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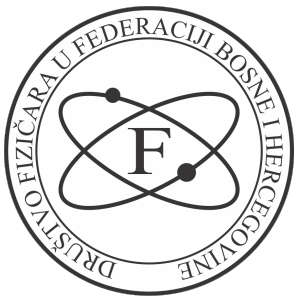
INTERNATIONAL PHYSICS CONFERENCE IN BOSNIA AND HERZEGOVINA

October 19, 2020
Sarajevo
BiH

Book of Abstracts



Title

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Preface

The second scientific meeting *International Physics Conference in Bosnia and Herzegovina* (PHYCONBA) is organized by the Physical Society in Federation of Bosnia and Herzegovina with support of the Academy of Sciences and Arts of Bosnia and Herzegovina. It is held in Sarajevo, on October 19, 2020, on premises of the Academy of Sciences and Arts of Bosnia and Herzegovina.

The First Physics Congress of Bosnia and Herzegovina was organized by the Physical Society of the Republic of Srpska, Banja Luka, Bosnia and Herzegovina and the Physical Society in Bosnia and Herzegovina, Sarajevo, Bosnia and Herzegovina, in the city of Teslić, December 20-22, 2008. This congress had international character with participants from Bosnia and Herzegovina, Serbia, Slovenia, Croatia, Germany, and Norway. Unfortunately, in spite of its success, this congress was not followed by similar events.

It took ten years until a group of enthusiasts, the members of the Physical Society in Federation of Bosnia and Herzegovina, which is a successor of the Physical Society in Bosnia and Herzegovina, has decided to organize, working on a voluntary basis, the *International Physics Conference in Bosnia and Herzegovina. T*he aim of the Physical Society in Federation of Bosnia and Herzegovina is promotion of physics as fundamental and applied science and one of its planned activities is to organize scientific conferences. *The first International Physics Conference in Bosnia and Herzegovina* was held in Sarajevo, October 25-26, 2018. The main motivation of this scientific meeting was to bring together physicists from Bosnia and Herzegovina as well as from neighbouring countries and scientific diaspora to exchange information, present their work and establish cooperation. The scope of this conference was rather wide, covering numerous areas of research in physics and related subjects.

It was planned that the *International Physics Conference in Bosnia and Herzegovina* becomes a biennial event. We planned to have the second conference with a two-day programme in October 2020. However, due to the Covid-19 pandemic situation, we have reduced our conference programme to one day. The conference covers different subareas of physics, divided into the following sections: Medical physics, Condensed matter physics and materials science, Nuclear physics, Elementary particle physics, Astrophysics and cosmology, Atomic, molecular and optical physics, Physics education, and Econophysics. Besides three plenary talks, the programme includes ten oral talks and seven poster presentations. Physicists from different universities, institutes, laboratories, and companies participate in the conference. In addition, the final-

year students also attend the conference and have an opportunity to hear renowned physicists of our region.

The aim of the conference is to provide all participants with the insight into different areas of current scientific research and physics application. Having in mind the Covid-19 pandemic situation, we are more than satisfied with the number of participants (33 participants and 3 invited speakers), which definitely proves that our conference is recognized by scientific community in Bosnia and Herzegovina.

This book contains abstracts of all presentations at the conference, including abstracts of three invited talks, ten oral presentations, and seven poster presentations. After the conference, the authors of these presentations will have possibility to publish their work in Journal of Physics: Conference Series, published by the Institute of Physics (IOP Publishing Ltd, GB).

We are particularly grateful to the Academy of Sciences and Arts of Bosnia and Herzegovina for its support and for providing a wonderful and stimulating place for this event.

We welcome our guests and hope that they will enjoy their stay in Sarajevo and that the conference will stimulate exchange of ideas and establishing new collaborations.

Looking forward to the next conference.

Dejan Milošević

Chairperson of the Scientific Committee

Programme

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COMPUTED TOMOGRAPHY PROTOCOLS OPTIMIZATION USING NON-PREWHITENING MODEL OBSERVER

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- Vinka Dakić,
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- Emina Dzaferovic-Masic,
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  ***AB INITIO* CALCULATIONS OF THE PHOTOELECTRON SPECTRUM: COMPARISON OF DIFFERENT METHODS**

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SEARCHING FOR PHYSICS BEYOND THE STANDARD MODEL USING PRECISION

Svjetlana Fajfer[1,2]

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The Standard Model (SM) is the gauge theory of elementary particles and their electromagnetic, weak and strong interactions. Numerous experimental results gave very precise tests of its validity. Even though the SM was confirmed, some theoretical and experimental issues seem to indicate that this cannot be the ultimate theory. For example, the SM does not explain origin of neutrino masses, presence of the dark matter in the universe. These issues stimulate searches for physics beyond the SM on theoretical and experimental level. Current experiments indicate that there are some discrepancies between theoretical predictions and experimental results. For example, there are anomalies in the decay of B mesons at level of three standard deviations. The anomalous magnetic moment of muon and electron, predicted very precisely by the SM, slightly differ from the existing experimental results. In construction of the models of the physics beyond the SM, these precisions are of crucial importance, since they offer severe constraints on new physics. I will illustrate its importance in the extension of the SM which contains leptoquarks, hypothetical particles mediating interactions between quarks and leptons.

SELF-ORGANIZED COMPLEX Ge NANOSTRUCTURES IN AMORPHOUS MATRICES

Lovro Basioli[1], Marija Tkalčević[1], Jordi Sancho-Parramon[1], Krešimir Salamon[1], Sigrid Bernstorff[2], Maja Mičetić[1]

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Ge quantum dots and nanostructures are attracting a lot of attention because they show very strong confinement effects and have many applications in modern nanotechnology. In our previous work we have shown how to produce regularly ordered Ge quantum dots in amorphous dielectric matrices by magnetron sputtering deposition [1]. These nanostructures show very interesting structural properties caused by their self-assembling growth. However, they usually have a lot of Ge oxide due to the presence of an oxide matrix, which diminishes their applicability.

Our current work is devoted to production of regularly ordered complex Ge nanostructures which consist of Ge-core coated by thin shell of another material, all embedded in the dielectric matrix. The presence of the shell strongly affects their optical and electrical properties, when compared to the properties of simple Ge quantum dots, and reduces significantly Ge oxidation. Thus, Ge/Si core/shell quantum dots show significantly enhanced absorption in comparison to the absorption of the pure Ge and Si components or their superposition. In addition, the position of the absorption peak is strongly tuneable over a large range by the small variation in the thickness of the Si shell [2,3].

Another very interesting material consists of Ge/metal core/shell quantum dots, metal = Al, Ti, Ta [4]. The presence of the metal shell induces enhancement of the electric field inside the Ge core, and the result is strong improvement of their electrical and optical properties, compared to the pure Ge quantum dots. The position of the absorption peak is intensely tuneable, including the infrared range which is hardly reachable using the pure semiconductors. In addition, the photo generated current is enhanced and dependent on the metal shell thickness. These effects occur because the

intensity of the incident radiation is strongly amplified in the region around the metal-semiconductor interface upon the excitation of plasmon resonances, hence increasing the probability of photon absorption and, thus, of charge carrier generation in the photo-active material. Figure 1 shows schematically these materials, calculated field enhancement and measured photocurrent for the case of pure Ge and Ge/Ta core/shell quantum dots. Due to the mentioned properties, the presented materials are very interesting for applications in photovoltaic devices, sensors and photodetectors.

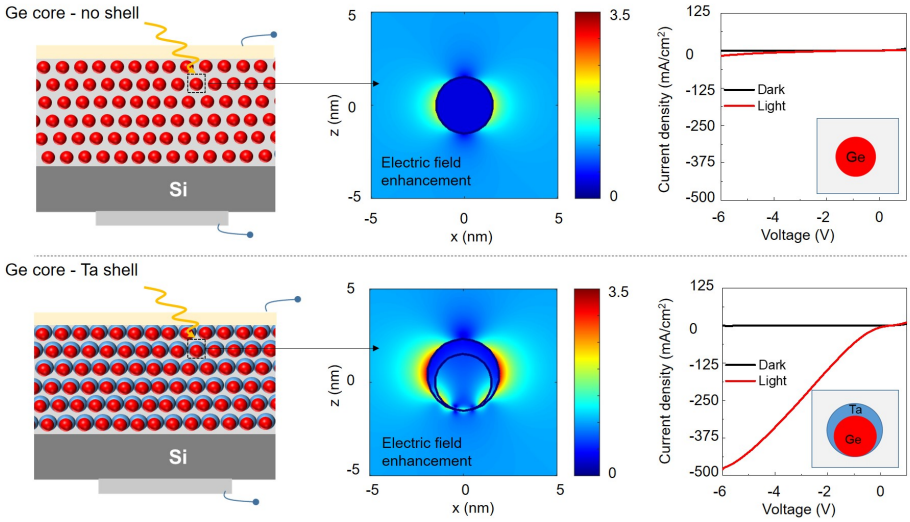

Figure 1. Scheme of the materials consisting of Ge quantum dots without (up) and with metal (Ta) shell (down), together with the calculated field enhancement in the quantum dots and arround them, as well as the measured photocurrent for each material [4].

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ATTOSECOND COHERENT CONTROL OF ELECTRON AND NUCLEAR DYNAMICS IN SMALL ATOMS AND MOLECULES BY MEANS OF STRONG LASER FIELD

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Since the turn of the century, continuous advances of the ultrafast lasers technologies have allowed for the opening of new horizons in the ultrafast sciences. Built upon these technologies, laser-driven light sources have provided novel ways to achieve a real-time manipulation of the correlated electron/nuclear wavepacket dynamics by means of attosecond XUV and femtosecond IR radiation [1-6]. However, twenty years upon the birth of attosecond physics, and after the Nobel Prize Award for femtosecond chemistry, the concept of attosecond chemistry has not yet been fully realized. In this talk, I will introduce the basic principles of the strong laser-field ionization and generation of attosecond XUV/X-Ray radiation. Then, I will show how the attosecond VUV and XUV light sources can be used to coherently manipulate molecular dynamics by means of electron wavepacket interferometry [7-9]. The use of attosecond VUV pulse-trains to coherently excite and control the outcome of a simple chemical reaction in a deuterium molecule, in a non-Born-Oppenheimer regime, presents intriguing new possibilities for bridging the gap between the attosecond physics and attochemistry [10]. Furthermore, I will discuss recent results that extend the use of the attosecond table-top techniques to the soft X-Ray regime in the water window [11], and how the laser-driven and FEL light sources can be combined [12].

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Oral presentations

COMPUTED TOMOGRAPHY PROTOCOLS OPTIMIZATION USING NON-PREWHITENING MODEL OBSERVER

***Edis Đedović*[1,2], *Dario Faj*[3], *Tomislav Bokulić*[4]**

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Non-prewhitening model observer, NPW-MO, allows assessing the performances of a whole imaging system, taking into account the specific aspects of a considered clinical task and also the aspects of the human visual system and an internal noise. This method is suitable to be used for the purpose of the CT scanning/imaging protocols optimization. The aim of this work is to determine the exposure parameters for a CT scanner so that they produce the satisfied performances of a human observer.

For different CT scanning protocols the assessment of image quality parameters, based on the standard and Fourier metric, have been performed as well as volume CT dose index ($CTDI_{vol}$) measurements. The Philips phantom is used for image quality assessment, Adult Head & Body Phantom and CT pencil beam ionization chamber are used for $CTDI_{vol}$ measurements. IQWorks and imQuest software packages are used for the images analysis.

The detectability index, d', of NPW-MO method is compared with the conventional image quality metrics. This index is also used to calculate the area under a ROC (”reciver operating characteristic”) curve (AUC) which is a basic figure of merit (FOM) for human observer performance assessment.

NPW-MO allowes to chose the suitable scanning protocols on the basis of a clinical task under the consideration, AUC value and $CTDI_{vol}$ values. The advantage of different NPW-MO methods is that they are able to take into account the human visual response function's dependence on spatial frequency, noise texture and an object's diameter which makes it closer to a the real conditions and clinical tasks under the consideration.

THE RELATIONSHIPS BETWEEN THE TOTAL VOLUMES OF OARs AND THE DOSES THEY RECEIVED IN THE CASE OF EBRT TREATMENT OF PROSTATE CANCER

Hasan Osmić[1], Edis Đedović[2,3], Muamera Emić[2]

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The treatment of cancer disease using external beam radiation therapy (EBRT) is one of the leading treatment modality, rather used alone or in combination with surgical treatment and hormone therapy. The EBRT treatment is accomplished by using a megavoltage photon beam or hadron beam therapy. As the other treatments the EBRT treatment also causes the side effects (toxicity) mainly related to the doses received by normal healthy tissues/organs. In the case of EBRT treatment of the prostate cancer there exists two categories of toxicity effects:

- Genitourinary (GU) – related to the dose contribution on bladder
- Gastro-intestinal (GI) – related to the dose contribution on rectum.

The main objective of this work is to investigate the relationships between the total volumes of organs at risk (OARs) and the doses they received in the case of EBRT treatment of prostate cancer. Knowing these relationships it could be possible to reduce the dose contributions to the OARs by increasing or decreasing their volumes by the intake of an amount of a fluid or applying a special diet during the EBRT treatment and consequently decreasing in such a way the possibility of appearing of toxicity effects.

Through this work the results obtained by analysis of data collected from dose volume histograms (DVHs) of 30 patients have been presented. The correlations between the doses received by bladder's volumes and the correlations between the coverage of the target volume by prescribed doses and the bladder volumes have been investigated.

On the basis of the analysis a correlation between bladder's volumes and the received doses is obtained. The ratios of bladder's volumes to the target's volumes show even stronger correlation with the doses received by bladder. The obtained results are the main argument for the need of introducing a special diet for the patients undergoing EBRT treatment of prostate cancer.

EXTRACTING PHOTOELECTRON SPECTRA FROM TIME-DEPENDENT WAVE-PACKET CALCULATIONS

***Benjamin Fetić*[1], *Wilhelm Becker*[2,3], *Dejan B. Milošević*[1,2,4]**

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Over the last three decades numerical solution of the time-dependent Schrödinger equation (TDSE) within the single-active-electron approximation has emerged as one of the main theoretical tools for studying atomic strong-field ionization. In order to analyse the photoelectron spectrum, one needs to extract the physical observables from the time-dependent wave function at the end of the laser pulse. The exact photoelectron spectrum (PES) can be obtained by projecting the wave function onto continuum states of the same binding potential. In order to obtain correct PES the corresponding continuum states have to obey incoming boundary condition [1]. This means that the continuum states at large distances from atomic or molecular targets have to be localized in the momentum space so that in an asymptotic region the continuum states can be approximated by the plane waves [2]. In this work we investigate under which conditions this approximation is valid.

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LASER-INDUCED PROCESSES IN ORTHOGONALLY POLARIZED TWO-COLOR LASER FIELD

***Dino Habibović*[1], Azra Gazibegović-Busuladžić[1], Mustafa Busuladžić[2], Aner Čerkić[1], Dejan B. Milošević[1,3]**

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When a molecular system is exposed to a strong laser field many nonlinear processes can happen [1,2]. The high-order above-threshold ionization (HATI) and the high-order harmonic generation (HHG) are particularly important for understanding the molecular structure, and the molecular dynamics on a subfemtosecond time scale. To observe these processes strong laser fields are requeste.

The easiest way to understand these processes is by using the so-called three-step model [3]. The first step describes the ionization, while the second step describes the propagation of the liberated electron in the laser field. If the laser field is strong enough the influence of the parent ion can be neglected in this step. Because of the oscillatory character of the laser field, the electron can be driven back to the parent ion. The situation where the electron rescatters elastically of the parent ion corresponds to the HATI process, while the situation where the electron recombines with the parent ion corresponds to the HHG process.

In [4] we have analysed homonuclear diatomic molecules exposed to an orthogonally polarized two color laser field (OTC). This field consists of two linearly polarized components with orthogonal polarizations. The frequencies of these components are $r\omega$ and $s\omega$, where r and s are integers.

In this paper, we analyse the HHG and HATI processes for various ratios of the intensities of the OTC laser-field components. We are particularly interested in frequency ratios 1:2 and 1:3. Also, we use the relative phase between the laser-field components as a parameter. We discuss the symmetry properties of the

HATI spectra. In addition, we show that the ellipticity of the emitted harmonics can be controlled using the relative phase and the ratio of the intensities of the laser-field-components. Finally, we analyse the interference minima in the HHG spectra.

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LAURENT-PIETARINEN POLE EXTRACTION FORMALISM

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The Particle Data Group (PDG) [1] has begun to include and emphasize the importance of pole-related quantities, de-emphasizing and eliminating many Breit-Wigner parameters, as the link between experiment and QCD.In spite of the fact that this single-channel L+P method is now generally applicable, extensively used in a wide array of problems [2,3,4], and already recognized by PDG as a confident tool for extracting pole positions of most baryon resonances [5], all applications in which one pole couples to several correlated quantities are still beyond its reach. A method to extract resonance pole information from single-channel partial-wave amplitudes based on a Laurent (Mittag-Leffler) expansion and conformal mapping techniques has recently been developed. This method has been generalized and applied to the case of a multi-channel fit, where several sets of amplitudes are analysed simultaneously. The final result provides a powerful, modelindependent tool for analyzing partial-wave amplitudes of coupled or connected channels based entirely on the concepts of analyticity and unitarity.

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CHARACTERIZATION OF $Cu_{47}Zr_{43}Al_6Y_4$ METALLIC GLASS

Maja Đekić, Matej Lozančić, Kerim Hrvat, Amra Salčinović Fetić

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This paper presents the research results of a melt-spun $Cu_{47}Zr_{43}Al_6Y_4$ metallic glass. Examinations of its surface, chemical composition and electric resistance had previously been performed and published [1]. Characterization was continued by an XRD analysis, DSC and microhardness measurements. XRD analysis has unambiguously confirmed that the sample is completely amorphous. DSC measurements were performed with different heating rates which made it possible not only to calculate activation energies, but also to analyse the crystallization process itself. Microhardness measurements have been performed on both sides of the sample.

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EFFECTS OF THE BOUNDARIES ON THE SCALING FORM OF HAMILTONIAN WALKS ON FRACTAL LATTICES

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Hamiltonian walks (HWs) on a lattice are random walks that visit each lattice site exactly once. They are commonly used to model compact polymer conformations. The scaling form for the number of HWs, on translationary invariant lattices, consists of the leading exponential factor with the power law and stretched exponential factor as corrections. The stretched exponential factor, with the exponent σ that depends on the lattice dimension only, is caused and determined by the boundary sites of the lattice and corresponds to the surface tension effects of the compact globule. On fractal lattices, on the contrary, the existence of the stretched exponential factor in the scaling form of HWs is not so straightforward, and such a correspondence cannot be drawn equivalently. In this paper, we reinvestigate the appearance of the stretched exponential factor in the scaling form of HWs on fractal lattices and consider the effects of some kind of 'boundary' condition on it. In particular, in the case of 4-simplex lattice, we explicitly show that the introduction of only two extra links between the corner vertices of the largest generator, leads to complete disappearance of the stretched exponential factor. We also discuss impact of the boundaries on the scaling form of HWs on other fractal lattices.

STRUCTURAL PROPERTIES OF SILICON IMPLANTED WITH Ag IONS THROUGH SELF-ORGANIZED POLYSTYRENE MASK

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Nanosphere lithography, an inexpensive and high throughput technique capable of producing nanostructure arrays, relies on the formation of a monolayer of self-assembled nanospheres. This study reports on nanostructuring of silicon samples by means of Ag ions implantation through self-organized polystyrene (PS) masks. Homogeneity of PS monolayer is influenced by many factors, such as the method of obtaining, choice of solvents, concentration of solution and the substrate preparation itself. The PS nanospheres with a diameter of ~150 nm were self-assembled in a hexagonal array on top of Si(100) wafers, and then used as a mask for subsequent 60 keV silver ion implantation. Different fluences were applied up to 2×10^{16} ions/cm^2 in order to create a distribution of different sizes and densities of buried metal nanoparticles. The surface morphology and the subsurface structures were studied by scanning electron microscopy and cross-sectional transmission electron microscopy, as a function of the mask deformation upon irradiation and the implantation parameters itself. We demonstrate that Ag is implanted into Si only through the mask openings, thus forming a regular array of amorphized regions over the wide area of silicon substrate. These fragments are of similar dimensions of the spheres with widths of about 190 nm and distributed over 60 nm in depth due to the given ion range. The formation of Ag nanoparticles is observed at subsurface of amorphized regions, even when only low ion fluences were applied.

CONSIDERATION OF DOSES TO SOME OARs DEPENDING ON DIFFERENTLY CHOSEN PTV MARGINS OF LYMPH NODES IN EBRT TREATMENT OF THE STOMACH CANCER

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Using the conformal external beam radiotherapy (EBRT) to treat a cancer it is possible to achieve a high degree of a tumor volume coverage by a prescribed radiation dose and in the same time maximally sparing the organs at risk(OARs). To cover appropriately the tumor volume with the prescribed dose is the ultimately task in the radiotherapy treatment making in such a way the possibility of the recurrence of the disease as low as possible. But this benefit comes at a cost of the higher dose on the OARs and surrounding tissues. In this work the dose contributions on the OARs (spinal cord, small bowel, colon and heart) and also the constrain exceeds for those organs are analysed for different tumor volume sizes in the case of the radiotherapy treatment of the stomach cancer.

For the analysis 40 patients (30 male and 10 female) have been selected and for each patient three radiotherapy treatment plans have been prepared for three tumor volume sizes. Different tumor volume sizes are obtained delineating the different margin sizes around the lymph node clinical target volume (CTV) getting in such a way three new, planning target volumes (PTV) for each of margin sizes (5 mm, 7 mm and 10 mm). The dosimetry data for the each organ of interest have been obtained on the basis of dose volume histograms (DVHs) and then statistically analysed (descriptive and inferential statistics).

It could be concluded, on the basis of the statistical analysis (ANOVA and Friedman's nonparametric test), that there is a significant difference in dose contributions to the OARs among the different groups (margins) but still the dose constrains were not exceeded.

THE INFLUENCE OF VARIOUS VASCULAR ACCESS PORTS ON MV PHOTON BEAM UNIFORMITY EXAMINED ON THE PMMA PHANTOM

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Implantation of the vascular access port into vascular system is indicated in cases when long-term treatment with chemotherapy agents and other aggressive medications is required. Since vascular access ports are widely used among radiation oncology patients, it is important to investigate how it influences radiation therapy dose distribution, as a high-density foreign object implanted into the human body.

This influence depends on numerous factors but in the first place on the composition material of a foreign object, its geometry and position relative to the target volume as well as on the geometry of the radiation field. In this work, an influence of the various vascular ports presence in a megavoltage (MV) x-ray beam is evaluated in terms of the radiation field uniformity parameters.

The vascular ports of various sizes are placed on the top of the polymethyl-methacrylate (PMMA) phantom which is then scanned on computed tomography (CT) simulator to generate the digitized image 3-dimensional image of the object to be irradiated using 6 MV x-ray beam. The treatment plan is prepared in matRad [1] treatment planning toolkit. The radiation field uniformity parameters (symmetry and flatness), the percentage depth doses and maximum doses are calculated. The radiation field profiles are also determined.

On the basis of obtained results, the possible effects of vascular ports on the dose distribution in the target volume, positioned at various depths behind the

port, as well as the possible dosimetric effects on the other structures, placed at the different positions, are discussed.

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Poster presentations

DETERMINING PARAMETERS OF GLOBULAR CLUSTER M92 USING LUMINOSITY FUNCTION

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This project analyses the determining parameters of globular cluster M92 using the luminosity function. The basic physical parameters of globular clusters are age, distance and metallicity, and in this project age and distance have been determined, and for metallicity we used a fixed value. The parameters were determined by comparing theoretical luminosity functions to the luminosity function from observation data. Comparing was done using three statistical methods, χ^2 minimization, Kolmogorov – Smirnov test and the method from the work by Jimenez and Padoan (1996). χ^2 represents a sum of proportions of difference between the observed and theoretical data squared and observation error squared. By applying the first method, we find an age of $t = 13.6^{+1.4}_{-5.4}$ gyrs and distance of r = 7.6±1.5 kpc. These values are in accordance with the ones from literature. Using the method from the work by Jimenez and Padoan, we find and age of t = 13.3±0.1 gyrs and distance of r = 7.3±0.1 kpc, and this values are in accordance with the data from literature. The Kolmogorov – Smirnov test quantifies the maximum of distance between the theoretical and empirical function and when we find these values, a minimum of them correspond to our empirical function. This method is not suitable for determining age and distance simultaneously, because luminosity functions are compared only at one point, not at the entire interval.

MISSING INFORMATION IN UNIVERSE AS DARK MATTER CANDIDATE BASED ON THE MASS-ENERGY-INFORMATION EQUIVALENCE PRINCIPLE

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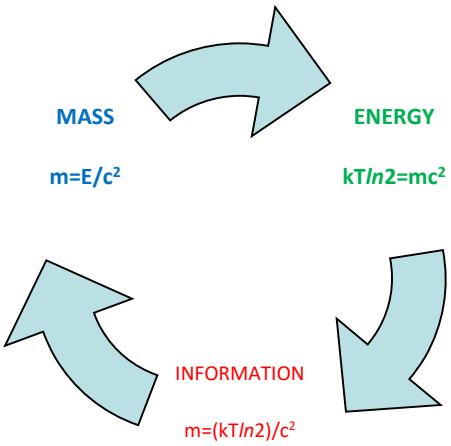
There are several theoretical models proposing dark matter candidates as well as different experimental searches for dark matter, collider and non-collider ones. one of the most intriguing dark matter candidates is missing information in cosmos. This is based on mass-energy-information equivalence principle presented by M.Vopson[1]. This review presents historical development of this principle from its roots in 1960s when Landauer's principle was firstly presented to the latest data on estimated value of mass of one bit of information as well as data on missing energy as potential dark matter. Another theoretical discussion presented here is re-formulation of the second law of thermodynamics as a possible step to great unification. In addition to this theoretical postulation with mathematical presentation focusing on statistics, we present some of the proposed experiments in this field. Two major proposals are in the direction of using ultra-accurate balance with measurement uncertainty low enough to be comparable with proposed theoretical limits, and originally developed sensitive interferometer similar to the one in LIGO experiment. [2]



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INVESTIGATION OF PARTIALLY CRYSTALLINE METALLIC GLASS $Fe_{38}Ni_{36}B_{18}Si_8$

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Partially crystalline metallic glass $Fe_{38}Ni_{36}B_{18}Si_8$ was produced by rapidly solidifying in the form of ribbon. Chemical composition and homogeneity of the sample were determined using Scanning Electron Microscopy, equipped with energy-dispersive X-ray spectroscopy. The diffractogram exhibits a characteristic diffuse halo pattern superimposed with crystalline peaks, indicating existence of crystalline phases. The crystallization kinetics in non-isothermal conditions was studied by Differential Scanning Calorimetry. The electrical resistivity and the dimensions of samples $Fe_{38}Ni_{36}B_{18}Si_8$ were measured at room temperature. The temperature dependence of electrical resistivity was studied from 80 to 273 K. The measurements have shown a positive coefficient of electrical resistivity.

HOW FAR HAVE WE SEARCHED FOR DARK MATTER SO FAR

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Dark matter as one of the cosmos' ingredients or rather constituents, has been searched for in various experiments. This review presents some of the searches for dark matter while focusing on the LHC mainly. In order to present various searches, it describes theoretical models followed by experimental verification. Since there are three types of searches among which most significant are direct and indirect ones, we will give an overview and short comparison between the two, with an emphasis on advantages and disadvantages of collider and non-collider searches. This review brings argumentative approach for collider's point of view since searches for dark matter in colliders are veritably ambitious when it comes to direct and indirect Dark Matter detection methods.

LHC starts its Run 3 in 2021 and here we present results from ATLAS experiment from Run 2[3] and bring some theoretical expectations from LHC in Run 3.

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BROADER PHYSICS SPECTRA OF THEORETICAL BACKGROUND AND PRACTICAL EXPERIMENT ON ATOMIC SPECTRA FOR HIGH SCHOOL AND UNIVERSITY STUDENTS

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Atomic spectra is one of the key subjects in teaching as well as studying Physics. It represents the combination of topics such as wave physics, atomic physics, particle physics etc. In view of its complexity, it takes a well prepared student and very creative and resourceful teacher to be adequately understood and comprehended. In this article, we present theoretical background with key points in physics that help teacher better organize its preparation for students, but also different aspects of experimental set for this specific experiment such as Nikola Tesla's transformer or some other high-voltage transformers. Another point of view for this experiment is a variety of subexperiment possibilities to choose from in execution of this practical exercise. This article also brings some difficulties that both teachers and students experience while preparing or doing this experiment such as lack in deeper quantum physics knowledge since conventional approach in teaching this specific topic in high schools and universities focuses on introductory course in history of this topic oriented towards early years of 20th century.

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MECHANICAL ANALYSIS OF THE S&P 500 INDEX TIME SERIES

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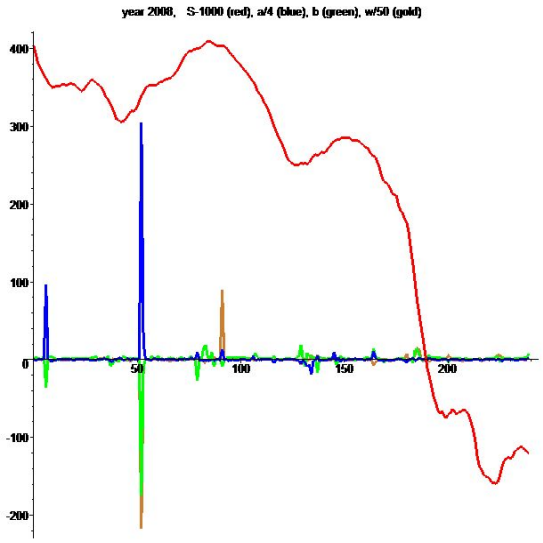
Daily values of the stock market index S&P 500 are considered as coordinate of an oscillating particle in discrete time. These driven nonlinear oscillations are occasionally damped, amplified and unstable. Large changes of the coordinate are usually preceded by exceptional values of the acting force parameters. Therefore, mechanical analysis enables an estimation of the risk of stock market crash. In order to a better understanding of the problem of predictability, we have considered some artificial time series with combination of chaos and stochasticity, generated by the appropriate differential equation of motion. We indeed can roughly predict the second half of the time series, with low enough level of stochasticity, if we know the first half of the series.



Decline of the stock market index (red line), during 2008, is preceded by high instability (blue), large damping (green) and deep minimum of force (gold), constant in a short time interval. Classical mechanics enables rough, but suitable for application, prediction of different non-mechanical complex systems.

AB INITIO CALCULATIONS OF THE PHOTOELECTRON SPECTRUM: COMPARISON OF DIFFERENT METHODS

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In strong-field physics numerical solution of the time-dependent Schrödinger equation (TDSE) within the single-active-electron approximation is often used as a benchmark case for validating experimental results and other theoretical models such as strong-field approximation, Coulomb-corrected strong-field approximation, semiclassical two-step model, classical-trajectory based Monte-Carlo method, quantum-trajectory based Monte-Carlo model and many more.
In order to analyze the photoelectron spectrum (PES), one needs to extract the physical observables from the time-dependent wavefunction at the end of the atom-laser interaction. The exact PES can be obtained by projecting the wavefunction onto continuum states of the same binding potential [1]. We call this the projecting-onto-continuum-states (PCS) method. Extracting the PES has also been attempted by alternative methods such as the window-operator (WO) [2] or the t-SURFF method [3]. In this work we explore these different techniques for extracting the PES from time-dependent wave-packet calculations and analyze their deficiencies in comparison with the PCS method.

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