BOOK OF ABSTRACTS

PLOVDIV | BULGARIA

22-24 April 2026

International Scientific Conference "Physics-Engineering-Technology"

Faculty of Physics
and Technology
University of Plovdiv
"Paisii Hilendarski"

Book of abstracts

ISCPET'26

International Scientific Conference „Physics-Engineering-Technologies“

22-24 April 2026

Plovdiv, Bulgaria

University of Plovdiv „Paisii Hilendarski“

The International Scientific Conference „Physics-Engineering-Technologies“ (ISCPET'26) is part of the traditional events organized annually by the Faculty of Physics and Technology at Plovdiv University „Paisii Hilendarski“ since 2011, in cooperation with the „Evrika“ Foundation. It began 15 years ago as a Jubilee Student Scientific Session in Physics to mark the 50th anniversary of Plovdiv University. Since then, the conference has continuously evolved and gained popularity within scientific circles. Subsequently, it grew into the National Scientific Conference „Physics-Engineering-Technologies“ with its last two editions featuring international participation. Thus, the idea for the conference to become fully international emerged naturally. The first edition of The International Scientific Conference „Physics-Engineering-Technologies“ is dedicated to the 65th anniversary of Plovdiv University „Paisii Hilendarski“.

ISCPET'26 covers a wide range of topics as part of the Innovation Strategy for Smart Specialization of the Republic of Bulgaria. It provides a forum for discussing current themes and innovative ideas in the fields of physics, engineering, bioengineering, and educational technologies. The conference invites both established specialists and leading experts in these fields from Bulgaria and abroad, as well as young scientists and PhD students, to present their latest scientific achievements. To encourage their participation, a competition for the „Best Young Scientist Poster Awards“ will be held during the international conference.

The event offers participants the opportunity to expand their scientific networks and establish new contacts. This is achieved through close cooperation between the academic community, industry, and the public sector, connecting them in areas of high technological applicability. Business representatives with strong interests in science, education, and innovation are also invited to the conference. As a result, it is expected to encourage the creation and practical integration of future technologies by promoting achievements in natural and technical sciences. This would enable the implementation of joint research projects, training programs, and technology transfer. Thus, the conference serves as a real platform for applying national and European priorities in the field of research and innovation.

The program features dedicated sessions exploring the following research areas:

A) Physics, Mathematics and Material Science

B) Engineering, Communications and Electronics

C) Educational Technologies

D) Bioengineering and Biosensors

A selection of the oral and poster presentations from the conference will be proposed for publication in the Journal of Physics: Conference Series (JPCS) by IOP Publishing.

The conference takes place from 22 to 24 April 2026 at DoubleTree by Hilton Plovdiv Center, Plovdiv, Bulgaria. Plovdiv is the second-largest city in Bulgaria after the capital, Sofia. It was the European Capital of Culture in 2019. The city is a key economic, transport, cultural, and educational hub. It is considered one of the oldest cities in the world and the oldest continuously inhabited city in Europe. Plovdiv has been inhabited since the 6th millennium BCE, when the first Neolithic settlements were established. Over the years the ciry has been known by many names: Evmolpia, Philippopolis, Trimontium, Pulpudeva, Puldin, Filibe, Plovdiv… The city has historically developed on seven syenite hills. Because of that, Plovdiv is often referred as “The City of the Seven Hills”.

Organizers and partners

The **Faculty of Physics and Technology** at PU "Paisii Hilendarski" has rich history and traditions in education of specialists in the fields of physics, communications, polymer materials, laser technologies, nuclear physics, mechanical engineering, electrical engineering, electronics and automation, as well as of physics and natural science teachers. The Faculty of Physics and Technology is located in two bases - Plovdiv and Smolyan, where students are educated in five professional areas**.** https://pu-ftf.eu/

The University of Plovdiv "Paisii Hilendarski" is one of the leading higher-education institutions in the Republic of Bulgaria. It is the largest university in southern Bulgaria and as well the second biggest in Bulgaria. The University is founded in 1961 as a Higher Institute of Pedagogy for Natural Sciences and Mathematics; however, it awarded university status in 1972. Today, University of Plovdiv "Paisii Hilendarski" provides degree-level education to students in more than 260 disciplines encompassing the humanities, social sciences and the aforesaid subjects. https://uni-plovdiv.bg/

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The Bulgarian National Science Fund (BNSF) aims to financially support projects and activities for the promotion and development of scientific research in the Republic of Bulgaria. The activities of the BNSF are carried out through the financing of national scientific programs and scientific research projects in higher education institutions and scientific organizations in the Republic of Bulgaria, following internationally recognized standards and taking into account the existing national scientific potential and public needs and priorities. **BNSF supports the International Scientific Conference "Physics-Engineering-Technology" (ISCPET'26) by grand КП-06-МНФ/36 from 12.12.2025. BNSF may not be held liable for the content of the reports and published materials of the scientific forum.** https://bnsf.bg

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"Ecotechnologies 21" is a civil society partnership between Plovdiv University "Paisii Hilendarski" and Aquachim JSC. The union was established based on long-standing cooperation between the two organizations on various scientific and infrastructure projects. The company was founded with the aim of creating and developing the Ecotechnologies 21 Technology Center as an environment for innovative scientific research, the results of which are geared toward industrial implementation in Bulgarian and foreign companies. The Technology Center operates in two main areas: molecular biotechnology and environmental ICT. https://uni-plovdiv.ecotech21.bg

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One of the primary objectives of the conference is to support the professional development of young scientists and PhD students by providing a platform for presenting their research, fostering interdisciplinary, and expanding international partnerships. To encourage the participation of young researchers, students, and doctoral candidates, a competition for the „Best Young Scientist Poster Awards“ will be held during the international conference. The most relevant topics and the most engaging poster presentations will be awarded by a scientific jury composed of Bulgarian and foreign scientists. The competition is organized with the kind support of the „Evrika“ Foundation and DSK Bank.
The following scientific jury will award the most current topics and the most attractive poster presentations:

SCIENTIFIC JURY

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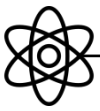

Section A

«Physics, Mathematics and Material Science»

A-I1

QUASI-STATIONARY OPTICAL GAUSSONS WITH ARBITRARY INTENSITY

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Abstract

This presentation is on the dynamics of optical solitons with log-law nonlinearity, also known as optical *Gaussons*, in the presence of perturbation terms. The governing model is the nonlinear Schrodinger's equation that carries logarithmic form of self-phase modulation. A few perturbation terms, with arbitrary intensity, are included to get a better understanding of the *Gausson* transmission dynamics. These include multi-photon absorption, Raman scattering, self-steepening effects, self-frequency shift, nonlinear dissipation, saturable amplifiers, and others. The multiple-scale perturbation analysis, together with the Wentzel-Kramers-Brillouin-Jeffrey's (WKBJ) hypothesis are implemented to retrieve the quasi-stationary optical *Gausson* solution. The WKBJ definition of the phase that is introduced reveals a couple of resonant conditions, which cannot be otherwise recovered.

A-I2

OPTICS OF BROADBAND LASER PULSES, POLARIZATION FORCES AND APPLICATION TO LASER DRIVEN NUCLEAR FUSION

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Abstract

The typical spectrally limited laser pulse in the near infrared region is narrowband up to *30-40 fs*. Its spectral width Δk is much smaller than the carrying wave number k_0 ($\Delta k \ll k_0$). For such kind of pulses, on distance of few diffraction lengths, the diffraction is Fresnel's one and their evolution can be described correctly in the frame of the well-known paraxial evolution equation. The established in 1985 technology of amplification through chirping of laser pulses gave the opportunity of fast progress and construction of femtosecond laser pulses up to *5-6 fs* which are broad-band ones ($\Delta k \sim k_0$). The spectra of femtosecond pulses can be enlarged to broadband by different nonlinear mechanisms and by synthesis of frequency bands also. The linear [1] and nonlinear [2] propagation dynamics of broad-band pulses is quite different form narrow-band ones. Form other hand, the longitudinal polarization force is inversely proportional to the pulse duration and becomes significant in the femtosecond region. This leads to confinement the neutral particles into the pulse envelope [3, 4]. This confinement allowing light atoms as helium to acquire kinetic energies of several *GeV*. Subsequently, we apply an external electric field to separate the nuclei at the cathode, concentrating billions helium nuclei in a small area. The kinetic energy of the *1.88 GeV* impacts, exceeding the α particle binding energy (*28 MeV*) by 2 orders of magnitude, induces powerful γ radiation and neutron emission from decay processes. The experiment in [4] marks demonstration of a laser induced decay method for helium nuclei for the first time. Moreover, helium isotopes or deuterium nuclei trapped on the cathode show significantly reduced Coulomb repulsion, enabling subsequent nuclear fusion reactions and substantial nuclear energy release.

References:

[1] E. Iordanova, P. Miteva, D. Dakova, H. Chamati, G. Yankov, D. A. Georgieva, and L. Kovachev, ACS Omega 2024, **9**, 20648−20657.

[2] E. Iordanova, G. Yankov, S. Karatodorov and L Kovachev , ACS Omega 2023, 8, ACS Publication, 3501-3508.

[3] G. Yankov, E. Iordanova, L.M. Kovachev, Optik, **273**, 170452 (2023).

[4] L. Kovachev, E. Iordanova, G. Yankov, and I. Angelov, ACS Omega 2025/01/28, https: //doi.org/10.1021/acsomega.4c10437.

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A-I3

ELECTRICITY AS THE DRIVING FORCE OF BIOLOGY

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Abstract

Electricity serves as a fundamental driving force in biological systems, precisely regulating cellular behavior and tissue organization. Bioelectric signals govern key cellular processes, including cell immobilization, proliferation, differentiation, and sorption capacity, which collectively determine tissue development, regeneration, and functional stability.

This report emphasizes the electrical functionalization of substrates as an effective strategy to control cell attachment, proliferation, and heavy-ion sorption capacity. Special attention is devoted to the application of near-threshold electron emission spectroscopy for advanced surface characterization and its relevance to bone regeneration.

Keywords: *electrical functionalization, surface, cell*

A-I4

THE CMS MUON SYSTEM FROM RUN-2 AND RUN-3 TO FUTURE HIGH LUMINOSITY LHC PHASE

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Abstract

Since the beginning of the LHC (Large Hadron Collider) physics program, the CMS (Compact Muon Solenoid) experiment has been collecting data from both proton–proton and heavy-ion collisions, providing a unique opportunity to study Standard Model (SM) phenomena and to search for experimental evidence of physics beyond the SM. Currently, CMS records data at a collision energy of *13.6 TeV* and an instantaneous luminosity of about $2.0\times10^{34}\ cm^{-2}\ s^{-1}$. The high quality of the physics results is ensured by the efficient operation of the detectors and the trigger system, as well as by the precision of the data-processing algorithms employed. The CMS muon system is composed of four subsystems based on different gaseous detector technologies, namely DT (Drift Tubes), CSC (Cathode Strip Chambers), GEM (Gas Electron Multipliers), and RPC (Resistive Plate Chambers). In parallel with the ongoing data taking, preparations are underway for the next Long Shutdown (LS) and the subsequent large-scale modernization and upgrade period. This talk will present a brief overview of the CMS muon system, together with a summary of the detector performance during the most recent data-taking period, Run 3 (2022–2026). An overview of the CMS muon system program will also be given in the context of ongoing activities and preparations for the challenging HL-LHC (High Luminosity LHC) phase, which will operate at an unprecedented collision energy of *14 TeV*, with approximately twice the instantaneous luminosity and significantly higher trigger rates.

Keywords: *Hadron collisions, LHC, HL-LHC, CMS, Muon detectors*

Acknowledgement: *This work is supported by the Ministry of Education and Science, Bulgaria, under the contract BG-175467353-2023-18-0002-C01 with National Science Fund of Bulgaria*

A-I5

METHODS TO SEARCH FOR HEAVY STABLE CHARGED PARTICLES IN PHASE II USING THE UPGRADED MUON SYSTEM OF CMS EXPERIMENT AT LHC AT CERN

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Abstract

The search for long-lived particles (LLPs) challenges our current understanding of the Standard Model and opens a unique window into new physics scenarios, including dark matter and supersymmetry. A recent analysis at CMS has pioneered the use of the new Level-1 Scouting dataset – collected without any trigger selection – to search for heavy stable charged particles (HSCPs) crossing the muon chambers across multiple bunch crossings. Using $3.7\ fb^{-1}$ of proton–proton collision data at $\sqrt{s} = 13.6\ TeV$, this approach has extended the sensitivity of HSCP searches to lower β values, demonstrating the power of analyzing correlations between consecutive bunch crossings. Building on these findings, this talk will outline a future program aimed at exploiting the full potential of the upgraded CMS muon system during the High-Luminosity LHC phase to detect long-lived, muon-like charged particles that traverse the detector without decaying. The discussion will focus on combining precise time-of-flight measurements, with resolutions reaching *200 ps* thanks to the newly installed Resistive Plate Chambers (iRPCs), with extended trigger and event reconstruction windows beyond the conventional *25 ns*. Such a temporal expansion could enable the detection of delayed or out-of-time signatures that conventional triggers miss, opening a new experimental avenue at the energy frontier.

Keywords: *CMS, High Energy Physics, Muon Detectors, HSCP*

Acknowledgement: *Research of the speaker is founded by TUBITAK BIDEB 2232-A Program* Project No: 127C524

A-I6

ON THE 4-BODY PROBLEM OF CLASSICAL ELECTRODYNAMICS

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Abstract

In 1921 W. Pauli (cf. G. Herglotz) obtained the relativistic form of the pondermotive force using the Lienard-Wiechert retarded potentials and derived an explicit form of the interacted fields. In 1940 J. L. Synge proposed a direct treatment of the 2-body problem of classical electrodynamics but the following problems arose: to introduce delays in the equations of motion, generated by the finite propagation speed of the interaction (basic Einstein's assumption); to introduce relativistic invariant radiation terms; to obtain non-overdetermined system of equations of motion. In 1963 R. D. Driver introduced delays in the equations of motion of neutral type in 1-dimensional case, depending on the unknown trajectories. We have obtained a relativistically invariant radiation term without changing the Dirac's physical assumptions. So, we introduced the following system for 2-body problem

$$m_k \frac{d\lambda_r^{(k)}}{ds_k} = \frac{e_k}{c^2}\left(F_{rl}^{(kn)}\lambda_l^{(k)} + F_{rl}^{(k)rad}\lambda_l^{(k)}\right), (kn) = (12),(21) (8 \text{equations})$$

and proved existence-uniqueness of periodic solutions (orbits). In this way, we have shown that the Bohr's hypothesis does not violate classical electrodynamics. We extended the Synge model to the N-body problem and derived the equations of motion:

$$m_k \frac{d\lambda_r^{(k)}}{ds_k} = \frac{e_k}{c^2}\left(\sum_{n=1,n\neq k}^{4} F_{rl}^{(kn)}\lambda_l^{(k)} + F_{rl}^{(k)rad}\lambda_l^{(k)}\right) (k = 1,2,3,4;\ r = 1,2,3,4)$$

.

Here we prove the existence-uniqueness of periodic solution for the 4-body problem of classical electrodynamics in the Kepler form using spherical coordinates.

Keywords: *Classical electrodynamics, 4-body problem,3D-Kepler problem, Periodic solutions, Fixed point method.*

A-I7

LONG PERIOD FIBER GRATINGS AS HIGHLY SENSITIVE PLATFORMS FOR BIOCHEMICAL SENSING APPLICATIONS

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Abstract

We present the principle of operation of optical fiber long period gratings (LPG) whose high sensitivity to surrounding refractive index (SRI) changes makes them a desirable and promising platform for biochemical sensing applications. The main LPG fabrication techniques using excimer UV laser in combination with phase masks, fibers splicers for tapered LPGs as well as pulsed CO_2 and IR femtosecond laser are addressed and compared. The characteristics of regular, π-shifted, cascaded and turn-around-point double resonance LPGs in standard, photosensitive and specialty fibers are described and discussed. The effect of thin overlays to achieve higher sensitivities to SRI changes are considered. The different functionalization techniques for chemical and biosensing applications such as self-assemblies, chemically and laser deposited materials needed for selective biochemical sensing are presented. The effects of strain and temperature changes on the LPG performance and their compensation or use as well as fine tuning mechanisms to maximize sensitivity are discussed. The advantages and disadvantages of LPG are compared to other sensing platforms such as surface plasmon resonance (SPR), lossy mode resonances (LMR) and fiber Mach-Zehnder interferometers (MZI). Hybrid schemes LPGs and SPR as well as LPGs are considered as well MZI.

Application in chemical sensing of water and acid vapors, volatile organic compounds (VOC), CO_2, ammonia, pH, ethanol, methanol, metal ions, glucose etc. are considered as examples.

The biosensing applications considered include the measurement of the concentration of bacteria like *Escherichia Coli*, *Helicobacter pylori*, viruses, proteins, DNA, inflammatory and tumor markers and others.

Keywords: *Long period fiber gratings (LPG), double resonance gratings, SRI, chemical and biosensing*

Acknowledgement: *The financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC) under the Discovery DDG-2025-00037 grant is acknowledged.*

A-I8

PULSED LASER DEPOSITION: EFFICIENT METHOD FOR FORMATION OF NOVEL FUNCTIONAL MATERIALS

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Abstract

The recent development of laser systems to a level where all known materials can be processed with a high spatial resolution, opens ways for design of new technologies for fabrication of novel functional materials. The developed laser-based techniques include both top-down and bottom-up ideologies, expressing clear advantages compared to the chemical and electron and ion beam ones. In this presentation, laser methods based on Pulsed Laser Deposition for fabrication of micro- and nanostructures will be discussed. Applications in vacuum and in air at atmospheric pressure will be demonstrated. A modification of the "classical" method will also be presented, where laser induced reverse transfer is applied for a stabile implantation of noble metal nanoparticles into glass substrate. The capabilities of the methods in direction of formation of structures used as sensor elements will be described. It will be demonstrated that with simple laser methods active nano- and microstructures that express high efficiency as resistive gas sensor elements and substrates in Surface Enhanced Raman Spectroscopy can be obtained. The efficiency is confirmed by the ability of fast and reliable detection of materials with a high social impact as nitrates and pesticides, and greenhouse gases, as detection of concentrations below the maximal allowed values is demonstrated.

Keywords*: pulsed laser deposition, laser micro- and nanostructuring, sensor applications*

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A-I9

MECHANICAL PROPERTIES FOR SOME BIO-BASED COMPOSITES

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Abstract

In this study, a series of composite materials were fabricated using the hand lay-up technique, employing a bio-based hybrid matrix composed of both a natural component (natural resin) and a synthetic component (epoxy resin). The natural component of the matrix was used in a predominant proportion, since the main objective of the research is to develop environmentally friendly composite materials with a reduced environmental impact compared to conventional polymer composites. The use of natural resins in combination with synthetic epoxy resins allows the formation of a hybrid polymer matrix, which may combine the sustainability advantages of natural materials with the improved mechanical performance and processing stability provided by synthetic resins. In this way, the study aims to explore the potential of partially replacing petroleum-based polymers with natural substances while maintaining adequate structural properties. The fabricated composites are reinforced with natural fibres, which further contributes to the sustainability of the material system. Natural fibres are increasingly used in modern composite materials due to their low density, biodegradability, renewability, and relatively good mechanical performance. After fabrication, the composite specimens are subjected to a series of mechanical tests in order to evaluate their behavior under different loading conditions. These tests allow the determination of key mechanical parameters such as strength, hardness or deformation capacity. Based on the experimental results, conclusions are drawn regarding the influence of the hybrid matrix composition and natural reinforcement on the mechanical properties of the obtained composites, as well as their potential applicability in sustainable engineering materials.

Keywords: *Bio-based composite, Hybrid resin, Natural fiber, Epoxy Resin*

A-I10

THE FUTURE OF RADIATION PROTECTION: MODULAR AND ADAPTIVE NEUTRON SHIELDING FOR HIGH-ENERGY PARTICLE FACILITIES

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Abstract

The widespread use of medical cyclotrons and accelerator-based systems has intensified the need for efficient radiation protection, particularly in mixed-field environments where both neutrons and secondary photons contribute significantly to occupational exposure. Conventional shielding solutions, typically based on concrete and lead, are often oversized, inflexible, and suboptimal for neutron attenuation, especially in facilities that require compact, adaptable designs.

This study presents a modular, adaptive shielding concept based on 3D-printable, lead-free polymer composites engineered for neutron interactions. Hydrogen-rich polymer matrices combined with neutron-absorbing fillers such as boron nitride (BN) and gadolinium oxide (Gd_2O_3) enable simultaneous neutron moderation and thermal neutron capture. Monte Carlo simulations (MCNP/FLUKA) were employed to model mixed-field radiation transport and optimize layered shielding configurations by adjusting material composition, sequence, and thickness.

Experimental results show that neutron-active composites (e.g., ABS–10%Gd_2O_3 and ABS–5%BN) provide the highest attenuation in mixed neutron fields, while multilayer configurations enhance shielding efficiency through sequential moderation–capture mechanisms. Complementary integration of high Z fillers (Bi_2O_3, W) enables attenuation of secondary gamma radiation, resulting in hybrid systems capable of addressing the full radiation spectrum. Multilayer structures demonstrate up to ~95% photon attenuation in specific energy regions while maintaining effective neutron dose reduction.

Dose assessment using gel dosimetry and film-based techniques confirms improved measurement accuracy (20–30%) with minimal beam perturbation (<5%).

These results highlight a transition toward compact, reconfigurable, and computationally optimized mixed beam shielding solutions (e.g., medical cyclotron target assembly shielding).

Keywords: *mixed neutron and photon beam; 3D printed shielding; gel dosimetry, MC modelling*

Acknowledgement: *This research was funded by the Research Council of Lithuania (LMT), project No. S-MIP-CERN-24-1*

A-O1

A NEW APPROACH TO THE MODELING AND ANALYSIS OF MULTILAYER MULTIMODE ANISOTROPIC WAVEGUIDES

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Abstract

The main goal of this talk is the precise determination of the propagation eigenvalues characterizing the multilayer multimode anisotropic waveguides with arbitrary number of layers and orientation of the optical axes.

The modeling is based on derivation of the dispersion equation in the form of a meromorphic function with zeros corresponding to the eigenvalues sought which, in turn, leads to a non-trivial task due to the complexity of the structure, the presence of anisotropy and the possible losses.

Here, we overcome this issue by applying our recently constructed two-stage numerical algorithm for the simultaneous extraction of all zeros of meromorphic functions (Applied Math. 5(4): 138, 2025).

We show that our method provides robustness and high accuracy in determining the complex propagation constants for all modes, including high-order or highly *leaky* ones, while allowing for a systematic analysis of the dispersion characteristics of complex anisotropic waveguides. Our results have direct application in the design of integrated optical devices and sensors based on anisotropic materials.

Keywords: *Anisotropic waveguides, Leaky modes, Meromorphic functions, Iterative methods, Simultaneous methods*

A-O2

DETERMINATION OF OPTICAL CONSTANTS AND DEPTH-DEPENDENT INHOMOGENEITY IN ZRO_2 THIN FILMS DEPOSITED WITH AND WITHOUT ION-ASSISTED DEPOSITION

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Abstract

ZrO_2 thin films were deposited by electron-beam evaporation under two different deposition regimes – with ion-assisted deposition (IAD) and without ion assistance. The influence of the deposition conditions on the optical constants and microstructure of the films was investigated. The optical constants (refractive index *n* and extinction coefficient *k*) were determined by combined analysis of spectrophotometric measurements and spectroscopic ellipsometry in the spectral range *320–1400 nm*. Special attention was given to the inhomogeneity of the refractive index along the film thickness. It is shown that films deposited without ion assistance exhibit more pronounced inhomogeneity associated with a columnar structure with high porosity, while the use of IAD results in denser films with a more homogeneous refractive index distribution. The structural differences are confirmed by X-ray diffraction measurements, indicating changes in the degree of crystallinity and crystallite size. The obtained optical constants were validated through the design and realization of a multilayer antireflection coating. The good agreement between the calculated and measured spectral characteristics confirms the reliability of the determined optical parameters. The results demonstrate the significant influence of deposition conditions on the optical constants and their depth distribution in ZrO_2 thin films, which is essential for accurate optical coating design.

A-O3

ENVELOPE-DRIVEN SUB-TUNNEL IONIZATION BY LONGITUDINAL POLARIZATION OPTICAL FORCES IN FEMTOSECOND LASER FIELDS

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Abstract

In modern large-scale laser infrastructures based on next-generation technologies, ionization processes in strong laser fields are commonly studied within the framework of the L. Keldysh theory, which classifies ionization regimes according to the Keldysh parameter γ, describing the value as multiphoton or tunnel ionization. In these experiments, the femtosecond laser pulse is typically treated as a strongly oscillating transverse electric field that directly induces ionization of intensity $I = 10^{16} - 10^{22} \left[\frac{W}{cm^2}\right]$ and above.

In the present work, a new physical mechanism for ionization in strong fields is proposed. Ionization effects have been observed, for which the Keldysh parameter formally does not imply ionization (below $= 10^{12} - 10^{13} \left[\frac{W}{cm^2}\right]$). The key mechanism is not direct tunneling of a free atom, but this which are trapped and accelerated by a femtosecond pulse. While the free atoms oscillate with the optical frequency of the laser pulse, the trapped ones oscillate with the carrier to envelope frequency, which is very low at frequency in *GHz* region for gases. That's why for free atoms the Keldysh parameter is above γ >1 and they are not ionized, but for confined in the pulse atoms, the Keldysh parameter is $\gamma \ll 1$ and they are fully ionized. This introduces a complementary strong-field interaction regime that extends the conceptual framework of ionization studies pursued at large laser facilities.

A-O4

INVESTIGATION OF FUEL CLADDING FAILURE PREVENTION IN A SPENT FUEL POOL

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Abstract

This study investigates the conditions under which cladding failure of spent fuel pool (SFP) fuel can be prevented through water injection during severe accident scenarios. The analysis was conducted using the integral severe accident code ASTEC, version 2.2.0.1, with the reference input deck for the Fukushima Spent Fuel Pool (Unit 4), developed by the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences. The model includes an active pump located at the top of the SFP, representing a severe accident management (SAM) water injection measure. A total of twelve simulations, organized into four calculation sets, were carried out to evaluate the influence of key SAM parameters, namely the injection initiation time and the injected water flow rate, on the structural integrity of the SFP fuel cladding. In addition, one simulation without the application of SAM measures was conducted for comparison. The calculation results allow a clear distinction between scenarios leading to cladding failure and those preserving cladding integrity. On this basis, threshold values and admissible ranges of injection timing and flow rate were identified that effectively prevent cladding failure. The results can serve as a basis for optimizing modeling and analyses related to the safety justification of spent fuel pools, including assessments of the effects of implementing of SAM measures.

Keywords: *fuel cladding failure, spent fuel pool, water injection, severe accident, SAM*

Acknowledgement: *This research was funded by the Ministry of Education and Science of the Republic of Bulgaria, through the National Program D01-99: Qualification improvement in the field of nuclear technologies and nuclear engineering.*

A-O5

RADIATION MONITORING SYSTEM FOR THE GAS ELECTRON MULTIPLIER DETECTORS OF THE CMS EXPERIMENT AT THE CERN LARGE HADRON COLLIDER

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Abstract

The muon system of the Compact Muon Solenoid (CMS) experiment at CERN consists of 4 muon detection subsystems, one of which is the Gas Electron Multiplier (GEM). 12 RadMon sensors are mounted on the 1st endcap station of the GEM detector (GE 1/1) for measuring the accumulated neutron fluence and total ionisation dose (TID). Processing and analysis of the RadMon data for the duration of Run-3 of the LHC (2021-2025) and comparison with data from FLUKA simulations for the accumulated neutron fluence and TID is presented. The results are shown as a function of integrated luminosity.

Keywords: *Radmon, LHC, CMS, Neutron fluence, Total ionisation dose*

A-O6

CNOIDAL WAVES AND OPTICAL SOLITONS IN NONLINEAR DISPERSIVE MEDIA

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Abstract

The study of the propagation of ultrashort optical pulses in isotropic nonlinear dispersive media remains a rapidly evolving frontier in modern photonics. Driven by advancements in optical communications, medical instrumentation, and high-intensity ultrafast optics, research has focused on the evolution of phase-modulated femtosecond and attosecond pulses within optical fibers and planar waveguides. We distinguish between broadband and narrowband optical pulses based on the relationship between spectral width ($\Delta\omega$) and carrier frequency (ω_0) of the laser light. Specifically, phase-modulated pulses (*20-30 fs*), bandwidth-limited pulses (*3-7 fs*) in the visible and near-infrared ranges, and attosecond pulses are characterized as broadband, satisfying the condition $\Delta\omega \approx \omega_0$. Conversely, bandwidth-limited pulses from the nanosecond range down to *15-20 fs* are treated as narrowband, where the condition $\Delta\omega << \omega_0$ is met.

The present work presents a review of the evolution of cnoidal waves and different types of optical solitons in isotropic nonlinear dispersive media. It is presented an analytical investigation into the propagation of broadband laser pulses in single-mode optical fibers, considering media with anomalous and normal dispersion. New exact solutions to the nonlinear amplitude equation (NAE) are derived in the form of periodic cnoidal waves. Furthermore, the evolution of such pulses in the atmospheric air is examined for regions of anomalous dispersion, where new analytical solutions are identified as bright solitons. The study also extends to the propagation of ultrashort broadband pulses in nonlinear dispersive media, accounting for third-order dispersion (TOD) and self-steepening (SS) effects. In this context, additional solutions to the NAE are obtained as periodic cnoidal waves. Finally, the dynamics of ultrashort pulses in hollow-core microstructured optical fibers is analyzed under conditions of negligible dispersion, yielding NAE solutions for both linear and nonlinear regimes of propagation.

Keywords: *optical solitons, cnoidal waves, nonlinear dispersive media*

A-O7

SEMILOCAL CONVERGENCE OF SUPER-HALLEY METHOD FOR THE SIMULTANEOUS APPROXIMATION OF POLYNOMIAL ZEROS

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Abstract

Recently, Ivanov (Mathematics. 8: 1599, 2020) has proved two local convergence theorems with a priori and a posteriori error estimates about the very known Super-Halley method for individual approximation of multiple polynomial zeros.

In this talk, we study the Super-Halley method as a method in n-dimensional complex vector space, that is, as a method for the simultaneous finding of all the zeros of a complex polynomial. By this means, we obtain a semilocal convergence theorem, about this method, which is of great practical importance due to its computable initial condition and error estimates. We demonstrate the practical applicability of our result via numerical experiments, where we apply our theorem to several real-world problems.

Keywords: *Semilocal convergence, Polynomial zeros, Super-Haley method, Iterative methods, Simultaneous methods, Real-world applications*

A-O8

DEVELOPMENT OF A MULTICHANNEL GAMMA SPECTROMETER FOR ENVIRONMENTAL RADIATION MONITORING

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Abstract

We have developed and built a custom electronic system that operates as a multichannel gamma spectrometer capable of registering individual gamma-ray events. The design supports the use of various scintillation sensors, while in this study, we employ a VA-S-968 scintillation probe. Signal processing, data acquisition, and preliminary analysis are performed by a Raspberry Pi single-board computer. The processed data are then transmitted to a server infrastructure, enabling public access and remote monitoring. The proposed system provides a low-cost, scalable solution suitable for environmental radiation monitoring applications. The system has been used to monitor radon in soil gas, and results obtained over a period of approximately 17 months are presented. Its performance is evaluated by comparison with AlphaSensor Lucas-cell detectors, which provide a volumetric estimation of radon concentration. This comparison demonstrates the system's capability for long-term, reliable environmental radon monitoring.

Keywords: *gamma spectrometer, raspberry pi*

Acknowledgement: *ФП25-ХФ-001*

A-O9

$\lambda^{(3)}$ DIFFRACTION IN MEDIUM WITH DISPERSION

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Abstract

Broadband and narrowband laser pulses behave differently during propagation. This work explores how diffraction and dispersion influence their evolution, particularly for femtosecond pulses in air where dispersion and diffraction lengths are similar. Experimental data shows reduced diffraction, consistent with our theoretical analysis. Unlike narrowband pulses, which allow for analytical solutions via Fresnel-type approximations, broadband pulses must be modeled numerically. By solving the nonparaxial amplitude equation in the spectral domain, we identified a unique chirped $\lambda^{(3)}$ diffraction effect specific to ultra-short pulses with minimal oscillations under the envelope.

Keywords: *Broad-band optical pulses, Linear regime of propagation, Dispersion, Diffraction*

A-O10

SPECIFIC FEATURES OF THE SURFACE MORPHOLOGY OF Ti6Al4V ALLOY FABRICATED VIA SELECTIVE LASER SINTERING

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Abstract

Selective laser sintering (SLS) is a process that provides production of personalized implants of pure Ti and Ti6Al4V alloy. The aim of present paper is to investigate surface morphology of Ti6Al4V alloy fabricated via SLS and to reveal its specific features. Cubic samples were 3D printed in parallel (Group 1) and inclined at 45^o position (Group 2) to the work table. Surface morphology, topography and chemical composition were studied by SEM. It is found that samples surface is characterized with layered morphology and high quantity of partially melted powder particles. The top surface of the samples of Group 1 possesses the smoothest surface and lowest number of powder particles, followed by inclined surfaces of the samples of Group 2. In both groups, the highest quantity of partially melted particles is observed on vertical surfaces, parallel to the building direction. These findings are confirmed by investigation of topography. Periodic surface profile is observed on all surfaces of samples in the two groups. The profile of the top horizontal surface in Group 1 is less pronounced, but with more even periodicity. The study of chemical composition has shown that Ti, Al and V are homogeneously distributed along the surfaces as well as powder particles. Small droplets of Ti alloy are found on the surfaces of nearly all partially melted powder particles. Open pores (*3-60 μm*) and tiny cracks (*20-35 nm* width) are observed on the vertical and inclined surfaces. The microstructure, porosity and mechanical properties will be studied in the near future.

Keywords: *Selective laser sintering, Ti6Al4V alloy, Surface morphology, Topography, Chemical composition*

Acknowledgement*: This study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0009-C02.*

A-O11

SURFACE MORPHOLOGY OF SLS-FABRICATED Ti6Al4V ALLOY AFTER HEAT TREATMENT AND SAND BLASTING

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Abstract

Pure Ti and its alloys are the mostly used materials for production of implants due to their high corrosion resistance, biocompatibility and mechanical properties. Modern additive technologies, including selective laser sintering (SLS), provide an opportunity for manufacturing of personalized constructions in general and dental medicine. The aim of present paper is to investigate morphology of SLS-produced Ti6Al4V alloy after heat treatment and sandblasting. Cubic samples were 3D printed in parallel (Group 1) and inclined at *45°* position (Group 2) to the work table. After that, they were heat treated and their surfaces were sandblasted. Surface morphology, topography and chemical composition were studied by SEM. It is found that top surface of the samples of Group 1 possesses the smoothest surface. All other surfaces, vertical or inclined to the work table, are characterized with layered morphology. In higher magnification, typical sand blasted morphology is observed on the surfaces of all samples in two groups. Small open pores are found on vertical and inclined surfaces. Topographical investigation has shown comparatively smooth top surface of the samples of Group 1 and periodic surface profile on all other surfaces. Lowest Ra value (*4-8 μm*) is found on the top surface in Group 1, followed by vertical surfaces (*Ra=11-18 μm*) and highest roughness is measured in inclined surfaces (*Ra=19-24 μm*). Study of chemical composition has revealed that Ti and V are homogeneously distributed. There is higher amount of Al and oxygen in certain spots, indicating presence of Al_2O_3 particles embedded on the samples surface.

Keywords: *Selective laser sintering, Ti6Al4V alloy, Heat treatment and sand blasting, Surface morphology, Topography, Chemical composition*

Acknowledgement*: This study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0009-C02.*

A-O12

OPTICAL VORTEX STRUCTURES IN A MEDIUM WITH SPATIALLY DEPENDENT LINEAR REFRACTIVE INDEX

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Abstract

The field of singular optics stands out as one of the most rapidly evolving branches of modern photonics. Optical vortices are typically categorized into two primary types: phase vortices and polarization (or amplitude) vortices.

In the present work, the vector linear 3D+1 non-paraxial amplitude equation is considered, taking into account the spatial dependence of the linear refractive index of the medium with anomalous dispersion. The equation is reduced to a system of two partial differential equations, describing the longitudinal and transverse components of the amplitude function. Exact analytical solutions have been found, describing amplitude-type vortex structures in the transverse components of a modulated optical waves.

These analytical solutions strengthen the theoretical framework of singular optics in anisotropic media, enabling sophisticated control over the spatial structure of light. Beyond conventional phase singularities, polarization vortices have the potential to redefine fields such as information encoding, polarization-sensitive sensing, and the development of specialized laser sources.

Keywords: *optical vortices, linear 3D+1 non-paraxial amplitude equation, modulated optical waves, amplitude singularity*

A-P1

STUDY OF CERAMIC COMPOSITE MATERIALS IN WASTEWATER TREATMENT

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Abstract

Nanotechnology provides an effective solution for the rapid, efficient and cost-effective removal of toxic pollutants from water. Among the novelties in the field are innovative nanomaterials with improved selectivity in the removal of heavy metals and other common pollutants. The article examines the potential areas of application of nanotechnology in water purification and the possibilities for obtaining ceramic composite materials that can be applied as adsorbents in wastewater treatment from various pollutants. The authors used a combinatorial approach and validated a two-stage technology for obtaining composite ceramic materials of the graphene/ceramic matrix type. Initially, fine-grained and porous corundum ceramics were synthesized. At the next stage of the experiment, graphene oxide was obtained in nano colloidal form, which was then impregnated in the synthesized solid, porous corundum matrices. Methods such as infrared spectroscopy, X-ray structural analysis, scanning electron microscopy, BET analysis and light microscopy were applied to characterize the obtained materials. The ceramic composite was studied in two directions: for dye decolorization and for heavy metal removal.

Keywords: *Nanotechnology, Waste water, Treatment, Nanocomposite materials, Graphene/ceramic matrix materials*

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A-P2

VERIFICATION OF IAEA REFERENCE MATERIALS WITH A POCKET-SIZED GAMMA SPECTROSCOPY DEVICE

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Abstract

Standard gamma spectroscopy like the High-Purity Germanium (HPGe) is well established but the use of pocket-sized gamma spectrometer has not been verified for reference material measurements. The study is amid at determining efficiency calibration with the International Atomic Energy Agency (IAEA)-478 and IAEA-493 certified reference material (CRM) using Radiacode 110 gamma spectrometer and multichannel analyser (MCA) BecqMoni Nuclear Edition 2025 software. The study verified the percentage deviation and Zeta score for the certified and measured values of IAEA-465 CRM. A red tip thoriated tungsten electrode (2% thorium) was used for energy calibrations, an IAEA-478 and IAEA-493 CRM was used for efficiency calibrations, a Lead-copper material of $\sim 30\ mm$ was used to shield the detector from background radiation. A 200 ml Marinelli container was used to house the detector, and a multi-channel analyser (BecqMoni software) was used for spectrum display and analysis. The IAEA-465 deviation (relative bias) for K-40, Cs-137, Th-232 (Ac-228), Ra-226 and U-238 ranged from 0.55-6.36 % and the Zeta (Z)-score ranged 0.18-1.79. The threshold for an acceptable absolute value for zeta-score test is 2.58 and a deviation within $\pm 7.5\%$ ($k = 1$) is acceptable. The capability of the pocket-sized gamma spectrometer has been validated, and it shows that it could be used in low resource areas where the availability of standard gamma spectrometer is scarce.

Keywords: *Gamma Spectroscopy, Zeta Score, Marinelli Container, Thoriated Tungsten Electrode, Multichannel Analyser (MCA), Cesium Iodide (CsI)*

A-P3

COMPARATIVE SPECTRAL ANALYSIS OF UNCONVENTIONAL VEGETABLE OILS WITH APPLICATIONS IN COSMETICS

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Abstract

The growing interest in unconventional vegetable oils derived from coffee (*Coffea*), raspberry (*Rubus idaeus*), neem (*Azadirachta indica*), and moringa (*Moringa oleifera*) is associated with their distinctive biological composition and promising cosmetic potential. A multiparametric analytical protocol was applied, including gas chromatography–mass spectrometry (GC–MS) for the determination of fatty acid composition. Optical characterization was performed using Fourier transform infrared spectroscopy (FTIR) in the spectral range of *4000-400 cm⁻¹*, UV–Vis spectrophotometry, and three-dimensional fluorescence spectroscopy. The analysis revealed a clear differentiation between oils rich in polyunsaturated fatty acids (PUFAs) and those dominated by monounsaturated or saturated fatty acid chains.

- Coffee bean oil and raspberry seed oil were characterized by high levels of linoleic (C18:2) and α-linolenic (C18:3) acids, reaching 44.6% and 29%, respectively, in coffee oil, and exceeding 80% in raspberry seed oil.
- Moringa oil demonstrated exceptional stability due to its high oleic acid (C18:1) content exceeding 85%, along with the presence of behenic acid (2.9%).
- Neem oil in the investigated sample showed an unusually high proportion of C18:3 (69%).

The FTIR spectra of coffee and raspberry oils displayed more pronounced C=C absorption bands, consistent with their higher degree of unsaturation. In the visible spectral range, neem oil exhibited the lowest transmittance due to its high chlorophyll a content, with a characteristic minimum at *674 nm*, whereas raspberry seed oil showed the highest transparency (over 80% transmittance). Three-dimensional fluorescence analysis revealed specific emission maxima associated with triterpenoids in neem oil and aromatic compounds in moringa oil.

Keywords: *GC–MS, FTIR, fluorescence spectroscopy, fatty acid profile*

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A-P4

TRENDS IN ATMOSPHERIC DEPOSITION OF METALS AND METALLOIDS IN BULGARIA: FINDINGS FROM THE 2020/2022 ICP VEGETATION SURVEY

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Abstract

For the sixth consecutive time, Bulgaria has contributed data on atmospheric deposition of heavy metals using moss biomonitoring to the United Nations Economic Commission for Europe (UNECE) International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation). During the summer of 2021, a total of 76 moss samples (Hypnum cupressiforme, Pleurozium schreberi, and Pseudoscleropodium purum) were collected across the country in accordance with the standardized ICP Vegetation sampling strategy.

The concentrations of 39 elements (Al, As, Ba, Br, Ca, Cd, Ce, Cl, Co, Cr, Cs, Cu, Fe, Hf, Hg, I, K, La, Mg, Mn, Mo, Na, Ni, Pb, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, Ti, U, V, W, Yb, and Zn) were determined in the moss samples using instrumental epithermal neutron activation analysis (ENAA) and inductively coupled plasma mass spectrometry (ICP-MS).

Long-term comparisons indicate that between the pilot survey conducted in 1995/1996 and the 2010/2011 survey, atmospheric deposition of metals in Bulgaria decreased by approximately 30%. However, the most recent survey shows an increased median concentration of Sb compared with the previous campaign. Overall, the results are comparable with those reported for other European countries within the ICP Vegetation programme during the 2015–2016 survey.

These findings contribute to the long-term assessment of spatial patterns and temporal trends in atmospheric metal deposition in Europe.

Keywords: *neutron activation analysis, trace elements, biomonitoring, bryophytes*

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A-P5

INFLUENCE OF MASTIC GUM CONCENTRATION ON THE PHYSICOCHEMICAL AND MECHANICAL PROPERTIES OF POLY(ε-CAPROLACTONE) FILMS

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Abstract

Polymeric materials are an indispensable resource in a number of areas and sectors such as medicine, pharmacy, cosmetics and food industry. Particular attention is drawn to those that are biocompatible as well as biodegradable. One of the most well-known and widely used polymer is poly(ε-caprolactone), due to its good biocompatibility and film forming ability. Therefore, structures based on it are a suitable matrix for developing composite films in combination with other polymers. An appropriate polymer with valuable qualities for both biomedical and food applications is mastic gum. This biopolymer is a resin extracted from the *Pistacia lentiscus* tree and it used both as polymer and bioactive compound. For this reason, the aim of the present research is to obtain composite structure on the base of these two polymers at different weight ratios and compare their properties to a film based on pure poly(ε-caprolactone). Among the most important parameters to investigate will be the mechanical ones (Young modulus, stress and strain at break), water vapor transmission rate and permeability. Their compatibility will be assessed based on their surface morphology and physicochemical study. To evaluate their potential application a study for their antimicrobial stability will be done along with gravimetrical study for their biodegradation rate.

Keywords: *poly(ε-caprolactone), mastic gum, composite structures, planar films, biodegradable*

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A-P6

INFLUENCE OF SINTERING TEMPERATURE ON STRUCTURE AND STRENGTH OF β-TRICALCIUM PHOSPHATE BIOCERAMIC OBTAINED BY FREEZE DRYING PROCESS

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Abstract

The aim of present paper is to investigate the influence of sintering temperature on structure and strength properties of *β*-tricalcium phosphate (*β*-TCP) bioceramic obtained by freeze drying process. Cylindrical *β*-TCP samples were prepared by freeze drying process and subjected to sintering at *1100*, *1200* and *1300 ºC*. The porosity, microstructure and phase composition were investigated by optical microscopy, XRD and pore analyzer. The maximum breaking force was measured through compression test and compression strength was calculated. It was found that there is no change in phase composition of *β*-TCP samples after sintering at *1100* and *1200 ºC*. Increasing the temperature up to *1300 ºC* led to shift of peaks to larger angles - evidence of allotropic transformation from *β*- to *α*-phase. However, *α*-phase was not identified may be due to reverse conversion during slow cooling. The sintered *β*-TCP samples were characterized with inhomogeneous porous microstructure: dense at the bottom, well-shaped elliptical pores in the top layer and mostly lamellar pores in the middle. Increasing the temperature led to shrinkage increase and linear decrease of porosity from 72% at *1100 ºC* to 55% at *1300 ºC*. Inverse proportional relationship was confirmed between the porosity and breaking force in compression. The maximum load increased from *13 N* up to *727 N* with temperature increase from *1100 ºC* to *1300 ºC*. A similar trend was observed in compressive strength: it increased with temperature increase from *0.06 MPa* at *1100 ºC*, *0.62 MPa* at *1200 ºC* and the highest *6.43 MPa* at *1300 ºC*.

Keywords: *β-TCP bioceramic, freeze drying, sintering temperature, structure and porosity, compression strength*

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A-P7

POWER OVER FIBER WITH PULSE WIDTH MODULATION FOR ELECTRONIC DEVICES

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Abstract

We study the performance of power over fiber (PoF) system with pulsed width modulation of the *980 nm* high power (*3W*) laser diode whose photonic power is transmitted over a multimode *62.5/125 μm* communication fiber and is converted to electric via a photovoltaic cell (PVC). We present the results on the deformation of the laser pulses and overall behavior of the PoF system for repetition frequencies *F* from *33 Hz* to *1 MHz* and the dependence on the duty cycle varying from 5% to 99%. The parameters of interest are the maximum converted from the photonic to electrical power P_{max}, the optimum load resistance R_0 required to maximize the output electrical power at the PVC. Also, the dependences of the maximum power P_{max} vs. the duty cycle η for different repetition frequencies *F* are presented. It has been found that for frequencies of up to about *5 kHz* the optimum load resistance is $R_0 \approx 110\ \Omega$. For higher frequencies the optimum load resistance increases. The results obtained permit the control of the electrical power delivered to the load by manipulating the frequency and/or the duty cycle as well as to use simultaneously the fiber optic system to transmit information and commands form the high power laser to the PVC based receiver.

Keywords: *Power over Fiber (PoF), pulse width modulation, duty factor, optimum load resistance*

A-P8

VLS GROWTH OF GaSb NANOSTRUCTURES ON A $TiO_2/Ag/TiO_2$ NANOLAMINATE STRUCTURE USING Ag NANOPARTICLES AS A CATALYST

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Abstract

GaSb nanostructures were grown on a transparent conductive nanolaminate $TiO_2/Ag/TiO_2$ structure by simple thermal evaporation method. Transparent conducting oxides are preferred as substrates for nanostructure deposition because they can work as transparent electrodes in various photosensitive devices. Nanolaminate structure was formed on a Si substrate by RF magnetron sputtering. The crystallization of GaSb was carried out via a vapor-liquid-solid (VLS) growth mechanism using Ag as a catalyst. During thermal heating, the Ag nanoparticles penetrate through the upper TiO_2 layer, and thus form catalytic seeds. Ga and Sb shots were used as sources for GaSb growth. The process occurred in a high purity hydrogen flow with a rate of 100 sccm. Depending on the temperature regime two type of structures were formed: nanoislands and nanowires. Nanoislands were deposited at a temperature of *800°C*, while at a lower temperature of *700°C*, mostly nanowires were formed.

The grown nanostructures were characterized by atomic force microscopy (AFM) and Scanning electron microscopy (SEM). The local microstructure of GaSb was determined by Raman spectroscopy measurements.

Keywords: *nanostructures, nanowires, nanoislands, GaSb, VLS growth, nanolaminate structure, $TiO_2/Ag/TiO_2$, conductive transparent oxides*

Acknowledgement: *This study was supported by European Regional Development Fund under "Research Innovation and Digitization for Smart Transformation" program 2021–2027 through the Project BG16RFPR002-1.014-0006 "National Centre of Excellence Mechatronics and Clean Technologies".*

A-P9

COMPARATIVE CHARACTERIZATION OF THE KLETT-FERNALD AND ANSMANN APPROACHES FOR RETRIEVING AND PROFILING OPTICAL PROPERTIES OF ATMOSPHERIC AEROSOLS FROM LIDAR DATA

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Abstract

Vertical profiling optical properties of atmospheric aerosols is essential for understanding the Earth's radiation balance and monitoring aerosol distribution. This report presents a comparative analysis of the two primary algorithms for lidar data processing: the Klett-Fernald inversion method and Ansmann's Raman technique. The traditional Klett-Fernald approach, widely used for processing elastic-backscatter lidar signals, relies on solving a Bernoulli equation derived from the single-scattering lidar equation. Its primary limitation stems from the mathematical necessity of determining two unknowns - extinction and backscatter coefficients, from a single measured signal. This requires a priori assumptions, such as a constant lidar ratio (extinction-to-backscatter ratio) throughout the measurement range. While backward integration improves numerical stability, the method remains highly sensitive to the chosen reference values and assumed aerosol characteristics. In contrast, the Ansmann's method utilizes inelastic (Raman) signals backscattered by atmospheric molecules (typically nitrogen ones) to enable the independent and direct determination of the aerosol extinction and backscatter profiles. A crucial advantage of this approach is that it eliminates the need for assumptions regarding the lidar ratio. Source material indicates that in complex atmospheric conditions, such as cirrus clouds, the lidar ratio can vary significantly (e.g., between 20 and 100 sr) within a single profile. Under such circumstances, the Klett solution can be highly erroneous, whereas the Raman method provides reliable data through a closed-form solution that avoids the strong instabilities and divergences of the retrieved profiles. In conclusion, while the Klett-Fernald method remains valuable for its conceptual simplicity and applicability to daytime measurements where Raman signals are too weak, the Ansmann method provides superior accuracy and physical insight. By independently measuring extinction and backscatter, it allows for the investigation of optical and microphysical aerosol properties and serves as a "gold standard" for validating lidar measurements in heterogeneous atmospheres.

Keywords: *atmospheric aerosols, lidar, aerosol extinction, aerosol backscatter, Klett-Fernald method, Ansmann's Raman technique, lidar ratio*

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A-P10

SURFACE PLASMON RESONANCE AS A SENSITIVE PLATFORM FOR RAPID CARBENDAZIM DETECTION

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Abstract

The widespread misuse of pesticides remains a critical global issue, as these compounds constitute a major class of persistent environmental contaminants. This study focuses on the analytical detection of Carbendazim (CBZ), a benzimidazole fungicide known for its high stability and documented toxicity toward diverse biological systems, including humans. Although CBZ is banned in the European Union, it continues to be routinely detected in fruit and vegetable samples due to its agricultural effectiveness and environmental persistence.

Current CBZ detection approaches-primarily chromatographic and immunoassay-based techniques-require specialized laboratory infrastructure, extensive sample handling, and trained personnel, limiting their suitability for rapid or on-site analysis. These constraints highlight the need for portable, sensitive, and selective detection platforms.

This work presents the development of a surface plasmon resonance (SPR) biosensor designed for rapid in situ detection of CBZ. Detecting low-molecular-weight analytes such as CBZ (191 Da) via SPR is inherently challenging due to the small refractive index changes generated upon binding. To address this limitation, two key strategies were implemented: (i) rational selection and optimized immobilization of a high-affinity biorecognition element, and (ii) enhancement of sensor surface sensitivity through tailored chip functionalization. Leveraging extensive expertise in SPR biosensor engineering, these modifications enabled analytical performance approaching that of established ELISA and chromatographic methods.

Initial proof-of-concept experiments demonstrate strong sensor response, high specificity, and detection limits compatible with food safety monitoring. The results confirm the feasibility of SPR-based biosensing for rapid CBZ screening and its potential applicability in in vitro toxicological assays at low exposure concentrations.

Keywords: *Surface Plasmon Resonance, Biosensor, In Situ, Pesticides, Carbendazim*

A-P11

CHANNELED POLARIMETRY FOR HYDROGEN DETECTION

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Abstract

Channeled polarimetry enables high-precision optical sensing of refractive-index variations and is particularly effective for surface plasmon resonance (SPR)–based hydrogen detection. A plasmonic sensor was implemented using a flow cell within which is places a gold-coated diffraction grating functionalized with a nanostructured WO_3 layer, which undergoes a reversible optical response when exposed to H_2 with different concentration (the complimentary gas is Ar). The interaction modifies the local refractive index at the plasmonic interface, producing measurable resonance shifts.

Amplitude-based SPR measurements did not provide statistically reliable discrimination of H_2 concentrations, as the resonance displacement remained within the spectrometer resolution and the intrinsic noise of the reflectivity minimum. In this work we report for implementation of phase-resolved channeled polarimetry, for hydrogen detection. As a results we achieved a sensitivity about 10^{-6} *RIU/nm* that is two orders higher then that at amplitude detection. The ability of channeled polarimetry to exploit phase information makes it a strong candidate for fast, reliable H_2 monitoring via SPR detection.

Keywords: *CSP (Channeled Spectropolarimetry), SPR (Surface Plasmon Resonance),* H_2 *detection*

Acknowledgement: *(КП-06 Н97/2 "Highly selective and sensitive field-effect hydrogen sensor based on plasmon resonance excited in diffraction gratings").*

A-P12

ENVIRONMENTAL EFFECTS ON PHENOLIC FLUORESCENCE SIGNATURES IN *SATUREJA HORTENSIS* L.

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Abstract

In the present study, the fluorescence and infrared spectra of summer savory (*Satureja hortensis* L.) samples originating from ten different regions of Bulgaria were investigated, and the relationship between optical parameters, phenolic composition, and environmental factors (altitude, solar radiation, etc.) was evaluated. The samples were finely ground, and fluorescence and IR spectra were recorded without extraction or dilution using the spectrophotometers AvaSpec-2038 (Avantes), Ocean Optics USB2000, and Jasco FT-IR-4X FTIR. The main phenolic compounds were identified by HPLC, while the total phenolic content and antioxidant activity were determined using the standard spectrophotometric assays as previously reported. Three main excitation-emission regions were distinguished in the obtained excitation-emission matrices (EEMs): $\lambda_ex = 310$ nm, $\lambda_em \approx (330–360)$ nm – associated with phenolic components; $\lambda_ex = (440–450)$ nm, $\lambda_em \approx (455–465)$ nm – associated with flavonoids; $\lambda_ex = 420$ nm, $\lambda_em \approx (680–730)$ nm – associated with the state of chlorophyll *a* and oxidized phenolic compounds, reflecting the presence of photosynthetic pigments and plant metabolic activity. Principal component analysis (PCA) and cluster analysis based on the intensities of the above-mentioned fluorescence maxima revealed two main clusters. The first cluster included samples exhibiting strong “red” fluorescence, whereas the second consisted of samples with lower but relatively uniform fluorescence in the blue-green region. Furthermore, samples originating from higher altitudes showed stronger fluorescence in the blue-green region, suggesting enhanced biosynthesis of phenolic compounds under conditions of increased UV radiation. The obtained results demonstrated that fluorescence spectroscopy using excitation-emission matrices provided an informative spectral fingerprint of phenolic compounds in Bulgarian summer savory samples.

Keywords: *FTIR, fluorescence spectroscopy, fatty acid profile, GC–MS, Satureja hortensis* L.

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A-P13

SELECTIVE MODE EXCITATION USING PERIODIC OPTICAL FIBER STRUCTURES

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Abstract

We present the experimental results on the fabrication and study of the performance of optical fiber periodic corrugated structures that cause selective mode coupling between different core modes of few mode optical fibers. The intended applications are few-mode and higher order fiber optic sensors and excitation of orbital angular momentum (OAM) vortex modes. The corrugated periodic gratings were fabricated using pulsed CO_2 laser (*10.6 μm*) in sections of SMF-28 optical communication fiber to cause coupling between the fundamental LP_{01} and the higher order LP_{11} and LP_{21} modes and in SM800 fiber for LP_{01} to LP_{11} mode coupling in the visible range (*532 nm*, *633 nm* to *680 nm*). Explicit expression for the relation between the corrugated structure period Λ and the resonance wavelength λ_c have been derived. The spectral responses of the corrugated gratings were measured as well as the mode field distributions of the excited modes. Side tunneling selective mode excitation through the corrugated structures was studied and the purity of the modes was evaluated. The obtained results were compared to those obtained from selective mode coupling in the visible observed in optical fiber 5%/95% splitters in the communication range that allow selective excitation of the LP_{21} mode in the visible. Example of a simple angular displacement fiber optic sensor using smartphone interrogation is presented. The sensor makes use of mode pattern rotation effect cause by mechanically induced optical activity. Also, simple all-fiber intermodal smartphone readable sensor has been demonstrated.

Keywords: *Corrugated fiber gratings, selective mode excitation, modal and intermodal sensors, smartphone interrogation*

Acknowledgement: *The financial support from the Natural Sciences and Engineering Research Council (NSERC) of Canada under the Discovery DDG-2025-00037 grant is acknowledged.*

A-P14

CHITOSAN–POLYVINYL ALCOHOL FILMS ENRICHED WITH *MARRUBIUM PEREGRINUM* EXTRACT: A PROMISING BIOMATERIAL FOR WOUND HEALING APPLICATIONS

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Abstract

Bioactive wound dressings based on natural polymers and plant-derived compounds are of great interest due to their biocompatibility, biodegradability, and therapeutic potential. The incorporation of plant extracts with antioxidant and antimicrobial properties into polymeric matrices is a promising approach for enhancing the functionality of wound healing materials.

In this study, multicomponent films from polyvinyl alcohol (PVA) and chitosan incorporating a methanolic extract from *Marrubium peregrinum* were prepared and characterized. The plant extract was prepared using 70% methanol combined with ultrasound-assisted extraction, followed by centrifugation, filtration, and solvent evaporation. The dry extract was incorporated into 1% polymer solutions, and films were prepared by the solvent-casting method using glycerol as a plasticizer. Two extract concentrations (*4* and *8 mg/cm²*) were investigated. Pure PVA-chitosan films were used as a control.

Scanning electron microscopy revealed a homogeneous structure in the control films, whereas films containing the extract exhibited a heterogeneous morphology with micron-sized structural units. Mechanical testing indicated that the incorporation of the extract decreased tensile strength, elongation at break, and Young's modulus, particularly at higher extract concentration. The presence of the extract increased water vapor permeability and moisture sorption, suggesting enhanced hydrophilicity of the film matrix. Release studies in phosphate-buffered saline demonstrated complete release of the extract within 24 h. The effect of glycerol concentration on release kinetics was also examined and an optimal concentration of 0.2% was identified.

These results indicate that PVA–chitosan films loaded with *Marrubium peregrinum* extract are promising candidates for the development of bioactive wound dressing materials.

Keywords: *PVA, chitosan, wound dressing, Marrubium peregrinum*, *physical properties*

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A-P15

PULSED LASER EVAPORATION: AN EFFECTIVE TECHNOLOGY FOR CREATING NANOSTRUCTURED COATINGS FOR HYDROGEN DETECTION

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Abstract

Reliable and fast hydrogen gas leak detectors are critical to the promising future of hydrogen technologies. However, despite decades of research, there are currently no hydrogen sensors that ensure its safe use, according to regulations. The lack of H_2 sensors that meet regulatory requirements is largely due to the absence of sensitive materials with the necessary properties. The sensitive materials are usually Pd, WO_3, or their alloys, which interact with H_2 and whose characteristics, changed as a result of the interaction with H_2, are measured. The creation of such materials involves studying the dynamics of material/H_2 interaction, methods of obtaining and depositing on the sensor element.

This study aims to synthesise and deposit layers of WO_3 via pulsed laser deposition (PLD). The stoichiometric composition of WO_3 is the key factor that determines sensitivity to hydrogen detection. To find the optimal ratio, WO_3 layers were deposited by evaporating tungsten (W) in an oxygen atmosphere under low-power conditions. The parameters characterising PLD were varied to investigate various evaporation modes: optical spectrum, laser pulse energy, repetition rate, and oxygen flow rate.

The composition and structure of the layers were investigated using XRD and EDS. The deposition conditions under which crystals with an appropriate stoichiometry, as determined by theoretical studies, were formed have been identified. Under these conditions, layers were deposited on surface plasmon wave transducers and their sensitivity to H_2 was investigated via surface plasmon resonance (SPR).

The measured H_2 detection parameters show that PLD is an effective technology for creating WOx as a H_2 sensing material.

Keywords: *hydrogen detection, nanostructured coatings, PLD, surface plasmon resonance*

Acknowledgement: *This work was performed with the financial support from the Bulgarian National Science Fund under project contract No. KP-06-H97/2 of 05.12.2025*

A-P16

NANOINDENTATION AS AN ADVANCED AND POWERFUL METHOD FOR STUDYING MECHANICAL CHARACTERISTICS OF NON-OXIDE NONLINEAR SINGLE CRYSTALS

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Abstract

Recently, increasing efforts are being devoted to the research of non-oxide binary, ternary and quaternary semiconducting crystals with non-centrosymmetric structure which find applications in nonlinear optics (frequency conversion of laser radiation in the mid-IR spectral range) [1]. Along with the basic linear and nonlinear optical characteristics, mechanical properties play an essential role for their practical implementation. For instance, they are important for mechanical treatments such as cutting, grinding and polishing.

Nanoindentation (NI) is a new, powerful method for simultaneous measurement of nanohardness, H_{IT}, and elastic modulus, E_{IT}. In NI a small diamond tip (area of about 1.10^{-9} m^2) penetrates into the sample in a controlled way, and the load and the corresponding depth are recorded in real time. E_{IT} is derived using the Oliver-Pharr equations [2], whereas H_{IT} is estimated by the load over the area.

Using NI for such crystals has many advantages [3]: 1) it is applicable to small samples; 2) it ensures very precise control over the load, avoiding surface damage; 3) one can choose between quasi-static and dynamic modes, depending on the material studied; 4) it enables depth dependence measurements with nanoscale resolution; 5) the accuracy, reliability and reproducibility are superior compared to microhardness tests since the area of the indentation is determined by the penetration depth.

Here we present results from systematic E_{IT} and H_{IT} studies of different non-oxide nonlinear single crystals of specified orientation obtained by NI in the continuous stiffness mode (CSM).

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Keywords: *Nanoindentation, Non-oxide nonlinear crystals, Nanohardness, Young's modulus*

A-P17

CHARACTERIZATION OF GELATIN-ISOMALT COMPOSITES FOR GUMMY CONFECTIONERY APPLICATIONS

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Abstract

Gelatin-based gels are widely used in the production of gummy confectionery, where the balance between the gelling agent and the sweetener plays a crucial role in determining the structural, mechanical and sensory properties of the final product. In this study, composite systems based on gelatin and isomalt were prepared in different mass ratios and systematically characterized in order to evaluate their stability for gummy confectionary applications.

The mechanical behavior of the samples was investigated using dynamometer-based mechanical testing. Industry standard TPA tests were conducted. Parameters such as Young modulus, deformation behavior, Cohesiveness, Springiness and other mechanical properties were determined in order to assess the influence of composition on the elasticity and structural stability of the gels [1,2].

The optical properties were investigated using a laser refractometric method at wavelengths of *405 nm*, *532 nm* and *635 nm*. The refractive indices were measured, dispersion dependencies were constructed and the coefficients of the one-term Sellmeier equation were determined [3].

This study on gelatin-isomalt compositions shows us how their relationship influences the structural integrity of the resulting candies as well as their light-reflective behaviors. By analyzing both the texture properties and the refractive performance we can obtain results which give us a framework for the precise design and quality control of gummy confectionery materials.

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Keywords: *gelatin, isomalt, mechanical properties, impedance spectroscopy, DSC, refractometry*

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A-P18

SPECTRAL CHARACTERIZATION OF MICROPLASTICS IN AQUATIC ENVIRONMENTS: FROM LABORATORY ANALYSIS TO FIELD MONITORING

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Abstract

Microplastic pollution is an increasing environmental concern in aquatic ecosystems, while existing detection methods remain complex, slow, and difficult to apply for large-scale monitoring. This work presents a concept for a new optical method and sensing approach for real-time, in-situ evaluation of microplastics in water.

The method is based on multispectral transmission measurements using specifically prepared pulsed coherent emission in the visible spectral range. The emitted radiation interacts with water and individual plastic particles as they pass through the active sensor volume. The study focuses on commonly occurring polymers such as polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET), investigating how particle composition, shape, and structure influence the optical response.

The paper outlines the theoretical basis of the approach and presents initial results from laboratory proof-of-concept experiments. The obtained data demonstrate the potential of the method for developing optical monitoring systems capable of rapid and reliable detection of microplastics directly in aquatic environments.

Keywords: *microplastics, optical spectroscopy, aquatic environment, laser–particle interaction, environmental monitoring*

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A-P19

RETARDING FIELD ANALYSER MEASURING THE ION TEMPERATURE IN THE DIVERTOR OF THE WEST TOKAMAK

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Abstract

A retarding field energy analyser (RFEA) has been installed in the divertor region of the WEST tokamak in order to measure the local ion temperature under various plasma operating regimes. The design of the diagnostic system and its operational principles are presented, together with preliminary experimental results obtained during initial campaigns. Measurements reveal that the ion temperature can deviate significantly from the commonly used assumption that it is equal to the electron temperature. In several observed cases, the ion temperature exceeds the electron temperature by up to a factor of four. These results highlight that relying solely on electron temperature as a proxy for ion temperature may lead to inaccurate estimations of plasma–surface interaction conditions. Direct measurements of the ion temperature are therefore essential for a more precise evaluation of heat loads on plasma-facing components and for improved predictions of material erosion processes in tokamak divertors. The implementation of the RFEA diagnostic in the WEST tokamak thus provides important insights into the plasma edge behaviour and contributes to the development of more reliable models for divertor physics and plasma–wall interactions.

Keywords: *fusion, divertor, retarding field analyzer, ion temperature, electron temperature*

Acknowledgments: *This work is financed by contract No KP-06-N68/2 between the Bulgarian National Science Fund and the Institute of Electronics, Bulgarian Academy of Sciences.*

A-P20

INSIGHTS INTO THE ROLE OF GOLD IN THE WGS PERFORMANCE OF CuZnAl LDH-DERIVED CATALYSTS

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Abstract

Hydrogen production has attracted considerable attention due to its potential to improve quality of life through environmental pollutant abatement and sustainable energy generation. Hydrogen energy represents a highly promising research area with increasing relevance to future energy challenges. The demand for high-purity hydrogen required for fuel-cell applications imposes new goals and challenges in the design of efficient water-gas shift (WGS) catalysts. Gold-based catalysts have demonstrated remarkable activity in the WGS reaction at low temperatures. In this context, the preparation of appropriate and economically viable supports with complex compositions represents an attractive strategy for improving WGS catalytic performance. In the present work, a co-precipitation procedure for the preparation of CuZnAl layered double hydroxide (LDH) precursors as a basis for Au-promoted catalysts was optimized. The procedure significantly reduced the synthesis time and enabled the preparation of materials with favorable phase composition and reducibility, as confirmed by X-ray diffraction (XRD) and temperature-programmed reduction (TPR) analyses.

Catalytic tests demonstrated promotional role of gold in the low-temperature WGS activity. The presence of Cu^{+} species was detected by X-ray photoelectron spectroscopy (XPS) in the Au-promoted catalyst after WGS testing. TPR profiles indicated that gold facilitates the reduction of CuO, while XRD analysis showed that after a 5-day test under the model gas mixture the Au-containing catalyst consisted of metallic copper particles with a larger average size compared with the CuZnAl carrier. These results confirm the successful scale-up of the CuZnAl precursor and highlight its economic and operational advantages.

Keywords: *Water-gas shift reaction, CuZnAl LDH-derived catalyst, Gold*

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A-P21

SCALE UP SYNTHESIS CO-PRECIPITATION TECHNOLOGY OF CuZnAl LAYERED DOUBLE HYDROXIDES AS CATALYSTS FOR ONE-STEP LOW-TEMPERATURE WATER-GAS SHIFT REACTION

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Abstract

The transition to a low-carbon economy has accelerated the search for alternative energy sources, with hydrogen emerging as a key solution for deep industrial decarbonization, long-term energy storage, and clean mobility. Among the various hydrogen production processes, the water-gas shift (WGS) reaction is widely regarded as an efficient method for both hydrogen generation and purification. The Cu-ZnO-Al_2O_3 catalyst, derived from a layered double hydroxide (LDH) precursor, has proven to be highly effective in the one-step low-temperature WGS reaction. Within project BG-RRP-2.017-0007, the synthesis of the CuZnAl LDH catalyst *via* co-precipitation was improved and scaled up from laboratory to larger batch sizes. In this study, the structural reproducibility and reducibility of the synthesized CuZnAl LDH through the developed co-precipitation methodology as well as its calcined derivatives, were evaluated using X-ray diffraction and temperature-programmed reduction. The results demonstrated consistent formation of identical Cu-containing crystalline phases and stable redox properties across batches ranging from *20* to *250 g*. The improved synthesis procedure, performed at constant pH and temperature, enabled reproducible production within an 8-hour workday, indicating strong potential for industrial application and technological readiness.

Keywords: *CuZnAl layered double hydroxides, Scale up synthesis co-precipitation technology, Structural reproducibility and reducibility*

Acknowledgement: *This research was funded by Investment C2.I2: 'Enhancing the Innovation Capacity of the Bulgarian Academy of Sciences in the Field of Green and Digital Technologies,' as part of the National Recovery and Sustainability Plan", Project BG-RRP-2.017-0007-C02. The authors gratefully acknowledge the equipment provided under Project № BG16RFPR002-1.014-0009, "Development and Sustainability of Centre of Competence HITMOBIL," funded by the Programme "Research, Innovations and Digitalization for Smart Transformation" 2021–2027, co-funded by the European Union through the European Regional Development Fund.*

A-P22

LASER-BASED UV LED TREATMENT OF RADISH SEEDS: EFFECTS ON GERMINATION AND EARLY SEEDLING DEVELOPMENT

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Abstract

Laser-based irradiation has emerged as a promising tool for modulating seed germination and early plant development through controlled photobiological stimulation. Seed germination is a complex physiological process regulated by hormonal, metabolic, genetic, and environmental factors, and its variability directly influences seedling establishment and crop quality. Among external stimuli, ultraviolet (UV) radiation has been shown to affect germination dynamics; however, plant responses depend strongly on irradiation parameters, including wavelength, intensity, and exposure time.

In this study, a targeted laser-based UV LED methodology was developed and applied to radish (Raphanus sativus L.) seeds. High-power UV LEDs emitting at 285 nm and 385 nm were used as coherent radiation sources. Each seed was individually irradiated under controlled conditions to ensure localized and reproducible exposure to monochromatic light of a defined wavelength. The irradiation time was set between 5, 10 and 15 minutes to assess dose-dependent effects. This individualized treatment strategy reduces experimental variability and improves reproducibility compared with bulk irradiation methods.

The applied UV exposure is expected to induce physiological responses associated with stress signaling and photobiological regulation, which may influence germination performance and early seedling development. The proposed methodology provides a controlled experimental framework for evaluating wavelength- and dose-specific effects of UV LED irradiation and supports the development of optimized light-based seed treatment protocols.

Keywords: *UV LED irradiation, Laser-based seed treatment, Seed germination, Radish (Raphanus sativus L.), Seedling development, Photobiomodulation*

A-P23

RAPID ELEMENTAL ANALYSIS OF CATALYSTS USING X-RAY FLUORESCENCE (XRF) TECHNIQUE

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Abstract

An X-ray fluorescence (XRF) spectrometer, which is essential for the rapid analysis and control of the quantitative composition and homogeneity of synthesized laboratory and industrial catalyst batches. XRF provides elemental analysis at concentration levels ranging from ppm to 100%. It was implemented to bench scale of batch-to-batch (*20, 50, 100 g*) of both oxide catalysts compositions for clean hydrogen generation: $CuOZnOAl_2O_3$ for water-gas shift (WGS); and CeO_2/Co_3O_4-SiO_2 for preferential CO oxidation of (COPrOx) processes. XRF technique enables:

1. Precise confirmation of the exact ratio of the components in the structure of the precurors, CuZuAl LDH and CeO_2/Co_3O_4-SiO_2, since the activity depends on the catalyst composition.
2. Measurement of low concentrations rare earth elements such as Ce with high accuracy.
3. Monitoring the homogenously of the $CuOZnOAl_2O_3$ and CeO_2/Co_3O_4-SiO_2 batches after synthesis and thermal treatment.
4. Control of remaining elements from the used reagents, such as sodium, chlorine, iron etc., which could be influence on the catalyst performance – activity and selectivity.

In conclusion, X-ray fluorescence analysis has established itself as a key tool for rapid and reliable monitoring within the analytical framework, ensuring optimal levels of activity and selectivity in the bench scale of the catalysts for the WGS and COPrOx processes.

Keywords: *XRF technique, Water-gas shift reaction, CuZuAl layered double hydroxide, COPrOx, CeO_2/Co_3O_4-SiO_2*

Acknowledgement*: This research was funded by Investment C2.I2: 'Enhancing the Innovation Capacity of the Bulgarian Academy of Sciences in the Field of Green and Digital Technologies,' as part of the National Recovery and Sustainability Plan", Project BG-RRP-2.017-0007-C02.*

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A-P24

ENGINEERING NEXT-GENERATION $CuOZnOAl_2O_3$ CATALYSTS FOR HIGH-PURITY HYDROGEN PRODUCTION THROUGH Re-DOPING

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Abstract

Hydrogen is increasingly recognized as a key energy carrier in the transition toward a low-carbon economy. The employment of H_2 for production of renewable, climate-independent, and emission-free energy required insurance of its high-purity for fuel cell units. Water–gas shift (WGS) process is applied as reaction for purification and enrichment of H_2-containing gas mixtures through the conversion of CO to CO_2 using steam (to residual CO less 1%).

The development of robust, efficient, and durable catalysts is key to enabling low-temperature single-stage WGS performance for applications in autonomous mobile energy systems.

The focus of this study is on strengthening the $CuOZnOAl_2O_3$ composition to achieve high activity and stability under high-CO syngas conditions produced in the utilization of waste through gasification. Re-doping to Cu-Zn-Al layered double hydroxide (LDH)-derived catalyst was applied as approach. Key aspects of how rhenium could modify $CuOZnOAl_2O_3$ catalyst include: (i) Electronic interactions between Cu and Re to fit Cu^0/Cu^+ ratio; (ii) H_2 mobility across the catalyst surface; (iii) Structural stabilization of Cu^+ species; collectively to improve catalytic efficiency and durability.

Current results of catalytic tests, X-ray diffraction, H_2 and CO temperature-programmed reduction and Diffuse reflectance spectroscopy highlight the importance of $ReOx/CuOZnOAl_2O_3$ composition and synthesis optimization.

Keywords: *Low-temperature single-stage WGS reaction, CuZnAl-derived catalyst, Re*

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A-P25

ENHANCED DYNAMIC MODELLING OF THE HYDROACCUMULATOR SYSTEM FOR KOZLODUY NPP UNIT 6 FULL-SCOPE SIMULATOR

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Abstract

The VVER-1000/V320 reactor at Kozloduy NPP Unit 6 is equipped with four hydroaccumulators (YT11B01–YT14B01) that provide passive emergency core cooling during loss-of-coolant accidents (LOCA). In previous implementations, the system was simulated using the GFLOW code based on a simplified modelling approach. The present study introduces an enhanced dynamic model developed within the JTOP/TOPMERET two-phase thermal-hydraulic framework.

The hydroaccumulator system is modelled using 60 nodes and 80 flow paths, with a simulation frequency of *40 Hz*. Each node resolves key thermodynamic parameters, including pressure, liquid level, enthalpy, temperature, and boron concentration. The gas volume is modelled separately to accurately represent nitrogen pressurization dynamics. Flow calculations are performed using implicit matrix methods for two-phase flow.

The developed model is integrated with principal simulator subsystems, including the TY drain and recirculation system, the containment (CH) system, the boric acid and makeup water tanks (TK), the nitrogen charging system (UG/TP), and the primary loop thermal-hydraulics modelled by RELAP5-HD.

The enhanced model provides a sustainable improvement in the fidelity of LOCA simulations and contributes to advanced operator training capabilities. In particular, it enables the realistic simulation of both design-based and maintenance-related scenarios, such as inadvertent valve actuation, hydroaccumulator depletion, and refilling procedures.

Keywords: *VVER-1000, hydroaccumulator, JTOP, TOPMERET, full-scope simulator, LOCA, emergency core cooling*

Acknowledgements: *The authors gratefully acknowledge Kozloduy NPP EAD for providing access to essential plant documentation and technical data. They also thank GCR AD for institutional support and computational resources, and GSES for their collaboration and expertise in full-scope simulator development.*

A-P26

CHARACTERIZATION OF Co-Ce/SiO_2 CATALYST WITH CO-TPR AND H_2-TPR MEASUREMENTS

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Abstract

The preferential CO oxidation (PROX) is an efficient and economic method for CO removal. Catalysts so far proposed for the PROX process are based mainly on noble metals, such as Pt, Rh, and Ru, deposited on different supports with or without any promoters. Due to high price of precious metals, non-precious metal catalysts have been considered as a potential alternative for the CO PROX reaction. It is known that Co_3O_4 exhibits high oxidation activity in CO oxidation at extremely low temperature. The presence of H_2 in the conditions of the PROX process provokes a gradual deactivation of the catalysts through the formation of surface species in a low oxidation state and even Co^0. The catalyst with the composition 20Co/15Ce/SiO_2, was identified as the most promising in our preliminary investigations. The following analysis methods were applied for characterization: CO-TPR and H_2-TPR measurements. TPR profile of a material is sensitive to the dispersion of the reducible phases, the interaction between them and their interaction with the support. The reduction of the cobalt phase occurs with TPR maxima observed at 310 °C, 330 °C, and a shoulder around *360 °C*. These peaks correspond to the sequential reduction of Co_3O_4 to CoO, CoO to Co, and the reduction of CoO in close contact and strongly interacting with CeO_2. Reduction of catalysis samples using CO typically occur at higher temperatures than with H_2 primarily due to kinetic limitations and the nature of the reducing species. While CO is thermodynamically a more exothermic reducer for some oxides at low temperatures, it faces significantly higher activation barriers and diffusion constraints when interacting with the lattice compared to H_2.

Keywords: *CO oxidation (PROX), CO-TPR, H_2-TPR*

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A-P27

SYNTHESIS OF SUPPORTED Co-Ce CATALYSTS FOR PREFERENTIAL CO OXIDATION IN H_2-RICH STREAMS: IMPLEMENTATION OF A 20 g BATCH SCALE-UP STRATEGY FOR CATALYST PRODUCTION

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Abstract

Preferential oxidation (PROX) of CO in the presence of H_2 and other syngas components is an established approach for decreasing carbon monoxide concentrations to levels suitable for the operation of a proton exchange membrane (PEM) fuel cell, usually below *10 ppmv*, or below *100 ppmv* for CO-tolerant PEM anodes. The PROX process represents a simple, efficient, and cost-effective technique for the removal of CO.

In recent years, catalysts with various compositions for the selective oxidation of CO have been studied. Among them, those based on Co and Ce have proven to be the most promising. Among the studied materials, the catalyst with a composition of 20Co/15Ce/SiO_2 demonstrated the most promising performance, achieving a CO conversion of 99% at *160 °C*.

A reproducible synthesis procedure for preparing *20 g* and *50 g* catalyst batches using the impregnation “exact soaking” technique was successfully developed and validated. This method involves impregnating the support with mixed diluted solutions of cobalt and cerium nitrates until the required quantity of active components is absorbed by the support.

The physicochemical characteristics of the *20 g* and *50 g* batches remain consistent. In all samples, two oxide phases, Co_3O_4 and CeO_2, were detected. Furthermore, no notable differences in surface area, pore volume, or average pore diameter were observed among the samples prepared in the *20 g* batch. The reduction behavior was also identical, indicating the formation of the same reducible oxide phases in all three batches.

In summary, a *20 g* catalyst with the composition 20%Co–15%Ce–SiO_2 was successfully synthesized. The preparation method proved to be stable and well optimized, as demonstrated by the preservation of catalyst characteristics across individual syntheses. Additionally, consistent activity and selectivity were confirmed for all samples within the batch.

Keywords: *PROX process, Co_3O_4, CeO_2, exact soaking*

Acknowledgement: *This research was funded by Investment C2.I2: "Enhancing the innovation capacity of the Bulgarian Academy of Sciences in the field of green and digital technologies" as part of the National Recovery and Resilience Plan, project BG-RRP-2.017-0007-C02.*

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A-P28

EFFECT OF PREPARATION METHOD ON Co-Ce/SiO_2 CATALYSTS FOR PREFERENTIAL CO OXIDATION IN HYDROGEN-RICH GASES

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Abstract

Hydrogen-polymer electrolyte membrane fuel cells (PEMFCs) are promising alternatives to conventional electricity generators. Operating at relatively low temperatures (*~80 °C*), their Pt anodes are highly sensitive to CO (1%) in reformed gases, which poisons the catalyst; CO levels must be reduced below 10 ppm. Preferential CO oxidation (PROX) is a simple, efficient, and cost-effective method for CO removal from hydrogen-rich streams. Co-based catalysts have shown high potential for this reaction, with highly oxidized cobalt species strongly interacting with supports to activate CO.

Two series of Co-Ce/SiO_2 catalysts were prepared: in the first, Ce was deposited and calcined before Co impregnation; in the second, Co and Ce nitrates were co-impregnated ((xCoyCe)/SiO_2). The catalysts were characterized by XRD, XPS, TPR, HRTEM, and UV–Vis spectroscopy.

Catalysts from successive impregnation showed low activity, while co-impregnated samples exhibited significantly higher activity. Homogeneous distribution and close contact of Co_3O_4 and CeO_2 were key to performance, providing more surface oxygen for CO oxidation. The (20Ce16Co)/SiO_2 catalyst remained stable for 200 h at 99% CO conversion, with outlet CO rising only from *10 ppm* to *70 ppm*.

Keywords: *Co–Ce catalysts, COPrOx, preparation of Co_3O_4–CeO_2/SiO_2 catalysts*

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Section B

«Engineering, Communications and Electronics»

B-I1

DYNAMIC FINITE ELEMENT AND EXPERIMENTAL STRAIN ANALYSIS OF A PASSENGER-CAR REAR AXLE

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Abstract

This research proposes an integrated numerical-experimental methodology for the durability assessment and optimisation of a passenger-car rear axle. A dedicated rear-suspension durability test bench was designed to impose a controlled cyclic vertical excitation on a dependent axle, reproducing service-like translational and rotational amplitudes of the beam and stabiliser bar. A detailed flexible multibody model of the bench-axle system was developed in MSC ADAMS 2023 and used to tune the kinematic excitation and determine an equivalent design load at the wheel spindles, consistent with the stiffness of the suspension assembly. Experimental strain measurements at nine locations on the axle, acquired with strain-gauge instrumentation on the bench, were converted into stresses and used to validate an explicit dynamic finite element model in ANSYS. The FE predictions agree with the experiments within about 10% at the beam mid-span and correctly identify a critical region at the junction between the side plate and the arm, where peak von Mises stresses of about *104 MPa* occur. The validated model then supports a response-surface-based optimisation of the safety-critical wheel spindle, yielding an optimised geometry in which spindle-fillet stresses remain around *180-185 MPa* under a severe loading case corresponding to the maximum admissible wheel load at the bearings, while the associated increase in mass is modest and compatible with practical design constraints.

Keywords: *rear axle, durability test bench, flexible multibody dynamics, explicit dynamic finite element analysis, strain-gauge measurements, response-surface optimization, wheel spindle design*

B-I2

EMOTION DATA ANALYTICS IN ASSISTIVE LEARNING PLATFORMS: A REVIEW FOR INCLUSIVE EDUCATION

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Abstract

Emotion Data Analytics (EDA) is becoming an important tool in making learning more inclusive and supportive for all students. It uses technologies like facial expression recognition, voice analysis, and behaviour tracking to understand how students feel while learning, such as whether they are confused, engaged, or frustrated.

This review explains how these emotion-aware systems can be used in assistive learning platforms, especially for students with disabilities or different learning needs. By understanding students' emotions, these platforms can adjust lessons, provide helpful feedback, and create a more personalized learning experience. This can make learning easier, more engaging, and less stressful. It also talks about challenges, such as protecting students' privacy, ensuring the technology is accurate, and respecting cultural differences in how emotions are expressed. Overall, Emotion Data Analytics has the potential to make education more caring, adaptive, and fair, but it must be used carefully and responsibly to truly benefit all learners.

B-I3

SELF-SUPERVISED FEATURE LEARNING FOR ALZHEIMER'S MRI CLASSIFICATION: DINOv2 WITH XAI-DRIVEN EXPLANATIONS

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Abstract

Early and accurate classification of Alzheimer's disease severity from MRI remains a critical clinical challenge, where subtle inter-class differences across dementia stages demand both high discriminative power and model transparency. Existing CNN based approaches fail to capture fine-grained neurological patterns while offering no interpretability, limiting their clinical trustworthiness. This study proposes a two-phase DINOv2 fine-tuning framework coupled with gradient-based saliency map visualizations to achieve both accurate and explainable Alzheimer's dementia staging from MRI. The proposed method attains a classification accuracy of 98.72%, a macro F1-score of 0.99, and a mean AUC of 0.9996 across four dementia severity classes on the Augmented Alzheimer MRI Dataset (33,984 images), with saliency maps yielding 100% correctness and an average prediction confidence of 94.0% on qualitative XAI evaluation. DINOv2 outperforms the VGG16 baseline by 4.25% in overall accuracy (98.72% vs. 94.47%), demonstrating superior generalization and clinically interpretable attention to diagnostically relevant cortical regions.

Keywords: *Alzheimer's Disease, MRI, DINOv2, Vision Transformers, Transfer Learning, Explainable AI, Medical Imaging*

B-I4

ENHANCING IoT SECURITY: A CONSORTIUM BLOCKCHAIN WITH ECDH-ECDSA APPROACH FOR SECURING ZIGBEE NETWORKS

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Abstract

Zigbee devices are widely adopted in Internet of Things (IoT) environments for low-power, short-range communication within personal area networks. However, these devices are inherently constrained by limited energy capacity, memory, and processing capabilities, which restrict their ability to support advanced security mechanisms. In contrast, Internet-connected systems possess abundant computational resources, creating a significant capability gap between edge devices and backend infrastructures. To bridge this gap, this paper proposes a secure and scalable architecture leveraging Zigbee Coordinators as intermediary nodes that facilitate communication between resource-constrained Zigbee End Devices and the Internet. The proposed framework integrates a consortium blockchain model, where Zigbee Coordinators function as validators responsible for maintaining the distributed ledger and providing trusted access to computational and storage resources for registered devices. To ensure secure onboarding and communication, a lightweight identification and registration protocol is designed using Elliptic Curve Diffie-Hellman (ECDH) for key exchange and Elliptic Curve Digital Signature Algorithm (ECDSA) for authentication and integrity verification. This cryptographic approach ensures confidentiality, authenticity, and resistance against common IoT attacks. By combining blockchain-based trust management with efficient cryptographic mechanisms, the proposed system enhances data security, privacy, and network reliability in Zigbee-enabled IoT environments. The architecture not only mitigates the limitations of resource-constrained devices but also provides a decentralized and tamper-resistant framework for secure device interaction. Overall, this work demonstrates the effectiveness of consortium blockchain in strengthening the security and dependability of next-generation Zigbee-based IoT networks.

Keywords: *Internet of Things (IoT), Zigbee Enabled IoT Networks, Consortium Blockchain System, Security, Zigbee Coordinators*

B-O1

COMPARATIVE INVESTIGATION OF CONCRETE STRENGTH, DURABILITY, AND ITS EFFECT WITH AND WITHOUT ADMIXTURE

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Abstract

This research investigates high-performance concrete targeting *40 MPa*, produced by optimizing silica fume, high-range water-reducing admixture, and crushed stone dust as a partial replacement for fine aggregate. A control mixture of ordinary Portland cement (OPC) concrete without admixtures was benchmarked against experimental mixtures with varying replacement levels. Five concrete mixtures were designed and tested, including a conventional mix without admixtures and five modified mixes with varying proportions of silica fume (8–15%), superplasticizer (1.2–1.8%), and crushed stone dust (30–60%). Mechanical performance including compressive, split tensile, flexural strengths, and static modulus of elasticity was evaluated at 28, 56, and 91 days. Durability was assessed through water absorption, rapid chloride permeability (RCPT), and sulfuric-acid resistance tests, while microstructural changes were studied using X-ray diffraction (XRD) and scanning electron microscopy with energy-dispersive spectroscopy (SEM–EDS). Results demonstrated that a moderate silica-fume content combined with balanced superplasticizer dosage and crushed stone dust replacement achieved the highest mechanical performance and chloride resistance, particularly at later ages, while another mixture with slightly lower silica fume excelled in workability and water absorption. Acid exposure confirmed reduced mass loss and higher residual strength in silica-fume mixtures compared with the control, supported by XRD and EDS evidence of densified microstructure and lower calcium hydroxide content. These findings suggest that tailored combinations of silica fume, superplasticizer, and crushed stone dust can enhance concrete performance, offering a pathway to develop high-strength, durable, and workable concrete for sustainable construction. This study provides valuable insights into mix optimization, contributing to the advancement of concrete technology and its practical applications.

Keywords: *Strength of concrete, Admixtures, Properties, Durability of concrete*

Acknowledgement: *The author would like to special thank the civil engineering department, Punjabi university India, and also grateful to the central lib of university, for giving me the opportunity to do research.*

B-O2

TRANSITION FROM MANUAL TO AUTOMATED SOLDERING OF ELECTRONIC COMPONENTS IN THE AUTOMOTIVE INDUSTRY: A COMPARATIVE ANALYSIS THROUGH OEE

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Abstract

The development of automation in the automotive industry leads to significant changes in production processes, including the connection of electronic components. This study examines the transition from manual to automated soldering of electronic components and analyzes its impact on production efficiency. The main objective is to compare the two production approaches using the Overall Equipment Effectiveness (OEE) indicator, which includes three main components: availability, productivity and quality. The study is based on the collection and analysis of production data from two different processes – manual soldering and automated soldering. By calculating OEE for each of the processes, the overall efficiency of the equipment is assessed and the main factors affecting productivity are identified. In addition to the positive effects of automation, such as increased process stability and reduced human factor, potential limitations related to investment costs, technical support and the need for specialized setup are also considered. The results obtained allow a comparative analysis of the two methods and to formulate conclusions regarding the effectiveness of automated solutions in the production of electronic components in the automotive industry.

Keywords: *automation, manual and automated soldering, electronic components, automotive industry, overall equipment effectiveness (oee), production efficiency, process comparison, manufacturing performance, industrial engineering, process optimization*

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Special thanks are extended to the Faculty of Physics and Technology of the Paisii Hilendarski University of Plovdiv for the academic support and creation of a stimulating scientific environment. The author also thanks the colleagues and specialists from the automotive manufacturing sector who contributed valuable ideas and practical information related to the production processes analyzed in the study.

B-O3

DESIGN AND CONSTRUCTION OF A DC CURRENT MEASUREMENT DEVICE BASED ON A HALL EFFECT SENSOR

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Abstract

The paper presents the design and implementation of a device for measuring direct current up to *50 A*, based on a Hall effect current sensor. The main objective of the development is to ensure non-contact measurement of load current without the need to interrupt the electrical circuit during the connection of the measuring device. For this purpose, a HASS 50-S current sensor is used, providing galvanic isolation between the power and measurement circuits and enabling safe measurement of relatively high currents. The paper also describes the development of a signal conditioning circuit based on the MCP6002 operational amplifier. The measurement system further includes a 16-bit analog-to-digital converter ADS1115, an Arduino Nano microcontroller, and a Nextion color display for real-time visualization of the measured current.
The proposed device is intended for integration as a stationary ammeter in a laboratory setup for studying a DC alternator, providing reliable and safe monitoring of load characteristics.

Keywords: *Hall effect sensor, DC current measurement, Arduino Nano, ADS1115, signal conditioning, non-contact measurement*

B-O4

RESTORATION OF WORKING SURFACES OF INJECTION MOLDS BY SANDBLASTING

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Abstract

The working surfaces of injection molds for the production of plastic parts are in most cases manufactured by spark electric discharge machining. Depending on the purpose of the part and the requirements of the plastic product designer, the grain size of the surfaces usually varies in the range from 21 to 42 according to VDI 3400. The wear of the working surfaces of the injection molds due to the action of abrasive fillers in the melt leads to a deterioration in the appearance of the parts being produced. The restoration of these surfaces is a serious challenge. The sandblasting method offers opportunities for effective restoration of worn surfaces.

Keywords: *injection molds, sandblasting, restoration, working surfaces*

B-P1

SATCOM AVIONICS VERIFICATION AND VALIDATION: V-MODEL, SAFETY & SECURITY STANDARDS, AND CRA COMPLIANCE

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Abstract

This paper presents a comprehensive verification and validation (V&V) methodology for SATCOM avionics systems compliant with the European Union's Cyber Resilience Act (CRA). The methodology integrates classical V-model safety standards such as DO-178C with modern cybersecurity practices per DO-326A and DO-356A. Advanced verification techniques such as static analysis, fuzzing, and penetration testing are mapped to SATCOM communication protocols and interfaces. The methodology ensures traceability between security requirements, CRA regulatory obligations, and test artifacts. A hybrid approach integrating safety and cybersecurity V&V ensures robustness and regulatory compliance.

Keywords: *Satellite Communications (SATCOM), Verification and Validation (V&V), Cyber Resilience Act (CRA), DO-178C, ARP-4754A, ARP-4761, Airworthiness Security Process (DO-326A), Airworthiness Security Methods (DO-356A), Software Bill of Materials (SBOM), Line Replaceable Unit (LRU), European Union Aviation Safety Agency (EASA), Aeronautical Radio, Inc. Spec (ARINC)*

B-P2

PHOTOVOLTAIC SYSTEMS AND THEIR APPLICATION IN MODERN SMART GRIDS

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Abstract

Photovoltaic systems are an important component of modern sustainable energy solutions and play a key role in the development of smart electrical grids. This study focuses on the investigation of photovoltaic systems, solar radiation, and energy yield in order to better understand their performance and practical application within contemporary intelligent energy networks.

The main objective of the research is to examine photovoltaic systems, solar radiation characteristics, and the resulting energy production. The methodology of the study includes system design, construction of a micro photovoltaic installation, data collection, monitoring, and analytical evaluation of the obtained results.

The research resulted in the accumulation of a structured database containing operational and environmental parameters related to the photovoltaic system. One of the primary contributions of this work is the development and implementation of a micro photovoltaic system equipped with continuous monitoring capabilities, enabling real-time observation and analysis of system performance.

The results of this study provide valuable insights into the behavior and efficiency of photovoltaic systems under real operating conditions. The developed system and the collected data create opportunities for practical applications in both industrial and residential energy systems, supporting the integration of renewable energy sources into modern smart grids.

Keywords*: Photovoltaic systems, Smart grids, integration of renewable energy sources*

Acknowledgement: *The author, Lubomir Angelov, gratefully acknowledges the co-author Nikolay Tyutyundzhiev for generously sharing the solar invertors made this study possible.*

B-P3

INVESTIGATION OF THE SURFACE ROUGHNESS OF PLA AND PETG PARTS AFTER REMOVING DIFFERENT SUPPORT MATERIALS (PVA AND SUPPORT FOR PLA/PETG)

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Abstract

This study investigates the influence of different support materials on the surface roughness of 3D-printed PLA and PETG components manufactured by fused deposition modeling (FDM). Two types of support materials were investigated: water-soluble PVA and a PLA/PETG support material (a specially designed filament for support material only). The 3D printer, filament and support filaments were manufactured by the same company for printing the samples. The surface roughness (Ra, Rz) was measured using a Mitutoyo SJ-210 roughness meter. The measurement was made in the areas that were previously in contact with the support materials. The results show that the use of these support materials leads to a significant reduction in roughness compared to standart suports. The PLA/PETG support material shows better results, but PVA is water-soluble, making it easy to remove in more complex geometries. The data obtained from the study can be used for the correct selection of support material and optimization of 3D printing.

Keywords: *3D printing, Support materials, PVA, Support for PLA/PETG*

B-P4

SMARTPHONE-READABLE PHOSPHORESCENT RGB TIME DECAY ENCODED TAGGANTS WITH WHITE LED EXCITATION

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Abstract

We present the experimental results on smartphone-readable phosphorescent security taggants for Internet of Things (IoT) applications. The security features of the labels are the individual phosphorescent decay responses of luminescent materials. The taggant contains seven different strontium aluminate samples whose phosphorescent time responses were individually tailored to be of the order of *1 s* by a proper choice of the precursors during the synthesis process. Our main objective is the study of these responses under white LED excitation and detected by a smartphone containing the same type of LED. As the decay times are between *0.2 s* to *10 s* a smartphone with a rate of 30 FPS allows a detailed measurement of the individual time responses. We report three essential results. The first is that the time responses as detected by the R (red), G (green) and B (blue) pixels are essentially different and individual. The second is the anomalous non-monotonic decay in the red spectral ranges measured by the R-pixels. The third is the dependence of the RGB time-responses on the period and on the duty cycle of the LED pulses. The particular case of responses to single excitation pulses has also been studied. The RGB-dependent parameters that can be used for security coding are the relative phosphorescence share of the overall luminescence, the average phosphorescence, the decay half-time, as well as the R:G:B proportion of the decay response. These strictly individual parameters allow the development of low-cost multilevel luminescent anti-counterfeiting taggants for identification/authentication in IoT applications.

Keywords: *Phosphorescent tags, strontium aluminates, IoT, anti-counterfeiting, identification, authentication, smartphone detection, RGB time responses*

Acknowledgements: *The financial support from the Natural Sciences and Engineering Research Council (NSERC) of Canada under the Discovery DDG-2025-00037 grant is acknowledged.*

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B-P5

EXCITATION DEPENDENT LUMINESCENT RGB ENCODED LABELS FOR SECURE AUTHENTICATION IN IOT APPLICATIONS

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Abstract

Internet of Things (IoT) devices are resource-constrained, and applications which are designed for authentication and identification must be lightweight and robust against different attacks such as cloning attacks or impersonation attacks. Several studies have been conducted on the usage of luminescent labels to improve IoT security and solutions have been proposed. However, some of these solutions have not been evaluated to prove their robustness against known attack vectors. In this study, we propose a lightweight authentication and identification protocol based on luminescent color labels. Our solution uses simple cryptographic functions such as HMAC and XOR. We have conducted an informal and a formal analysis of our protocol to prove its resistance to known attack vectors. The proposed scheme has minimal computation and communication costs and can be deployed in IoT environments. We propose in this work a simple approach for phosphorescent security labels whose time responses are excitation wavelength dependent. Each of the labels is composed of seven phosphorescent Strontium aluminate tags. The excitation sources are UV LEDs emitting at 365 nm and 385 nm causing different RGB dependent time responses of the label. These time responses are measured using a smartphone at 30 FPS. The rise and decay time responses as measured by the red (R), green (G) and blue (B) are separately analyzed and converted to series of numbers which represent the relative share of the R, G and B components and are then used as a security code for authentication and identification for IoT applications.

Keywords: *Luminescent security taggants, IoT, authentication, RGB smartphone detection*

Acknowledgement: *The financial support from the Natural Sciences and Engineering Research Council (NSERC) of Canada under the Discovery DDG-2025-00037 grant is acknowledged.*

B-P6

THREE-DIMENSIONAL MEASUREMENT AND ANALYSIS OF MAIN, EDGE, AND LEAKAGE MAGNETIC FLUXES USING A 3D HALL SENSOR MLX90393 AND AN EPSTEIN APPARATUS

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Abstract

This work presents an integrated methodology for three-dimensional measurement and analysis of magnetic flux components in a transformer core with an air gap, using the MLX90393 Triaxis® Hall sensor. The study combines the classical Epstein frame, used to generate controlled magnetic induction levels, with a modern 3D smart sensor architecture capable of resolving magnetic flux along the X, Y, and Z axes. A dual-sensor measurement technique is introduced to distinguish between the main magnetic flux within the core, the fringing flux in the air gap, and the leakage flux surrounding the windings. The first sensor is positioned inside the air gap to capture the primary and fringing components, while the second sensor is placed externally to measure leakage flux only. The system is implemented on an Arduino-based data acquisition platform, providing low-cost and high-resolution vector measurements of magnetic induction. Experimental measurements were performed for magnetic induction values ranging from *0.1 T* to *0.5 T*. The obtained results demonstrate a deviation of 2-4% between calculated and measured induction values, confirming both the validity of the proposed method and the reliability of the MLX90393 sensor for laboratory magnetic-field characterization. The methodology is applicable for material testing, magnetic circuit evaluation, and educational laboratory environments, offering a cost-efficient alternative to conventional gaussmeters and magneto-optical measurement systems.

Keywords: *MLX90393, 3D Hall sensor, magnetic flux, fringing flux, leakage flux, Epstein frame, Arduino, magnetic circuit analysis*

Acknowledgement: *This work was supported by Project No. ФП25-ФТФ-007, entitled: "Application of the Internet of Things (IoT) and Sensor Technologies for the Creation of Practically Oriented Educational Tasks in Physics and Engineering Disciplines", funded by the Scientific and Production Activities Department of Plovdiv University "Paisii Hilendarski".*

B-P7

POWER QUALITY ASSESSMENT OF GRID-CONNECTED PHOTOVOLTAIC SYSTEMS IN BUILDINGS WITH DISTRIBUTED RENEWABLE ENERGY

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Abstract

The increasing penetration of distributed renewable energy sources, particularly grid-connected photovoltaic (PV) systems, has introduced new challenges related to the quality and stability of electrical power in low-voltage distribution networks. Buildings equipped with distributed generation units often integrate both single-phase and three-phase PV inverters, which may influence voltage stability, harmonic distortion, phase balance, and overall power quality in the electrical installation. As photovoltaic capacity continues to expand in urban and institutional buildings, systematic assessment of power quality parameters becomes essential to ensure compliance with international standards and reliable operation of electrical infrastructure.

This paper presents an experimental investigation of power quality characteristics in a building equipped with distributed photovoltaic generation connected to a three-phase low-voltage electrical system. The analyzed installation includes both single-phase and three-phase PV systems with a nominal capacity of *10 kW* each. Measurements were carried out using a Class-A power quality analyzer compliant with IEC 61000-4-30 measurement standards. The monitoring campaign was conducted over an extended period under different operating conditions, including periods without photovoltaic generation, partial generation, and peak solar production. The study focuses on the evaluation of key power quality indicators such as voltage magnitude variations, frequency stability, harmonic distortion, voltage unbalance, power factor, and flicker levels. Particular attention is given to the impact of single-phase photovoltaic inverters on phase voltage asymmetry within the three-phase building supply network. The obtained results are compared against the limits specified in international standards such as EN 50160 and IEEE 519. The measurement results reveal that photovoltaic generation can lead to noticeable variations in phase voltage levels, particularly in cases where single-phase PV systems inject power asymmetrically into the distribution network. Under high solar generation conditions, localized voltage rise and increased phase voltage imbalance were observed. Furthermore, harmonic distortion associated with inverter operation was analyzed through spectral decomposition and total harmonic distortion (THD) evaluation.

Keywords: *Power Quality, Photovoltaic Systems, Voltage Unbalance, Harmonic Distortion, Distributed Renewable Energy, Power Quality Monitoring*

B-P8

NEXT-GENERATION AUTOMOTIVE NETWORKING: FROM CAN AND LIN TO ETHERNET BASED ARCHITECTURES

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Abstract

This paper presents a comprehensive and integrative analysis of the evolution of in-vehicle communication architectures, combining foundational insights from classical bus systems such as Controller Area Network (CAN) and Local Interconnect Network (LIN) with the latest developments in Ethernet-based architectures. The study highlights the technical, architectural, and functional transformations driving the transition toward high-speed, software-defined vehicular networks capable of supporting data-intensive applications such as Advanced Driver Assistance Systems (ADAS), autonomous driving, and vehicle-to-everything (V2X) communication. Comparative evaluations of legacy and emerging communication standards are provided, along with an overview of zonal E/E architectures, Time-Sensitive Networking (TSN), and gateway integration strategies that enable interoperability across heterogeneous domains.

Keywords: *Automotive networks, CAN, TSN, FlexRay, Automotive Ethernet*

B-P9

DIGITAL TWIN MODEL ARCHITECTURE FOR FUNCTIONAL SAFETY VERIFICATION OF A BRAKE-BY-WIRE SYSTEM: AN EMPIRICAL APPROACH

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Abstract

Digital twin technology is emerging as a powerful tool in the safety domain for system design, testing, and maintenance. However, its formal application in functional safety assurance, governed by standards such as ISO 26262 and IEC 61508 remains underdeveloped. This paper proposes a novel digital twin model architecture for a brake-by-wire braking system and demonstrates how such a twin can support functional safety verification. The architecture integrates software control models with physics-based simulations of brake mechanics in a modular, layered design emphasizing determinism, traceability, and fidelity. A top-level safety requirement is defined: the brake-by-wire system shall ensure safe deceleration within *500 ms* of a brake command even in the presence of a single-point failure. The digital twin is then used to verify this requirement under normal and fault conditions. Empirical results indicate that the digital twin can predict braking performance within ±5% of physical benchmarks and significantly expand test scenario coverage while maintaining deterministic behavior and traceability. The paper further discusses alignment with ISO 26262 and IEC 61508 through verification and tool qualification measures, showing that digital twins can enhance safety assurance by enabling virtual testing of hazardous or impractical failure scenarios.

Keywords: *digital twin, functional safety, brake-by-wire, ISO 26262, IEC 61508, verification, validation*

B-P10

MATLAB-BASED VIRTUAL BRIDGE MODEL FOR PARAMETER ESTIMATION OF POLARIZING DIELECTRICS

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Abstract

Characterization of dielectric materials and lossy capacitors requires accurate determination of the parameters of equivalent electrical models. Bridge measurement methods remain widely used for such purposes due to their high sensitivity and clear physical interpretation of the balancing process.

This paper presents a MATLAB-based virtual model of a bridge circuit for determining the parameters of a three-element equivalent model of a polarizing dielectric. The proposed virtual environment enables numerical simulation of the bridge operation, visualization of the complex trajectories of the bridge unbalance voltage, and implementation of an automatic bridge balancing procedure.

In the proposed virtual model, bridge balancing is achieved using a numerical optimization algorithm by minimizing the magnitude of the bridge unbalance voltage. In this study, Monte Carlo simulations are employed to evaluate the robustness of the parameter estimation procedure under random variations. Sensitivity analysis is used to investigate the influence of the model parameters over a wide frequency range.

The simulation results demonstrate successful automatic balancing of the bridge circuit. The Monte Carlo analysis confirms the robustness of the parameter estimation process, while the sensitivity analysis provides insight into the influence of the model parameters and the informative frequency ranges for measurement.

The obtained results confirm that the developed virtual model reproduces the analytically predicted behavior of the bridge circuit and provides a useful tool for numerical investigation of bridge measurement methods, uncertainty analysis, and the development of automated impedance measurement systems. The model may also serve as an educational tool in courses related to electrical measurements, electrotechnical materials, and insulating structures.

Keywords: *impedance bridge, dielectric polarization model, MATLAB simulation, virtual measurement system, automatic bridge balancing, Monte Carlo simulation, sensitivity analysis*

B-P11

AN ADAPTIVE FRAMEWORK FOR SECURE DATA MIGRATION IN CLOUD COMPUTING ENVIRONMENTS

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Abstract

The dynamic nature of modern cloud computing environments necessitates a paradigm shift from traditional, static security approaches, particularly during the critical process of data migration. This paper presents an innovative **Adaptive Security Framework** designed to protect sensitive information during transitions to cloud and hybrid infrastructures by automatically adjusting its defensive mechanisms in response to shifting environmental conditions and emerging threats.

The research is structured around three primary pillars:

- **Architecture:** The proposed architecture integrates context-aware access control, dynamic cryptographic key management, and continuous monitoring algorithms that adapt encryption levels based on real-time risk profiles and network overhead.
- **Implementation:** The framework is practically implemented as a functional prototype capable of integration with leading cloud service providers. The technical stack and automation processes for securing all phases of migration are detailed.
- **Empirical Evaluation:** The effectiveness and feasibility of the solution are validated through a series of experiments in a controlled testbed environment. The system was subjected to various workload scenarios and simulated cyberattacks during active data transfer.

The results of the empirical evaluation demonstrate that the adaptive framework significantly outperforms conventional static models. It **reduces response time to potential breaches by [X]%**, increases data resilience, and maintains a performance overhead within an acceptable **[Y]%**, thereby minimizing the impact on migration velocity. This study proves that the proposed model is a viable, scalable, and secure solution for contemporary enterprise needs.

Keywords: *adaptive security, data migration, cloud computing, empirical evaluation, cyber resilience, dynamic encryption, security architecture*

B-P12

AN EFFECTIVE SECURITY FRAMEWORK FOR DATA MIGRATION IN CLOUD COMPUTING

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Abstract

Data migration to cloud computing environments is a critical process for modern organizations seeking greater scalability, flexibility, and cost optimization. However, this transition poses significant information security risks, including potential leakage of confidential information, data integrity breaches, and unauthorized access during the transfer.

This article proposes an effective and comprehensive security framework specifically designed to protect data throughout all stages of the migration process—planning (pre-migration), actual transfer (during migration), and validation (post-migration). The proposed architecture integrates modern cryptographic methods (encryption of data at rest and in transit), robust identity and access management (IAM) mechanisms, as well as protocols for continuous monitoring and auditing.

Through a detailed analysis of potential vulnerabilities and risk assessment, the framework ensures compliance with leading regulatory standards and personal data protection requirements (such as the GDPR), while minimizing business process downtime. The results show that implementing this model significantly reduces the likelihood of successful cyberattacks and ensures a smooth, transparent, and secure transition to cloud infrastructure. The article provides both a theoretical foundation and practical guidelines applicable to IT professionals, cloud solution architects, and cybersecurity researchers.

Keywords: *cloud computing, data migration, information security, security framework, encryption, risk assessment, access management*

B-P13

NEURAL NETWORK–BASED APPROACH FOR TERRAIN-FOLLOWING FLIGHT CONTROL

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Abstract

In this work, a neural network-based approach is used to improve terrain-following performance of an aircraft. The neural network structure is incorporated into the acceleration command to stick dynamics. The proposed method is tested on a nonlinear model of an aircraft.

The performance of the control scheme is evaluated in terms of tracking performance and control activity in terrain-following flight. The validity of the proposed method is demonstrated by comparing the simulation results with those obtained using a conventional PID controller. The results show that the neural network-based control approach improves tracking performance as well as control activity of the aircraft in terrain-following mode.

Keywords: *flight control, terrain following, neural networks, PID, aerospace systems*

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B-P14

FREQUENCY ANALYSIS OF THE BUZZING CHARACTERISTICS OF A BEE COLONY USING A MICROPHONE IN RELATION TO ENVIRONMENTAL CHANGES

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Abstract

Bees as primary pollinators are an indispensable part of the food production chain. However, over the past decade a serious decline in bee populations has been observed, with the most severe decreases occurring in recent years, with mortality reaching peaks of 80-90%. Over the past two years Bulgaria has faced bee population losses reaching 70-100%. According to data from the Ministry of Agriculture, more than 60,000 colonies perished in 2025 due to a lethal combination of climate stress, pesticide exposure, and disease.

To gain a deeper understanding of bee behavior, we examined how factors like sunlight intensity and hive temperature affect the frequency of bee buzzing. To achieve this, we developed an automated system based on the Arduino MEGA platform to monitor external environmental parameters alongside internal hive temperature and acoustic activity. An external microphone was also positioned within the hive to serve as a high-fidelity sound reference.

Frequency spectral analysis was performed using *100 ms* windows to ensure sufficient data points for a robust Fast Fourier Transform. With a sampling rate of 8,000 samples/s, each window contained 800 samples, which allowed for an accurate spectral determination up to a frequency of *4 kHz* without aliasing.

Our results revealed that sunlight intensity directly dictates the buzzing behavior of the bees: as light intensity fades, the buzz frequency decreases, suggesting that the bees are transitioning into a sleep phase. These findings demonstrate that bee behavior is closely linked to environmental dynamics, with sunlight intensity being a primary driver.

Keywords: *Arduino-based sensors, Internal and external temperature, Light intensity/ Illuminance, Acoustic analysis/Sound*

B-P15

EXPERIMENTAL VALIDATION OF A KINEMATIC BRAKING DISTANCE MODEL UNDER VARYING ROAD CONDITIONS AND ABS STATES

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Abstract

This study presents an experimental validation of a kinematic braking distance model based on the classical equation of uniformly decelerated motion. The objective is to evaluate the model's predictive accuracy under varying road surface conditions and vehicle types, while analyzing the influence of the Anti-lock Braking System (ABS). Field tests were conducted with three passenger vehicles (BMW 318i, Seat Leon, and Opel Astra) on dry, wet, and sand-covered asphalt at initial speeds of *40*, *50*, and *60 km/h*, with both active and forcibly deactivated ABS. Dynamic braking parameters (deceleration and braking time) were recorded using a contactless decelerometer system, while actual stopping distances were measured directly. Theoretical braking distances, calculated from the mean measured dynamic parameters, were compared against the experimental data. The findings demonstrate minimal deviations between theoretical and experimental values across all 162 test runs. The highest model accuracy was observed for the vehicle with active ABS on dry asphalt, yielding relative deviations between 1.14% and 2.99%. Furthermore, active ABS consistently reduced deviations by stabilizing the braking deceleration profile. The validated model confirms the practical applicability of classical kinematic equations for predicting braking distances, providing a reliable framework for traffic accident reconstruction, road safety assessment, and Advanced Driver Assistance Systems (ADAS) calibration.

Keywords: *braking distance, kinematic model, experimental validation, ABS, deceleration, road safety, ADAS*

B-P16

EXPERIMENTAL STUDY OF 3D PRINTED LATTICE STRUCTURES OF 1.4548 STEEL

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Abstract

Additive manufacturing (AM) provides broad opportunities for manufacturing lightweight components with complex geometry and small dimensions. Modern technological advances in the field of AM significantly expand its application in industrial practice. Metal 3D printing allows the realization of complex internal and external structures with high precision, which cannot be achieved by conventional manufacturing methods. The use of AM is particularly promising for creating lattice structures characterized by low density and multifunctional mechanical and physical properties. The present study presents a comparative analysis of samples made of steel 1.4548, containing a rhomboid lattice with different filling percentages. The samples are subjected to tensile tests in order to determine their strength and assess their potential for practical application. The use of lattice structures leads to a significant reduction in the mass of the product - a parameter of key importance in many engineering areas, where weight optimization is critical for the functionality and efficiency of the structure.

Keywords: *additive manufacturing, 3D metal printing, steel 1.4548, lattice structures*

B-P17

EXPERIMENTAL STUDY OF THE QUALITY OF 3D PRINTED MARAGING STEEL 1.2709

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Abstract

Three-dimensional (3D) printing, or additive manufacturing (AM), is a set of manufacturing technologies based on the step-by-step layering of material to build objects with complex spatial geometry. Unlike traditional subtractive methods, AM allows for the realization of structures with a high degree of structural complexity, optimized internal architecture and minimized material waste. These characteristics make additive processes a key element of modern strategies for digitalized and sustainable production. Within the framework of the Industry 5.0 concept, which integrates automation, artificial intelligence and digital technologies with human expertise and creativity, additive manufacturing occupies a central place. It contributes to the creation of adaptive, personalized and environmentally efficient production systems, while expanding the possibilities for rapid prototyping, product individualization and optimization of production chains. Additionally, the main advantages and limitations of additive technologies are systematized, including their impact on mechanical properties, production speed, surface quality and economic efficiency. This present work examines the application of 3D printing in the manufacture of a rotor for gerotor hydraulic motor. Parameters such as surface roughness, geometric deviations and dimensional accuracy are analyzed using Direct Metal Printing (DMP) technology. Experimental results are presented that assess the suitability of the process for the production of functional mechanical parts.

Key words: *additive manufacturing, 3D metal printing, maraging steel 1.2709*

B-P18

ADDRESSING TECHNICAL, PRACTICAL, AND ADMINISTRATIVE LEGAL CHALLENGES IN OCCUPATIONAL MEDICINE PRACTICE

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Abstract

Occupational medicine is essential for promoting and protecting workers' health and well-being in diverse industries. Issues related to safe working conditions are notable for their relevance in every historical and economic stage of the development of societies. The Republic of Bulgaria is no exception.

Practitioners often face numerous challenges, ranging from technical complexities to administrative and legal obstacles. This article examines the multifaceted landscape of occupational medicine, examining the technical, practical, administrative and legal problems faced by practitioners, and suggests strategies for overcoming them.

Keywords: *occupational medicine, risk management, workplace health, industrial health, practice challenges*

B-P19

AN INTEGRATED FRAMEWORK FOR INVESTMENT ASSESSMENT IN FTTH PASSIVE OPTICAL NETWORKS

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Abstract

The deployment of Fiber-to-the-Home (FTTH) networks based on Passive Optical Network (PON) architectures represents a capital-intensive investment decision for telecommunications operators. While numerous studies address the technical aspects of FTTH network design, fewer offer an integrated approach that links engineering decisions with economic feasibility. This paper proposes a structured techno-economic framework for evaluating investments in FTTH PON networks. The framework integrates technical design parameters, cost structures, market assumptions, and financial performance indicators into a single evaluation process. Key indicators such as ROI, payback period, and sensitivity to subscriber adoption are assessed only after technical feasibility is assured. The applicability of the proposed framework is validated through a real-world GPON-based FTTH deployment project. The results show how technical design decisions and subscriber dynamics directly impact the sustainability of investments. The proposed framework can assist operators and planners in making informed decisions regarding investments in FTTH networks and can be extended to next-generation PON technologies.

Keywords: *networks, technologies, economic feasibility, economic and financial assessment*

Section C

«Educational Technologies»

C-O1

THE TEA LEAVES PARADOX

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Abstract

Tea drinking is one of the more popular activities in the world and thousands of people observe a peculiar phenomenon – when the tea is stirred in the cup, the leaves gather in the centre of the cup. This seems like a paradox, since in rotating situations there tends to be a centrifugal effect – objects move towards the periphery, not the center. Explaining this phenomenon has attracted the attention even of Albert Einstein but it remains somewhat unsatisfactory. A full proper explanation exists but it relies on hydrodynamics so advanced that even most professional physicists find it hard to understand. All the simpler explanations are a bit too vague and, as we found out, not fully correct. We propose a set of relatively simple experiments to explore the tea leaves paradox, uncover some weaknesses in previous qualitative explanations and propose a new explanation that does not rely on advanced hydrodynamics.

Keywords**:** *educational experiments, hydrodynamics, tea leaves paradox*

C-O2

EVOLUTION OF VISUALISATION IN PHYSICS EDUCATION (1996–2026)

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Abstract

This report analyses the evolution of visualisation in physics education from 1996 to 2026, tracing the transition from reproductive to interactive and constructive-immersive visual aids. It examines the fundamental transformation from static external representations (material models and diagrams as defined by Gilbert) to dynamic digital simulations (PhET model), now established as the standard for conceptual understanding, which provides evidence that while dynamic visualisations are more effective for processes involving motion, static models remain appropriate for objects at rest.

Cognitive aspects are examined through the lens of Mayer's Multimedia Learning Theory, Dual Coding Theory (DCT), and the Visual Imagery Hypothesis (VIH). These frameworks explain how graphical representations reduce working memory load. Special attention is given to Representational Analysis Tasks (RATs) and eye-tracking research, which reveal that experts focus on structural aspects of diagrams, whereas novices are often misled by superficial visual features.

The report evaluates the potential of Virtual (VR) and Augmented Reality (AR) technologies for the 3D spatial visualisation of abstract concepts, such as magnetic fields and quantum states. The final section analyses the integration of Generative Artificial Intelligence (AI) in personalised visualisation creation. Data from 2025–2026 indicate that current language models (such as ChatGPT-4 and DeepSeek-R1) can still generate physically inaccurate models or "hallucinations" regarding complex spatial relationships. It is argued that visualisation has evolved from a passive illustrative tool into an active "cognitive bridge," serving as a fundamental component of modern scientific literacy.

Keywords: *Visualisation Evolution, Physics Education, Digital Simulations (PhET), Cognitive Theory of Multimedia Learning, Representational Analysis Tasks (RATs), Eye-tracking research, Virtual and Augmented Reality (VR/AR), Generative AI in Education, Cognitive Bridge, Scientific Literacy*

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C-O3

NEW APPROACH IN TEACHING THERMODYNAMICS IN SECONDARY SCHOOL

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Abstract

EU has developed strategic framework which aims to develop key competences, basic skills, and attitudes needed by all for personal fulfilment and development, employability, social inclusion and active citizenship [1]. The successful realization of the goals of the strategy requires a high-quality education by implementing competence-based teaching and variety of learning approaches and contexts, and exploring approaches to assess and validate key competences. In line with this, in the present work we present an innovative approach of teaching thermodynamics [2], divided into 7 lessons, covering First principle, isoprocesses, and hear engines. In each lesson, we applied different methodical techniques, among which brain storming, experiments, problem solving, and project-based learning. The lessons were focused on physics-mathematics interdisciplinary connections although the other sciences were not neglected. We also propose an assessment method, where the prior-knowledge, before the training starts, is compared with the after-training knowledge. During the training, we offer a gradual correction of misconceptions.

Keywords: *Competence approach, Teaching in secondary schools, Thermodynamics, Learning assessment*

Reference:

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[2] Ministry of education and science, program in Physics and Astronomy, 8th grade, https://www.mon.bg/nfs/2023/12/up_viii_fa.pdf

C-O4

DESIGNING AND EVALUATING A STRUCTURE-PRESERVING DOCUMENT PIPELINE FOR ENHANCED AUTOMATED REVIEW OF SCIENCE EXAMINATIONS USING LLMs

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Abstract

Regular school examinations are important for evaluating student achievement, so it is essential to minimize errors in test items. Science examination papers are particularly challenging to review, because they are complex documents densely intermixed with tables, equations, and figures, and the subtle phrasing of answer choices makes linguistic misreading easy to overlook. LLMs have recently evolved into multimodal systems, and these documents can be reviewed automatically. But when we submit school examination papers to general-purpose chatbots in PDF format, structural loss arises during the OCR process. As a result, misinterpretation of figures and texts occurs. This study presents an automated examination review pipeline that converts .docx files into a structured format that LLMs can process more easily. A comparative evaluation using the same LLM (Gemini 3 Flash) was conducted on three actual school examination papers: a Grade 10 Integrated Science, a Grade 11 Physics I, and a Grade 12 Physics II (66 items in total). The PDF direct input method produced 14 errors in total, including misreadings of plain-text items, whereas the proposed pipeline produced only 3 errors, all attributable to the visual recognition limitations of the LLM itself. An additional 4 errors were shared by both methods, occurring in cases where the quality of figures was poor or difficult to interpret even by the human eye. These findings suggest that explicit preservation of document structure can substantially improve the accuracy of LLM-based examination review, and the pipeline offers teachers the ability to conduct repeated review cycles in real school settings.

Keywords: *Large Language Model (LLM), automated examination review, document structure preservation, multimodal document processing, science education*

C-O5

EXPLORING PRE-SERVICE ELEMENTARY TEACHERS' MODEL CONSTRUCTION OF PLANE-MIRROR IMAGE FORMATION USING AN AR-HMD LEARNING ENVIRONMENT

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Abstract

Understanding image formation in a plane mirror can be challenging for learners because it requires coordinating spatial reasoning and abstract representations of light paths. Augmented reality (AR) technologies offer new possibilities for visualizing optical phenomena while maintaining interaction with real environments. In particular, AR head-mounted displays (AR-HMDs) can overlay virtual representations of optical rays onto physical settings, potentially supporting learners' understanding of otherwise invisible processes of light propagation.

The purpose of this study is to explore how an AR-HMD learning activity can support pre-service elementary teachers' understanding of plane-mirror image formation from a model-construction perspective. The AR content used in this study was developed based on prior research and enables learners to visualize ray paths and image formation while interacting with physical objects in real space.

Approximately 18 pre-service elementary teachers participated in the activity in pairs. Data were collected through questionnaires examining participants' perceptions of AR-based learning and assessments designed to capture their scientific understanding of plane-mirror image formation in terms of model construction.

This presentation introduces the design and development process of the AR-HMD learning content and presents several illustrative cases drawn from the collected data. These cases highlight how students engaged with AR-based ray visualizations while constructing explanations for optical phenomena. Implications for the use of AR technologies in teacher education and science learning will also be discussed.

Keywords: *Augmented Reality (AR), AR-HMD, Plane-Mirror Image Formation, Model Construction, Pre-service Elementary Teachers*

C-O6

ECOSYSTEMS OF NON-FORMAL ASTRONOMY EDUCATION: COMPARATIVE ANALYSIS OF MODELS IN BULGARIA AND LEADING GLOBAL PRACTICES (2000–2026)

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Abstract

This study analyzes the positioning and adaptability of the Bulgarian model of non-formal astronomy education within the context of global trends for the period 2000–2026. The primary objective is to identify national specifics and their potential for modernization against contemporary educational paradigms.

The first section delineates four conceptual pillars defining the current state of astronomy for society worldwide: **citizen science** (mass participation through digital platforms), **social inclusion** (accessibility for individuals with specific needs and geographically isolated areas), **STEAM integration** (synthesis between science and art), and **technological digitalization** (application of artificial intelligence and big data).

The second section examines Bulgaria's unique institutional model based on the network of National Astronomy Observatories and Planetariums. The analysis highlights the country's leadership in elite education, evidenced by sustained success on the international Olympiad stage. The integration of projects like LOFAR-BG and activities of private foundations demonstrate capacity for incorporating innovations.

In conclusion, the Bulgarian hybrid model successfully combines traditions with high scientific achievements. However, the modernization process requires more intensive implementation of inclusion methods and accelerated digital transformation through AI. This will ensure the equitable and innovative presence of the national school in the global scientific-educational space, transforming it into a sustainable benchmark for quality and adaptability.

Keywords: *non-formal education, astronomy, olympiad, observatories, digitalization*

C-P1

INDUSTRY 5.0 – EDUCATION 5.0: HOW TECHNOLOGIES ARE TRANSFORMING HIGHER EDUCATION

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Abstract

The transition to Industry 5.0 has a significant impact on the functioning of higher education institutions and requires a rethinking of the educational paradigm in the context of the emerging opportunities and challenges arising from the integration of high-tech digital potential into the educational process. The thesis is put forward that the transformation to Education 5.0 is linked to the level of digital maturity of universities and their ability to adapt educational models, learning content, and teaching and assessment methods to the requirements of Industry 5.0. In this regard, a conceptual framework is proposed that links the instruments of digital and technological progress with digital maturity and educational transformation processes as key factors for the competitive positioning of higher education institutions.

Keywords: *Industry 5.0, Education 5.0, Higher Education, Digital Maturity, Educational Transformation, University Competitiveness*

Acknowledgement: *The publication was carried out under Project FP25-FISN-012 funded by the Research Fund of Plovdiv University "Paisii Hilendarski".*

C-P2

CORPUSCULAR-WAVE DUALISM OF THE PARTICLES: COMMON MISCONCEPTIOS AND A CONCEPT MAP DESIGN

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Abstract

The corpuscular-wave dualism of the particles is one of the most significant, but also most often misunderstood concepts in quantum physics. The effective teaching requires targeted diagnosis and overcoming misconceptions by applying adequate pedagogical approaches to build mental models consistent with the modern scientific picture of the world. The concept map method is an effective didactic tool that helps learners build meaningful connections between concepts, develop analytical thinking, and overcome misconceptions. This article presents common misconceptions about the corpuscular-wave dualism of the particles, analyzes possible reasons for their occurrence, and suggests teaching strategies for overcoming them. A sample test (combining quantitative and conceptual elements) for diagnosing misconceptions is included. A concept map for the corpuscular-wave dualism of the particles is proposed, and ideas for its application are discussed, both as a learning resource to support knowledge organization and as a tool for diagnosing conceptual understanding. The proposed didactic tools (test and concept map) are suitable for high school students and for students at lower levels of undergraduate education in physics and engineering.

Keywords: *quantum physics education, secondary and lower undergraduate education, corpuscular-wave dualism, misconceptions, concept map*

C-P3

INTEGRATING SIMULATION TECHNOLOGIES INTO REMOTE ACCESS LABORATORIES

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Abstract

The development of digital technologies and the growing importance of distance and hybrid learning place new demands on laboratory training in higher education institutions. Traditional laboratories, based solely on physical equipment, are often limited by high costs, limited access and the need for on-site presence. In this context, the integration of simulation technologies and virtual laboratories is becoming an effective approach to expand the possibilities for learning and experimentation in engineering disciplines.

This study presents the concept and implementation of a virtual laboratory environment based on the LabVIEW (Laboratory Virtual Instrument Engineering Workbench) platform, which allows the integration of simulation models and laboratories with remote access. The developed system provides an interactive environment for simulating engineering processes, visualizing measurement data and analysing experimental results in real time. Using the LabVIEW graphical programming language, virtual instruments are created that imitate the behaviour of real measuring devices and allow laboratory exercises to be conducted in a controlled digital environment.

The proposed solution demonstrates the capabilities of modern simulation technologies for creating interactive laboratory environments with remote access, which can complement traditional laboratory training and support the acquisition of engineering knowledge.

Keywords: *virtual laboratories, remote access laboratories, LabVIEW, simulation technologies, engineering education*

Acknowledgement: *This report was funded by a project No MUPD25-FtF-018 at the Scientific Research Fund at the University of Plovdiv Paisii Hilendarski.*

C-P4

GRAPHIC REPRESENTATION OF DIRECT CURRENT LAWS

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Abstract

This paper considers the matter of the graphical representation of direct current laws. Ohm's law in several variations and Kirchoff's second law are drawn based on the graphical representation and the appropriate interpretations.

The notions of potential and potential difference are used. Stress is put on the so-called potential diagrams that graphically represent the change of potential along the circuit. The sum of the potential differences along the circuit is composed, the separate potential differences are graphically interpreted and on that basis the corresponding laws are derived.

The graphic representation of the laws is clear, accessible, informative and interesting for the students.

Keywords: *direct current laws, graphic modeling, potential diagrams*

Section D

«Bioengineering and Biosensors»

D-I1

STRUCTURAL OPTIMIZATION AND PROTOTYPE DEVELOPMENT OF A NEW LOWER-LIMB EXOSKELETON FOR HUMAN GAIT REHABILITATION

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Abstract

This research presents an integrated workflow for developing a manufacturable lower-limb exoskeleton for gait rehabilitation, linking kinematic synthesis to CAD, multibody dynamics (MBD) evaluation, and finite element (FE) optimization. Since practical devices still face challenges related to human–robot interaction, joint alignment, comfort, personalization, and performance assessment, the proposed pipeline connects biomechanically compatible mechanism design with simulation-driven load prediction and efficient components. The device is based on a planar linkage with nine rigid links and fourteen revolute joints, resulting in a single-input actuation layout. Two identical leg mechanisms are mounted on a common frame, with the driving links assembled in *180°* phase shift to obtain step alternation. The architecture is first defined as a planar kinematic scheme, then transformed into a 3D stick model and a manufacturable CAD assembly prepared for rapid prototyping. Dynamic assessment is performed in MSC.ADAMS using a coupled exoskeleton–human mannequin model, with hip, knee, and ankle joints aligned to ensure kinematic compatibility. Foot–ground interaction is represented through an impact-based contact model using a heel sphere and a forefoot cylindrical element. Simulations provide joint-angle histories and joint reaction forces used as structural load cases. The predicted kinematics show gait-like periodic patterns comparable to healthy reference trends, with hip motion between *+15°* and *−25°* and knee flexion reaching *60–65°* before returning near full extension. A key clevis-type link is then optimized in ANSYS Workbench using response surfaces and a Multi-Objective Genetic Algorithm (MOGA) to obtain a minimum-mass manufacturable solution satisfying stress and deformation constraints. Future work will address experimental validation, optimization of additional components, and improved safety features.

Keywords: *lower-limb exoskeleton, gait rehabilitation, multibody simulation, structural optimization, rapid prototyping*

D-I2

CENTER-OF-MASS CONSIDERATIONS IN THE DESIGN OF A PEDIATRIC EXOSKELETON: APPROACHES AND CHALLENGES

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Abstract

The behavior of the human center of mass (CoM) plays a crucial role in maintaining stability and efficiency during walking, especially in children affected by locomotion disorders such as Duchenne Muscular Dystrophy (DMD). This research investigates the modeling and implementation of a mechanical solution capable of reproducing and assisting CoM behavior within a pediatric rehabilitation exoskeleton. Initially, an experimental analysis was performed using motion capture techniques to evaluate CoM trajectories during gait for a control child and a child diagnosed with DMD. The obtained data highlighted significant differences in vertical and transversal oscillations of the CoM. Based on these results, a simplified kinematic model representing the human locomotion system was developed using a spring–mass–damper mechanism to simulate vertical CoM oscillations. The model was numerically processed and validated against experimental data.

Furthermore, a conceptual mechanical device consisting of a translational joint and an elastic component was designed and integrated into an exoskeleton prototype intended for gait rehabilitation. The proposed system was validated through comparative analyses between experimental measurements, numerical simulations, and prototype testing.

The results demonstrate that the introduced mechanical device reproduces CoM behavior with an average accuracy of approximately 93.95%, confirming its effectiveness in improving exoskeleton functionality and supporting stable gait rehabilitation for children with DMD.

Keywords: *pediatric exoskeleton, center of mass kinematics, human gait rehabilitation, spring – mass – damper model*

D-O1

ASSESSMENT OF THE INFLUENCE OF ZEOLITE IN SOILS ON CUCUMBER PLANT GROWING USING NEAR-INFRARED SPECTROSCOPY AND AQUAPHOTOMICS

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Abstract

Zeolites can be beneficial for plant growth and soil health. They could act as a slow-release fertilizer, improve water retention, and help purify the soil by absorbing heavy metals. This study aimed to assess the influence of zeolite additives on cucumber plant development and to evaluate the ability of near-infrared spectroscopy and the aquaphotomics approach to detect differences in cucumber leaves depending on zeolite in soil.

A mixture of two soil types (Luvisol and Fluvisol) was prepared with zeolite at 25% and 50% concentrations. An experiment was conducted to grow Gergana variety cucumber plants in pure soils and soil-zeolite mixtures. The water regime, temperature, and lighting remained consistent across all variants. The SPAD-502 Plus Chlorophyll Meter was used to measure the Chlorophyll Content Index (CCI). A handheld spectrometer, AlbaNIR, was used for plants' spectra measurements in the *900–1650 nm* region. The cotyledons, the first and second true leaves, were measured. A Pirouette 4.5 (Infometrix, Inc.) software was used to process spectral data and develop the PLS models for CCI determination. Additionally, so-called aquagrams were calculated.

There were differences in the near-infrared spectra of measured cucumber leaves depending on soil type and zeolite content in the soil. Aquagrams showed changes in the organization of water molecules in leaves. Variations in chlorophyll content in leaves were also found. The accuracy of the developed PLS models for determining CCI content on the base of spectral characteristics of leaves was very high.

Keywords: *Zeolite, Cucumber plant, Chlorophyll index, Near-infrared Spectroscopy, Aquagrams*

Acknowledgements: *This research was funded by the project "Integrated intelligent systems and approaches for improving water and soil quality", National scientific research fund of Bulgaria (Contract No. KP-06-PN87/51).*

D-O2

PANEURHYTHMY INSPIRED WALKING AS A NATURAL HEART-MIND COHERENCE BOOSTER: A PILOT STUDY

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Abstract

Heart-rate dynamics can reveal the impact of subtle changes of natural environmental stimuli on our overall being. Rhythms such as circadian entrainment and deep breathing are important health boosters. Musical rhythm, on the other hand, plays an uplifting role in our society. Taking into account Paneurhythmy, this pilot study investigates the impact of Nature's rhythms onto our heart rate dynamics. Seven individuals were monitored by means of a HeartMath coherence, a WHOOP strap to estimate physical strain, and an Arduino-based Nadi Pariksha three-electrode system in two walking sessions: a natural and a Paneurhythmic one, divided by relaxation sessions of deep breathing. The obtained data confirmed that deep breathing can boost heart coherence, a natural short walk can further increase it, while Paneurhythmy walk can maximize the coherence output of the system. The latter finding is attributed to the music dynamics of Paneurhythmy, oscillating strongly around *0.1 Hz*, a frequency promoting heart-brain optimal workflows. Surprisingly enough, participants who received lower HeartMath coherence average score, had highest spectral power at the onset of the deep breathing session following the Paneurhythmy walk, which confirmed the importance and long-term influence of Nature's rhythms on the heart rate oscillatory dynamics, corresponding to a rise in Vata signal, linked to respiration, even beginning at a relatively lower baseline than the rest. Notably, Paneurhythmy bears high potential to promote stress relief, mental clarity and creativity, all linked to optimal heart-mind interactions, based on maxima of achieved heart-rate coherence.

Keywords: *heart-rate dynamics, biosensors, heart coherence, 0.1 Hz breathing, rhythmic walking, musical rhythm, Paneurhythmy, Nadi Pariksha, Arduino system, mind-body coherence, creativity*

D-O3

REAL-TIME ELECTRICAL IMPEDANCE ANALYSIS FOR STUDYING KEY PROPERTIES OF CELL CULTURES

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Abstract

The study focuses on the potential of the xCELLigence system (ACEA Biosciences, USA) for real-time monitoring of the functional characteristics of cell cultures. For this purpose, primary smooth muscle cell cultures obtained from isolated gastric corpus tissue of Wistar rats were used. Smooth muscle cells possess a wide variety of receptors, which enables the analysis of diverse cellular responses and mechanisms. This makes them a suitable *in vitro* model for studying physiological processes and cellular behavior.

The real-time cell analyzer utilizes a microelectronic biosensor consisting of gold microelectrodes integrated into the bottom of each well of electronic microtiter plates (E-Plate), where the cells are cultured. When an electrical potential of *22 mV* is applied, adherent cells act as insulators on the electrode surfaces. Changes in electrical impedance are quantified using a unitless parameter called the "Cell Index".

This impedance-based analysis allows continuous monitoring of several important cellular processes, including cell adhesion, proliferation, survival and viability. However, interpretation becomes more complex when cells are exposed to pharmacological stimuli that activate specific receptors or induce contractile responses. In such cases, impedance changes may result from multiple overlapping cellular processes, such as alterations in cell shape, contraction, or changes in cell–substrate adhesion. Therefore, it can be difficult to attribute the observed impedance signal to a single specific cellular mechanism.

While impedance-based monitoring is a valuable tool for studying overall cellular behavior, additional experimental approaches may be required to precisely interpret receptor-mediated and contractile responses.

Keywords: *RTCA, Real-time cell analyzer, primary cell cultures, smooth muscle cells, proliferation, viability, contractility of smooth muscle cells*

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D-P1

NEAR-INFRARED SPECTROSCOPY AND AQUAPHOTOMICS FOR RAPID MONITORING OF LAKE VAYA WATER PURIFICATION

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Abstract

This study explores a pilot multi-stage filtration system for treating irrigation water from Lake Vaya, heavily affected by anthropogenic pollution. Two filters were tested: one with natural zeolite (clinoptilolite) and another with biomass from the macrophyte *Stuckenia pectinata*. After 60 minutes of recirculation, total nitrogen decreased by 67–76%, nitrate nitrogen by 19–38%, and orthophosphate by 58–66%, and concentrations of aluminum, iron, sodium, calcium, and magnesium were also significantly reduced, demonstrating effective nutrient and metal removal. Near-infrared (NIR) spectra (*900–1650 nm*) were measured, and partial least squares (PLS) models were developed to predict pollutant removal. Aquagrams revealed changes in the water's molecular structure, reflecting modifications in hydrogen-bonding networks.

These findings show that combining multi-stage filtration with NIRS and aquaphotomics provides a rapid, non-invasive method for monitoring water purification, supporting sustainable reuse, and minimizing secondary pollution in impacted water bodies.

Keywords: *aquaphotomics, near-infrared spectroscopy, monitoring, water purification*

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