main purpose of the coupled model

is to improve the description of lower boundary conditions and to provide more accurate forecasts for urban regions in order to assess the impacts of UHI.

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S11-EPASE-210 / **Poster presentation (virtual)**

Study of Zn electrode active mass with added cuprates ceramic by electrochemical impedance spectroscopy

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Presenter: O. Petkov (ogikrpetkov@gmail.com)

The nickel-zinc electrochemical system is a promising candidate for alkaline batteries due to its low toxicity, high energy densities and power. Their main disadvantage is the solubility of the zinc electrode and the formation of dendrites during operation. Previous studies having used B(Pb)SCCO ceramic as additive in the Zn electrode mass proved its positive effect on improving the electrochemical properties [1,2]. Recently, the silver (Ag) is emerging as a promising component for the development of high-performance anodic materials for Zn-nickel batteries [3]. In the present work the effect of Ag additives, as well as conductive ceramics B(Pb)SCCO on the electrical properties and behavior of the Zn electrode was studied. The incorporation of these additives in the Zn electrode active mass was assisted by ultrasonic treatment. The phase composition and morphology of the electrode material were characterized by scanning electron microscopy (SEM) and X-ray diffraction (XRD). Zn electrodes prepared by inserting a Zn paste with a different amount of additive B(Pb)SCCO 2212 and Ag into the copper foam matrix were used as working electrode. The electrochemical behavior of the modified Zn electrodes was investigated using a three-electrode configuration in a 7M KOH electrolyte. The effect of the additives on the AC electrical response of the studied electrochemical system was estimated by electrochemical impedance spectroscopy (EIS).

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References:

1. M. Mladenov *et al.*, Electrode mass for zinc electrode of alkaline rechargeable batteries, BG Patent Reg. No 66730/28.08.2018

2. A. K. Stoyanova-Ivanova *et al.*, Comptes rendus de l'Acad´emie bulgare des Sciences,75, No 3, 2022, pp. 358-366
3. Y. Rong, Z. Yang, L. Deng, Z. Fu, Ceramics International 46 (2020) 16908

S11-EPASE-211 / **Poster presentation**

Formation of Silver Selenide and Copper Selenide synthesized by Pack Cementation and Mechanical alloying processes

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Presenter: D. Stathokostopoulos (dstat@physics.auth.gr)

There is a strong demand for new energy sources due to the growing population and limited natural resources. Among the different renewable energy resources, thermoelectric material plays a key role. Selenides compounds, such as Ag2Se and Cu2Se, have received a lot of attention because of their interesting properties, low toxicity, and abundance. Particurarlly, Ag, Cu, and Se are less toxic than Bi, Pb, Sb, and Te, while Se is about 10 times more abundant than Te. High-energy ball milling1,2, (HEBM) process is a powerful solid-state synthesis/powder mechanical alloying method. Chemical Vapor Deposition by Pack Cementation (CVDPC) is an ideal synthesis procedure because it is simple, easily controllable and inexpensive . The objective of this work is to synthesize Ag2Se and Cu2Se compounds by using two different techniques: HEBM and CVDPC processes. In HEBM a series of experiments were carried out by various milling times (from 1h to 20 hrs). In CVDPC process two different deposition times (3 and 4 hours) was selected at $238C$ heating temperature.

The structural and morphological characterization of the selenides were studied by Fourier Transform Infrared Spectroscopy, X-ray Diffraction, X-ray Photoelectron Spectroscopy and Scanning Electron Microscopy. It was found that the selenides were successfully synthesized by HEBM and pack cementation process.

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2014 2020», that is co-funded by the European Regional Development Fund and Greece.

References
1. W.K. Min et al., Materials Science Forum, 534-536 (2007).
2. C. Lee et al., J Appl. Phys. 101, 024920 (2007)
3. D. Stathokostopoulos et al., Results in Materials 13, 00252 (2022)

S11-EPASE-212 / **Poster presentation**

Synthesis and Characterization of Mg2Si and Al doped Mg2Si formed by Pack Cementation process

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Presenter: D. Stathokostopoulos (dstat@physics.auth.gr)

Increased energy consumption worldwide, combined with reduced energy reserves and environmental protection, leads to the necessity of alternative sustainable energy generation methods such as thermoelectric energy conversion. In last few decades, considerable research effort has been concentrated to develop materials which can be used to transform heat into electric power. These materials have been considered as a potential environment-friendly high performance thermoelectric material. Metal silicides are promising thermoelectric materials and characterized by low resistance, high thermoelectric figure of merit ZT, low density, high melting point, thermal stability, low toxicity and fabrication cost. A variety of techniques have been used to prepare silicides, as ball milling, solid state reaction, sputtering, reactive deposition epitaxy. Here, a new environmental friendly, low cost and simple technique, thermochemical diffusion process (pack cementation) was used to synthesize Magnesium silicide (Mg2Si) and Al doped Mg2Si [1,2]. Magnesium silicide is a prospective narrow gap semiconductor for thermoelectric energy conversion at high temperatures. The current study focuses on the fabrication of new thermoelectric materials, aiming towards the development of compounds with advanced thermoelectric properties. For this process a powder mixture which contains Si powder Mg (donor material), Al (doping) and a halide salt which is the chemical activator are packed and sealed in a ceramic. The sealed crucible is then heated in an electric furnace under Ar atmosphere. A series of experiments were carried out at temperatures ranging from 450oC to 650oC at different durations from 120min to 240min to compose Mg2Si and Al doped Mg2Si thermoelectric powders [3]. The morphology and the chemical composition were determined by SEM equipped with EDS analyzer, the phase identification was performed using XRD analysis, the chemical state was identified via XPS and the oxidation resistance of silicides was investigated by TGA.

References
1. D. Stathokostopoulos et al, Results in Materials 13, 100252, (2022)
2. D. Stathokostopoulos et al, Appl. Surf. Sci. 285P, 417-424, (2013)
3. D. Stathokostopoulos et al, J Therm. Anal. Calorim. 121, 169-175, (2015)

S11-EPASE-213 / **Poster presentation (virtual)**

Separation, characterization and identification of microplastics collected from the Axios river in Greece

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Microplastics (MPs) have globally been detected in aquatic and marine environments, which has raised scientific interests and public health concerns during the past decade. MPs are those polymeric particles with at least one dimension <5 mm [1]. They possess complex physicochemical properties that vary their mobility, bioavailability, and toxicity toward organisms and interactions with their surrounding pollutants [2,3]. Despite the increase in studies on this field, it is a common assumption of researchers that research is still in its early stages, with a lot of unresolved questions that need to be answered. However, it is critical to have accurate and reliable detection and measurement of MPs and their properties in order to have a complete understanding of their environmental and ecological effects.

In this work, microplastics were collected from the Axios river which is the second longest river in Greece, and the second-longest river in the Balkans in order to evaluate some of the most widely used polymers covering a variety of applications in modern everyday life. Greek rivers are heavily polluted by municipal waste in the most highly populated areas of Greece. Different techniques were introduced to demonstrate their working principles, applications, limitations, and advantages, followed by a discussion of perspectives that shed new light on future research and directions. So, the structural and morphological characterization of the selected microplastics were studied with the help of Infrared Spectroscopy with Fourier transform (FT-IR), X-ray Diffraction (XRD), and Scanning Electron Microscopy (SEM). Additionally, Pyrolysis - Gas Chromatography/Mass Spectrometry (Py-GC/MS) was

employed for the thermal characterization and dynamic study of polymeric materials. The complementary use of these techniques provides conclusive and convincing results from the studies being carried out on microplastics and their ever-increasing abundance in the environment.

References

1. S. Sharma et al., Chem. Eng. J. 408, 127317 (2020).
2. D. Barcelo et al., J. Environ. Chem. 7, 103421 (2019).
3. P. Schwabl et al., Ann. Intern. Med. 171, 453 (2019).

S12-PSSAP
Physics of Socioeconomic Systems and Applied Physics

S12-PSSAP-001 / **Invited talk (virtual)**

The role of self-organized criticality in social dynamics

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Recent advances in social sciences are based on extensive data analysis. In this context, theoretical physics concepts such as self-organized criticality are precious to making sense of the available empirical data. Self-organized criticality refers to the properties of driven dynamical systems of many interacting elements under repeated perturbations to reach a stationary state with long-range spatial and temporal correlations resembling the critical fluctuations near the second-order phase transitions. The self-organized critical states appear as the attractors of the nonlinear dynamics, which are characterized by avalanching, scale invariance and universality. Besides physical and biological systems, signatures of self-organized criticality are increasingly found in human dynamics; they are often related to the appearance of fractal patterns and complex network geometries, see [1,2] and references there.

In this lecture, we first present fundamental features of self-organized critical states in different dynamical systems. We show how this physics concept facilitates data analysis and provides evidence of the emergent collective knowledge in the empirical data of a prominent example of human cooperation to create new knowledge [3,4]. We demonstrate self-organized critical behaviours through quantitative data analysis and agent-based modelling. Furthermore, we discuss several open questions, particularly the origin of critical states in social dynamics vs better understood driven physical systems, as well as the essential role of critical fluctuations in them. We highlight the importance of self-similarity in the underlying stochastic process to reveal robust patterns in the empirical data. Furthermore, the universality of critical states helps differentiate relevant parameters that drive the dynamics, thus enabling efficient agent-based modelling simulations and predictions of various scenarios. Finally, regarding the information-theoretic aspects of social dynamics, it is expected that the scale invariance of these critical states optimizes information complexity as a key to the relevance of information stored in the data.

References

1. B. Tadic, R. Melnik, Self-Organised Critical Dynamics as a Key to Fundamental Features of Complexity in Physical, Biological, and Social Networks, Dynamics 1(2), 181-197 (2021)
2. B. Tadic, Self-organised criticality and emergent hyperbolic networks: blueprint for complexity in social dynamics, Eur. J. Phys. 40(2), 024002 (2019)
3. B. Tadic. M. Mitrovic Dankulov, R. Melnik, Mechanisms of self-organized criticality in social processes of knowledge creation, Phys. Rev. E 96, 032307 (2017)
4. M. Mitrovic Dankulov, R. Melnik, B. Tadic, The dynamics of meaningful so-

cial interactions and the emergence of collective knowledge, Sci. Rep. 5, 12197 (2015).

S12-PSSAP-100 / **Oral presentation**

Porous semiconductor compounds: characterization and applications

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Over the last two decades, it has been demonstrated that electrochemistry is one of the most accessible and cost-effective approaches for nanostructuring semiconductor materials in a controlled fashion. Moreover, taking into account that electrochemical nanostructuring in NaCl-based neutral electrolyte of semiconductor compounds such as InP, GaAs, and GaN was demonstrated, we succeeded to make this method also environmentally-friendly [1].

Semiconductor compounds in comparison with Si provide more space for tailored nanofabrication in terms of compositions, bandgaps, mechanisms of the pore growth and new properties with large potential for applications. Besides, semiconductor nanotemplates which properties can be easily controlled by external illumination, applied electric fields etc. provide wider possibilities for nanofabrication, compared with dielectric nanotemplates. Combining two methods, namely electrochemical etching and electrochemical deposition, one-dimensional nanostructures such as nanowires, nanotubes and their networks have been successfully fabricated.

Metal nanodots are obtained routinely in solutions, but positioning them on a chip remains a significant challenging. Conventional controlled patterning approaches like electron beam lithography, stencil lithography, and extreme ultraviolet interference are very expensive.

The walls of the porous semiconductor skeleton, exhibiting good electrical conductivity in comparison with the walls of dielectric nanotemplates, create good conditions for uniform nucleation of metal dots. Along with this, one monolayer of gold nanodots on porous semiconductor structures can be deposited using the so-called "hopping electrodeposition" [2]. In particular, uniform deposition of Pt on the inner surface of pores was demonstrated, regardless of the pore shape (e.g. circular, triangular-prism like pores etc.) [3].

The report will focus on different aspects of pore growth, transition from the porous semiconductor structures to the formation of semiconductor nanowires, as well as technologies for controlled electrochemical deposition of metal nanostructures into porous semiconductor templates. The obtained metal-semiconductor structures were exploited in a variable capacitance device elaboration with a record capacitance density variation of about $6\cdot 10^{-3}$ pF/V per 1 μm^2 of surface [3]. An IR photodetector based on a single GaAs nanowire with good sensitivity and dynamic characteristics was demonstrated [4]. The fabricated core-shell GaAs/Fe nanowire arrays, along with possibilities to tune the orientation to the substrate surface, showed magnetic anisotropy with respect to the coercivity and the remanence ratio [5].

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References:
1. E. Monaico, I. Tiginyanu, and V. Ursaki, Semicond. Sci. Technol. 35, 103001 (2020).
2. I. Tiginyanu, E. Monaico, and K. Nielsch, ECS Electrochem. Lett. 4, D8 (2015).
3. I. Tiginyanu, E. Monaico, V. Sergentu, A. Tiron, and V. Ursaki, ECS J. Solid State Sci. Technol. 4, P57 (2015).
4. E.I. Monaico, E.V. Monaico, V.V. Ursaki, S. Honnali, V. Postolache, K. Leistner, K. Nielsch, and I.M. Tiginyanu, Beilstein J. Nanotechnol. 11, 966 (2020).
5. E.V. Monaico, V. Morari, V.V. Ursaki, K. Nielsch, and I.M. Tiginyanu, Nanomaterials 12, 1506 (2022).

S12-PSSAP-101 / **Oral presentation**

Physical Parameters of Chocolate with the addition of Spirulina Platensis

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Presenter: G. Gavrailov (`georgi.gavrailov@mu-varna.bg`)

The physicochemical properties of chocolate mass with 85% cocoa content and respectively content of 3%, 5%, and 10% of freshwater algae Spirulina Platensis have been studied. The algae are grown into a bioreactor in Varvara, Bulgaria. The present work aims to create an innovative chocolate product with appropriate physicochemical properties and organoleptic characteristics, contributing to the healthy nutrition of consumers. To achieve this goal, it developed a technological scheme for obtaining chocolate mass with Spirulina Platensis. Rheological, X-ray structural,

and sensory analyses were performed. Data from reflective microscopy and fluorescence spectroscopy were also obtained. X-ray analysis shows peaks of crystalline sucrose and cocoa. In addition to these peaks in the X-ray diffraction pattern of the sample with 10% Spirulina Platensis content, some peaks may be due to complex crystals of the protein structure of freshwater algae.

The rheological curves of the samples show that the studied systems are non-Newtonian fluids. Increasing the concentration of Spirulina Platensis does not affect the stickiness, softness, and hardness. According to sensory analysis, the samples with 5% Spirulina Platensis have a pronounced sweet taste, and those with 3% - cocoa taste. Reflective microscope images were taken to examine the fracture section.

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`S12-PSSAP-102` / **Oral presentation**

Structure of transmission paths induced by stratified simplicial communities embedded in complex networks

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Presenter: S. Maletić (`sloba@vinca.rs`)

Complex systems display the structural organization of patterns that span over various inherent scales and accordingly affect the functioning of the system. Transcending pairwise interactions in complex networks introduces the study of higher-order structures [Battiston, F., et al. (2020), Physics Reports 874, pp. 1-92.], where the versatility of criteria for aggregation of elements imposes challenges on the reconstruction of organizational patterns. In this context, the focus of the work that will be presented is on the potential mesoscale structures which have the role of building blocks in generalized communities within the simplicial clique complex [Maletić, S. and Rajković, M., (2012) Eur. Phys. J. Special Topics 212, 77–97]. These higher-order structures are considered as embedded in the hierarchical strata of simplicial complex and their relationships are captured by the higher-order combinatorial Laplacian [Goldberg, T. E., Combinatorial Laplacians of Simplicial Complexes, (Annandale-on-Hudson, New York, 2002)]. The discretized Laplacians have already been proven as useful for considerations of topology constraints on flows over the system, such as problems related to the diffusion over complex networks, or Kirchhoff's analysis of electrical networks resulting in the matrix tree theorem, to mention a few. Since the stratified structure of the simplicial complex induces the hierarchy of possible flows, the k-carrying graph is introduced as the structure built by the possible routes of transmission over k-dimensional simplicial clique communities. In other words, the k-carrying graph represents possible paths of the flow over higher-order structures, and its graph Laplacian captures connectivity. The similarity between the structure of clique simplicial communities and the induced k-carrying graph is considered by the mutual information [Cover, T.M., Thomas, J.A., Elements of Information Theory (Wiley ed. 1991)] of the obtained spectra of associated combinatorial Laplacians. As the case studies two real-world networks are considered, and the results reveal new insights into the organizational patterns embedded in networks, in particular the emergence of characteristic similarity k-dimension.

S12-PSSAP-103 / **Oral presentation**

The role of trust in sustainability of knowledge-sharing social groups: the case of Stack Exchange Q&A communities

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Knowledge-sharing communities are fundamental for the development and evolution of any knowledge-based society. Their emergence, function, and disappearance determine the course of evolution of a knowledge-based society. The sustainability of these groups is crucial for the success of the knowledge-transfer process in modern societies and the efficiency and success of this process. This work explores the role of the structure of social interactions and social trust in the emergence of sustainable knowledge-sharing communities. We combine tools and methods from complex networks theory, statistical physics, computer science, and sociology to explore roles mentioned in the sustainability of StackExchange communities on four different topics: astronomy, physics, economics, and literature. StackExchange is one of the most successful online knowledge-sharing networks that hosts more than 150 communities on various topics. To control the influence of the subject, we select a pair of active and one closed community for each topic and analyze and compare their early evolution. We adapt the dynamical reputation model to quantify the change in social trust in these communities. We analyze the evolution of the social interaction network and social trust between members during the first 180 days of their existence. Our results show that sustainable communities have higher local cohesiveness and develop stable, more strongly connected cores. The social trust between members is more heightened in sustainable communities. In these communities, the trust between core members develops early and remains high over time. This work shows that the emergence of a stable, trustworthy core may be determining factor in building a sustainable knowledge-sharing community.

S12-PSSAP-200 / **Poster presentation**

Competitive Influence Diffusion Through Social Networks

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The dynamic of the information distribution is complex and affects everyday life, especially with the multiple ideas that are being released in social networks. These multiple ideas often have competing nature for the same nodes of the network. In this work we will discuss two competitive influence diffusion models in social networks. First, we take in consideration the competitive cascade model and at a certain point, the network will behave according to a competitive linear threshold dynamic model. We will assume that when a certain number of the nodes will have a specific information and when this number will grow up beyond a critical percentage of the active nodes, then we will reach an automatic collective change behaviour of the network. Each node in the network can be inactive or active (positively or negatively). If we can control the diffusion processes of the information in the network, we can predict the popularity of the innovation introduced. Since is a challenging task to predict the popularity of an innovation, by analyzing the dynamic of the network according to the competitive diffusion models as extended of single item diffusion. By joining the two models for the diffusion of the information on the directed networks, we will better understand the dynamic of the information distribution through the network, and how this distribution is affected from the different attitudes of the individuals when they firstly have this information. By combining and analyzing the two competitive diffusion models, extending them with two influence distribution functions, we take as a result as a better way to outperform in term of efficiency and effectiveness.

S12-PSSAP-201 / **Poster presentation**

Direct Conversion Of Ionizing Radiation Into Electrical Energy Using PIN Diodes

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Presenter: S. Ilić (stefan.ilic@nanosys.ihtm.bg.ac.rs)

The energy that comes from the source of ionizing radiation is enormous and quite unused. Using energy from ionizing radiation is a novel concept, while so far in the literature (to the best of our knowledge), only beta radiation has been treated as a possible source of energy (Quenon 2021). This paper focuses on utilizing gamma radiation energy using the Cobalt-60 radiation source. Direct conversion of radiation into electrical energy is possible using pn or pin junction-based semiconductor structures. When high-energy photons hit a semiconductor structure, a built-in electric field of pn junction can separate the generated electron-hole pairs before they recombine, creating the potential difference at the component electrodes. The PIN diodes used in this paper were made in planar technology, with three different active area surfaces: 0.8, 5 and 80 mm^2, at the Center of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia. The experiment was conducted in controlled laboratory conditions at the Department of Radiation and Environmental Protection at the Vinča Institute of Nuclear Sciences, Belgrade, Serbia. The range of gamma radiation dose rates for which the PIN diodes have been tested is from 1 μGy/h to 10 Gy/h under controlled conditions at room temperature. It is necessary for the diode to operate in a photovoltaic mode to act as a current source in an electrical circuit. Therefore, during irradiation, the characteristics of diodes: short-circuit current and open-circuit voltage were measured as the most important parameters of the current source. The lowest detected dose rate value of the PIN diode with the largest active area (80 mm^2) was 5 mGy/h, while diodes with middle (5 mm^2) and the smallest active area (0.8 mm^2) were 100 mGy/h. The short-circuit current values of PIN diodes for all active area dimensions have a linear dependence with a given dose rate range. By calculating the short-circuit current density, we obtain that diodes with different active areas have almost the same dependence on the dose rate. This result indicates that the current generated under the ionizing radiation directly depends on the size of the active region of the PIN diode. On the other hand, open-circuit voltage values do not have a linear dependence on the dose rate, even the diode with the smallest active area (0.8 mm^2) has higher values than the diode with the middle active area (5 mm^2). For the highest dose rate (10 Gy/h), the short-circuit current value of the PIN diode with the largest active area is 37 nA, and the open-circuit voltage is 118 mV, which can enable power supply of the low power electric circuits by connecting diodes in series and parallel. The research should continue in order to develop a self-powered circuit that will monitor radioactive sources and their environment.

References

1. Quenon, Alexandre, Evelyne Daubie, Véronique Moeyaert, and Fortunato Carlos Dualibe. "On the Possibility to Use Energy Harvesting on Beta Radiation in Nuclear Environments." In 2021 IEEE 12th Latin America Symposium on Circuits and System (LASCAS), pp. 1-4. IEEE, 2021.

S12-PSSAP-202 / **Poster presentation**

Mechanical Analysis of Dollar Index Trend

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Presenter: D. Malivuk Gak (`dragana.malivuk-gak@pmf.unibl.org`)

In this paper is presented a mechanical analysis of dollar index trend, as one of the possibilities of a new review of data obtained on the stock market exchange. The close values of the dollar index on every first day of the month from January 1, 1971 to January 1, 2021 has been considered as coordinates of unit mass particle. Dollar index close values time series were transformed to the time dependent force parameters using Newton's second law. According to the force parameters values obtained after solving nonlinear differential equations, the behavior of the system can be roughly predicted.

References:
1. J. P. Bouchaud and M. Potters, Theory of Financial Risks: From Statistical Physics to risk management, Cambridge University Press (2000)
2. Zoran Rajilic et al., J. Phys.: Conf. Ser. 1814 012004 (2021)

`S12-PSSAP-203` / **Poster presentation**

Universal patterns of social group growth: a statistical physics approach

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Presenter: M. Mitrović Dankulov (`marija.mitrovic@ipb.ac.rs`)

A social group is a characteristic element of every social system on a mesoscopic level. The growth of social groups is indissolubly connected to the structure and dynamic of a social system. Social systems differ in their purpose and the type of communication and activity their members engage in. At first glance, one would expect that the growth of social groups in these different systems is driven by different mechanisms that result in different patterns. This work applies methods and tools from statistical physics and complex network theory to study group growth in different social systems: Meetup groups based in London and New York and Reddit. In Meetup groups, members interact predominantly face-to-face by engaging in various activities during offline events. Reddit members interact online only by posting different online content and commenting on this content. Using empirical analysis, we show that social group growth has similar growth patterns in both systems, which remain stable for more than one decade. The distribution of group

sizes follows log-normal behavior for all three considered systems. We explore the underlying mechanism through a theoretical model that simulates the growth of social groups. The model combines social and random diffusion of members between groups to simulate the roles of social interactions and members' interest in the growth of social groups. We show that the model can reproduce social group patterns for all considered systems.

Furthermore, the model allows us to explore the differences in the values of distribution parameters. Our analysis shows that social interactions are more critical for the diffusion of members in online groups, such as Reddit than offline groups, such as Meetup. Universal growth mechanisms were earlier observed in the growth of companies and cities. This work further confirms that growth patterns on the mesoscopic level in different socio-economic systems are universal and independent of the properties of interaction and activities in them.

`S12-PSSAP-204` / **Poster presentation (virtual)**

The Effectivness of Germicidal UV-C LED on Different Microorganisam

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Recent occurrence of the pandemic revived the interest for germicidal ultraviolet (UV) lamps for disinfection. The use of the UV-C Light Emitting Diodes (LED) can deactivate microbes in air and water, but to achieve safe and successful disinfection of surfaces, careful and precisely defined usage is required that needs additional research. Commercially available UV-C LED lamp with the wavelength of 253,7 nm is used on two types of bacteria (one of them drug resistant) and one fungus.

The presented research results show that, in addition to the dependence of the efficacy on the time of exposure and surface distance from the lamp, the relative effectiveness of disinfection for the same conditions varies for the type of microbe. For E-coli it was between 72% and 90%, for Pseudomonas aeruginosa between 81% and 97%, while for the Candia albanicas it went from 93% to 98%.

S12-PSSAP-205 / **Poster presentation**

Synthesis and characterization of titanium boride coatings fabricated by selective electron-beam surface alloying

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Presenter: S. Valkov (stsvalkov@gmail.com)

In this study, Ti-B coatings were fabricated by a selective electron-beam surface alloying technology. On a pure titanium substrate, a boron film with a thickness of about 1 μm was deposited by an electron-beam physical vapor deposition technique. During the deposition procedure, the accelerating voltage was 50 kV, the electron beam current was 18 mA, the beam diameter was 10 mm, and the deposition time was 90 seconds. The obtained specimens were then subjected to a selective electron-beam surface alloying technique. During the alloying procedure, the accelerating voltage was 55 kV, the electron beam current was 25 mA, the diameter of the electron beam was 0.5 mm, the scanning frequency was 1000 Hz, and the speed of the specimen motion was varied from 5 to 50 mm/s.

The specimens were characterized in terms of their phase and chemical composition, microstructure, and microhardness. The phase composition was studied by X-ray diffraction (XRD) using Cu Kα (1.54 Å) characteristic X-ray radiation. The experiments were carried out in symmetrical Bragg-Brentano mode. The microstructure was investigated by scanning electron microscopy (SEM), where back-scattered electrons were used. The chemical composition was studied by energy-dispersive X-ray spectroscopy (EDX). The EDX detector system integrates P/B ZAF quantitative corrections (Z being the atomic number correction factor; A – X-ray absorption correction factor; F – fluorescence correction factor). Investigations of the microhardness were carried out on an EMCO Test DuraScan 20 G5 device using a load of 25 g, time 10 s, and gradient of 10 g/s.

The microhardness of the fabricated samples is discussed concerning the applied technological conditions of the selective electron-beam surface alloying procedure, corresponding phase and chemical composition, and microstructure.

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S12-PSSAP-206 / **Poster presentation**

Topology of evolving networks: the role of growth signals

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Complex networks theory provides methods and tools for studying the structure and dynamics of various complex systems. Real complex networks, although representing very different complex systems, have some common properties. They have broad degree distribution, small average shortest path compared to their size, high clustering, and degree-degree correlations. Knowledge about how these properties emerge in complex networks and the fundamental mechanisms is imperative if we want to understand complex systems' dynamics and function. Complex network models represent a unique tool for uncovering essential factors that govern the emergence of complex network properties. We have detailed knowledge on how different linking rules shape network topology. However, we are still lack comprising understanding of the role of the growth signal.

In this work, we study how the growth signal's properties that describe the addition of new nodes in the evolving network influence its structure. In complex network models, we typically add one or a constant number of nodes each time step. However, real complex systems' growth is usually not linear, and signals have long-range correlations, trends, and cycles. We modify the model of aging nodes to enable non-linear growth of the network. We use two growth signals from real systems from MySpace data and TECH Meetup community that are multifractal signals with long-range temporal correlations quantified with Hurst exponent and three random signals with short-range correlations and no cycles or trends.

We use D-measure to quantify the difference between the structure of networks generated with time-varying growth signal and ones with constant growth. This work shows that networks obtained with time-varying growth signals have a different structure than ones grown with linear growth. The D-measure has the highest value for the networks with power-law degree distributions, and the networks grown with multifractal signals with long-range correlations. Our further analysis shows that these networks are correlated and clustered. Our results confirm that the growth signal properties determine the structure of the obtained networks and should be considered prominently in models of social systems.

S13-BMP
Biophysics and Medical Physics

S13-BMP-001 / **Invited talk**

Bioflexoelectricity: a Physical Motor of the Living Cell

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Presenter: A. Petrov (agpetrov1948@yahoo.co.uk)

Several motors driving living cell alive have been recognized: electric motors, light motors, chemical motors, thermal motors, mechanical motors, etc. etc. Recently, the existence a new type of electro-mechanical motor has been recognized in cell membranes: bioflexoelectricity.

Phenomenon of bioflexoelectricity has been postulated, discovered, and investigated by us in the last 45 years. In this lecture the theory and experiments of biomembrane flexoelectricity of model and living memdranes are reviewed. In general, flexoelectricity is a reciprocal relation between electricity and mechanics in soft lyotropic systems, i.e., in case of membranes, between curvature and polarization.

Experimental evidence of model- and bio-membrane flexoelectricity (including the direct and the converse flexoelectric effects) is reported. The biological implications of flexoelectricity are underlined. Flexoelectricity enables membrane structures to function like soft micro- and nanomachines, sensors and actuators, thus providing important input to nanobioionics applications. Nanobio manifestations include membrane transport, membrane contact, mechanosensitivity, electromotility, hearing, nerve conduction, etc.

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S13-BMP-100 / **Oral presentation**

Non-supervised algorithms for Raman spectral decomposition in the in-vitro study of oxide nanoparticles effects on human cells

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Study of the effect of inorganic nanoparticles on the human cells has been intensified due to emerging applications of such nanoparticles in diagnostics, drug delivery, medical therapy, etc [1]. Several classes of nanoparticles have been proposed

for use in cancer therapy as they were demonstrated to decrease cancer cells viability in the scientific studies. Nanoparticles that have so called dual effect, diminishing the cancer cell numbers but preserving the healthy cells are of importance here since this is the primary criterion for application of nanoparticles in living organisms.

Raman spectroscopy has a potential to be used for in-vitro study of integral biomolecular changes induced in the cells by treatment with different chemicals or resulting from a particular disease [2,3]. Cellular Raman spectra contain vibrational modes characteristic for different biomolecules with a high degree of overlapping. Various multivariate algorithms can be applied to deduce small spectral changes in the spectra of cells in abnormal states [2]. Supervised multivariate algorithms are mainly used for classification of cancerous or other abnormal cells and their separation from the healthy ones, hiding the information about the nature of the differences that the classification model is built upon. On the other hand, unsupervised algorithms can be used for detection of spectral changes that can be correlated with specific biomolecular changes.

We have used standard principal components analysis (PCA), non-negative PCA and non-negative matrix factorization (NNMF) methods to decompose Raman spectra of the cancerous HeLa cells and healthy fibroblast MRC-5 cells into spectral components. Whereas PCA produces components expressing highest degree of spectral variance, non-negative PCA and MF components are more closely related to the Raman spectra of the individual cell molecules that are more abundant.

Spectra of several cell sets were analyzed, each of the sets containing untreated cells and cells exposed to the oxide nanoparticles of CeO2 and ZnO for several nanoparticle concentrations. Decrease of DNA content, changes in lipid-to-protein ratio and in lipid saturation degree are some of the processes that were possible to follow based on the behavior of certain spectral features contained within algorithm-obtained spectral components, acting as markers. Spectral decompositions obtained with non-negative algorithms for particular cell types and particular nanoparticles were cross-compared and combined in order to obtain more general model for the assessment of the magnitude of nanoparticle-induced changes in the cells.

References

1. S. Bayda et al., Curr. Med. Chem. 25, 4269 (2018).
2. D. W. Shipp, F. Sinjab and I. Notingher, Adv. Opt. Photonics 9, 315 (2017).
3. E. Brauchle, S. Thude, S. Y. Brucker and K. Schenke-Layland, Sci. Rep. 4, 4698 (2014).

`S13-BMP-101` / **Oral presentation (virtual)**

An overview on medical imaging system in Albania during the COVID-19 pandemic

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Albania is a small country in the western Balkans with a population of 2.8 million. The health system has undergone major transformations especially in the last 10 years especially with the involvement of the private sector in health services. Despite the improvements made, the global pandemic COVID-19 19 found the Albanian health system unprepared, highlighting the problems and its limitations. Diagnostic imaging played an important role in diagnosis of patients affected by Covid-19. In this work we made an overview study of Albanian medical imaging system focused on the current situation of the equipment, technology and the standards in the entire public and private health system. In our study we gather information from public sector (25 district hospitals, 11 regional hospitals, 4 university hospitals, 1 trauma university center), 10 major private hospitals and more than 60 radiologic centers from public and private health sector. In other hand we analyzed the information's provided by the national medical register regarding the technical specifications of these equipment and compared the result with OECD indicators and COCIR "Golden Rules". Diagnostic imaging in Albania uses a great variety of equipment. In total are in use 18 MRI, 60 CT, 1 PET-CT, 50 CBCT and more than 500 conventional and digital radiography devices, fluoroscopy and mammography equipment. Compared with OECD units per million population, the report of units per 1 million habitants in Albania is under the average number (OECD Health Statistics 2018). Albania. Dental imaging prioritizes the sector with the best ratio while the number of PET equipment is extremely low. We found deterioration of the situation regarding the fulfilment of COCIR "Golden Rules" compared with 2015. Actually, more than 65 % of the installed equipment base is between six to ten years old, 20 % is less than five years old and 15 % of the installed equipment is more than ten years old.

S13-BMP-102 / **Oral presentation (virtual)**

Advantages of hadron therapy in the treatment of cancer compared to other radiotherapy modalities with the example of Montenegro

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The project examines the current state-of-the-art and use of radiation therapy in treatment patients with cancer. Through it different treatments are explained with special emphasis on those currently accessible in Montenegro and South - Eastern Europe (SEE). Both, advantages and disadvantages of each kind of treatment were

considered. Especially, detailed analysis of hadron therapy (HT) is presented when it comes to technology and possible benefits. The aim of this project is to investigate the scope for HT in the SEE region. Thanks to data collected about the oncological patients in Montenegro during 2013 it is possible to analyse them and make further conclusions. The overview of this scientific data is crucial for concluding whether a different kind of treatment is needed in Montenegro.

S13-BMP-103 / **Oral presentation**

LGAD enabling technology for 4D tracking and timing measurements in experiments with ions, accelerators and for medical applications

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Presenter: G. Lastovicka-Medin (gordana.medin@gmail.com)

In this contribution we will review a wide variety of LGAD applications ranging from the timing measurements for HL-LHC (HGTD for ATLAS and MIP Timing detector for CMS) to reaction time detector for experiments utilizing proton and pion beams with the High Acceptance Di-Electron Spectrometer (HADES), at GSI Darmstadt, Germany, and to beam structure monitoring for medical applications (MedAustron). Very brief overview of LGAD's application in astrophysics will be presented as well. In addition, a prospect of LGAD to be utilized at the Future Circular Collider (FCC) will be discussed. The advantages as well as the limits of LGADs in regard to the specific experimental conditions and the nature of beams and particles to which they are exposed will be explained.

S13-BMP-104 / **Oral presentation**

Self-Association of Antimicrobial Peptides in Mono- and Multicomponent Solutions: a Computational Study

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Presenter: E. Lilkova (elena.lilkova@iict.bas.bg)

Antimicrobial peptides (AMPs) are a diverse class of short proteins, that are a key element of the nonspecific innate immunity in most organisms, displaying a wide range of antimicrobial, antifungal, antiviral and even anticancer effects. Lately, AMPs have attracted great research interest in the context of strategies to combat multi-drug resistant bacterial infections. AMPs come in nature in the form of multicomponent secretory fluids that exhibit certain biological activity. Although these small proteins are usually cationic and amphiphilic, their antimicrobial action is not completely understood, neither is their behaviour in bodily liquids prior to attacking the target membrane. We studied various linear AMPs behavior in mono- and multicomponent solutions, prior to their engagement with the pathogenic membrane, by means of long-scale molecular dynamics simulations. We observed that the peptide monomers self-associate into clusters, which consist of a non-polar hydrophobic core and exposed to the solvent charged and polar residues. We consider the so-formed structures as the perfect transport system – locking the hydrophobic uncharged residues in the core of the cluster prevents the interaction with the uncharged eukaryotic membranes, and positioning the charged residues on the cluster surface enables for electrostatic interaction with the bacterial surface. The very formation of the clusters but also the peptide folding, promoted by the amphiphilic structure in the aggregates, allow for an increase of the local concentration of AMPs to be delivered to the target membrane in a functionally active conformation.

Acknowledgments: This work is partially supported by the Bulgarian Science Fund (Grant KP-06-OPR 03-10/2018). Computational resources were provided by the BioSim HPC Cluster at the Faculty of Physics at Sofia University "St. Kl. Ohridski", Sofia (Bulgaria) and by CI TASK (Centre of Informatics – Tricity Academic Supercomputer & networK), Gdansk (Poland).

`S13-BMP-105` / **Oral presentation**

The SEEIIST project

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A project for the establishment of an international intergovernmental scientific organization in the region of South East Europe (European Institute for Sustainable Technologies - SEEIIST) is under way. The research infrastructure will include a powerful next generation accelerator that will provide proton and ion beams for tumor treatment and biomedical research. The center will comprise three rooms for patient treatment and two large experimental halls. The institute will carry out clinical trials to develop new methods and protocols for the treatment of tumors with protons and light ions, development of methods of combined radio and immunotherapy and research in the field of radiation genetics. A wide range of preclinical in-vitro and in-vivo radiobiology studies are also envisaged. A large program of research in the field of medical physics related to the formation and control of proton and ion beams, control and measurement of the dose received by

patients, medical imaging and biophysical modeling and planning of patient treatment is also planned. Design and investigation of the properties of new material is part of the research program as well. Production of isotopes for cancer diagnosis and treatment is envisaged. Ten Balkan countries are involved in the realization of the SEEIIST project.

`S13-BMP-106` / **Oral presentation (virtual)**

Comparison of Co-60 and Ir-192 in brachytherapy treatment planning

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Presenter: R. Mema (`rodiana.mema@gmail.com`)

Many radionuclides have a history as a source for brachytherapy, but today only a few are commonly used. They are characterized by the rate at which their strength decays (half-life), by how much radioactivity can be obtained for a given mass of the radioactive source (specific activity) and by the energies and types of the radiation particles that are emitted from the source (energy spectrum) [1]. This paper compares the isotopes Co-60 and Ir-192 as radiation sources for high-dose-rate (HDR) afterloading brachytherapy. The smaller size of Ir-192 sources made it the preferred radionuclide for temporary brachytherapy treatments.

Recently also Co-60 sources have been made available with identical geometrical dimensions. This paper compares the characteristics of both nuclides in different fields of brachytherapy based on scientific literature. In an additional part of this paper reports from medical physicists of several radiation therapy institutes are discussed. The purpose of this work is to investigate the advantages or disadvantages of both isotopes for HDR brachytherapy in the treatment plan system. The motivation is to provide useful information to support patient treatment procedures by using a more cost-effective resource while maintaining the quality of their treatment. The results of this work show that no advantages or disadvantages exist for Co-60 sources compared to Ir-192 sources with regard to clinical aspects. The advantage lies in the potential logistical issues of Co-60 resources due to the longer half-life (5.3 years versus 74 days), making it an interesting alternative, especially in developing countries or countries with limited economic resources.

S13-BMP-107 / **Oral presentation (virtual)**

Dosimetric evaluation of radiation bundles without flat filter in linear accelerators used in radiotherapy

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The flattening filter is a piece of metal with conical shaped mounted within the treatment head of a linear accelerator, used to produce a flat, uniform beam of X-rays from the forward-peaked distribution exiting the target. They have been used since the introduction of the linac in the 1950's, however, there are still several unresolved issues surrounding their use. The photon scatter and electron contamination introduced by modifying the fluence are difficult to model, as is the variation in energy spectrum caused by differential absorption across the field.

Leakage radiation also causes increased whole body doses to the patient, and the filter itself acts as an amplifier for beam bending and steering issues.

With advances in imaging, dose optimisation and imageguidance it is now possible to locate a tumour accurately in space and to design radiation fields conform to its shape, avoiding adjacent normal and critical tissues. This active production of non-flat fields means that the prerequisite for flat fields no longer exists, and the filter is potentially no longer a necessary component.

This thesis reports on research of two filter-free linear accelerator, from basic operation and optimisation, dosimetric characterisation and beam modelling, through to treatment planning and dose delivery. FFF beams have been shownto produce beams that are more stable, simple to model and with reduced patient leakage (leading to reduced secondary cancers). The increase in dose rate also translates into shorter treatment times for many treatments, aiding patient comfort and reducing problems associated with intra-fraction motion. during a treatment fraction.

S13-BMP-108 / **Oral presentation**

Phase Plane Rotation as Variance Reduction Method in Monte Carlo Simulations of Axial-Symmetric Radiation Sources

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Presenter: S. Pecic (stevan.pecic@ff.bg.ac.rs)

Monte Carlo algorithms often require large computing resources, primarily in the form of processing time. Knowledge of the underlying principles governing the simulated problem under specific circumstances allows the use of certain variance reduction methods. This work introduces a novel approach to variance reduction based on the partial axial symmetry of the clinical accelerator.

The development of the title method was performed using an accelerator simulation that was divided into two phases: The first phase involves simulating the fluence through the symmetrical part of the accelerator, while the second one involves fluence through the non-symmetrical part. Simulation outputs of the first phase in the form of phase space files were manipulated using in-house software for rotation of the intermediate phase plane. This way, multiple simulations of particle fluence from the source to the last rotationally symmetric component were effectively replaced by multiple random rotations of the phase plane. Analysis of phase plane rotation effects and usability of this approach as a variance reduction method is further investigated in the EGSnrc code.

Usage of phase plane rotation increased the number of particles by the number of rotations factor, resulting in less variance of the estimated dose. However, rotation introduces artifacts that can be treated as a systematic error and these artifacts are discussed throughout this work. Qualitative analysis of the dose profiles undoubtedly shows the superiority of phase space rotations in comparison to particle recycling variance reduction. Also, notable improvement is achieved in terms of the efficiency of the simulation.

The presented results demonstrate improvement in the overall accuracy of the simulation. Given the geometry independent software solution, it is to be expected that the presented method can be applied with equal success to a variety of axial symmetrical radiation sources, and further extended to other packages for Monte Carlo simulations of radiation transport.

References

1. K. Bush, S.F. Zavgorodni, and W.A. Beckham, Physics in Medicine and Biology 52, 4345 (2007).
2. D.W. Rogers, B.A. Faddegon, G.X. Ding, C.-M. Ma, J. We, and T.R. Mackie, Medical Physics 22, 503 (1995).
3. T.D. Hoang, T.T. Duong, O.T. Luong, and L.T. Truong, Science and Technology Development Journal 22, 258 (2019).

S13-BMP-109 / **Oral presentation**

Evaluation of the influence of some polymers on the physical stability of lipid self- double emulsifying systems with Alendronate Sodium

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Presenter: I. Pehlivanov (ivaylo.pehlivanov@mu-varna.bg)

The Self-emulsifying drug delivery systems (SEDDS) containing lipids, surfactants, and co-surfactants are a promising oral platform for drugs with problematic solubility and permeability. However, especially those systems representing a liquid phase may show some shortcomings, such as in vivo drug precipitation, limited lymphatic transport, and storage problems. These shortcomings can compromise their application. The inclusion of some polymers in their composition would increase the system's stability both during storage and during dispersion in the gastrointestinal tract. For example, alendronate sodium, a BCS class III drug, is characterized by low permeability (2.5%) and good solubility (23.7 mg.mL-1).

The present study aimed to investigate the effect of the natural polymer gelatine and co-emulsifier soybean hosphatidylcholine on the physical stability of w/o/w self-double emulsifying drug delivery systems based on coconut oil with Alendronate Sodium (w/o/w SDEDDS-NaALD). For the preparation of the model systems, lipids were used ordinarily present in the diet and surfactants approved for use in the pharmaceutical and food industries.

Four models have been developed containing 70 mg Alendronate sodium and a combination of excipients (Polysorbate 80, Sorbitan Monooleate 80, and soybean phosphatidylcholine) with and without gelatine. For the determination of the excipient ratios of self-emulsification pseudo-phase diagrams were used. The two-phase emulsification technique was used with a high-speed homogenizer (65℃) to obtain the self-emulsifying systems.

Sedimentation analysis (by centrifugation) and spectrophotometric analysis (%T, λ=540 nm) were used to determine the stability and dispersion of the prepared model systems. In addition, the self-emulsification time of the different self-double emulsifying systems and the average particle size of the dispersed phase was determined by DLS. The self-emulsification time of the systems varies from 70 to 110 min.

As a result of research, it was found that the system containing (w/w): Alendronate sodium 6%, water 17.5%, gelatine 0.6%, Sorbitan Monooleate 80 2.9%, coconut oil 17.5%, Polysorbate 80 51.5% is characterized by mono dispersion, average dispersed phase size 200 nm and the best stability compared to other studied models, which

retains its degree of dispersion for one week. Therefore, this model is a suitable candidate for further research and development of a lipid-based dosage form for Alendronate sodium.

S13-BMP-200 / **Poster presentation**

Determination of spatial resolution of nonlinear laser scanning microscopy

Authors: Aleksa Dencevski[1]; Jovana Jelic[1]; Marta Bukumira[1]; Aleksandar Krmpot[1]; Ana Senkic[2]; Antonio Supina[2]; Mihailo Rabasovic[1]; Natasa Vujicic[2]; Stanko Nikolic[1]

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Presenter: M. Bukumira (marta@ipb.ac.rs)

Microscope resolution is the shortest distance between two points on a sample that can be distinguished as separate entities. Due to the wave nature of light and the phenomenon of diffraction, it is fundamentally limited: even under theoretically ideal conditions and optical components, the microscope has a finite resolution.

In this paper, we determined lateral and axial resolution of a nonlinear laser scanning microscope by measuring its point spread function (PSF) in two ways: by imaging fluorescent beads using two-photon excited fluorescence (standard method), and by using monolayers of molybdenum disulfide – MoS_2 (non-standard method), obtained by chemical vapor deposition [1], which, due to the lack of central symmetry, efficiently generate second harmonic signal.

Parameters such as the numerical aperture of the objective and the excitation wavelength contribute to the resolution, so it changes depending on the current setting of the microscopic system. Measurements were performed for two different objectives and several standard excitation wavelengths, depending on the type of sample. As expected, the best resolution was obtained for the objective with the largest numerical aperture (40x 1.3) and the shortest excitation wavelength (730nm): $R_{lat} = 260nm$, $R_{ax} = 1648nm$. In addition, the values obtained by the non-standard method are closer to the theoretical values of the resolution, because the contributions of the out-of-focus signal are significantly smaller due to the two-dimensional nature of the layers. This implies that it is better to use this type of sample to determine the resolution of the microscope. The measured PSF can be further used to deconvolve the images obtained on this microscope.

Due to its properties such as large penetration depth of incident radiation and label-free imaging, as well as the possibility of obtaining 3D models, our microscope is widely used in examination of the samples of biological origin, such as: erythrocytes [2], chitinous structures [3], human colon tissue [4], collagen and dentin.

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References

1. A. Senkic *et al.*, in preparation, CVD growth parameters on global and local optical properties of MoS2 monolayer
2. K. Bukara *et al.*, J. Biomed. Opt. **22**(2), 026003 (2017)
3. MD Rabasovic *et al.*, J. Biomed. Opt. **20**(1), 016010 (2015)
4. SZ Despotovic *et al.*, Sci. Rep. **10**, 6359 (2020)

`S13-BMP-201` / **Poster presentation (virtual)**

Calorimetric Tracking of the Plasma and CSF Proteome in Children With Acute Lymphoblastic Leukemia

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Presenter: Y. Dimitrov (`yoandimitroff@gmail.com`)

Leukemia is the most common type of cancer found in children. It accounts for around 33% of all malignant diseases in pediatrics.

Differential scanning calorimetry DSC is a highly sensitive technique that measures temperature-induced conformation changes in proteins. As such, it is useful in measuring the exact values of concentration, conformation and interaction between proteins and other molecules and allows for observing specific insignificant changes in blood plasma and CSF (cerebrospinal fluid), related to various pathological processes. This way, plasma and CSF proteins could serve as biomarkers for the diagnosis and monitoring of the disease.

In this study we have used DSC to compare alterations in the protein thermal denaturation profiles of blood plasma and CSF, taken from children with acute lymphoblastic leukemia (ALL), with the corresponding fluids from other children in continuous remission with healthy clinical and hematological statuses, used as controls.

Here we present DSC measurements of blood plasma in children in cases with leukemic infiltration present in the bone marrow. In some cases they are about newly developed disease or relapsed one, and in other cases about Non-Hodgkin's lymphoma with secondary spread to the bone marrow and also lymphoid blast crisis of chronic myeloid leukemia. The results we have obtained reveal that in the early stages of leukemia development in the bone marrow, the reaction of the plasma proteome is relatively weak – the recorded denaturation profiles do not differ significantly from those of the controls. However, in the course of the disease progression huge differences were found in the state of the plasma proteins. We have found that at least three of the main protein components of blood plasma have specific shifts in their denaturation curves, namely, albumin, with shift from ~62ºC to ~64ºC, globulins Ig, with shift from ~70ºC to ~72ºC, and transferrin, which undergoes denaturation at ~82ºC is shifted to ~ 3ºC, while fibrinogen at ~50ºC is not affected.

In the second group of studies we have presented results from DSC analysis of CSF from children with meningeal relapse of ACC. In one of the patients a high intensity specific peak at ~72ºC was observed in the CSF thermogram (probably caused by the presence of lymphocytic proteins in the CSF) which flattens after negating the neoplastic pleocytosis. In another patient were observed two specific peaks, at ~52ºC and ~68ºC were observed, which decrease in intensity after applied therapy, later we found different CSF protein peaks at ~65ºC and ~83ºC. Changes in the thermograms persist even when a minimum amount of pathological proteins is present. The denaturation profile of a CSF can be used as an indicator for the presence of a blast invasion in the CSF and for measuring the achieved therapeutic effect.

This study contributes to the validation of DSC as a powerful tool for monitoring malignant diseases and for evaluating the efficacy of applied chemotherapy.

`S13-BMP-202` / **Poster presentation (virtual)**

Surface electrical properties of model membrane structures in the presence of neurotransmitters

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Presenter: V. Doltchinkova (`dolchinkova@biofac.uni-sofia.bg`)

Acting as chemical signals neurotransmitters are expected to influence biological membranes' electrical properties, related to the transmission of electrical impulses and the interaction of cells with external electric fields. Closed membrane structures such as erythrocytes represent model system successfully exploited in the investigation of the electrical properties of biological membranes. In the present study we address the effect of dopamine on the electrokinetics properties of erythrocytes to deduce their structural changes and the surface charge density of their membranes.

Dopamine is one of the most important neurotransmitters, both excitatory and inhibitory. Its motor and motivational behavior dysfunction is involved in psychiatric disorders such as drug addiction, schizophrenia, Parkinson's and Huntington's disease.

The effect of dopamine on erythrocytes and model lipid bilayers is characterized by investigating their electrokinetic parameters, mechanical properties and lipid peroxidation. Erythrocytes in the presence of 0.005 mM dopamine have increased zeta potential and surface electric charge. In the presence of 0.010 mM dopamine in the erythrocyte suspension, a decrease in the zeta potential by about 2 mV and a decrease in the negative surface electrical charge are observed. Erythrocytes are also characterized by a greater increase in zeta potential and surface charge when treated with 0.02 mM, 0.10 mM and 0.40 mM dopamine. A similar increase in the electrophoretic mobility, zeta potential and surface electrical charge in the presence of 0.2 mM dopamine in the erythrocyte suspension is observed, followed by a slight decrease in zeta potential in the presence of 0.05 - 0.30 mM dopamine. Higher dopamine concentrations of 10 mM and 15 mM lead to strong aggregation and reduction in the zeta potential and the negative charge density of the erythrocyte membrane.

With increasing dopamine concentrations (5 - 40 mM), an increase in lipid peroxidation from the erythrocyte membranes is observed. Significantly lower is the increase in TBARS products after exposure to 1 - 4 mM dopamine or 0.3 mM dopamine on erythrocyte membranes. A protective effect of dopamine is observed in the concentration range of 0.005 - 0.040 mM, where a reduction of lipid peroxidation by erythrocytes is observed. These data suggest that lipid peroxidation is not involved in the mechanism underlying dopamine alteration of electrokinetic properties of erythrocytes. The role of the surface charge of erythrocytes in affecting its aggregation by neurotransmitter is studied by comparing the behavior of normal erythrocytes with that of cells treated with dopamine which alter the zeta potential and oxidative stress status.

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`S13-BMP-203` / **Poster presentation (virtual)**

Modulation of membrane electrokinetic properties by semiconductor nanoparticles

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Presenter: V. Doltchinkova (dolchinkova@biofac.uni-sofia.bg)

Core/shell CdSe/CdS nanocrystals are one of the most important II–VI semiconductors with applications in solar cells, optoelectronics and electronic devices. CdSe / CdS nanocrystals are coated with thioglycolic acid to be water soluble. CdSe / CdS core-shell quantum dots have also been used, which reduce the toxicity of CdS nanocrystals on biological membranes. Semiconductor nanoparticles have great potential serving as a new generation of multifunctional agents for clinic diagnosis and treatment (Wang et al., 2018). This study will highlight the main biophysical points to be considered in order to evaluate the electrokinetic potential of erythrocyte membranes under treatments with semiconductor nanoparticles and discuss the issues and challenges emerging in the field of nanotechnology and electroketic stability of the erythrocytes.

We measure the electrophoretic mobility of human erythrocytes using three types of core/shell CdSe/CdS nanocrystals (NP1, NP2, NP3) by the method of microelectrophoresis. The restricted change in electrokinetic properties of erythrocyte membrane indicated that the structural phenomena observed are due to the erythrocyte-nanocrystals interaction.

A strong decrease in membrane transport across the human erythrocyte membrane is occurred due to OH-/Cl- antiport as well as H+/Cl- cotransport' inhibition. Higher lipid peroxidation of erythrocytes in the presence of CdSe/CdS nanocrystals is determined compared to untreated erythrocyte membranes.

Concern about the toxicity potential of semiconductor nanoparticles is mainly attributed to this small size, large surface area and high reactivity compared to bulk-sized materials (Oberdörster, 2010). The results of the present study provide new insights into the biological impacts of semiconductor nanoparticles in vivo.

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References

1. X. Wand, J. Yu, R. Chen (2018) Scientific Reports, 8:17323
2. G. Oberdörster (2010) J Intern Med, 267 (1): 89-105

S13-BMP-204 / **Poster presentation (virtual)**

Membrane-protein biophysical interactions: Electrokinetic and light scattering studies in the presence of polylysine and wheat germ agglutinin in model membranes

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The mechanism of interaction between proteins and phospholipids in biological membranes has been shown to play an important role in the regulation of both the structural and dynamic properties of biomembranes and of the biological function of membrane proteins.

In an attempt to characterize the electrokinetic properties of human erythrocyte membranes and extrinsic proteins, the action of poly-L-Lysine (PL) and wheat germ agglutinin (WGA) to erythrocyte ghosts has been investigated. Polylysine-lipid molecular interactions are mainly due to the electrostatic binding between the polar headgroups of phospholipid and polylysine molecules, according to the literature data. Polylysine has broad biomedical applications (Zhang and Liu, 2017). Lectin (WGA) is often used as a biological probe for membrane stability, as well as for analyzing the surface components of the biological membrane with considerable potential to improve biomedical field (Balčiūnaitė-Murzienė and Dzikaras, 2021). Binding of lectin to the erythrocyte membrane causes significant topographic changes in the location of the respective receptor sites. This is accompanied by changes in the cell surface electric charge. The determination of the electric charge and its changes after the lectin-membrane contact can serve as a manner to register changes in the erythrocyte membrane.

Significant alterations in the cell electrokinetic potential under the influence of the PL polycations in a low ionic strength medium have been found. The electrostatic effect is significantly reduced in the presence of doses of 20 - 600 μg PL / mL, which is accompanied by a sharp decrease in aggregation between erythrocyte membranes. Polyvalent ions of wheat germ agglutinin strongly affect their electrostatic effect on the outer membrane surface of erythrocyte ghosts at doses of 20 - 200 pg WGA/mL. Upper concentrations of lectin treatment do not alter the electrophoretic motility of erythrocyte ghosts. This process is accompanied by a lack of changes in aggregation between membranes at high doses of lectin exposure.

The aim of this work is the evaluation of the action of the poly-L-Lysine and wheat germ agglutinin on the electrokinetics of erythrocyte membranes. The results of biophysical techniques indicate that the upper interactions are related to the reduction of zeta potential due to the decrease in the negatively exposed groups on the membrane surface upon polycation and lectin interaction with the hemoglobin-free cells.

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References

1. W. Zhang and F. Liu (2017) Journal of Nanoscience and Nanotechnology, 17(1):251-255.
2. G. Balčiūnaitė-Murzienė and M. Dzikaras (2021) Applied Sciences, 11(2), 884.

S13-BMP-205 / **Poster presentation**

Polarimetric characterization of collagenosis tissue samples

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Presenter: S. Ilyov (stoyan.ilyov@gmail.com)

Polarimetry is one of the emerging optical modalities for implementation in diagnostic. Polarimetric measurements are mostly informative about structural changes in the tissue. Collagenosis diseases affect connective tissue and arise from changes in collagen structure or metabolism. Their diagnosis is quite challenging, since the symptoms are not unambiguous.Considering that collagen is responsible for most of the skin structure, we investigated the feasibility of polarimetry for assessing tissue samples for different collagen degenerative diseases.

We will present the result of histology tissue slides evaluated through Stokes polarimetry in transmission geometry.

Acknowledgments: The investigations were supported by the Bulgarian National Science Fund under grants #KP06-N28/11/14.12.18 and KP-06-Rila/3.

S13-BMP-206 / **Poster presentation**

Lipid content changes in cancerous and non-cancerous cells induced by ZnO nanoparticles: Raman spectroscopy approach

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ZnO nanoparticles (NPs) applied in sufficient doses exhibit cytotoxic effect in vitro [1]. However, selective cytotoxicity towards certain cell types is also registered [2]. Proposed selectivity of ZnO NPs for cancer cells is an issue of special importance for the development of new drugs based on ZnO. By generating the reactive oxygen species (ROS) and by acting themselves as an electron-hole redox system, ZnO NPs can alter composition and structure of all main biological macromolecules in

the cell, among which the lipids occupy a significant place. Peroxidation of lipids in the cell membrane can directly lead to the cell death of necrotic type, while the products of oxidized lipids act as the signal molecules in induction of apoptosis and autophagy. In this study we have investigated the effect of ZnO NPs on changes in lipid content and structure in cancerous HeLa and non-cancerous MRC-5 cells, using Raman spectroscopy and non-negative principal component analysis (nnPCA) [3]. Common for both cell types are quantitative changes in lipid content and lipid-to-protein and lipid-to-DNA content ratio, in favor of lipids. These changes are mainly deduced from the analysis of 1659 cm^{-1} and 1444 cm^{-1} vibrational modes in the low spectral region and 2855 cm^{-1} and 2933 cm^{-1} vibrational modes in the high region of Raman spectra, whose intensity ratios are used as common markers for relative quantification of cellular lipid and protein content [4]. Nevertheless, in non-cancerous cells the described changes occur after exposure to lower doses of NPs than in cancer cells, which is in accordance with higher sensitivity of MRC-5 cells to ZnO NPs shown by conventional biological cytotoxicity assays. However, there is a significant difference in the spectral components which act as markers of lipid unsaturation, represented by high relative intensity ratio of I_{1300}/I_{1260} and prominent mode at 1659 cm^{-1} [5], suggesting higher degree of lipid saturation in treated MRC-5 than in treated HeLa cells. It is possible to recognize the increase of an early-apoptotic lipid marker in the Raman spectra of treated HeLa cells, while the spectra of treated MRC-5 cells contain lipid markers which indicate a later phase of apoptosis. The differences in lipid structure between untreated HeLa and untreated MRC-5 cells are also deduced from their Raman spectra and correlated with a higher sensitivity of MRC-5 cells. It is concluded that Raman spectroscopy has a great potential in tracing the changes of lipid molecules in the cells, being in that way useful in the studying of NPs cytotoxic effects.

References

1. M.J. Akhtar et al, Int J Nanomedicine, **7**, 845 (2012)
2. J.W. Rasmussen, E. Martinez, P. Louka, D.G. Wingett, Expert Opin Drug Deliv, **7**, 1063 (2010)
3. A.L. Blee et al, J Raman Spectrosc, **52**, 1135 (2021)
4. M. Lasalvia, G. Perna, V. Capozzi, Sensors (Basel), **19**, 2418 (2019)
5. K. Czamara et al, J. Raman Spectrosc, **46**, 4 (2014)

`S13-BMP-207` / **Poster presentation**

Pigmented skin lesions assessment with optical coherence tomography

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Objective diagnosis on site, in real time is still a challenge for skin lesions, specifically pigmented skin lesions. Different optical tools are currently under development or clinical implementation process to assist this process. Some of the techniques applied are diffuse reflectance spectroscopy, fluorescence spectroscopy, even confocal fluorescence microscopy. They provide information about biochemical and morphological alterations in the tissue, but no insight on an important for successful treatment parameter- the thickness of the lesion. However, another optical modality could "shine light" on that matter – optical coherence tomography.

Optical coherence tomography has been an established tool for diagnosis in ophthalmology; however, its application as imaging modality in dermatology requires more work in creating guidelines for its application.

The objective of this work is to elaborate on specifying peculiarities of pigmented lesions, specifically malignant melanoma, observed through OCT imaging.

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S13-BMP-208 / **Poster presentation (virtual)**

Effect of Melittin on the Human Erythrocyte and Rat Liver Mitochondrial Membranes

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Melittin as the major toxic component of the bee venom from Apis mellifera has previously been shown to be potent antibacterial agent with application in anticancer therapy. In the present study we analyze the action of melittin on biological systems using human erythrocytes and rat liver mitochondria as test systems. Alterations of lipid bilayer electrical resistance by melittin are probed by electrochemical impedance spectroscopy. We demonstrate that the melittin increases the electrophoretic mobility (EPM), zeta potential and surface electrical charge of erythrocyte membranes, suspended in phosphate buffered saline (PBS, pH 7.4). Melittin reduces the EPM of intact mitochondrial membrane in saline sorbitol suspending buffer (SSB, pH 7.2) and 2 ng/mL but causes an enhancement of negative electrokinetic potential at higher concentrations by 7 mV – 10 mV and net surface charge. The molecular mechanism of action of the cationic peptide on the electrostatics of the membrane is not completely established. Lipid peroxidation of melittin-treated

erythrocytes and mitochondria show altered LP products compared to the untreated cell and sub-cellular structures.

Melittin influences transport pumps and increases the permeability of cell membranes to ions. Melittin alters the function of Band 3 of erythrocyte membranes which could accelerate the reaction with peptide. The apparent proton efflux assay is performed and the effectiveness of melittin is discussed. It is established that 0.2 μg/mL and 0.35 μg/mL accelerate the membrane transport of protons outflux the cells. There is a strong reduction of slope of membrane transport in the presence of 0.1, 0.3 and 0.4 μg/mL. We propose that the melittin disrupts the erythrocytes because of electrostatic interactions with membranes and changes in membrane transport via Band 3 alteration.

The results of the present study suggest that melittin treatment and the following enhancement of electrokinetic stability of mitochondrial membranes depends on the existence of high electrochemical membrane gradient ($\Delta\psi$) across the energized membrane. De-energized mitochondria with lack of electrochemical membrane potential and without an electrochemical proton difference across the membrane possess an increase in stability upon melittin action.

The significance of melittin interaction with biological membranes increases its electrokinetic stability and provides a potential explanation of inflammatory diseases and anti-oxidative stress.

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`S13-BMP-209` / **Poster presentation**

The dependence of the radiation dose on the angle and the field size for radiation beam with energy 18 MV.

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The cell proliferation is a process that takes place through the cell cycle. Normally there is a balance between cell proliferation and death, when mutations that occur in ADN interrupt this process resulting in the birth of tumors. The spread of tumor diseases has led to the need to develop different methods for treating tumors. One of the methods of treating tumors is also through radiotherapy. In the treatment of tumors through radiotherapy are used accelerators which provide radiation beams with different energies. In the treatment of tumors with radiotherapy, electronic beam can be used for tumors that are located on the surface of the human body up to a depth of 7 cm or photonic beam for tumors that are located in different organs. The treatment of tumors using the radiotherapy provided by accelerators, it is also known as external beam radiotherapy, where the patient is placed at a certain distance from the accelerator head or radiation source as it is otherwise called. In external beam radiotherapy, it is very important to know the characteristics of the beam of radiation that will be used in the treatment of a certain tumor or tumor mass. A very important element in the treatment of external beams is the knowledge of the factors that affect the dose of radiation given to the tumor mass, in order to give the exact dose needed to stop the process of tumor cell proliferation. In this material we will present two important factors, which affect the given dose, which are the size of the radiation field and the angle at which the radiation beam is given by the accelerator head. The factors listed above affect the dose distribution within the tumor mass. In our case we have used an accelerator type Elekta synergy platform with radiation beam with energy 18 MV. To see the dependence of the radiation dose on the factors defined above, we take some radiation field size with different dimensions and look at the changes in the radiation dose values. We notice that with the increase of the field size we have a decrease of the value of the radiation dose compared to the cases with small field size. This dependence helps us to evaluate the dose of radiation that we must give to the tumor mass in order to damage the tumor cells. Treatment of tumors with radiotherapy requires high accuracy and resolution of difficult cases. To treat tumors in different organs of the human body, the radiation source is placed at different angles depending on the position of the tumor. In these cases a correlation is observed between the radiation dose and the angle of the radiation source. The knowledge of the behavior of the radiation dose in relation to the angle of the radiation source, is used in giving the right dose in order to protect healthy organs. We have to be careful in report with given dose on the tumor mass on purpose that we have good results.

`S13-BMP-210` / **Poster presentation**

Support vector machine for evaluation of autofluorescence cancer diagnostic parameters

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Presenter: L. Zaharieva (`zaharievalidia@gmail.com`)

A number of optical techniques have been investigated for implementation in the clinical practice for cancer detection in the gastrointestinal tract. The aim of those, so called "red-flag" modalities is to navigate and point out suspicious areas with

pathological alterations in the tissue. Autofluorescence diagnostic is largely preferred, since it is patient friendly and cost-effective. The main drawbacks of this technique is the scarce signal, which makes detection and data processing a challenge and the insufficient diagnostic specificity that the current diagnostic algorithm provides.

In this work we will present our evaluation of autofluorescence excitation-emission matrices with support vector machine (SVM) and multispectral analysis (MA). With the purpose of identifying diagnostically valuable parameters, which will improve the accuracy of autofluorescence diagnostics.

Spectroscopic measurements were performed of ex vivo tissue samples, excised during surgical procedure for tumor removal, without any processing. Excitation wavelengths applied were in the range of 280-440nm and the emission was detected in the range of 300-800nm.

The accuracy of differentiation based on fluorescence spectra was tested through SVM. Differentiation based on a whole spectrum will be too cumbersome for clinical implementation, which is why we used MA to define suitable diagnostic parameters. Further with SVM the diagnostic accuracy of differentiation between cancerous and healthy tissue with those parameters was tested. The results demonstrate diagnostic accuracy of more than 90%.

Acknowledgments: The author acknowledges the support of the National Science Fund – Bulgaria under grant #KP06- N23/8/2018 "Innovative photodynamic methods for treatment of stem cells cultivated from glioblastoma tumors". Spectrofluorimetric equipment used was purchased under the NSF grant #DO-02-112/2008.

S14-PEHPP
Physics Education, History and Philosophy of Physics

S14-PEHPP-001 / **Invited talk**

Everlasting educational reforms – on the road to quality and permanent knowledge or...

Author: Lambe Barandovski[1]

Co-authors: Vera Zoroska [2]; Aneta Gacovska-Barandovska [3]

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Presenter: L. Barandovski (barandovski@gmail.com)

The Macedonian educational system is under continuous reforms and changes made to the syllabuses and methods of teaching. In the last two decades, almost every aspect of teaching mathematics and physics in primary school has been changed. The last three major changes cover different approaches: coordinated teaching in 2008, curriculum changes towards research methods and problem solving in learning and teaching - according to the Cambridge International Examinations Center in 2016, and the newest concept according to the European Strategy 2020 (based on six dimensions: quality, inclusion and gender equality, green and digital transitions, teachers, higher education, a stronger Europe in the world) and the new Action Plan for Digital Education 2021-2027 (with initiatives for high quality, inclusive and accessible digital education in Europe). Different opinions appeared in public, mostly among teachers and parents, for and against the „new ways" in education. Hereby some of the arguments for and against will be presented, problems and questions will be stressed out and curriculum differences will be shown. Are we losing the chance for laying the foundations of mathematics and physics while walking on the road to digitalization? Are we ready as a country to embrace the new social challenges? Have we done enough research before introducing the new concepts, do we know if we are professionally, materially and mentally ready to let the „digital books" and „interculturalism" on a small door in the classrooms? Finally, yes, the freedom in finding personal creative ways of teaching and using open source material is great, so is stimulating critical thinking among students. But is the majority of the population ready to trade the classical textbooks for digital ones? Has there been continuing professional education for teacher in the classroom to be ready to grasp the new concept? Are we ready for this kind of transition in education as a way for a complete social transition?

S14-PEHPP-100 / **Oral presentation**

Students' interpretation of graphs in physics and mathematics

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Students are learning and using graphs in compulsory education in Republic of Serbia within physics and mathematics. Nevertheless, students have difficulties in using kinematics graphs and their misinterpretation is often [1]. Students' difficulties with graphs in physics are not necessary caused with the unsatisfying level of knowledge of graphs in mathematics [2]. Integration of physics is possible within every school subject, and the most obvious connections are in relation with mathematics [3] and chemistry [4]. Notwithstanding, students often do not recognize connection between these subjects and are not able to apply their knowledge of math graphics to physics. In order to assess the situation in Republic of Serbia, the research aiming to analyze students' interpretation of graphs in physics and mathematics was carried out.

Graphs are a part of the Physics 7th grade Curriculum while 7th grade Mathematics is dealing with dependent quantities. The research was conducted in an elementary school (Republic of Serbia). A suitable research sample was selected. Two classes of seventh grade students (13 years old) participated in the research, i.e., 57 students (26 boys and 31 girls). The test consisted of 10 tasks that were compiled by the researchers according to the subject Curriculum. Therefore, 5 tasks were based on the Motion (Physics) and another 5 on Direct and Inverse Proportion (Mathematics). This testing was realized through a standard paper and pen test that lasted for 45 minutes.

The result analysis showed that students had better accomplishments and understanding in math graphs. Also, the gender analysis showed that boys had better accomplishments in Physics than girls while girls had higher scores than boys when it comes to Mathematics. Based on the test results, it can be suggested that teaching graphs should be simultaneous in both subjects, Physics and Mathematics. Kinematics graphs, which are used in Physics, can be good examples when teaching and learning inverse proportion in Mathematics and the students can connect the formulas they learn in Physics with the appropriate formulas in Mathematics, that is, Direct and Inverse Proportion.

References

1. R.J. Beichner, Am. J. Phys. 62, 750 (1994).
2. M. Planinic et al., Int. J. Sci. Math. Educ. 10, 1393 (2012).
3. M.V. Pavkov-Hrvojević and I.Z. Bogdanović, in AIP Conference Proceedings 2075, 2019, edited by T.M. Mishonov and A.M. Varonov (AIP Publishing, 2019), 180013.
4. S. Cvjetićanin, D. Obadović and I. Rančić, Croat. J. Educ. 17 (3), 11 (2015).

S14-PEHPP-101 / **Oral presentation**

How to Increase Students' Motivation to Learn Magnetism

Authors: Agron Begotaraj[1]; Polikron Dhoqina[2]; Silvana Mico[2]

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Presenter: P. Dhoqina (polikron.dhoqina@fshn.edu.al)

Electromagnetism is considered one of the most complex topics of physics. Students face significant difficulties trying to get familiar with magnetic and electric phenomena. If the laws of electricity and magnetism and their theories are unclear to students, these phenomena become even more challenging to understand. In these situations, students usually start memorizing concepts without understanding them. One of the main reasons is that students are not paying attention to the basic fundamental operations, meaning students do not participate enough in inter-curricular activities to practice. Another reason that intensifies the difficulties that students face is time pressure. Limited-time to learn and practice will most likely cause a decrease in the ability of students to store this knowledge and use it in the long run.

In order to overcome this difficulty, there is a need for students to practice more, which in most cases, practice is missing, leading to not understanding phenomena entirely. Numerous experiments give a more practical understanding of magnetism and electricity, using easy-to-find and cheap materials. Experimenting with materials before reading about the theory and concepts behind phenomena will most likely increase students' curiosity and will to learn about the phenomena and understand them instead of simply memorizing. On top of that, students gain the needed expertise to watch the phenomena and make a replica of it.

This paper aims to present the strategy and the steps needed to do these experiments, which are most likely to increase students' interests in learning and understanding magnetism.

S14-PEHPP-102 / **Oral presentation (virtual)**

The Use of Natural Light for Educational Purposes in the Formation of Natural Scientific Literacy of Students in Primary School

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"Tell me and I will forget; show me and I will remember; include me and I will understand."

This report presents lessons conducted in regular Sience, Physics, and Astronomy classes related to a content area of expertise related to natural sunlight. Interdisciplinarity is presented through STEAM - based learning approaches and methods: exploratory approach, experiential learning, learning by doing, small group work, etc. Results of a survey are presented survey of the students about the lessons. Application of methods such as "Learning by doing", "Learning by experience" in science education is presented for: formation of science literacy, development of creativity related to making a solar device, applicable in direct teaching process. Attention is paid to the application of the above approaches and methods as motivating responsible behavior of students, building attitudes of teamwork, support, cooperation among students of the lower secondary stage. In the course of the work, information from various literature sources and schemes was selected and analyzed in connection with the elaboration of the final product of the conducted activities

S14-PEHPP-103 / **Oral presentation (virtual)**

From Students' Misconceptions to Reasoning: Lessons Learned from Physics Education Research

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Presenter: O. Gkioka (olga.gkioka@boun.edu.tr)

The paper starts with a brief discussion of research studies investigating students' misconceptions related to physics concepts, ideas and laws1. Then, we discuss the rich information on undergraduate students' understanding when research focuses on investigating students' reasoning in various areas of physics2, 3. The main body of the paper reports on recent research on undergaduate physics students' reasoning when they evaluate experimental measurements in the laboratory4. Secondly, we present ongoing research investigating students' reasoning when they analyze experimental data in the context of physics lab reports. The focus is on how they use best fist lines and curves and appropriate formulas linked to their reasoning behind various approaches. The paper concludes with implications for physics instruction, assessement and physics education research. The main argument is that physics instructors need to develop open-ended tasks in which they ask undergraduate physics students to demonstrate their full reasoning. The aim is for instructors to make sense of particular difficulties in order to address them in follow-up instruction.

References
1. J. Clement, Am. J. Phys. 50, 66 (1982)
2. L. C. McDermott, L. C. 67, 755 (1999)
3. L. Viennot, Am. J. Phys. 53, 432 (1985)
4. P. Van Kampen et al., Eur. J. Phys. 42 (2021)

S14-PEHPP-104 / **Oral presentation (virtual)**

Improving the Students' Learning of Optics and Atomic and Molecular Physics by Computer-assisted Spectroscopic School Experiments

Authors: Fabien Kunis[1]; Konstantin Ilchev[2]; Milena Stoyanova[3]; Vesela Dimova[3]; Christina Andreeva[4]

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Presenter: F. Kunis (f.kunis@125su.com)

In the present work, we investigate the possibility to improve the students' understanding of the spectral properties of different light sources and the transmission/absorption of different media by means of a partially computer-based school experiment in physics. Numerous studies have identified certain difficulties in understanding and applying atomic models [1,2], and more specifically, atomic spectra [3,4]. Savall-Alemany et al. [3], for example, identify the following students' misconceptions: do not take into account the quantization of atomic energy levels; assume that the atom can absorb a photon with arbitrary energy; do not differentiate between the quantities intensity and frequency or assume them to be directly proportional; often assume violation of the energy conservation law with respect to the emission of a photon; do not consider the possibility of an atom to decay into an excited state with lower energy, etc.

The experiment includes data acquisition and analysis of the spectra of different light sources, as well as the transmission spectra of different media. The numerical data are then used to calculate and visualize the absorption spectra of the media, with an analysis of the energy level structure of the absorber. A detailed description of the experiments will be provided, together with results from a survey performed among 10-grade students before and after the experimental work. Our hypothesis is that the proposed combined practical work on physics and information technology will improve the students' understanding of optics and atomic and molecular physics, as well as their data analysis skills.

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№80-10-42/10.05.2022 г.

References
1. R. Salazar (2019). Evaluating a Didactic Strategy to Promote Atomic Models Learning in High School Students through Hake's Method. Online Submission, 7(5), 293-312.
2. Cardoso, P. S. S., Nunes, M. C. S., Silva, G. P. S., Braghittoni, L. S., & Trindade, N. M. (2020). Conceptions of high school students on atomic models, radiation and radioactivity. Physics Education, 55(3), 035030.
3. F. Savall-Alemany, J. L. Domènech-Blanco, J. Guisasola, J. Martínez-Torregrosa (2016). Identifying student and teacher difficulties in interpreting atomic spectra using a quantum model of emission and absorption of radiation. Physical Review Physics Education Research, 12(1), 010132.
4. F. Savall-Alemany, J. Guisasola, S. R. Cintas, J. Martínez-Torregrosa (2019). Problem-based structure for a teaching-learning sequence to overcome students' difficulties when learning about atomic spectra. Physical Review Physics Education Research, 15(2), 020138.

S14-PEHPP-105 / **Oral presentation**

On the voltage measurements in the presence of varying magnetic fields

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Presenter: S. Mico (silvana.mico@fshn.edu.al)

The electromagnetic field behavior is described by the set of Maxwell equations relating the electric and magnetic fields, charge density and current density. The electric and magnetic fields E and B can be written in terms of scalar and vector potentials.

Faraday's law of induction is fundamental to understanding how electric and magnetic fields interact. Time-varying magnetic field give rise to electric field, the induced electric field, which is different from the electrostatic field. The electrostatic field is a conservative field with zero curls and a given divergence, while an induced electric field is a vector field with nonzero curl and zero divergences. The induced electric field is non-conservative and is described by vector potential.

In this work we discuss on didactic aspect of Faraday's law and the induced electric field. We consider the following example: a time-dependent current flowing in an ideal solenoid produces a varying magnetic field. If a wire loop surrounds the solenoid, there is an induced current through the loop. Electric charges move in response to electric fields, which means that an induced electric field is associated with a changing magnetic field. Experiments show that the changing magnetic field is confined inside the solenoid and vanishes outside. How can an induced electric field exist at positions where the magnetic field is zero? What is induced emf? Does induced emf produce any potential difference? What does the voltmeter measure

in the presence of varying magnetic fields? Discussions around these issues are presented here.

S14-PEHPP-106 / **Oral presentation**

The Balkan Physics Olympiad – a little piece of history

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Presenter: S. Popescu (sebastianpopescu888@gmail.com)

Founded in 1985, the Balkan Physical Union (BPU) strives to actively promote Physics, science, education, and cooperation between the Balkan countries. In accordance with these aims, as well as the goals of the Balkan Physics Olympiad, the BPU Council which was held in Sofia, in 2018, agreed that it should organize the First Balkan Physics Olympiad, which would function as a platform where the gifted high school students of the participating countries could participate. The first edition took place in Thessaloniki (Greece), in 2019, while the other two editions which were held in 2020 and 2021 were organized online, under the organization of Romania and Bulgaria.

The organization of the Olympics provided a very appropriate framework for dialogue on the teaching of physics and the curricula in the Balkan countries. Thirty seven participants from a total of eleven countries attended the first contest in Thessaloniki, while 47 participants from 12 countries participated in the second edition, which was organized by the University of Craiova, Romania. The third edition of the contest, which was organized by the University of Sofia, Bulgaria, had a total of 15 participating countries, out of which 10 were BPU member countries, and 5 novel ones.

With notable results after the three editions so far, and with an increasing number of participating countries, it can be said that the Olympiad wins in recognition, prestige and interest. This paper aims to provide an overview of the previous history of the competition as well of its development, and to compare the results of the high school pupils from the Balkans at the IPhO, before and after the BPO1-3, alongside the perspectives of the BPO.

References

1. https://balkanphysicalunion.info/?page_id=657

2. Goran Djordjević and Milena Simić, The First Balkan Physics Olympiad – BPO2019, in e-EPS November 2019, http://www.epsnews.eu/2019/11/the-first-balkan-physics-olympiad-bpo2019/

S14-PEHPP-107 / **Oral presentation**

Image of an engineer among the primary school students

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Inflow of young learned community into the field of pure physics research has been declined throughout the world including Romania. The initial attitude and the understanding of the nature of scientific endeavors and the people associated with them have a great role in determining the choice of engineering as career. How children perceive the engineers can indicate how they perceive the nature of science. The present study finds the images of a physicist among the primary level students through a projective technique to identify any stereotypical perceptions. The study also indicates their understanding of the nature of science and suggests modifications in the science curriculum.

S14-PEHPP-108 / **Oral presentation**

Achievements of Gymnasium Students in Montenegro on Electric Circuit Test

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Abstract. Electric circuits are an important element of physics class. However, many students leave secondary school without having an adequate conceptual understanding of simple circuits. Voltage in particular is a difficult concept since students understand voltage as a property of the electric current. Gymnasium students in Montenegro did test which contained problems of understanding concepts of electrical current. Percentage of students who understand a concept of current is relatively high, but percentage of students who succeed to deal with voltage concept is

decreasing rapidly. This investigation reveal the problems that students have on microscopic level about the charges in battery. Since great fraction of students assume that only battery determines the value of current same as the charges from battery flow to wire, it implies that more time, more lessons, should be devoted to this area. Those findings should be useful for teaching community in creating pathways that will replace those wrong mental models or ideas with scientific ones.

S14-PEHPP-200 / **Poster presentation**

Introducing Wetting Models in Science Club

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Over the last 20 years more inventions have emerged from NanoScience and Engineering (NSE) than any other scientific field (1). By 2030, its implications in regards to science, technology innovation, economy and society are expected to overcome even the ones from the digital revolution. Scientific research and development of technological applications in the nanoscale has provided every field that has been applied to with state of the art achievements. Given the above, the need of NSE's introduction to formal and informal education is clear and imperative. Biomimetics consists of a large ambit in NSE. Even though its foundation ground, which is the transfer of function and design principles from Biology to Technology(2), appeared along with mankind its self, NSE has significantly broaden the horizons of it. Its introduction to education is considered to be of major importance in order to form scientific literate citizenship that will be able to function and make the right decisions under the current circumstances. Non formal education environments are considered to be breeding ground to the communication and development of positive attitude towards science. To this end, in this paper a suggestion for teaching Wetting Models based on the Model of Educational Reconstruction in a Science Club is being presented.

Wetting Models portray the different ways of a surface's wetting and the way the procedure is actually determined by its micro- and nano- roughness. Although a subject rarely encountered among educational interventions about Biomimetics, it provides fundamental context for comprehending phenomena such as hydro- and oleo- philicity and phobicity, the Lotus Effect, the Rose Petal Effect and so on. Their introduction is thus considered appropriate to occur in advance in order to establish a solid theoretical background concerning the aforementioned phenomena.

In the present study the design of a teaching sequence about Wetting Models addressed to Secondary Education is being described. To the means of structuring a

specific teaching plan to present the subject with the most advantageous way possible, Educational Reconstruction Model (MER), has been utilized.

Decontextualizing scientific content and recontextualizing it taking into account the characteristics and the factors affecting the learning procedure, has resulted in compiling two teaching units, whose learning goals, association with the 9 Big Ideas of NSE(3), as well as misconceptions expected to emerge, will be presented.

Acknowledgements The corresponding author acknowledges the Research Committee of Aristotle University of Thessaloniki (RC-AUTH) for the financial support of the participation in BPU11.

References

1. K. Winkelmann and B. Bhushan, Global Perspectives of Nanoscience And Engineering Education, 2nd ed. (2016).
2. B. Bhushan, Biomimetics: Bioinspired Hierarchical-Structured Surfaces For Green Science And Technology (Biological And Medical Physics, Biomedical Engineering), 2nd ed. (Springer Berlin Heidelberg, Columbus, Ohio, 2012), p. v.
3. S. Stevens, L. Sutherland and J. Krajcik, The Big Ideas Of Nanoscale Science And Engineering, A Guidebook For Secondary Teachers (David Beacom, Arlington, Virginia, 2009).

`S14-PEHPP-201` / **Poster presentation**

Representation of history of science in teaching physics: Students' knowledge about physics scientists

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A number of students, as their field of interest, prefer social sciences to science. History of science can be the bridge between science and social sciences.[1],[2] Therefore, it can be a useful tool for getting students with an affinity for social sciences interested in physics and vice versa, it can get students with an affinity for physics interested in social sciences. History of physics has an important role in teaching physics.[3] In most schools, at all levels of education, a logical approach is most often used in physics teaching. In this approach the best way of presenting the subject matter to the students is being chosen, without regard to its historical development. The history of science material is occasionally presented (for instance, contributions of various scientists to physics, facts about important scientific discoveries, life of scientists and similar). The research aim was to assess students' knowledge about physics scientists in order to get insight into the extent to which history of science material is present in teaching physics in Serbia. The research was carried out with a convenient sample that included students interested in physics because it would be expected that these students were attentive in physics classes. Research sample consisted of 28 university physics students (17 enrolled in the first and 11 in the second year) in Novi Sad, Serbia. The students were from various regions of Serbia, mostly AP Vojvodina. The questionnaire about physics scientists that students have learned about in primary school and high school physics classes (with open ended answers) was administered to students during their attendance in mandatory classes that they take. Research results showed that only eight scientists were remembered by more than 20% of students. Interestingly, there was no scientist that all students remembered. Albert Einstein and Nikola Tesla were listed most frequently as scientists that students learn about in primary school and high school (by the same number of students, 85.7%) and next was Sir Isaac Newton (64.3%). All other scientists were listed by less than 50% of students. In total 31 scientists were mentioned by students, but 15 of them by only one or two students. More detailed analysis was carried out and its results were presented and discussed. Based on the results it can be stated that the extent to which history of science material is present in teaching physics in Serbia is varying from school to school. Accordingly, it can be suggested that some basic knowledge about physics scientists and history of science in general need to be presented in physics classes regardless of the teacher's preferences for teaching material.

References

1. S.B. Brush, Phys. Teach. 7, 271 (1969).
2. F. Seroglou and P. Koumaras, Sci. Educ. 10, 153 (2001).
3. I. Galili, in Connecting Research in Physics Education with Teachers Education, edited by M. Vicentini and E. Sassi (I.C.P.E., 2008).

S14-PEHPP-202 / **Poster presentation**

Work with motivated and gifted students in physics in RCT "Mihajlo Pupin" from Pancevo – a review of the last 15 years

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Since the very beginning, Regional Center for Talents "Mihajlo Pupin" in Pančevo had a physics group. Over time, the number of classes has grown, but so did the number of students and mentors. Consequently, the achievements on national and even international competitions in physics were growing steadily. After first few years spent in experimenting different possibilities in the field of work with talented students in physics, the standard of classes has been established. Such standard, with the help of motivated students and mentors has produced a successful mechanism for preparing students for various challenges in the field of physics and beyond. This paper presents a model of working in the physics group in Regional Center for Talents "Mihajlo Pupin" in Pančevo, as well as the results our students have achieved on national and international physics and science competitions in the last 15 years of work.

S14-PEHPP-203 / **Poster presentation**

Inquiry Based Learning Approach in Teaching "Phase Transitions" for Experimental Skills Formation in 16 Years Old Students

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Inquiry-based learning is an important pedagogical approach through which teachers can introduce students to the world of science and scientific research. Learning through inquiry is an active learning that requires students to take responsibility, make decisions, cooperate and self-assess. The role of the teacher is crucial when using the research approach in physics lessons, so it is important that he knows the experience of other colleagues, their ideas and good practices. The teacher is the one who guides the students in conducting research, supplying equipment and processing experimental data. We are convinced that the best way for students to understand the essence of science is by doing their own scientific research.

The report offers an idea for the formation of experimental skills by conducting inquiry on several specific problems related to thermal phenomena. Teams of students are formed, who choose to work on one of several proposed experimental tasks related to phase transitions. These tasks are borrowed from the International Young Physicists Tournament (IYPT) and are adapted to the conditions of the Bulgarian school and the respective curriculum. In solving them, students follow the steps of a scientific research - discuss the specific situation and formulate a scientific question, perform a physical experiment, collect and analyze results, draw conclusions that are confirmed experimentally. The proposed tasks are related to the following topics:

- Melting and solidification of crystalline and amorphous bodies (two tasks)

- Conditions on which the evaporation process depends (one task)
- The specifics of the boiling process (one task).

The formation of experimental skills occupies an important place in the physics curriculum for 8th grade Bulgarian schools. In recent years, there has been a tendency in the teaching of physics to develop more and more active practical and experimental skills. Teachers are looking for ways to do this both during classes and extracurricular activities, using modern interactive methods and approaches. The report describes the methods by which the learning process is organized and offers a proven technology of training on these physics topics.

S14-PEHPP-204 / **Poster presentation**

Hierarchical Structure and the Rose Petal Phenomenon. A Proposition for Educational Reconstruction in Secondary Education.

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Nature has developed materials, objects and procedures that occur in the macroscale as well as the nanoscale. The results of millions of years of biological evolution and the optimized "techniques" developed by the organisms are available to scientists who seek new ideas by studying the solutions provided by nature. The scientific field that allows man to imitate nature and to develop nanomaterials, nanomachines and processes with various desired properties is called Biomimetics. The widespread use of Nanotechnology products by our modern technological society and the growing need of the industry for a working force specialized in this field are two of the main reason for the introduction of Biomimetics and Nanotechnology in school curricula.

This paper presents a proposal for the introduction in Secondary Education of a highly popular phenomenon from the field of Biomimetics known as the Rose Petal Phenomenon. This is the phenomenon of strong adhesion of small water droplets on some superhydrophobic variants of rose petals. By studying the phenomenon, students have the opportunity to come in contact with several big ideas of science, to understand the possible misconceptions they might have, to get acquainted with scientific processes, scientific instruments, scientific models and to develop important skills. Getting familiar with the hierarchical structure of the surface of a rose petal is essentially an acquaintance with the complexity of surfaces in general. The familiarity with the properties of superhydrophobic surfaces helps them to understand

their application of the superhydrophobic behavior in consumer products such as clothing and footwear that are waterproof, windows that do not blur, paint that protects the surface from oxidation, corrosion and pollution etc.

The scientific content the Rose Petal Phenomenon comes from Bharat Bhushan's book "Biomimetics: Bioinspired Hierarchical-Structure Surfaces for Green Science and Technology"(1). For the effective integration of this subject in the school classroom, the Model of Educational Reconstruction MER was applied. Following a constructive epistemological orientation, the students' perceptions, interests, needs and expected difficulties were taken into account. The results of the application of the MER model are the creating of 2 modules and their respective learning objectives to get students acquainted with the phenomenon as well as the science behind it.

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Referencess
1. Bhushan, B. (2016). *Biomimetics: bioinspired hierarchical-structured surfaces for green science and technology*, Springer.

S14-PEHPP-205 / **Poster presentation**

The way we teach: The cases of backward pedagogy, through prototyping and aiming for the societal benefits

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In this paper we present the three cases of innovative pedagogy; the teaching of physics was conceptualized and designed in a such way to bring outcomes in order to serve the society.

The first one exploits the backwards pedagogy where physics was thought to non-physics students; the students were future teachers of primary school. By prototyping the microgenerators we promote harvesting of the micro-energy as societal responsibility and by utilizing the recycled components we emphasize the way circular economy can be sustained. The examples of the pedal and wind-belt generators will be shown.

The second case exploits the use of open source and open hardware, such as Arduino and Raspberry pi in Physics lessons. Different set-ups covering the applications such as for COVID, Parkinson and dementia will be presented.

The third case utilizes the mobile technology and the sensors that are built in mobile phones. To access the sensors from the phone and to perform the specific measurement an Android app was utilized. The applications in tracking human movements with an emphasize on potential of their use in prosthetics or towards the support in communications of deaf people will be presented.

S14-PEHPP-206 / **Poster presentation**

International Physics Olympiads as effective resources of knowledge source for high school students

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Often in physics classes we are faced with the need for demonstration attempts. Some physics classes can be well organized using certain educational content from the numerical assignments and experimental assignments given at the International Physics Olympiads. As mentors of students and participants in the Olympics, we want to share some experiences from using texts, draft schemes or whole experimental settings from the Olympics, in the teaching itself, making the teaching of physics more observant and motivating.

S14-PEHPP-207 / **Poster presentation**

Experimental study of a circular motion by smartphone technology

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Technology has the potential to dramatically improve our everyday life aspects, including the time we spend in the educational environments. If we want to add the teaching means and methods, then one of the solutions would be to include the smartphones in it.

The purpose of this paperwork is their use as an experimental tool to aid the students who study physics in a way that their concepts about physics remain long in their memories.

With the integration of the smartphones in the teaching process the students get better informed about their functions and use. They learn about the sensors incorporated in them, which make them more suitable to use and measuring devices more reliable in simple teaching experiments.

The pedagogical framework proposed is focused on the active teaching and wants to develop the critical thinking on the students and the ability to research and experiment. The merging of the theory and experiments makes this method have positive premises towards a successful teaching process.

Technology is developing fast every day. The smartphone represents an essential part of it and together with the other methods that are an integral part of it they are inclined to be the best nowadays.

S14-PEHPP-208 / **Poster presentation**

A Proposition for the Introduction of the Lotus Effect in Secondary Education

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The field of Nanoscience and Engineering (NSE) is a modern and dominant field of research that is developing rapidly, already offering useful products and applications. Nanoscience is the scientific branch that concerns the research of interactions at the nanoscale (1-100nm) while nanotechnology deals with the management and reconstruction of matter at the nanoscale. The development of NSE prompted researchers of the Didactics of Natural Sciences to focus on educating students in the field of NSE, as they are the generation that will encounter many of its applications.

The lotus effect is a typical issue found in almost all proposals for the introduction of NSE in education, regardless of age. In most cases, however, the approach to the subject is limited to a phenomenological level. The lotus effect refers to the water repellent capacity of the leaves due to the architecture of their surface at micro- and nanoscale, which minimizes the adhesion of droplets. The surface characterization of the hydrophobic and hydrophilic leaves helps us determine the role played by the micro- and nanostructures on the surface, to justify the macroscopic properties

of the leaves. Understanding the functions provided by processes found in nature, such as the study of the lotus effect, is a modern and interesting topic for students, which can increase their motivation for Physics itself. However, it is necessary to transform the scientific content into knowledge appropriate for the age and mental abilities of the students.

This paper suggests a didactic proposal for the introduction of the lotus effect in secondary education. Through the MER methodology (Model of Educational Reconstruction), the scientific content is analyzed and transformed into a content structure for instruction, defining the learning objectives of each unit and considering the difficulties and misconceptions that students may have. This work will present the implementation of the educational reconstruction considering all the parameters involved in the learning process of this section.

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S14-PEHPP-209 / **Poster presentation**

Extending the MVD model and produce a video to foster students' understanding of climate change

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The term climate change refers to the change in the global climate and to changes in meteorological conditions that extend over a large scale of time. Such changes include statistically significant fluctuations in the average state of the climate or its variability, extending over a period of decades or even more years. Climate change is due to natural processes, as well as human activities with an impact on the climate, such as changing the composition of the atmosphere.

Students' everyday ideas of climate change and greenhouse effect are difficult to change. Students may enter science lessons with already developed ideas and explanations of these natural phenomena. Integrating environmental issues into the science classroom is one way to increase students' knowledge and improve students' attitudes and behaviors toward climate change. Environmental education faces the challenge of developing instructional settings that foster students' conceptual understanding of these natural phenomena. However, teaching and learning about environmental education are conceptually challenging, since everyday thinking may be incompatible with, or incomplete in relation to, school science.

The use of multimedia in education has significantly changed the way teaching is done in recent years. Knowledge about multimedia educational content applications accumulates over time, due to the ability to directly provide material from texts, images, sounds and various other forms of data. One of the main multimedia that has been widely used in recent years in the teaching process is the educational video. The widespread use of educational video is due to its effectiveness as a means of transferring knowledge, as new research shows that audio-visual stimuli more easily stir students' interest than traditional teaching.

Following a modification of MVD (Methodology for educational Video Development), we created an educational video that aims to highlight how one can easily construct and process the information one wants to convey. It should be emphasized that our research is not a mere repetition of previous work on a different subject. We extend MVD so as not only to resort on the transformation of the scientific knowledge and how appropriate is for the students' understanding this complex subject, but also to find out how the students conceive the video as a media and whatever attracts their attention.

We propose that the most appropriate framework to present the climate change is through the energy balance model. Therefore, the concepts needed to be included in the video are the energy transferred from the Sun to the Earth, and the radiation of energy from Earth to space and the factors that control these processes. Regarding the evaluation of the video, we investigate the functions of video as an educational tool, but also the proper use of multiple representations, to address students' misconceptions about climate change and the greenhouse effect. According to the results from the pre-and post-tests, the learning objectives we set during the design of the video were achieved for the most part and most of the participants were satisfied by our video as an educational tool.

`S14-PEHPP-210` / **Poster presentation**

Realization problems in the Individualized Educational Plan of physics teaching in elementary schools in Serbia

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An Individualized Education Plan (IEP) is a specific document, which provides the opportunity for the pupils with development disorders, disabilities, and children from the sensitive groups, regardless of their material status, to have the access to all levels of education1. Preparation and implementation of IEPs in physics teaching for elementary schools are done on the basis of a unique curriculum for physics in Serbia. Using this unique curriculum as a guideline, the inclusive education team

has the task of developing an IEP for each student who needs it. Physics provides great opportunities for the development of functional and applied knowledge for students with special needs2,3. The development of an IEP is a very important and delicate task for teachers, which is why it is necessary for them to constantly improve in this area.

Physics teachers have problems in the preparation and implementation of IEPs. The aim of this paper is to research and systematize these problems in order to contribute to overcoming them4. For that purpose, research was done on the application of IEP in some primary schools. Problems are systematized into three groups: problems in preparing classes for work with students on IEP; problems in the organization of working with those students during the physics class; sources of materials used by physics teachers to prepare IEP classes.

The research results show the following percentage of answers: the biggest problem is the lack of literature for teaching preparation (64%), then adjusting the way of teaching to the needs of students working on IEP (52%) and adjusting the content of subjects (46%). Surprisingly, not many teachers point out the lack of time and standard tests to check student achievement as a problem. Most teachers have a problem with the organization of work with students according to the IEP during physics classes (68%), while a smaller number of teachers have a problem with the interaction with students (14%). The existence of more than two students per IEP in the class was a problem for 40% of teachers, while 48% of teachers point out filling out documentation and writing a personalized plan as problem4. Physics teachers need seminars that provide specific information about working with students on IEP, as well as the presence of a pedagogical assistant in class.

References
1. Rulebook on detailed instructions for determining the right to an individual educational plan, its implementation, and evaluation, Education Gazette, Official Gazette of the Republic of Serbia, 74/18 (2018).
2. G. Nikolić, D.Gačić Bradić, M.Trkulja, Handbook for teachers to work with students with disabilities from 5th to 8th grade of elementary school, (Klett, Beograd, 2019).
3. J. Popović, Lj. Kostić, The adapted Individualized Education Plan in elementary school related to Physics as a school subject, Physics Education, 8 (2019).
4. J. Popović, master thesis, The Individualized Education Plan in elementary school related to Physics as a school subject – examples and problems in the implementation of IEP-1 and IEP-2, (Faculty of Sciences and Mathematics, University of Niš, Niš, 2020).

S14-PEHPP-211 / **Poster presentation**

Some challenges for teachers in natural sciences in the context of distance learning during the Covid 19 pandemic

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Distance teaching in an electronic environment involves the application of different pedagogical approaches and methods than those used in traditional face-to-face teaching and interaction with students. At the same time, unequal opportunities for students to learn fully from a distance in an electronic environment and the lack of adequate adaptation of the distance learning process to their needs can provoke a number of adverse consequences in terms of their motivation to learn and academic achievement.

Therefore, in the context of the present study, we consider the specific attitudes, behaviors and practices of teachers related to the process of teaching during distance learning. A questionnaire was constructed and used in the study including two groups of questions. The first group aims to allow assessment of:
- practices for adapting the learning process to the needs of students;
- stimulating students to participate in the construction of knowledge;
- models of group learning through interaction between students;
- practices for monitoring the results of students' work and their progress;

The second group of questions examines how teachers evaluate their efforts related to specific aspects of distance learning in comparison to the traditional work in face-to-face form - main problems and challenges of technical, didactic and psychological nature.

Nearly 83% of teachers find significant differences between the way of teaching in an electronic environment compared to the face-to-face learning process. At the same time, the majority of them continue to emphasize to a large extent practices that are similar to traditional teaching methods in the classroom - presenting and explaining learning content online during a synchronous lesson, setting of tasks for independent work and verification of results, conducting tests.

During distance learning the vast majority of teachers often used procedures for formative evaluation of student achievement and progress. Data on approaches used to assessing students show that quantifying is still the most common way of evaluation of the students' work and performance as well as of their achievements

and knowledge. The assessment of students was carried out mainly through online tests. Most often, students took online tests (88%), and 75% received grades for their participation during online classes. About 81% received evaluations for the implementation of projects, 56% - feedback or quantitative evaluation for the implementation of their homework.

It can be summarized that in the school year 2021/2022 there are more sustainable pedagogical practices related to the conduct of distance learning in an electronic environment compared to the previous school year, which probably largely reflects the accumulated experience of schools and teachers for work in such a format. Participation in various qualification activities related to the organization and conduct of the learning process in an electronic environment leads to better results in the application of various methods and approaches to stimulate student activity. Teachers who have participated in such trainings in the last two years are relatively more active in using various constructivist elements in their teaching in an electronic environment than their counterparts who have not participated in such trainings.

S14-PEHPP-212 / **Poster presentation**

Wetting and Roughness of Surfaces As Biomimetic Concepts in Teaching – A Proposal for Science Clubs

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The world consists of millions of different living organisms. Through their huge diversity in terms of characteristics they have managed to live in all the possible extreme conditions in the planet that we live in. Every organism had millions of years to adapt to its environment and the results of this continuous evolution are there to be studied in order to benefit human lives through the field of Biomimetics. Both the science subject of biomimetics and the related field of nanotechnology are considered rapidly growing fields and their results help to considerably improve many parts of our lives.

In nature, many of the characteristics of living organisms are determined from the interaction between a surface (like the skin of an animal or the leaf of a plant) and water. Therefore, the study of the interaction between a solid surface and a fluid is a fundamental concept in the field of Biomimetics. The result of the interaction defines the wetting state, which in turn is defined by the characteristics of the surface. Biomimetics can be defined as a form of technology that uses or imitates nature to improve human lives. This is achieved by the study of physical phenomena (like

the wetting state) and through their subsequent quantitative measurement (using units like contact angle and hysteresis angle). This research reveals the surface characteristics (like roughness and surface energy) which contribute to the phenomenon.

The central idea of the paper is that not only the integration of Biomimetics in secondary education is possible, but it is also a subject that can increase student interest. However, in order to achieve this aim, it is important to produce a content structure for instruction that originates from the scientific content, and it is concomitantly suitable for classroom implementation. In this study, the Model of Educational Reconstruction (MER) was used as a tool in order to clarify and analyze the scientific content. Through the core ideas of biomimicry, an attempt is made to design a content for instruction. The final goal is the construction of a teaching framework that can lay the groundwork for the integration of the subject in secondary education.

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`S14-PEHPP-213` / **Poster presentation**

The High-Energy Positive Solar Particles Invading Earth with Contribution to the Mortality from Ischemic Heart Diseases?

Author: Nikolay Takuchev[1]

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Presenter: N. Takuchev (`nnnppptttt@gmail.com`)

Introduction: According to the results from several studies [for example 1,2] high-energy positive solar particles fluxes, invading Earth are correlated with mortality from ischemic heart diseases, Ischemic heart diseases, according World Health Organization (WHO) statistics [3], are the first in the list of the 10 most frequent causes of death in 2016, regardless of the state's economic situation.
Objective. A possible mechanism of the observed phenomenon is discussed. An example of the short-term impact of high-energy alpha fluxes on the area of USA, affecting the short-term female mortality in the region, is explained by the proposed mechanism.

Material and Methods: Data on solar corpuscular radiation was obtained from an NOAA site – from the Geostationary Operational Environmental Satellite series (GOES). High-energy protons and alpha particles' path length through the atmosphere and corresponding energy were calculated by PSTAR and ASTAR databases and calculators. Data for mortality of ischemic heart diseases in the interval 1974 –

2019 from reliable statistical source – Centers for Disease Control and Prevention USA, were used.

Results: Between the annual fluxes of protons and alpha particles on the one side and the male and female ischemic diseases mortality in several states in USA, on the other side, a high statistically significant correlation was found.

Discussion: A hypothetical mechanism is proposed [2], explaining the observable data. According to this mechanism, positively charged high-energy solar particles penetrate the atmosphere to the Earth's surface, reaching relatively small areas (spots) with typical dimensions of hundreds of kilometers, where they affect the biosphere. The spots are places, where the directions of geomagnetic field induction and the direction of the invasion of particles in the atmosphere are parallel – no deflecting force acts in this case to the charged particles. The energy required for the particles to overcome the interaction with the particles in the atmosphere was estimated. The particles reach the Earth's orbit for minutes, and penetrate the atmosphere in its thinnest part – the places where the Sun is at its culmination at the time of the arrival of particles. The described mechanism allows calculation of the width of the zone of latitudes with the most intensive impact – mainly between 28°N and 48°N. The mechanism allows calculating the dates with increased risk depending on latitude on the Earth's surface. According to satellite observational data (GOES 13), a significant flux of alpha particles with energies above 3.4 GeV is observed in geostationary orbit, while the proton flux with energies above 0.7 GeV is hundreds of times weaker. This makes it more likely to conclude that high-energy alpha particles reach the Earth's surface and cause death.

References

1. Most Common Causes of Death. Available:http://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death, last visited on 14.8.2018.
2. Takuchev N 2019 Solar corpuscular radiation and mortality from various forms of ischemic heart disease in Bulgaria for the interval 2005 - 2015. AIP Conference Proceedings 2075, 130005; 13005-1 - 13005-6; Available:https://doi.org/10.1063/1.5091290
3. Takuchev N 2021 Does the Angel of Death Sometimes Use Solar Alpha Particles to Take Our Souls? BP International ISBN 978-93-91215-44-6 (eBook) DOI: 10.9734/bpi/mono/978-93-91215-36-1.

S14-PEHPP-214 / **Poster presentation**

Introduction of the virtual lab in Physics class

Authors: Errikos Ovannisian[1]; Panagiotis Dimitsakis[1]

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Presenters: E. Ovannisian (), P. Dimitsakis (panagiotis_dimitsakis@yahoo.com)

Most physics professors would agree that laboratory experience is an important part of science education. Learning through experiments encourages students to bring scientific thinking to the processes of a strong, innovative, and logical path between concepts and phenomena. Virtual labs through computer simulation-based methods of studying physics happened to be one of the most powerful methods of experimentation in a lab recently during coronavirus. After the hands-on lab courses were replaced with their online lab counterparts numerous studies were conducted, to compare the two approaches and define their effectiveness.

First and foremost, the virtual labs provide a good alternative or supplement the traditional hands-on labs, while requiring significantly less amount of time and money for setting them up and maintenance. Furthermore, these types of labs ensure the students' safety when they are performing their experiments and negate the consequences in the case of missteps. On the other hand, learners who regularly complete their lab courses virtually lack the development of general intellectual skills that are extremely helpful in scientific activity. These abilities cover both fundamental abilities (such as estimating quantities, identifying errors, or using practical measuring procedures) and more complex (such as effectively describing experiments and flexibly adapting the resulting knowledge to different conditions. Furthermore, a scientist needs to have the experience of working in a team, which cannot be accomplished efficiently in virtual laboratories.

In this paper, we conclude that both, hands-on and virtual, labs can be used in combination. On some occasions, the student understands certain concepts and experiments with many real-life variables better through a simulation, though, the on hands approach is a better way at understanding basic concepts in physics. Finally, a good virtual lab guarantees the student's education when their presence in the real-life course is impossible.

Acknowledgements The corresponding author acknowledges the Research Committee of Aristotle University of Thessaloniki (RC-AUTH) for the financial support of the participation in BPU11.

References

1. Marjorie Darrah, Roxann Humbert, Jeanne Finstein, Marllin Simon and John Hopkins, Journal of Science Education and Technology volume 23, pages 803–814 (2014)
2. ICRSME, Electronic Journal for Research in Science and Mathematics Education volume 24

S15-MI
Metrology and Instrumentation

S15-MI-001 / **Invited talk**

Thermal radiation measurements in biophotonics

Authors: Branislav Salatić[1]; Dejan V. Pantelić[2]; Danica Pavlović[1]

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[2] *Senzor INFIZ*

Presenter: D. Pantelić (dejanvpantelic@gmail.com)

Thermal radiation is omnipresent, radiated by any object in the universe, including universe itself. For a long time, Planckian radiation was used as a reliable "fingerprint" of a thermal state of a matter – human body, homes, industrial objects and, regrettably, weapons, among many other things [1]. Here we provide an overview of thermal measurements in biophotonics in order to study how life maintains favorable thermal state enabling survival in the environment. We will present how micron and submicron sized structures may influence emission and absorption of radiation.

Insects are extremely interesting in that respect, because they have developed diverse and efficient mechanisms to sustain optimal temperature of their bodies. Many of them, such as ants (Formicidae) [2] and beetles (Coleoptera) [3], developed micro/nano structures to dissipate thermal energy and maintain life supporting conditions within extreme environments. We will present how elytra (modified, hardened wings, enveloping Coleoptera body) have been evolutionary adapted to efficiently collect or dissipate thermal energy [4]. Appropriate measurement and inspection methods, based on the infrared thermography, will be described, too [5].

References

1. C. Ibarra-Castanedo, J. R. Tarpani, X. P. V. Maldague, Nondestructive testing with thermography, Eur. J. Phys. 34, (2013) S91–S109
2. Keeping cool: N. N. Shi, C-C. Tsai, F. Camino, G. D. Bernard, N. Yu, R. Wehner, Enhanced optical reflection and radiative heat dissipation in Saharan silver ants, Science 349, (2015) 298 – 301
3. D. Pavlović, D. Vasiljević, B. Salatić, V. Lazović, G. Dikić, Lj. Tomić, S. Ćurčić, P. Milovanović, D. Todorović, D. V. Pantelić, Photonic structures improve radiative heat exchange of Rosalia alpina (Coleoptera: Cerambycidae), J. Therm. Biol. 76, (2018) 126-138
4. D. Vasiljević, D. Pavlović, V. Lazović, B. Kolarić, B. Salatić, W. Zhang, D. Zhang, D. Pantelić, Thermal radiation management by natural photonic structures: Morimus asper funereus case, J. Therm. Biol. 98, (2021) 102932
5. H. Liu, R. Lusk, R. Gallardy, Infrared thermography for insect detection: lighting up the spotted lanternfly in the field, J. Pest. Sci. 94, (2021) 231–240

S15-MI-200 / **Poster presentation**

System for monitoring and acquisition of physical processes dynamics: the decomposition of CaCO3 tablets in deionized water

Author: Šušić Djordje [1]

Co-authors: Ivan Petronijević [2]; Nebojša Potkonjak [3]; Zoran Nikolić [2]

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Presenter: I. Petronijević (ivanpetronijevic@ff.bg.ac.rs)

A software application developed from open-source code libraries has been used to analyze digital video recordings of physical system evolution. The process of calcium carbonate tablet decomposition in deionized water was recorded with a digital video camera at 12 Mp resolution and 30 frames per second. The tablets were formed by compressing micronized CaCO3 powder with a cylindrical press mold and a Perkin Elmer hydraulic press. Applied pressures were in the interval from 174.89 MPa to 813.4 MPa with an increment of 73.95 MPa and three different particle sizes of the micronized calcium carbonate powder were used: 20 µm, 40 µm, and 90 µm. All prepared tablets were the same mass of 1 g. The used code libraries were the standard Windows C++ library and the open-source code library OpenCV. For application development, the standard Windows C++ library was exploited for the storage and export of the output data. The OpenCV library provides information about the position of objects within the frame by analyzing the recorded video frame by frame. The colored image was transformed into a grayscale format followed by a blur function as a sort of low-pass filter to remove noise from the image. Finally, a threshold function was applied to the image, which turned the grayscale image into a binary one. The threshold function was assigned the level of detail of the image, which allowed keeping the contours of the tablet itself and removing unwanted noise in the form of air bubbles or particles floating in the water. In addition, erosion and dilatation operations to remove noise from the contours were also used. The contour detection function was used to determine the image moments of the given frame. The image moments were used to calculate the centroid of the given image. The time dependence of the centroid position graph provided a possibility to extrapolate the time interval needed for the tablet's dissolution. The correlation between the particle size of the CaCO3 powder, the pressure applied during the tablet production, and the time required for the decomposition of the tablets was established. The developed analytical software presented here could be useful for monitoring and analyzing the dynamics of a wide range of physical systems as they evolve over time. Also, the applicability of the presented software could be in the pharmaceutical and chemical industries for optimization of the process of tablet production and decomposition.

S15-MI-201 / **Poster presentation (virtual)**

Thermal Monitoring for Condition Based Maintenance of an X-ray Generator

Authors: Plamen Petkov[1]; Anton Zyapkov[1]; Nedislav Veselinov[1]; Kaloyan Genkov[1]; Dimitar Todorov[2]; Nikolay Zografov[3]

[1] *Faculty of Physics, Sofia University*

[2] *Danlex EOOD Research center*

[3] *Faculty of Physics, Sofia University & Danlex EOOD Research center*

Presenter: A. Zyapkov (azjapkov@uni-sofia.bg)

The modern Non-Intrusive Inspection Systems (NIIS) are a highly sophisticated machines that incorporate quality x-ray generation and detection capabilities, supported by state-of-the-art electronics, electro-mechanics, software algorithms and solutions. They are the backbone of air transportation security, and the commercial aviation is impossible without NIIS. Thus, the adequate real-time evaluation of the NIIS technical condition is critical for airport operators. However, most of the NIIS operating worldwide are designed before the Internet of Things (IIoT) era, and they don't have options to provide sensor data in real-time. A solution for condition-based and predictive maintenance, developed recently, aims to provide an early warning for possible failures based on predictive algorithms using machine learning and AI technologies [1]. That solution relies strongly on the technical data collected from the NIIS itself, along with retrofitted sensors designed to monitor different physical and environmental parameters [2].

In the present study, we propose a 2D thermal monitoring approach as a new source of valuable data for estimating the x-ray generator's technical condition and input to the predictive models. The study provides both semi-analytical and experimental results. The proposed semi-analytical model has been compared with the experimental results based on the large datasets (big-data), collected by the sensors. The experimental setup consists of contact sensor arrays and a distant infrared sensors system, combined with mapping of the entire x-ray generator body outer side thermal boundary conditions. The examined x-ray generator is the most common type, equipped with a stationary anode x-ray tube, mounted on an HS 100100V (Smiths Heimann Gmbh). This x-ray generator type is widely implemented on similar x-ray security inspection systems for luggage and cargo. The thermal parameters of the x-ray generator were studied during many long tests run series conducted on HS 100100V, located at the Danlex research centre. To reach a steady state of the x-ray generator thermal parameters, most of the respective test runs have lasted more than 24 hours of continuous workload (x-ray beaming), simulating real-live operating conditions.

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References:

1. Georgi Nalbantov, Dimitar Todorov, Nikolay Zografov, Stefan Georgiev, Nadia Bojilova. Predictive Maintenance Tool for Non-Intrusive Inspection Systems.

https://arxiv.org/abs/2103.01044 1 Mar 2021.
2. Nikolay Zografov, Danlex EOOD. EP3955707 - METHOD AND SYSTEM FOR PREDICTING A FAILURE PROBABILITY OF A COMPONENT OF AN X-RAY SYSTEM https://register.epo.org/application?number=EP20190781
https://data.epo.org/publication-server/document?iDocId=6754017

Frontiers

FT-01 / **Invited talk**

Challenges in supersymmetric cosmology

Author: Ignatios Antoniadis[1]

[1] *LPTHE - CNRS - Sorbonne University, Paris, France*

Presenter: I. Antoniadis (antoniad@lpthe.jussieu.fr)

I will discuss the problem of scale hierarchies in particle physics and cosmology and propose ways to address it. In particular I will present a framework of natural inflation within supergravity dubbed 'inflation by supersymmetry breaking'. The main idea is to identify the inflaton with the superpartner of the goldstino, in the presence of a gauged R-symmetry that may contain the R-parity of the supersymmetric Standard Model.

FT-02 / **Invited talk (virtual)**

On the nature of optical rogue waves

Authors: Milivoj R. Belić[1]; Stanko N. Nikolić[2]; Omar Ashour[3]; Najdan B. Aleksić[4]

[1] *Texas A&M University at Qatar*

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[3] *Department of Physics, University of California*

[4] *Institute of Physics Belgrade, University of Belgrade*

Presenter: M. Belić (milivoj.belic@qatar.tamu.edu)

We present rogue wave solutions to the standard cubic nonlinear Schrődinger equation that models many propagation phenomena in nonlinear optics. We propose the method of mode pruning for suppressing the modulation instability of rogue waves. We point to instances when rogue waves appear as numerical artefacts, due to inadequate numerical treatment of modulation instability and homoclinic chaos of rogue waves. In the end, we display how statistical analysis based on different numerical procedures can lead to misleading conclusions on the nature of rogue waves. Thus, we will discuss the nature of optical rogue waves in view of conflicting opinions expressed in the literature. In particular, we address three pairs of opposing suppositions on their nature: Linear vs. nonlinear [1]; random vs. deterministic [2]; and numerical vs. physical [3]. In our opinion, a short answer to the three suppositions is that rogue waves in optics are essentially nonlinear, deterministic, and physical. They are nonlinear because the major cause of rogue waves is the modulation or Benjamin-Feir instability, which by its nature is the basic nonlinear optical process. Rogue waves are deterministic because modulation instability (MI) leads to deterministic chaos; random phenomena are probabilistic and may look chaotic but are not deterministic. Rogue waves are physical because they appear in

many experiments and media, with similar statistics. Our opinion is supported by extensive numerical simulations of the nonlinear Schrődinger equation in different regimes that touch upon the aspects of all three conflicting suppositions.

Unfortunately, in numerical simulations optical rogue waves may appear fictitiously, as numerical artefacts. Different numerical algorithms represent different dynamical systems and in chaotic regimes may provide different evolution pictures for exactly the same inputs, leading – distressingly – to significantly different statistics [4]. The statistics appear similar, but the number of peaks, the maximum of intensity, and the slope of distributions, among other things, are different. Hence, in the chaos produced by modulation instability, optical rogue waves and their statistics may appear as numerical artefacts. Owing to a vague definition of rogue waves and exponential amplification of numerical errors, there are situations in which optical rogue waves may appear as linear, random, and numerical. In the very end, we demonstrate how to produce stable Talbot carpets – recurrent images of light and plasma waves – by rogue waves, for possible use in nanolithography.

References

1. F.T. Arecchi, U. Bortolozzo, A. Montina, S. Residori, "Granularity and inhomogeneity are the joint generators of optical rogue waves," Phys. Rev. Lett. 106,153901 (2011).
2. J.M. Dudley, F. Dias, M. Erkintalo, G. Genty, "Instabilities, breathers and rogue waves in optics," Nature Photonics 8, 755 (2014).
3. B.M. Herbst, M.J. Ablowitz, "Numerically induced chaos in the nonlinear Schrödinger equation," Phys. Rev. Lett. 62, 2065 (1989).
4. M.R. Belić, S.N. Nikolić, O.A. Ashour, N.B. Aleksić, "On different aspects of the optical rogue waves nature," Nonlinear Dyn. 108, 1655 (2022)

`FT-03` / **Invited talk**

Quantum Gravity and the Swampland

Author: Emilian Dudas[1]

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Presenter: E. Dudas (`emilian.dudas@polytechnique.edu`)

The Swampland is defined as the set of consistent Quantum Field Theories that cannot be coupled to Quantum Gravity. The goal of the Swampland is to find or to conjecture, based on the intuition gained from String Theory, general principles that a field theory coupled to quantum gravity should respect. One example is the "gravity as the weakest force" (or "weak-gravity conjecture").

I will summarize some of the recent conjectures and their potential implications for particle physics and cosmology.

FT-04 / **Invited talk**

Time dependent problems in superconductivity - some recent advances

Author: Predrag Miranovic[1]

[1] *Montenegrin Academy of Sciences and Arts*

Presenter: P. Miranovic (pedjam@ucg.ac.me)

In this lecture, we will give an overview of some of the latest results related to superconductors under the influence of time-varying electric and magnetic fields.

Round Tables and Satellites Events

Round Tables

- **RT1** HEP – Roadmaps to the future
- **RT2** Integration – Widening Participation
- **RT3** Young Minds – Career in Physics
- **RT4** Young Minds – Quantum and New Technologies
- **RT5** Models of Studying Physics in European Universities – Specificities in Balkan Countries

Satellites Events

- COST CA18108 Workshop on theoretical aspects of quantum gravity (1 – 3 September 2022, Belgrade, Serbia)
- SEENET-MTP Assessment Meeting and Workshop on Theoretical and Mathematical Physics 2022 – BWAM22 (1 – 4 September 2022, Belgrade, Serbia)
- COST CA18108 Second Training School Quantum gravity phenomenology in the multi-messenger approach (3 – 10 September 2022, Belgrade, Serbia)
- CERN – SEENET-MTP – ICTP PhD School Gravitation, Cosmology and Astroparticle Physics (BS2022) (4 – 10 September 2022, Belgrade, Serbia)

RT-101 / **Invited talk**

The Future Circular Collider at CERN

Author: Emmanuel Tsesmelis[1]

[1] *CERN*

Presenter: E. Tsesmelis (emmanuel.tsesmelis@cern.ch)

The proposed Future Circular Collider (FCC) at CERN aims to continue the exploration of open questions in particle physics beyond the LHC and its high-luminosity upgrade in a staged research programme, integrating in sequence lepton (FCC-ee) and hadron (FCC-hh) collider programmes, and with the option of a hadron-electron collider (FCC-he), to achieve further understanding of the Standard Model and of electroweak symmetry breaking, and to maximise the potential for the discovery of phenomena beyond the Standard Model. The talk will present the status of the FCC Feasibility Study, launched to address the recommendation of the update in 2020 of the European Strategy for Particle Physics with the objective to provide an analysis of the technical and financial feasibility of a new collider infrastructure at CERN through a global collaboration of universities, scientific institutes and high-tech companies.

RT-301 / **Invited talk**

Career Paths for Physics Graduates

Author: Petra Rudolf[1]

[1] *University of Groningen, Netherlands*

Presenter: P. Rudolf (p.rudolf@rug.nl)

First I shall discuss possibilities and choices after being awarded the bachelor's, master's and PhD degree in physics or applied physics. I shall talk about advantages and disadvantages of different career paths and illustrate the relationship between job security and personal freedom for the various categories. After giving tips on how to decide, I shall focus on a career in academia, where first step is a temporary job, namely becoming a postdoctoral research fellow. I shall discuss what a young researcher needs to achieve in her/his postdoctoral period and what consequently s/he has to consider in making his/her choice where to go (place, topic, type of supervisor,…).

After one or two postdoc appointments it will be time to go for the second step, a tenure track assistant professorship. Now not only the scientific productivity is an important criterion, but the selection committee will want to know about teaching experience, whether the candidate has been the daily supervisor of bachelor's, master's and PhD students and if s/he has ever attracted any funding, done any outreach or done anything to serve/influence the community in his/her field. They

might also like it if the candidate has already been distinguished with a prize. I shall give tips on what a young researcher at the PhD and postdoc level can do to acquire experience and skills in all these areas.

For extra info I recommend three books:
"Survival Skills for Scientists" by Federico Rosei and Tudor Johnston
"A PhD is not enough" by Peter J. Feibelman if you want to spend part of your career in the USA.
"What is out there for me? The landscape of post-PhD career tracks" by Natalia Bielczyk discusses choices after the PhD
And a good guide for grant proposal writing:
"Art of Grantmanship" by Jack Kraicer, on https://www.hfsp.org/node/5761 gives an outline of what to do from 1 year before the deadline until the actual grant proposal submission

`RT-302` / **Invited talk**

From Science to Science Policy

Author: Enrique Sanchez-Bautista[1]

[1] *European Physical Society*

Presenter: E. Sanchez-Bautista (`enrique.sanchez@eps.org`)

With this talk, Dr. Enrique Sánchez would like to give an inspirational view about professional activities and opportunities for physicists outside academia based on his personal experiences, putting special focus on the science policy activity, where he develops his professional career representing the European Physical Society in Brussels.

`RT-303` / **Invited talk**

The science and technology of metamaterials

Author: Kosmas L. Tsakmakidis[1]

[1] *Section of Condensed Matter Physics, Department of Physics, National and Kapodistrian University of Athens, Greece*

Presenter: K. Tsakmakidis (`ktsakmakidis@phys.uoa.gr`)

Metamaterials and nanoplasmonics bridge the gap between conventional optics and the nanoworld. Exciting and technologically important capabilities range from subwavelength focusing and stopped light to invisibility cloaking, with applications across science and engineering from biophotonics to nanocircuitry. In the talk, we shall present past and recent advances in this exciting field, underscoring important

current trends that may lead to improved active imaging, ultrafast nonlinearities on the nanoscale, and topological rainbow trapping.

RT-401 / **Invited talk**

The Revolution of Quantum Information

Author: Yasser Omar[1]

[1] *PQI – Portuguese Quantum Institute & IST, University of Lisbon*

Presenter: Y. Omar (yasser.omar@tecnico.ulisboa.pt)

In this talk, I will discuss how Quantum Physics give us a new type of information, and how it can be exploited to develop new and revolutionary paradigms for computation, communications, and sensing. Furthermore, I will discuss the state of the art of this novel domain, and the challenges and opportunities lying ahead.

RT-402 / **Invited talk (virtual)**

Quantum Cryptography with BB84 protocol

Author: Ioannis Theodonis[1]

[1] *National Technical University, Athens, Greece*

Presenter: I. Theodonis (ytheod@mail.ntua.gr)

We will discuss an introduction to the concept of quantum information and its application to quantum cryptography. I will go through an educational approach based on a laboratory demonstration of the BB84 quantum cryptography protocol. Quantum cryptography is based on quantum key distribution through a quantum channel. In the BB84 protocol the quantum state of the polarization of the photons is used in order to encode information. Due to the no cloning theorem an unknown quantum state carrying information cannot be cloned or copied and thus theoretically the key distributional through a quantum channel is protected from evesdroppers.

RT-403 / **Invited talk**

The quantum ecosystem: careers and resources

Author: Araceli Venegas-Gomez[1]

[1] *QURECA, United Kingdom*

Presenter: A. Venegas-Gomez (araceli.venegas-gomez@qureca.com)

In this talk I will provide an overview of the current quantum ecosystem and its funding landscape. I will then follow with career opportunities, including my career path and the role of QURECA, to finish with some advice on how to improve your CV and prepare yourself for a career in quantum.

RT-501 / **Oral presentation**

Project-Based Learning Methods for Science and Engineering Education. An Approach Based on Backward Educational Design and Design Thinking

Author: Mihai Girtu[1]

[1] *Ovidius University of Constanta, Romania*

Presenter: M. Girtu (mihai.girtu@univ-ovidius.ro)

I will present recent progress in changing the way Physics is taught at Ovidius University of Constanta, Romania, following two projects the university has been involved in: Restart4Edu, an Erasmus+ project focusing on Project-Based Learning and a national project preparing the trainers for master's programs in education. I will illustrate how we applied our approach, based on backward educational design and design thinking in Phyiscs, Mathematics, and Engineering.

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