PHYSICS CONFERENCE IN BOSNIA AND HERZEGOVINA

October 25-26, 2018

Sarajevo

BiH

Book of Abstracts

DRUŠTVO FIZIČARA U FEDERACIJI BOSNE I HERCEGOVINE

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Preface

Physical Society in Federation of Bosnia and Herzegovina is a citizen's association whose aim is promotion of physics as fundamental and applied science. One of its planned activities is to organize scientific conferences but due to the lack of funding this had been somehow put aside. It was only recently that we decided to move things forward despite all obstacles.

Preparations for the Physics Conference in Bosnia and Herzegovina (PHYCONBA) started a couple of months ago, have been successfully completed and here we are.

I am proud to say that during this short period of time, a group of enthusiasts, the members of the Organizing Committee, working on a voluntary basis, managed to provide funds through different projects and to attract partners to support us in this endeavour.

Our main motivation was to bring together physicists from Bosnia and Herzegovina as well as from neighbouring countries and scientific Diaspora in order to exchange information, present their work and establish cooperation. Since this is our first conference to be held in Sarajevo, its scope is rather wide, covering numerous areas of research in physics and related subjects. Besides physicists from Universities and Institutes, we also wanted to include our colleagues who work in different laboratories or companies, as well as in schools. In addition we invited final-year students in order to give them an opportunity to hear renowned physicists of our region and get acquainted with various possibilities for their future careers.

The aim of the Conference is to provide all participants with the insight into different areas of current research and physics application. We are more than satisfied with the number of participants (59), which definitely proves that such a conference has been welcomed by scientific community in Bosnia and Herzegovina.

A two-day programme covers different areas, divided into the sections as follows: theoretical physics, applied physics, educational physics and experimental physics. Besides 5 plenary talks, the program includes 15 oral and 14 poster presentations, round table discussion and hopefully a number of informal talks.

We hope that all our guest will enjoy their stay in Sarajevo and that the conference will foster exchange of ideas and expertise.

Taking into account a significant interest of participants, the members of the Organizing Committee are optimistic regarding the conference success and new collaborations that are to be established and continued in the years to come.

Looking forward to the next conference.

Maja Đekić

Chairperson of the Organising Committee

Organising Committee

Maja Đekić, (University of Sarajevo, Faculty of Science, BiH), Chairperson

Dijana Dujak (University of Zenica, BiH)

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Ena Žunić-Ćejvanović (University of Sarajevo, Faculty of Science, BiH)

Amra Salčinović Fetić, Technical Secretary
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DISCOVERY OF THE HIGGS BOSON AND MEASUREMENT OF ITS PROPERTIES

Jelena Jovicevic

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The Large Hadron Collider (LHC) has been designed to collide two counter-rotating beams of protons at a centre of mass energy of up to 14 TeV - a higher energy than has ever been achieved before in a laboratory, in order to test our current understanding of the elementary particles and their interactions. One of the main physics questions to be addressed by the LHC and its accompanying experiments was that of the existence of the Higgs boson, a particle postulated in the 1960's as a cornerstone of the modern understanding of elementary particles and their interactions. On the 4th of July, 2012, the ATLAS and CMS experiments announced the discovery of a new boson consistent with the Standard Model Higgs boson [1][2]. This discovery has been followed by a comprehensive set of measurements of the properties of the new boson, with a focus on answering whether the new boson is the Standard Model Higgs boson and if there are any indications for physics beyond the Standard Model.

In this talk, I will present the road to the discovery, as well as the latest results of the measurements of the Higgs boson properties (cross-sections, couplings, mass, differential measurements, width) based on collision data collected by the experiments until end of 2017, corresponding to the integrated luminosity of up to ~80fb^{-1}. I have been contributing to the discovery and measurements of the Higgs boson properties by the ATLAS experiment since 2011.

[1] ATLAS Collaboration, Phys. Lett. B 716, 1 (2012)

[2] CMS Collaboration, Phys. Lett. B 716, 30 (2012)

METAMATERIALS AND WAVES

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For centuries, scientists have tried to control the trajectories of light. The paradigm of a man-made device which bends light trajectories and brings them to a focus is a bare curved piece of silica: a convex lens. It is common belief that during the Siege of Syracuse (214-212 Before Christ), the great physicist Archimedes destroyed enemy ships with fire using convex mirrors as a weapon. A large curved mirror, sometimes called the Archimedes heat ray, was used to focus sunlight onto approaching ships, causing them to catch fire. We see that from the begining, greeks showed that who control de waves (see figure 1) control the world. Here we will show how the concept of transformational physics is a nice tool for design of cloaking systems. [1-3]

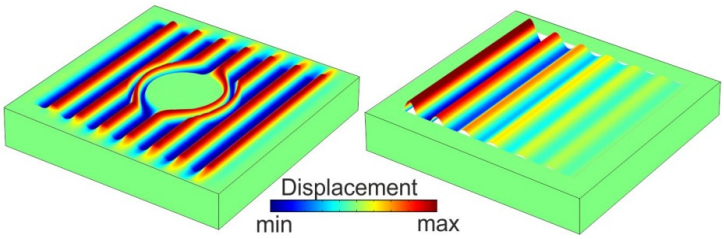

Figure 1. Idea of transformational physics: (left) an obstacle is hidden and appears as absent to the incoming elastic wave; (right) an elastic wave is progressively absorbed by a medium.

The world „meta" is also coming from greek and means „beyond". It is said that certain materials or structures can present some unusual properties regarding their properties (electromagnetic, thermal, mechanics...). The most common example of the extraordinary material is the Veselago-Pendry lens made out of a material with a refractive index of -1. Pendry's work [2] was the main motivation for many people in metamaterial field as it suggest that one could beat the optical resolution and thus experimentally realise a superresolution lens.
Thought this talk we will focus on this two points: waves [1-4] and metamaterials [4-7]. Which waves? Electromagnetic or Mechanics and with

which materials? How to control wave propagation? How to build metamaterial? What is the "meta" aspect and what is not? What are the bounds and limitation in physics of waves and different domain (electromagnetism or mechanics). Finally we will see how to beat bounds in other type of physics such as magneto-transport [6-7].

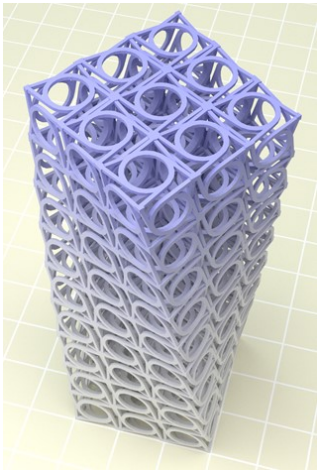

Figure 2. Example of mechanical metamaterial. Adapted from [5] (Illustration from Tobias Frenzel)

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ATTOPHYSICS

***Dejan B. Milošević*[1,2]**

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Electrons and photons have played a central role in the scientific and technological revolution of the 20th century. It is enough to mention the discovery of transistors and lasers to confirm this. Photonics is nowadays one of the key drivers of scientific and technological innovations stimulating economic growth. The 21st century is frequently referred to as the century of photonics. This plenary talk is devoted to attophysics, a newly developed area of science, related to extreme photonics, which study electronic motion in atoms, molecules and nanoscale structures on their natural attosecond time scale (the atomic unit of time is 24.2 as = 2.42×10^{-17} s). I will briefly present historical development of attophysics, having in mind that nowadays the borders between the physics, chemistry and biology tend to disappear, so that the terms attochemistry, attobiology and, in general, attoscience are also used. The development of attophysics is based on the discovery of new laser sources and strong-laser-field physics. A part of this talk is devoted to these themes. I will also introduce a new direction of strong-laser-field physics – quantum dynamics in taylored intense laser fields – and show the latest results of the research group Samophys (Sarajevo Atomic, Molecular and Optical PHYSics) obtained using the so-called bicircular field.

INFLUENCE OF DISORDER AT DIFFERENT LENGTH SCALES ON THE PROPERTIES OF MATERIALS

Damir Starešinić

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Disorder is inherent to the systems studied by solid state physics, consisting of vast number of atoms. Ranging from glasses with inherently random atomic structure to fractal-like aerogels, from crystals with intrinsic or intentionally introduced point defects to nano- and polycrystalline materials, the influence of disorder at different spatial scales often leads to stark differences between the fundamental properties related to the starting atomic-level structure and the functional properties of bulk technological materials.

The contribution of the solid state physics to the science of materials, based on the rigorous experimental and theoretical approach, grew continuously to become indispensable today in the advent of nanostructured materials. Motivated by my contributions to the investigation of various systems influenced by disorder, I will present some current directions in investigation of the origins and the consequences of disorder in solid materials.

Hard carbon, obtained by collapsing C_{60} fullerene molecules at moderate pressure and temperature, shows hierarchical granular morphology from the atomic up to the sample size length scale [1], as shown in Fig. 1. The unusual fractal-like structure correlates with very low, almost linear thermal conductivity measured in a wide temperature range [2].

As inhomogeneity at different length scales reduces substantially the thermal conductivity, hierarchically structured thermoelectrics could achieve high efficiency required for wide-scale application. New experimental and theoretical methods are developed for the investigation of the mechanisms for the formation of hierarchical structures and concomitant mechanisms of the heat, as well as charge transfer.

The low temperature heat capacity of CuHfTi metallic glasses [3,4] and TiZrNbCuNi high entropy metallic glasses [5] shows so-called boson peak (BP) contribution in excess to the usual Debye heat capacity of acoustic vibrations, Fig. 2. BP is typically attributed to finite frequency modes of medium range order in glasses, the origin of which is still strongly debated [6]. Moreover, as

shown in Fig. 2b, the BP strength shows a systematic but non-monotonous composition dependence [4,5] which, in the case of CuHfTi metallic glasses, correlates with the glass forming ability [4].

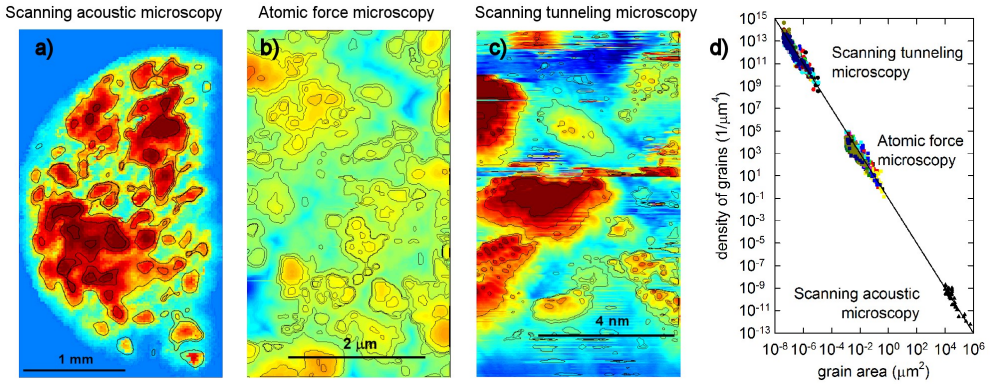

Figure 1. The granular structure of hard carbon seen by a) scanning acoustic microscopy, b) atomic force microscopy, c) scanning tunnelling microscopy together with d) the power-law distribution of the density of grain sizes [1].

The glass transition is still not understood on the fundamental level. Finding a "hidden" order which governs it would enable better understanding of the properties of glasses and probably other disordered materials.

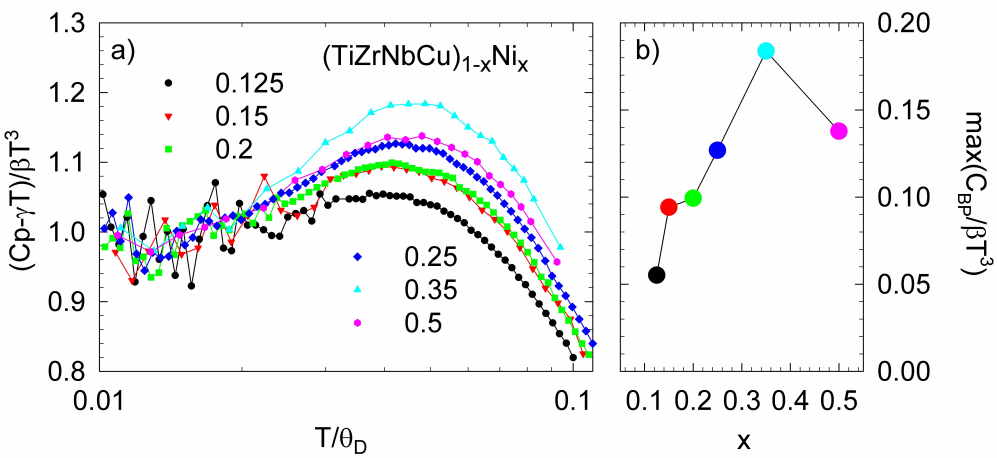

Figure 2. a) The ratio of the low temperature heat capacity C_p of high entropy metallic glass $(TiZrNbCu)_{1-x}Ni_x$ and βT^3, the Debye contribution of acoustic vibrations. b) Excess contribution to C_p as the function of Ni content [5].

Dielectric response of charge density wave (CDW) collective state is dominated by the low frequency relaxation mode, so-called α mode, exhibiting enormous

dielectric constant ε [7]. However, in CDW system o-TaS_3, substitution of Ta with 0.5% of isoelectronic Nb completely removes α mode and reduces the dielectric constant by several orders of magnitude [8], as shown in Fig. 3. Systematic introduction of disorder by proton irradiation of o-TaS_3 shows that α process disappears near 0.1% atomic concentration of defects [9]. In another example, the small S deficiency in CDW system NbS_3 can change the majority carriers from holes to electrons, affecting both the electric conductivity and the thermoelectric power [10].

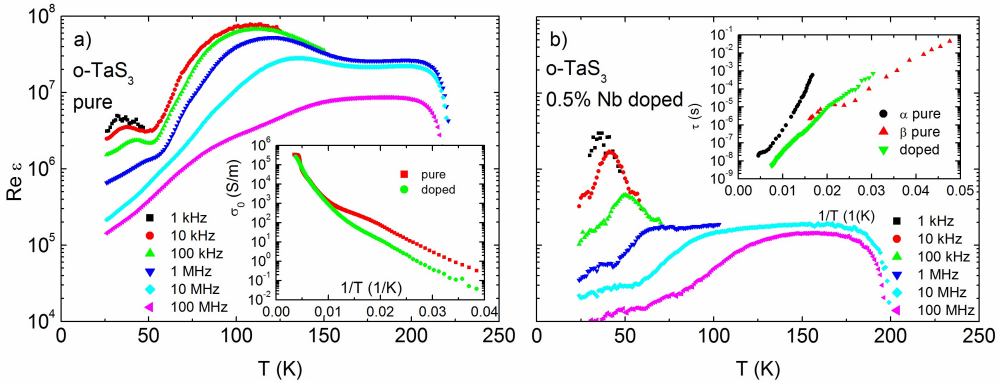

Figure 3. Dielectric response ε as the function of temperature for different frequencies of a) nominally pure and b) 0.5% Nb substituted (doped) CDW system o-TaS_3 [8]. Inset of a) shows the dc conductivity of two systems and inset of b) relaxation times for high (α) and low (β) temperature relaxation processes in two systems. Notice that α process is absent in doped system, while the conductivity remains unaltered and typical for CDW state.

The defects in non-stoichiometric materials or solid solutions cannot be treated as small perturbation even at moderate levels. The concomitant changes in the crystal structure, including the defect ordering, have been observed experimentally and modelled in various systems.

The temperature dependence of the resistance, $R(T)$, in thin films of yet another CDW system $K_{0.3}MoO_3$ [11], deposited by pulsed laser deposition technique [12], is shown in Fig. 4. The granular nature of the films, shown in the inset of Fig. 4, is responsible for the difference of $R(T)$ in films and in bulk crystals, even though the CDW ground state is preserved within the grains [12]. Both the confinement of charge within the grains and their tunnelling through the grain boundaries are invoked to explain the variable range hopping mechanism of charge transport [11].

In nanocrystalline materials the thickness of the grain boundary becomes comparable to the grain size and it is more useful to consider them on equal terms, as a heterogeneous mixture of, usually ordered and disordered, phases. Moreover, at these length scales it is necessary to take into account the quantum size effects as well.

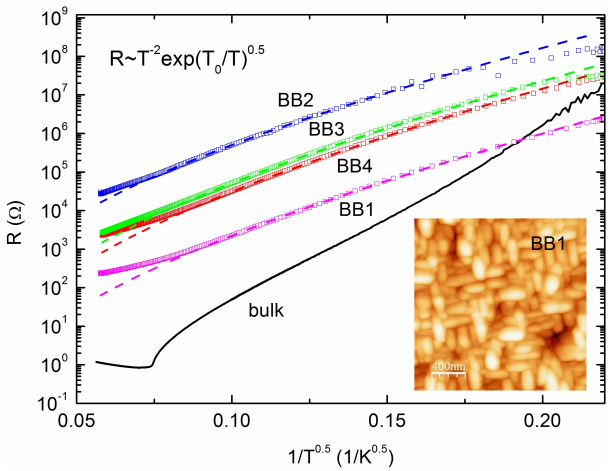

Figure 4. The temperature dependence of the resistance $R(T)$ in thin films of CDW system $K_{0.3}MoO_3$ [11]. $R(T)$ of different films BB1-BB4 is presented by symbols, $R(T)$ of bulk crystals by solid line and fits to the VRH formula given in the Figure by dashed lines. In the inset is the AMF image of the surface of BB1 film.

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AFTER THE HIGGS BOSON

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While with the discovery of the Higgs boson in 2012, Standard model was completed, many open questions remained. Many of the observed phenomena can be explained by new models which either predict existence of additional Higgs bosons or new resonances decaying to pairs of Standard model Higgs bosons. Since a branching ratio of the Higgs boson to a pair of b-quarks is enhanced in many scenarios, efficient triggering and reconstruction of jets originating from b-quarks is a key element in many of these searches. We will present latest techniques used to identify b-jets and how these are used in a search for these new models involving Higgs bosons. Further, we will discuss the latest results from ATLAS experiment, and briefly describe how some of these searches can further shed a light on the Standard model.

Oral presentations

STUDENTS' EXPERIMENTAL PROPOSALS TO TEST ALTERNATIVE EXPLANATIONS OF BOTTLE-AND-WATER-JET DEMONSTRATION OF WEIGHTLESSNESS

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The concept of weightlessness is introduced through "thought experiment" with free-falling lift in which a person standing on a balance reads "zero weight". We could not find any experimental study concerned with students' explanations of this particular demonstration of weightlessness which can be easily performed in classrooms: water-jet flow out of a bottle with hole when the bottle is at rest and water-jet stop flowing out when the bottle is in free-fall. This is an important study because some physics textbooks require that students explain why a water-jet stops to flow out from a bottle in free fall. We designed and carried out a corresponding research with students of primary and high schools in Sarajevo. Students' tasks in a paper-and-pencil format were: Why does water flow out of a bottle with hole when the bottle is at rest? Why does water stop flowing out when the bottle is in free-fall? Propose an experiment showing that your explanation is right. What should happen in that experiment and why? Students' answers and drawings revealed many different alternative explanations. The most unexpected was "water does not flow out because it goes above the hole".

In this report, we have described the answers related to the last two tasks given by the students, who believed in "water goes up" explanation. Many of the proposed experiments are not related to the alternative explanation and, therefore, are useless for testing it. Nevertheless, some of the proposed experiments are logically derived from the alternative explanation and can be easily used to test and disprove it. The proposals of the experiment proved to be an excellent idea because students have the ability to propose and plan experimental activity themselves as well as to decide for themselves whether the proposed experiment is good or not.

FLIGHT SIMULATORS

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The need of training pilots is growing very fast. The quality requirements for pilots training are changing imposing the usage of latest achievements in gaming, projection and computing technologies.
The flight simulator industry needs to satisfy this fast grow for a new flight simulators and a request for implementation of a new technologies. The development needs to include a development of new training strategies and new simulators that will support those new strategies.
The new simulators need to offer bigger FOV (field of view), better resolution (close to human being limit), more illumination (brightness), faster simulator reaction and more realistic training.
A lot of flight simulators important characteristics are subjective and Authorities certifying the flight simulators together with the companies providing training services and the flight simulators are looking to find the best objective tests to evaluate the flight simulators. The higher precision of the information and bigger brightness of the simulated images require more analysis and better understanding of the perception of the reality and a difference between the real world and simulation.
A possibility of a virtual reality application in flight simulators needs to be evaluated.
The fast grow of the flight simulator market has a very important impact on the production and the design. The competition between flight simulators companies is growing and the schedules have become very short meaning that there is no place for mistakes.

TIME RESOLVED RAMAN SPECTROSCOPY ON COLLECTIVE STATES DRIVEN FAR AWAY FROM THE EQUILIBRIUM

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An intense laser pulse can drive a charge density wave (CDW) system far enough to reach a nonthermal state or to melt the order, as resolved by ultrafast pump-probe (P-p) studies, revealing Raman-active collective modes in time domain [1]. Three pulse techniques further elucidate these states [2-5].

One such technique was used to study several collective-state systems: weak P-p sequence records the collective response at time t_{12} after strong D-pulse [2]. With its excitation density set to melt the order, periodic modulations of amplitudes and phases in respect to t_{12} appear, Fig. 1. Amplitudes even enhance at moments, while phases reach nonsteady state values, seeking for new approaches than the existing theoretical models [3,5,6].

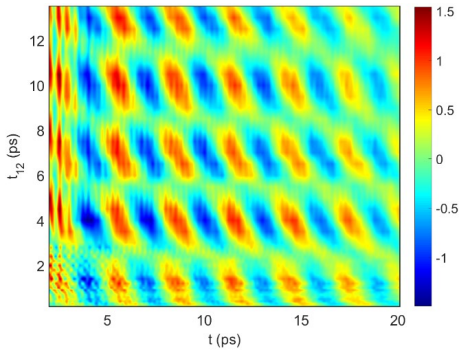

Figure 1. P-p traces of Raman modes in time t of $(NbSe_4)_3I$ at 5 K, as a function of t_{12}. D-fluence was set to 2 mJ/cm^2 and the laser wavelength set at 800 nm.

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RANDOM SEQUENTIAL ADSORPTION ON A DISCRETE SUBSTRATE

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The Random sequential adsorption model (RSA) considers adsorption process as sequential addition of objects on the n-dimensional substrate such that at each time step only one object is added on the substrate at a randomly selected position. Objects are made by self-avoiding random walks, and they can be of different shapes and sizes. Newly added objects are forbidden from overlapping with the already adsorbed objects. The adsorbed objects are permanently fixed at their spatial positions so that they affect the geometry of all later placements. If the desorption of the objects is allowed model is considered as the irreversible RSA. As the substrate we have used a triangular lattice. We have done all our research numerically by means of Monte Carlo simulations.

In our previous research [1] we studied percolation phenomena for RSA process with two kinds of deposited objects, where one type of objects was adsorbed on the substrate contaminated by other type of objects called impurities. It is shown that for the large impurities, percolation threshold of all examined objects increases with the impurity concentration.

Lately we have considered the lattice, which is initially occupied by immobile objects (obstacles), as a crowded environment, and examined the diffusion of individual agents through such environments. The main goal is to find out the connection between percolation theory and our model of a crowded environment.

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CHALLENGES ON TEACHING PARTICLE PHYSICS IN HIGH SCHOOL

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Particle Physics is not that new and unknown topic in Physics, but with recent discoveries and developments in the field, it poses itself challenging for teachers in high schools. These challenges might vary regionally, but they persist regardless of high school type, students' environment and financial possibilities. We will present the current situation in teaching Particle Physics in high schools in Sarajevo Canton as well as the challenges and obstacles teachers face from year to year in presenting the matter to students. A survey conducted among high school Physics' teachers has given us solid ground on where and how to direct our research, what specific points to tackle and how to help in making this particular topic more understandable and closer to teachers as well as to students.

Similar experiences are present in Norway [1], the United States of America, Spain [2] etc. We will try to present some features that might enrich teaching Particle Physics in high school, as well as approaches and methods that might help to ease the problems that teachers encounter with this topic.

Problems we will present here vary from literature choice, lack of experiments to insufficient knowledge and understanding of matter itself. We offer solutions and ideas on how to overcome the problems on both practical and theoretical level. Theoretical in the sense of proposing changes in the field of administration and organisation of classes, and practical in the sense of presenting experiments, group works and other ideas that teachers actually can try in their classrooms.

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CLASSICAL ASPECTS IN ABOVE-THRESHOLD IONIZATION OF MOLECULAR HYDROGEN CATION

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Many underlying physical insights and features of above-threshold ionization (ATI) can be explained and understood with the help of classical electron trajectories in a strong laser field. In the strong-field community this approach is known as the *simple man's theory* (SMT). In SMT it is assumed that, after an electron is released into continuum, it is moving solely by the influence of the laser field, neglecting the influence of the atomic or molecular potential, except in time of rescattering event. In this work we will show how the classical electron's trajectories are reveleaed in a quantum mechanical probability distribution (QMPD) obtained from a numerical solution of the full 3D time-dependent Schrödinger equation (TDSE) for molecular hydrogen ion H_2^+ in a linearly polarized strong laser field [1]. The same method has been previously used in order to show emergence of classical trajectories in ATI of atomic hydrogen [2]. In the presented figure we show probability distribution obtained from the TDSE calculations as a function of electron position at the end of a laser pulse and the final electron energy. The wave packets are clearly oriented along classical trajectories which are shown in the right-hand panel.

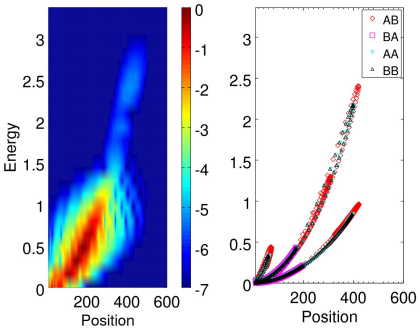

Figure 1. In the left-hand panel we show QMPD in energy-position space obtained from TDSE using following laser field parameters: 10^{14} Wcm^{-2}, 800 nm and sin^2 pulse with total duration of four optical cycles. The right-hand panel corresponds to classical electron energy and position.

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SYMMETRIES IN MOLECULAR HATI

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When atoms or molecules are subjected to laser field, photoionization can occur if laser photon energy is higher than corresponding ionization potential. If the laser field intensity is high enough to modify (bend) atomic potential, atoms (molecules) may be ionized through tunneling mechanism in the case that laser photon energy is lower than corresponding ionization potential. In that case electron absorb several photons to escape parent atom, and it can absorb more photons than necessary to escape, resulting in high kinetic energy. For the laser intensities high enough photoelectron energy spectra consist of two plateaus. We call that kind of photoelectron spectra HATI spectra (High-order above-threshold ionization spectra). Symmetries of molecules and laser field applied shall influence the symmetries of corresponding HATI spectra. We are considering here rotational and reflection symmetries [1]. As the result, one can retrieve some information about molecular target from corresponding HATI spectra [2].

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EPITAXY OF ADVANCE NANOWIRE QUANTUM DEVICES

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InSb nanowires provide an ideal platform for low-dimensional quantum devices. Majorana zero modes (MZMs) can emerge when InSb nanowire is coupled to a superconductor. To uncover the special properties of MZMs well-controlled braiding operations are required. Essential hardware for braiding is a network of hybrid semiconductor-superconductor nanowires.

Here we demonstrate a technique for bottom-up synthesis of nanowire networks having a predefined number of superconducting islands.[1] Structural analysis confirms the high quality of the nanowire junctions, as well as superconductor–semiconductor interface. Quantum transport measurements of nanowire 'hashtags' reveal Aharonov–Bohm effects, indicating a phase coherent system. In addition, hybrid nanowires show a proximity-induced hard superconducting gap, highlighting the successful materials development necessary for a first braiding experiment. Our approach opens new avenues for the realization of quantum architectures.

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GRAPHENE MATERIALS IN ENERGY STORAGE AND CONVERSION SYSTEMS – "LOW-QUALITY" FOR HIGH PERFORMANCE

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Quality of graphene can be assessed by how much the particular material is close to the ideal, two-dimensional, defect-free, all-sp^2-hybridized carbon sheet with the theoretical surface area of 2629 m^2g^{-1}. From the fundamental point of view, as well as for some applications in electronics, ideal (*ie*, „high-quality") graphene is desirable; on the other hand, electrochemical processes in energy storage and conversion systems depend on different structural deffects and chemical functionalities. Nevertheless, these features come at the expense of the conductivity of graphene, which is also essential for the application in electrochemical systems. Hence, performance of these materials is dependent on the balance between conductivity, deffects and functionalities. According to both computational and experimental results, oxygen functional groups adsorbed on the graphene basal plane are responsible for pseudocapacitive contribution to the total capacitance of graphene. Furthermore, aggregation of functional groups increases their stability on the graphene plane, leading to the reversible interactions with the ions, even at the quite negative potentials attained in lithium-ion batteries and similar systems. Also, deffects and functional groups interact strongly with transition metal atom clusters, which could enable high dispersion of metallic nanoparticles over the deffect-rich graphene basal plane. Taking into account an active role of graphene-based materials, that we observed in our recent experimetns with metal@graphene electrocatalytic composites, these results indicate possibilties for simple preparation of high-perfomance, platinum-group-metal-free electrocatalytic materials for hydrogen-based energy conversion systems.

TEMPERATURE METROLOGY IN BOSNIA AND HERZEGOVINA

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Institute of Metrology of Bosnia and Herzegovina (IMBiH) started developing the temperature standards laboratory (Laboratory for Temperature and Humidity) in 2011. The Laboratory, at present, consists of two sub-laboratories in the areas of contact temperature and humidity measurements.

Temperature scales, such as the International Temperature Scale of 1990 (ITS-90), are established to ensure unique temperature measurements throughout the world with smallest possible uncertainties. These include thermometric fixed points which are based on melting-, freezing- or triple points of pure substances. The comparison of fixed-point temperatures and the interpolation of the scale between fixed points in the temperature range between about -259 °C and 962 °C is carried out by platinum resistance thermometry. Noble metal thermocouples of type S, R and B (platinum-rhodium alloys) and pure metal thermocouples made of gold and platinum (Au/Pt) and platinum and palladium (Pt/Pd) can be calibrated at the melting and freezing points of pure metals up to temperatures of 1600 °C.

The primary level calibrations of standard platinum resistance thermometers (SPRTs) defined by the International Temperature Scale of 1990 (ITS-90) as the interpolating instrument are carried out by the IMBiH laboratory from -38.8344°C (HgTP) to 961,78 °C (AgFP). The Laboratory also performs secondary level temperature calibrations, by comparison method, in the calibration range from -40°C to 1350°C (calibration of resistance thermometers, thermistors, thermocouples and other kinds of contact sensors). The Laboratory is continuously developing its capabilities through active participation in EURAMET (European Association of National Metrology Institutes) research programs in the field of thermometry and technical cooperation with other NMIs (National Metrology Institute).

GOOD PRACTICES ON LOW COST EXPERIMENTS IN PHYSICS EDUCATION

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Low cost experiments present a unique opportunity to supplement and enhance the student experience in physics education, thus motivating them to pursue a further scientific or science education career.

Often, especially in lower income countries, they may be the only tool that is both practical and accessible to teachers and educators responsible for physics teaching.

Focus in bringing these examples into everyday use is on building an easily accessible, open source database that would include references to all the resources which were used to create the database itself.

The issue of such a database would be its accessibility on an international level. Currently, such databases exist, but are mostly available only in a single language, while most teachers across Europe do not share a single language, or are not proficient in foreign languages, which limits the use of those databases.

This would ask for the consolidated effort of an international group of interested parties to create a more robust and multilingual database, compared to already existing ones, to gain a more significant impact with the target audience.

Low cost and accessible experiments have become a dire need in the current educational paradigm, supplementing and enhancing the classroom experience, for all sides involved. These examples were chosen to help and guide the future research on integration of modern trends and technologies, widespread in society, to drive the advancement of affordable inquiry based approach.

The main part of this talk will focus on existing resources and their implementation.

SURFACE PLASMON RESONANCE OF SILVER NANOPARTICLES FORMED IN MONOCRYSTALLINE SILICON

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The investigation of the specific features of metal nanoparticles have been recently the subject of the numerous studies due to their strong absorption in the visible region, which is referred to as a surface plasmon resonance (SPR). In this paper we investigate the changes in SPR of silver (Ag) nanoparticles embedded in silicon. The nanoparticles were formed by single or multiple low energies (60 and 75 keV) Ag ions implantation in Si (100) wafers, with the fluences in the range of 10^{13}-10^{16} ions/cm^2. The size and depth distribution of silver nanoparticles after Ag ions implantation of Si substrates were analyzed by cross-sectional transmission electron microscopy. The evolution of the optical properties of the Ag-implanted Si samples was followed by spectroscopic ellipsometry measurements. The results showed that after single energy implantations the Ag atoms are located in the near surface region of the implanted Si, at depths of ~30 nm and ~40 nm for the energy of 60 keV and 75 keV, respectively. The nanoparticles are nearly spherical with the average size of approximately 1 nm. The synthesized Ag particles show a strong SPR peak in the visible region associated with the surface plasmon excitations. Depending on ions energy as well as ion fluence the SPR peak shifted in the position in the range of 694-1271 nm. The experimental results were discussed based on the contribution of particle-particle interaction. In this context the experimental SPR values were compared with those predicted by the Maxwell–Garnett theory. Multiple energy implanted samples show enhancements in the optical absorption as compared to the single energy implantations.

EFFECTIVENESS OF SCIENTIFIC MINI-PROJECTS FOR TEACHING PHYSICS TO HIGH SCHOOL STUDENTS

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Having great potential, Bosnia and Herzegovina is not sufficiently represented at the international platforms for networking in education, research and science. At the same time, global tendency shows decline in engagement of talented high school students into studying sciences at the university level.

Promoting the Culture of Science Popularization in Bosnia and Herzegovina is a long-term project, which needs a comprehensive approach.

One of the ways to increase engagement of high school students into studying STEM subjects at the university is developing bonds between the university and high school students while working on small scientific projects, which can later be presented on local and international platforms.

Such approach has already been tested in Ukraine while developing collaboration between ECYGDA private educational center and Karazin Kharkiv National University. [1] School teachers and University staff have been working on selecting kids who have potential to present small research projects, which have been done at the premises of the university and its research facilies, and further presentation of these projects at the international conferences and competitions. Such activities help students to get acquainted with university standards, as well as with scientific approach while still studying at high school.

Results of implementation of this system at the premises of Karazin Kharkiv National University show that such students become successful university students, who successfully continue pursuing their scientific career.

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PARTIAL WAVE ANALYSIS AS A TOOL IN BARYON SPECTROSCOPY

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Partial-wave analysis, a textbook method to identify resonances and determine their quantum numbers, is a standard procedure used to analyze a wide class of experimental scattering data. We study the partial-wave amplitudes of meson photoproduction reactions and their use in a model independent way in baryon spectroscopy. Instead of using theoretical models as an constraint in order to achieve solutions which is continuous in energy, we enforce the analyticity of invariant amplitudes at fixed values of the Mandelstam variable *t*. We present an iterative, model free procedure with successive fixed-*t* amplitude analyses and a single energy partial wave analysis.

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GLASS FORMING ABILITY AND THERMODYNAMIC PROPERTIES OF NiZr AND CuHfTi METALLIC GLASSES

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We have investigated correlation between thermodynamic parameters given by low-temperature heat capacity (C_p) measurements and glass forming ability (GFA) of NiZr and CuHfTi metallic glasses. C_p of metallic glasses at sufficiently low temperature deviates from the Debye T^3 law with a very well known anomaly named Boson peak (BP) which can be observed as a wide peak in C_p/T^3(K) approximately at 10 K.

C_p measurements were conducted in wide temperature range from 1.8 K to 300 K for as cast and relaxed $Ni_{23}Zr_{77}$ and $Cu_{55}Hf_{45-x}Ti_x$ (x=0, 5, ... and 45) samples. BP, given as subtraction of the measured C_p and sum of the Debye phonon and electronic contributions, surprisingly in NiZr sample having a low GFA was not detected [1]. Low temperature phonon and electronic contributions to C_p of CuHfTi system depend monotonically on Ti concentration (x), same as reported before [2], but BP has pronounced maximum for Ti concentrations with enhanced GFA.

Finally, we can conclude that GFA can be related with low temperature properties of alloys and the strength of BP could be a measure of GFA for metallic glasses produced under the same conditions [3].

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Poster presentations

MEASUREMENTS WITH NaI(Tl) SPECTROMETER

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This paper presents an analysis of the energy spectrum of gamma radiation, obtained by the emission of different radioisotopes. Radioisotopes evaluated were ^{60}Co, ^{57}Co, ^{137}Cs, ^{131}I and ^{18}F. These are often used radioisotopes in nuclear medicine, so it is very important to know their energy spectrum. NaI(Tl) scintillation detector, Inspector 1000, has been used to detect this radiation. This detector has large number of applications in radiation detection. It enables the identification and location of radioisotopes, activity determination, dosimetric measurements, and provides a detailed view of the energy spectrum.

The introductory part of this paper describes the basic concepts of ionizing radiation, radioactive decay, radiation interaction with matter, and radiation detection. The principle of operation and types of scintillation detectors, and especially the NaI (Tl) detector, are described.

The phenomena that occur in the detector during exposure to radioactive radiation, the method of obtaining the energy spectrum, and its analysis are shown. The energy spectrum of a radioisotope is usually represented as graph of the dependence of the number of detected counts on energy, and with it we can see and analyze the characteristic energy peaks of the individual radioisotopes.

The energy of certain peaks in the spectrum was measured, and with the analysis was obtained the detector's energy resolution, full width at half maximum, the surface area of the spectrum, and the accuracy of the measurements relative to the expected results.

INVESTIGATION OF CALIBRATION BATHS UNIFORMITY FOR PRECISION TEMPERATURE MEASUREMENTS

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In this paper we present evaluation of uniformity of calibration baths used in temperature calibration laboratories. Calibration baths may have different construction (shape and size) and use different media (water, alcohol, silicon oil etc.), regulation of temperature and insulation. Since they are used for calibration of thermometers by comparison, it is of the utmost importance to investigate their homogeneity and stability. In temperature calibration the largest uncertainty component is most likely to be uncertainty of the calibration bath [1]. A certain inhomogeneity inside of the used media can always be observed as a temperature gradient, that is a difference in thermometer reading in accordance with the change of its position inside the calibration bath [2]. Bath's stability depends on the media's flow inside it. Here we investigate homogeneity of a cylindrical calibration bath by measurement of axial and radial temperature gradient. Two thermometers are used, one as a reference and the other is moved axially and radially inside of the bath. During the stability investigation we observe only the change in temperature reading of the reference thermometer during 20 minutes. The obtained results can be used as measurement uncertainty of the bath during calibration of thermometers.

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ELECTRON COLLISION CROSS SECTIONS AND TRANSPORT COEFFICIENTS FOR TETRAFLUOROETHANE – $C_2H_2F_4$ AND DIMETHYL ETHER – CH_3OCH_3 OBTAINED BY USING THE SWARM METHOD

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We present electron collision cross sections and transport coefficients in $C_2H_2F_4$ and CH_3OCH_3 obtained by applying the swarm method, that is the iterative procedure of adjusting cross sections in order to achieve the agreement of calculated and measured transport coefficients with a satisfactory accuracy. Experimental values of transport coefficients were taken from de Urquijo *et al* [1], and Oettinger *et al* [2] in case of $C_2H_2F_4$ and CH_3OCH_3, respectively. The procedure was performed for pure gasses and their mixtures with noble gasses simultaneously and over an extended range of applied reduced electric fields (E/N). The initial cross sections for CH_3OCH_3 were taken from Biagi [3] and for $C_2H_2F_4$ it was a compilation of our previously published data [4] and some new calculations and findings. All calculations were done by using Boltzmann equation solver (Bolsig+) and our Monte Carlo (MC) simulation code. The derived sets of cross sections have been further used to calculate other transport data such as characteristic energies and collision rates for individual processes in order to complete databases for modelling low temperature plasmas and their applications.

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PHYSICS AT ILC AND COMPARISON OF ITS CAPABILITIES WITH LHC

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LHC (Large Hadron Collider) has been the world's largest and most powerful particle accelerator. The discovery of Higgs boson was a milestone which led to complete particle spectrum of a "Standard Model" that could be correct up to very high energies. However, there are still unanswered questions.

ILC (International Linear Collider) is a proposed electron-positron collider, which differs from LHC in several aspects such as type, size, energies etc. But one of the main differences is its purpose. While LHC is being upgraded to higher and higher energies over the years (14 TeV), ILC infrastructure would provide a basis for collisions at 500 GeV (up to 1000 GeV). ILC is a precision measurement machine and the LHC is a discovery machine. Processes to be studied are large fractions of the total electron-positron annihilation cross section where event selections give high purity, over backgrounds that are straightforward to compute [1]. We review the capabilities of ILC for experiments on the Higgs boson, the top quark and proposed new particles.

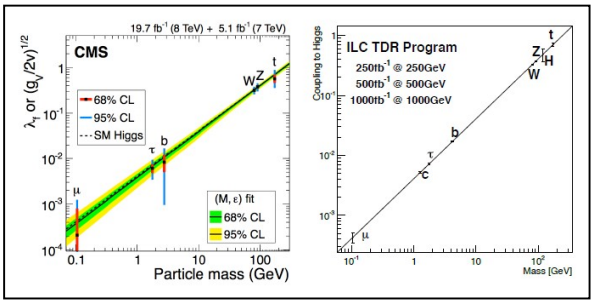

Figure 1. Left: the CMS to the current Higgs data, from Ref. [2], Right: the expected improvement in the precision in the measurement of the Higgs couplings at the ILC, from Ref. [3]

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STRONG-FIELD IONIZATION OF DIATOMIC MOLECULES BY A TWO-COLOR LASER FIELD

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High-order above-threshold ionization (HATI) is nonperturbative phenomenon, which occurs when an atom (molecule) is exposed to an intense laser field. In the first step of this process, the considered system absorbs more photons from the laser field than is necessary for ionization. The electron, liberated in such a way, can go directly to the detector. We call this process the direct above-threshold ionization (ATI). Due to the laser field, the ionized electron may also return to the parent molecular ion and elastically scatters off it, before reaching the detector. In this process, the electron can absorb many more photons from the laser field than in the direct ATI. This process was named HATI. The energy spectra of HATI is characterized by a plateau which manifests itself as a broad energy interval of the spectrum in which the photoelectron (HATI) yield is practically constant. In this paper we investigate strong-field ionization of diatomic molecules by a two-color laser field of frequencies rω and sω having coplanar corotating elliptically polarized components. We observe molecular-orientation-dependent interference and plateau structures. We explain the observed minima in the ATI spectra by the interference of two electron wave packets emitted from the two centers of the diatomic molecule. Some of these effects strongly depend on type of molecule and its symmetry. Also, we have checked that these effects are observable for a wide range of the laser field parameters.

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NON-ISOTHERMAL KINETIC ANALYSIS OF THE CRYSTALLIZATION OF THE PARTIALLY CRYSTALLINE CUZR(AL) METALLIC GLASSES

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Partially crystalline metallic glasses $Zr_{45}Cu_{55}$, $Zr_{55}Cu_{45}$ and $Zr_{40}Cu_{54}Al_6$ were prepared by melt-spinning, in the form of ribbon. Numbers indicate atomic percents. X-ray diffraction confirmed the presence of crystallites in the amorphous matrix. Homogeneity and the chemical composition were investigated using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDX). The crystallization process was studied by means of differential scanning calorimetry (DSC). It were concluded that Šesták-Berggren reaction model should be applied for the studied crystallization processes.

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MULTIDISCIPLINARY APPROACH AND INTEGRATION OF NATURAL SCIENCES IN THE MODERN AGE

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In its inception in the ancient times, scientific thought was considered part of one discipline, called philosophy. Whether it was a study of plant or animal life, shifting of seasons and tides etc., or existential thoughts, moral codes and so forth, there was no clear differentiation, and indeed many of the intellectuals of those days dwelled in many aspects of life and nature in comparable amounts. Development of scientific method and rapid advances has led first to the separation of science from philosophy and to further balkanization of science into different disciplines including physics, chemistry, biology and so forth, and even these were further differentiated info subdisciplines, often independent of each other, leading to establishment of vast web of disciplines and fields of research. Howe.ver, in many cases, challenges of modern times demand solutions that no single discipline can provide on its own. This has led to reverse of separation trend of sciences and has opened the way to multidisciplinary approaches to modern day problem-solving. These include medicine, biotechnology, modern materials design, tackling pollution and ecological challenges, the design of modern personal devices and many more, as well as the increased integration of science study in formal and informal education, or STEM (Science, technology, engineering, mathematics). In addition to science integration, data analysis, application of computer models and simulations provides invaluable assistance in solving complex problems and complementing experimental work by reducing number of attempts and spent resources and time.

COMMON STUDENT DIFFICULTIES TO USE DIFFERENT REPRESENTATIONS: FREE-BODY DIAGRAMS IN MECHANICS

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The results of previous research show that there are often significant difficulties for physics students in both the use of traditional representations and the coordinated application of multiple representations (charts, vectors, verbal representations). The most important representations in the field of solving mechanical problems are the free-body diagrams. Rosengrant, van Heuvelen & Etkina (2009) define the diagrams of the force as "diagrammatic sequences that focus only on the observed body and the forces that other objects operate on that body." Since earlier research has been a challenge for pupils to draw force components first when drawing a diagram, it is therefore recommended drawing and using diagrams through manipulation with vectors. The aim of this study is to examine the effect of displaying the force diagram with the task setting in the experimental group as well as without setting the diagrams in the control group. The results of this study have shown that a mere set-up of finished power diagrams in task settings can even make it difficult to solve physical tasks, students drawing graphics diagrams are more successful in solving tasks from mechanics than students who do not draw these diagrams.

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INVESTIGATION OF GROWTH AND DISSOLUTION MECHANISMS OF SMALL SODIUM CHLORATE CRYSTALS

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Depending on supersaturation and temperature, there is a variety of crystal growth mechanisms which compete and lead to different growth regimes. Under the same solution and external conditions, different crystals of the same material grow at different rates. This phenomenon is termed as the growth rate dispersion (GDR). The investigations regarding the growth and the dissolution behavior of small sodium chlorate crystals at temperatures near saturation temperature of (31.00 ± 0.02) °C was performed. Above this temperature all

the observed crystals dissolved, as was expected. At temperatures between 30.5 °C and 31.0 °C coexistence of growing, non-growing and dissolving crystals was occurred. At temperatures below 30.5 °C dissolution of the crystals did not occur. A significant growth/dissolution rate dispersion existed at all temperatures. Possible reasons for simultaneous growth and dissolution are discussed here.

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ON SOME ENUMERATION PROBLEMS IN PHYSICS

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Overlap between statistical physics and discrete mathematics, primarily regarding combinatorial enumeration problems, has become more and more pronounced in recent times. Many topics that have regularly been studied in discrete mathematics had been motivated by the real phenomena in physics or chemistry. Statistical physics is based on the probability theory so that combinatorics is inherently built into it. In such an approach the central question is the enumeration of all possible states available to the considered system and calculation of the probability of the system being in a particular state. Then, one is usually faced with the sequence of numbers which obey some hidden law, and finding the closed-form expression for the *n*-th element by which any other element of that sequence can be predicted, lies at the heart of the problems. This article presents a review of some of the models in statistical physics where various methods have been used for the enumeratation of the configurations (states), among which are self-avoiding walks as a model of polymer configurations and spanning trees in connection with electrical networks.

EXAMINING THE CHAOTIC PROPERTIES OF THE FOUCAULT'S PENDULUM WITH FIRST AND SECOND ORDER NONLINEARITIES

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The main aim of this work is to try to recognize the main notions defined in the usual analysis of a chaotic system using Foucault's pendulum with introduced nonlinearities. In this work, we modify the usual Foucault's pendulum by replacing the inextensible string, used in the original problem, with the spring whose constant is known and is considered to be one of the "control parameters" in our problem. We set up the problem by quoting the Newton's second law of motion applied to non-inertial reference frames and by expressing the elastic force in terms of the instantaneous length of the spring. That procedure leads us to the system of three coupled differential equations whose structure we are able to examine. One of the most important aspects of this work is to relate the structure of the spectrum with the sets of initial conditions used to generate the particular spectrum. In this part we also include the approximate results for the oscillation frequency Ω and we compare them to the exact values obtained using computational analysis. In the second and third part we introduce the non-linear terms into the coupled system and obtain the plots. By varying the sets of the initial conditions we are able to notice how the qualitative behaviour is significantly altered. Different spectra which yield the different plots are presented in each of the three sections of our work. Asymptotic behaviour upon introducing the drag is also examined in the second part. Finally, we introduce the three most important notions of the chaotic systems, which include the Poincaré mapping, bifurcations and attractors, and we try to recognize them in our work. We conclude our work by mentioning a couple of other examples where this kind of analysis might potentially be applied.

RESEARCH CAPABILITIES FOR RADIATION PROTECTION DOSIMETERS (17RPT01 DOSEtrace)

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EU regulation on ionising radiation requires states to have adequate equipment and procedures for measuring and assessing exposure of persons and radioactive contamination of the environment, assure effectiveness of measures and ensure regular calibration of measuring equipment. Similar requirements come from local stakeholders.

Radiation protection dosimeters are used to assess human exposure and environmental contamination due to ionizing radiation in a variety of settings, including hospitals and industry. To meet regulatory requirements, technical services across Europe need to be established or improved for the calibration of radiation monitoring equipment. By having facilities with trained staff, emerging National Measurement Institutes could deliver the traceable measurements needed and participate in research activity.

The overall objective of 17RPT01 DOSEtrace project is to improve SI traceable measurements of operational radiation protection quantities in the participating National Metrology Insitutes (NMIs) from emerging countries. For legal measurements according EU COUNCIL DIRECTIVE 2013/59/EURATOM traceable measurements are required. This project will ensure that all affected NMIs and Designated Institutes (DIs) have adequate equipment and procedures for the required measuring and assessing human exposure and radioactive contamination of the environment. The main goal of this project is to establish and harmonise the procedures for the calibration of radiation protection dosimeters in various types of radiation protection beams with a special focus on achieving a measurement uncertainty of 5 % (k=2) or less. The improvement will be accomplished through research on operational quantities for external radiation exposure and secondary standards for eye lens dosimetry. In addition to these main goals, participating NMIs will prepare individual strategies for radiation protection metrology development and they will discuss them with the EURAMET community in order to ensure a coordinated and optimised approach.

DEVELOPMENT OF PEROVSKITE PHOTOACTIVE LAYER FOR HIGH EFFICIENT AND STABILIZED PEROVSKITE SOLAR CELLS

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Hybrid metal halide perovskite is a term used for one whole group of organic-inorganic materials with general formula ABX_3, where A is an organic (monovalent) cation, B aninorganic cation (divalent metal) and X an anion. This structure is based on crystalline structure of calcium titanium oxide, $CaTiO_3$, which was discovered in the Ural Mountains, by Gustav Rose, and named after famous Russian mineralogist Lev Perovski. Different elements are used for A, B and X ions, with characteristic that A cation is much larger then B, and X anion. Perovskite sollar cells are complitely new product in the present photovoltaic scene, and they are drawing huge attention. Their greatest advantage is in relatively easy and cheap production, and high efficiency. Despite of high efficiency and interest, the instability of perovskite solar cells is a hold-back to its commercialization. They have a high potential to become alternative to conventional photovoltaic (PV) technology. Study of the stability of perovskite solar cells was performed on two kinds of devices. One kind was reference stack, with anode made of gold. Other, were devices with, everythig same, except anode was made of aluminium and MoO_x as a interlayer. We tried to understand the mechanisms of degradation testing different outside impacts, and using the EIS (Electrochemical Impedance Spectroscopy) characterization technique. This was the first time, in our research group, that EIS technology was used on perovskite solar cells.

STUDY OF THE PRODUCTION OF THE HIGGS BOSON IN ASSOCIATION WITH A SINGLE TOP QUARK

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The production of the Higgs boson in association with a single top quark or "*tH"* is a very important process for testing the Standard Model theory. At leading order (LO) there are three production modes of a single top quark without the Higgs boson: associated production with W (hereafter referred to as "tHW"), t-channel (hereafter referred to as "tHq"), and s-channel. In this study only *tHq* production with Higgs boson decay to bottom quark-antiquark pair and top leptonic decay has been generated and analyzed. The *tH* production is important for probing the sign of the Higgs-top Yukawa coupling, *yt*. Namely, there is an interference between diagrams which depends on the relative sign of *yt*. A tool which is used as a tool for generating events, calculating the cross-sections and Feynmann diagrams is LO Madgraph. As a continuous function of *yt* the cross-section is parameterized. The kinematics of the process appears to be dependent on the *yt* used. In addition, the dominant background from $t\bar{t}$ production with heavy flavor jets has been generated and potential discriminating variables to separate *tH* from this background have been analyzed and discussed.

The ongoing work is to study this process using the events with fully reconstructed objects in the ATLAS detector and the corresponding author's master's thesis is based on this.

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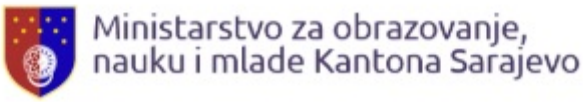


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