MatFyz CONNECTIONS 2025

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Book of Abstracts

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Pozvané prednášky

ID:4# Fluid Dynamics in Porous Media

Author: Andrej Zlatos[None]

The motion of fluids is modeled by various systems of partial differential equations, depending on the properties of the fluid, the medium through which it moves, or the space-time scales on which the motion is studied. I will start by discussing two of the most fundamental of these models: the 2D Euler equations modeling motions of ideal fluids, and the incompressible porous media equation (IPM) for fluids in porous media such as oil or ground water in an aquifer. These are also some of the most elementary fluid models because they can each be re-stated as a single scalar transport equation for either the vorticity or the density of the fluid. Nevertheless, their analysis is far from elementary due to non-local dependence of the transporting velocity on the transported quantity. In the second part of the talk I will present a recent result that shows development of finite time singularities for the two-fluid IPM. It is based on the observation that for a large class of initial data, certain physically relevant quantities - the maximal slope of the interface between the two fluids as well as the potential energy of the system - always decrease in time.

ID:6# Research into pedagogical forms to support active learning

Author: Zuzana Kubincova[1]

[1] *Comenius University Bratislava*

One of the key challenges in contemporary education is how to meaningfully engage students in the learning process. Teachers at all levels of education, including university, often encounter declining motivation, fragmented attention, and passive study habits among students. The current young generation has grown up in an environment saturated with technology, instant access to information, and constant online interaction. Although these characteristics bring new opportunities for creativity and collaboration, they also appear to have a negative impact on, for example, the ability to maintain attention, read longer texts, and so on. The learning styles of this generation differ significantly from those of previous generations, and it is necessary to provide more support to motivate them to learn.

We will present our research on pedagogical forms that support active learning, which emphasizes participation, problem solving, discussion, and reflection rather than the mere transfer of information. We will look at strategies such as collaborative learning, team-based projects, peer assessment, and others, as well as how these methods can be adapted to the cognitive and motivational profiles of today's students.

The goal is to highlight how thoughtful instructional design –supported by research –can engage students in the learning process as co-creators of their educational experiences and, instead of passively receiving information, encourage their curiosity, autonomy, and deeper understanding.

Študentské, doktorandské, postdoktorandské osobnosti

ID:121# Matched Asymptotic Analysis of the Luria–Delbrück Distribution in a Reversible Fluctuation Assay

Authors: Anna Hlubinova[1]; Pavol Bokes[1]

Co-author: Abhyudai Singh [2]

[1] *Comenius University Bratislava*

[2] *University of Delaware, USA*

We study a fluctuation test where cell colonies grow from a single cell to a specified population size before undergoing treatment. During growth, cells may acquire resistance to treatment and pass it to their offspring with a small probability. Unlike the classical Luria–Delbrück test, which assumes irreversible resistance, our model allows resistant cells to revert to a drug-sensitive state. This modification, motivated by recent research on drug resistance in cancer and microbial cells, does not alter the central part of the Luria–Delbrück distribution, where the Landau probability density function approximation remains applicable. However, the right tail of the distribution deviates from the power law of the Landau distribution, with the correction factor given by the Landau cumulative distribution function. Using singular perturbation theory and asymptotic matching, we derive uniformly valid approximations and describe tail corrections for populations with different initial cell states.

ID:122# Datovanie artefaktov s využitím rádioaktívneho uhlíka ^{14}C a stanovenie prvkového zloženia pigmentov metódou PIXE

Author: Karol Sucak[None]

Co-authors: Miroslav Jeskovsky ; Boris Bobal ; Jakub Kaizer [1]; Ivan Kontul ; Jakub Zeman ; Pavel P. Povinec

[1] *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava*

Určenie veku artefaktov s presnosťou na niekoľko desaťročí v závislosti od veku vzorky, je dnes možné vďaka rádiouhlíkovému datovaniu a použitiu vysokocitlivej urýchľovačovej hmotnostnej spektrometrie. Datovanie pomocou rádiouhlíka využíva koncentráciu ^{14}C na určenie veku vzorky a patrí medzi deštruktívne analytické metódy. Táto metóda v minulosti pomohla s odhaľovaním falzifikátov a ochranou kultúrneho dedičstva. Ďalšou často využívanou metódou pre tieto účely je prvková analýza pigmentov vykonaná metódou PIXE (z angl. particle induced X-ray emission). PIXE je nedeštruktívna analytická metóda založená na analýze energie röntgenových kvánt, ktorá umožňuje presnú identifikáciu prvkov vo vzorke. V práci boli analyzované 3 vzorky (dva obrazy a jeden ozdobný tanierik). Vzorky obrazov boli analyzované oboma metódami, zatiaľ čo ozdobný tanierik bol analyzovaná len metódou PIXE. Vzorka na rádiouhlíkové datovanie obrazu od autora Frey bola odoberaná z drevovláknitej dosky, na ktorej bol obraz namaľovaný. Rádiouhlíkový vek tejto vzorky bol určený na 327 BP, čo by s najväčšou pravdepodobnosťou zodpovedalo intervalu

rokov 1412 –1695. Druhá vzorka bola odoberaná z dreveného rámu obrazu „Kvety a ovocie“a interval bol určený 1965 –1967. PIXE metóda bola využitá na všetky pigmenty nanesené na vzorkách. Samotné zloženie sa líšilo aj pre rovnaké farby v rámci všetkých vzoriek. To nasvedčuje tomu, že na vzorkách boli nanesené rôzne pigmenty. Z hľadiska prvkovej analýzy v prípade prvého obrazu najzaujímavejší pigment bol červený, ktorý obsahoval relatívne vyššie množstvo ortuti (14,1 ± 0,7 %). Druhý obraz mal relatívne vyššie koncentrácie bária vo viacerých farbách a ozdobný tanierik zase kobalt v modrom pigmente (0.36 ± 0,06 %) a olovo v glazúre.

ID:123# Využitie programu Algodoo vo vyučovaní fyziky

Author: Ľubomír Varchol

Co-author: Klára Velmovská

Táto práca sa zameriava na využitie programu Algodoo vo vyučovaní fyziky. Algodoo poskytuje učiteľom fyziky možnosť doplniť experimenty realizované na hodinách fyziky počítačovým modelom alebo, v prípade potreby, niektoré experimenty úplne nahradiť, najmä v oblastiach mechaniky a optiky. Súčasťou práce je vytvorenie konkrétnych modelov a aktivít pre žiakov, ktoré podporujú rozvoj ich zručností a vedú ich k objavovaniu kľúčových fyzikálnych vzťahov a zákonitostí.

ID:124# From Noise to Readable Images: Eavesdropping on Computer Screens via Custom Hardware and Deep Learning Image Reconstruction

Authors: Filip Tuch[1]; Richard Ostertág[1]

[1] *Comenius University*

A computer transmits visual information to a monitor as a continuous stream of RGB pixels, with their intensities encoded as voltage levels in the signal traveling through the video cable. The high-frequency voltage transitions of the signals generate unintentional electromagnetic emissions, which can be intercepted and used to reconstruct the displayed image. Under standard conditions, using conventional software-defined radios with the TempestSDR software, such reconstruction is only feasible at very short distances, typically below one meter. This work presents methods to extend both the range and the quality of these reconstructions. By employing a directional Yagi–Uda antenna, a low-noise amplifier, and a band-pass filter, we increased the effective capture distance to approximately 20 meters. To further enhance image quality, we automated the dataset generation process, creating a large dataset representing typical computer usage scenarios. We trained two image restoration convolutional neural networks, DRUNet and DnCNN, and achieved improvements across all tested image quality metrics. Additionally, we integrated the trained models into TempestSDR, making high-quality image reconstruction easier for users. Our findings demonstrate the potential vulnerability of display devices and emphasize the need for preventive measures to enhance their security.

Významné výsledky z matematiky, fyziky, informatiky a didaktiky

ID:125# Topology of manifolds

Author: Tibor Macko

Co-authors: Ajay Raj ; Marián Poturnay ; Samuel Kalužný ; Serhii Dylda

We present selected results from the work in the topology group at KAG FMFI UK supported by the grant VEGA 1/0425/25. The main focus is on the results of the PhD student Ajay Raj, who defended his thesis in August 2025. His work is located in surgery theory which is a specific way of approaching classification problems of topological and smooth manifolds. His aim was to calculate the so-called surgery structure sets of manifolds which are total spaces of $S4k-1$-bundles over $S4k$. The topological structure set classifies topological manifolds equipped with homotopy equivalences to the total space of the bundle up to homeomorphism. The smooth structure set does the same for smooth manifolds up to diffeomorphism. The objective was to calculate the topological structure set and determine which of the elements in it can be realized as such bundles. Furthermore, the forgetful map between smooth and topological versions of structure set was completely determined. We briefly mention other work in the group, some of which will also be presented in other posters.

ID:126# Towards the minimal effective theory for leptogenesis, dark matter, and neutrino masses

Authors: Tomáš Blažek[1]; Peter Maták[1]; Ján Ramaj[1]; Martina Sabová[1]

[1] *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava*

We present a bottom-up approach to an effective theory that simultaneously explains the matter–antimatter asymmetry via leptogenesis, the dark matter relic abundance via freeze-in or freeze-out mechanisms, and neutrino masses via the Weinberg operator. We show that, in the minimal scenario, only two new particles and a single portal operator coupling the visible and dark sectors are sufficient beyond the Standard Model. This contribution is primarily based on arXiv:2504.15164.

ID:127# Innovative Approaches to Teaching Probability in Secondary Schools

Authors: Michaela Vargova; Peter Vankus

In this paper, we present innovative approaches to teaching probability that were developed as part of the KEGA 037UK-4/2024 project Innovative learning technologies in the preparation of future mathematics teachers and the project Digital Transformation of Education and Schools (DiTEdu, code ITMS2014+: 401402DVR6). These approaches aim to foster a deep conceptual understanding of probabilistic concepts through their gradual constructivist development, with an emphasis on

visualization, manipulative activities, and experimentation. The topics covered include conditional probability, geometric probability, and expected value.

ID:128# Addition is almost all you need: Compressing neural networks with double binary factorization

Author: Vladimir Boza[1]

Co-author: Vladimir Macko

[1] *Comenius University*

Binary quantization approaches, which replace weight matrices with binary matrices and substitute costly multiplications with cheaper additions, offer a computationally efficient approach to address the increasing computational and storage requirements of Large Language Models (LLMs). However, the severe quantization constraint (± 1) can lead to significant accuracy degradation.
In this paper, we propose Double Binary Factorization (DBF), a novel method that factorizes dense weight matrices into products of two binary (sign) matrices, each accompanied by scaling vectors. DBF preserves the efficiency advantages of binary representations while achieving compression rates that are competitive with or superior to state-of-the-art methods.
Specifically, in a 1-bit per weight range, DBF is better than existing binarization approaches. In a 2-bit per weight range, DBF is competitive with the best quantization methods like QuIP\# and QTIP. Unlike most existing compression techniques, which offer limited compression level choices, DBF allows fine-grained control over compression ratios by adjusting the factorization's intermediate dimension. Based on this advantage, we further introduce an algorithm for estimating non-uniform layer-wise compression ratios for DBF, based on previously developed channel pruning criteria.

Poster session + káva: prezentácie študentov Matematika

ID:12# Matched Asymptotic Analysis of the Luria–Delbrück Distribution in a Reversible Fluctuation Assay

Authors: Anna Hlubinova[1]; Pavol Bokes[1]

Co-author: Abhyudai Singh [2]

[1] *Comenius University Bratislava*

[2] *University of Delaware, USA*

We study a fluctuation test where cell colonies grow from a single cell to a specified population size before undergoing treatment. During growth, cells may acquire resistance to treatment and pass it to their offspring with a small probability. Unlike the classical Luria–Delbrück test, which assumes irreversible resistance, our model allows resistant cells to revert to a drug-sensitive state. This modification, motivated by recent research on drug resistance in cancer and microbial cells, does not alter the central part of the Luria–Delbrück distribution, where the Landau probability density function approximation remains applicable. However, the right tail of the distribution deviates from the power law of the Landau distribution, with the correction factor given by the Landau cumulative distribution function. Using singular perturbation theory and asymptotic matching, we derive uniformly valid approximations and describe tail corrections for populations with different initial cell states.

ID:77# Homotopy type of G/TOP and G/O

Author: Marian Poturnay

The classification of smooth structures on a manifold X is a classical problem in topology. Surgery theory provides a framework for solving this problem by calculating the structure set of X. One of the steps in this process involves finding normal invariants, which can be represented by a homotopy class of maps from X to the space G/O. A similar notion exists in the TOP category, in which the space G/TOP plays a central role. In this work, we study the homotopy types of both G/TOP and G/O, with the aim of applying these results to the study of lens spaces.

ID:104# Classification of smooth manifold structures on products of CP(n) with a k-dimensional disk

Authors: Samuel Kaluzny; Tibor Macko

This project is concerned with the problem of classifying different smooth structures admitted by a smooth manifold up to homotopy. This classification is made possible by the tools of surgery theory and is summarized in the notion of the smooth structure set $\mathcal{S}^{DIFF}(X)$ of a smooth manifold X. We focus on cases when X is the product of the complex projective space with a k-dimensional disk. As a result, we obtain a full classification in dimensions $n, k \leq 6$. By comparing these results to

known computations of the topological structure set $\mathcal{S}^{TOP}(\mathbb{C}P^n \times D^k)$ we obtain examples of "exotic" topological manifolds, that is manifolds with no admissible smooth structure.

Poster session + káva: prezentácie študentov Fyzika

ID:14# Verification of photometric transformations for small Solar System bodies on Main-Belt asteroid color data

Author: Vitalii Kuksenko[1]

Co-authors: Eva Lilly [2]; Jiří Šilha [1]; Peter Jevčák [1]

[1] *Comenius University*

[2] *Planetary Science Institute*

The light reflected from the surface of solid celestial bodies like asteroids contains information about chemical composition, physical and structural properties of their near-surface material. Measurements of this reflected light through different broadband photometric filters enable us to study color properties of minor bodies. Color-color diagrams, constructed from photometric color indices, help to group minor planets into different taxonomic classes, which provide insights on origin, physical and dynamical evolution, and mutual relations of small Solar System bodies.

However, interpretation of the results is complicated because different observers use different combinations of detectors, filters and telescopes, meaning that the colors of observed objects are derived in different photometric systems. The two most popular photometric systems are Johnson-Kron-Cousins and Sloan systems. While older observations of minor planets have been mostly obtained in the Johnson-Kron-Cousins system, most modern professional observatories and surveys utilize the Sloan photometric system. The passbands of these two systems do not match each other, which makes it problematic to calibrate archive and new color data. There are many different transformation equations between these two systems, but most of them were derived for stellar and galactic communities. Unfortunately, there are no explicit relations for small Solar System bodies, and there is still no consensus among the minor planet community on which transformations are more accurate.

The aim of our work was to asses the validity of existing transformations applied on small bodies' observations. For this purpose, we observed the chosen bright Main-Belt asteroids and Centaurs in both Johnson-Kron-Cousins and Sloan photometric systems using the AGO 70 cm optical telescope located in Modra, Slovakia. In this poster, we will compare the results obtained from our observations and from photometric transformations applied on our collected data. We checked several sets of transformation equations found in literature. We will present our conclusions and show the application of the most suitable transformation relations on archive data on Centaurs obtained by various large telescopes in the past.

The results of our work are useful to the whole minor planet community and will be applicable on different types of small Solar System bodies: near-Earth asteroids, Main-Belt asteroids, Centaurs, etc. The transformations are especially interesting in the perspective of future Vera Rubin Observatory (VRO), which will implement the photometric system similar to the Sloan and provide exceptional data on physical and color properties of small Solar System bodies. Our validated transformations will allow the community to reliably compare the new VRO data with archive measurements.

ID:114# Impact of Air Humidity, Reactor Geometry and AC/DC Power on Electrical and Chemical Characteristics of Discharge in Honeycombs

Author: Gokul Selvaraj

Co-authors: Karol Hensel ; Ramavtar Jangra

Abstract
Car exhaust treatment is essential for mitigating harmful environmental and health effects caused by emissions from car engines. A usual approach for car exhaust emission control is the use of honeycomb monoliths integrated with advanced catalytic materials. Catalytic systems are widely used in diesel and car exhaust treatment due to their large surface area and effectiveness in converting harmful pollutants. Traditioemphasized textnally, these systems rely on thermal energy to drive catalytic reactions. However, integrating non-thermal plasma (NTP) technology into these reactors offers a promising alternative. It reduces dependence on thermal energy while significantly enhances reaction rates and pollutant removal efficiency [1]. NTP enables accelerated chemical transformations under varied operating conditions such as gas composition, humidity, and flow rate, making it a versatile and energy-efficient solution for modern exhaust treatment applications.

The present investigation examines the effects of reactor geometry and critical operating parameters on the stabilization of plasma discharge within a honeycomb monolith reactor. Experiments were conducted at different gas flow rates and relative air humidity levels to characterize discharge behavior. Comparative analyses of AC and DC power sources were performed to evaluate energy efficiency and to identify conditions capable of sustaining a stable and intense plasma discharge with minimal power input. Upon achieving discharge stabilization, the generation and chemical composition of reactive species were systematically analyzed using FTIR spectroscopy, allowing for the elucidation of underlying reaction mechanisms between plasma-generated species and volatile organic compounds. Building upon the optimized operating conditions, the reactor design was further scaled up through the incorporation of a second honeycomb monolith. This two-stage configuration is intended to expand the active discharge region and enhance the residence time of gas-phase molecules, thereby improving overall treatment efficiency.

Acknowledgement
This work was funded by Slovak Research and Development Agency APVV-20-0556 and by EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V02-00036.

Reference

[1] S. Saud, D. B. Nguyen, R. M. Bhattarai, N. Matyakubov, V. T. Nguyen, S. Ryu, H. Jeon, S.B. Kim, Y.S. Mok, Journal of Hazardous Materials 426 (2022) 127843

ID:58# Optical study of the interaction between Transient Spark and Electrospray

Authors: Peter Toth[1]; Sergei Smirnov[None]

[1] *Comenius University Bratislava*

Transient spark (TS) produces high concentrations of reactive oxygen and nitrogen species (RONS). Solvation of these gaseous molecules in water promotes various environmental applications. The solvation can be enhanced by an electrospray (ES), directly in TS discharge zone. In this work, we focus on the precursors of RONS, investigating the time resolved optical emission spectra of TS w/wo ES. The ES has no significant effect on the lifetime of the studied species, but showed alterations in relative emission intensities. TS with ES increases the iron ion emission intensity, enhancing electrode erosion. Furthermore, the plasma-water interface was examined using ultrafast imaging. The results showed mutually influenced TS and ES generation, and a complex behavior of ES, with a prolonged water accumulation on the electrode.

ID:67# Absorption spectroscopy of radicals produced by atmospheric-pressure discharges

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Absorption spectroscopy utilising an optical cavity represents a technique frequently employed for the purpose of investigating particle concentration, particularly in the context of analysing gases and atmospheric conditions. However, its use for investigating phase interfaces, particularly in the context of plasma discharges, is less well studied. The utilisation of incoherent broadband light in this technique confers several advantages, including in situ analysis and detection of particles at low concentrations, thereby facilitating a more profound comprehension of the chemical-kinetic processes in plasmas. Recent investigations suggest the significant potential for the application of non-thermal plasmas, particularly. Consequently, the focus of our experimental endeavours is directed towards the air-plasma interface. The present experiments are focused on the use of a detector under development using absorption spectroscopy enhanced by an optical cavity with a broad-spectrum light source (so-called IBB-CEAS - Incoherent Broad Band Cavity Enhanced Absorption Spectroscopy) for in situ plasma analysis. The primary focus of our research endeavours pertains to the detection of NO_2 and NO_3 radicals, the meticulous monitoring of temporal changes in their concentrations during the discharge process, and the development of a chemical-kinetic model to facilitate a more profound comprehension of the experimental data. NO_2 and NO_3 are of particular significance in the domain of atmospheric chemistry, particularly during nocturnal periods. The detection of these substances in plasma discharge, in particular NO_3, is a challenging process due to their high reactivity and low concentration. Consequently, the primary focus of our laboratory is the detection of these specific radicals and the potential optimisation of plasma sources for NO_3 production, which represents a potential practical application of our detector.

ID:56# Study of transient spark using schlieren imaging

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Transient spark (TS) a pulsed, atmospheric-pressure discharge transitioning between non-equilibrium and equilibrium plasma is important for applications like sterilization. This work focuses on optical diagnostics of the TS is high-speed gas-dynamic behavior. We employed high-speed schlieren imaging to visualize gas density gradients, complemented by numerical simulations of the electric field. Preliminary schlieren results identify three phases: a pre-discharge (initial heating, ionic wind), the main discharge (spark channel formation, shockwave), and a post-discharge (shockwave expansion, heat flux decomposition).

ID:92# Optimisation of the lithography and pyrolysis process of su-8 resist for fabrication of conductive microstructures

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This work presents the fabrication and characterization of carbon microstructures from SU-8 photoresist by rapid thermal pyrolysis. The aim was to optimize lithography
and pyrolysis parameters to obtain conductive microstructures for sensor use. Structures were prepared on Si/SiO_2 and Al_2O_3 substrates and pyrolyzed up to 1200 ℃
in nitrogen. The effect of temperature and dwell time on electrical properties was studied, showing that higher temperatures and longer dwell times lower electrical
resistance. The results confirm rapid thermal pyrolysis as an efficient, low-cost method for producing carbon microelectrodes for sensor applications.

ID:47# Analysis of Low-Temperature Plasma Treatments on Polymer Surface Properties

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Polymeric materials are widely used across industries due to their low weight, high mechanical strength, chemical resistance, and cost-effectiveness. Despite these advantages, most polymers exhibit low surface energy and hydrophobicity, which limit their performance in applications such as coating, adhesion, painting, and composite interfaces [1]. Consequently, surface modification has become essential to enhance polymer functionality. The modification of polymer surfaces using low-temperature plasma (LTP) treatments has attracted significant attention due to its effectiveness in improving surface properties without altering bulk characteristics [2]. However, the desired surface changes on the polymer substrate induced by plasma treatment are not permanent and gradually revert to the initial state. This behaviour is called hydrophobic recovery or the ageing effect. It depends on many parameters, such as the properties of the polymer substrate, the type of plasma source, plasma treatment conditions, and storage conditions. The relationship and mutual effects of these conditions on the stability of plasma-induced changes and the rate of hydrophobic recovery are still not fully understood.
In this study, we investigate low-temperature plasma treatments of the surface properties of polyamide (PA), polypropylene (PP), and polycarbonate (PC). Two plasma systems, Diffuse Coplanar Surface Barrier Discharge (DCSBD) [3,4] and Piezobrush PZ3 [5], were employed to assess their effectiveness in modifying surface free energy, wettability, and chemical composition. Surface characterisation was conducted using Water Contact Angle (WCA) measurements and Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR). The ageing effect was monitored under three different storage conditions: water, vacuum, and ambient room temperature. The results demonstrate that both plasma treatments significantly enhance surface energy and wettability for all polymers, accompanied by chemical modifications that improve surface functionality. The study of hydrophobic recovery provides a complex view of how individual parameters of plasma treatment (such as plasma source and exposure time), along with different storage conditions, influence the rate and degree of hydrophobic recovery. This analysis offers valuable insights for selecting suitable plasma sources in polymer surface engineering applications, including adhesion improvement, coating, and biocompatibility enhancement.

Keywords
Low-temperature plasma, Polymers, DCSBD, hydrophobic recovery, surface modification

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ID:61# Reactive species stability in plasma-activated water generated by different atmospheric pressure plasmas

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Abstract

Because of their unique components, particularly reactive oxygen and nitrogen species (RONS), non-thermal plasma and plasma-activated water (PAW) are used in a wide range of applications. PAW is mostly used in food safety [1] and biomedical applications [2], agriculture, and surface treatment and alterations [3]. Even though a lot of study has been done on the use of PAW [4], understanding the stability and temporal development of reactiveness in PAW is essential.
In this work, three distinct plasma setups—Transient Spark (TS) batch water treatment, Transient Spark-Electrospray (TS-ES), and Fountain Dielectric Barrier Discharge (FDBD)—are employed to generate PAW using both tap and deionized (DI) water. TS and TS-ES use DC high voltage and operate in pin-to-plane geometries. For each, the spark pulse frequency and gap distance are set at 1 kHz and 1 cm, respectively. For TS-ES, a flow rate of 0.5 ml/min was established, while batch TS treated 10 ml for 10 minutes. We utilized a neon-sign AC high-voltage power source with 15 kV pk-to-pk and 20 kHz for FDBD, and we cycled 1 L of water for 20 minutes. PAW characteristics, including the RONS (H_2O_2, O_3, NO_2^-, and NO_3^-) concentrations and pH, electric conductivity (EC), oxidation reduction potential (ORP), temperature, and total dissolved solids (TDS), were investigated in short and long times after plasma treatment. For a short time, the behavior of physiochemical characteristics of water was measured in the first 24 hours (0, 2, 4, 8, 12, and 24 hours) after treatment and 1, 2, 4, 8, 16, and 30 days after treatment for long-term stability. The results show that RONS in naturally buffered tap water are more stable than in DI water; however, most of the RONS disappear after 10 days in tap water. All reactions between RONS occur faster in the acidified DI. NO_3^- is the only species that stays in tap and DI water after a long time.

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ID:93# Theoretical investigation of plasma induced degradation of chlorpyrifos

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Chlorpyrifos (O,O-diethyl O-3,5,6-trichloro-2-pyridyl phosphorothioate) is one of the harmful pesticide that persist long time in the environment and effect human health [1]. As a result of its accumulation in the environment and the effect it causes on human health its degradation into non-harmful substances is of high importance. In recent days, Plasma assisted degradation that involves

highly energetic species such as radicals, ions to induce molecular fragmentation is emerging as an effective method for their removal.

In this work, Potential energy surface (PES) scans were performed to identify the most stable conformer of chlorpyrifos by systematically varying key dihedral angles [2]. Then, degradation mechanisms were identified by modelling the reaction pathways of atomic oxygen and nitrogen radicals with chlorpyrifos. Degradation studies revealed that, under radical attack chlorpyrifos gets converted into reactive intermediates and fragmentation into less harmful products. Further, potential protonation sites were identified by the calculation of proton affinities, relevant for charge transfer reactions identified in positive corona discharge. In addition to radical attack and protonation, attachment of water clusters to chlorpyrifos has also been studied to understand the structural stability and also to explore other possible degradation pathways.

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ID:63# Datovanie artefaktov s využitím rádioaktívneho uhlíka ^{14}C a stanovenie prvkového zloženia pigmentov metódou PIXE

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Určenie veku artefaktov s presnosťou na niekoľko desaťročí v závislosti od veku vzorky, je dnes možné vďaka rádiouhlíkovému datovaniu a použitiu vysokocitlivej urýchľovačovej hmotnostnej spektrometrie. Datovanie pomocou rádiouhlíka využíva koncentráciu ^{14}C na určenie veku vzorky a patrí medzi deštruktívne analytické metódy. Táto metóda v minulosti pomohla s odhaľovaním falzifikátov a ochranou kultúrneho dedičstva. Ďalšou často využívanou metódou pre tieto účely je prvková analýza pigmentov vykonaná metódou PIXE (z angl. particle induced X-ray emission). PIXE je nedeštruktívna analytická metóda založená na analýze energie röntgenových kvánt, ktorá umožňuje presnú identifikáciu prvkov vo vzorke. V práci boli analyzované 3 vzorky (dva obrazy a jeden ozdobný tanierik). Vzorky obrazov boli analyzované oboma metódami, zatiaľ čo ozdobný tanierik bol analyzovaná len metódou PIXE. Vzorka na rádiouhlíkové datovanie obrazu od autora Frey bola odoberaná z drevovláknitej dosky, na ktorej bol obraz namaľovaný. Rádiouhlíkový vek tejto vzorky bol určený na 327 BP, čo by s najväčšou pravdepodobnosťou zodpovedalo intervalu rokov 1412 –1695. Druhá vzorka bola odoberaná z dreveného rámu obrazu „Kvety a ovocie“a interval bol určený 1965 –1967. PIXE metóda bola využitá na všetky pigmenty nanesené na vzorkách. Samotné zloženie sa líšilo aj pre rovnaké farby v rámci všetkých vzoriek. To nasvedčuje tomu, že na vzorkách boli nanesené rôzne pigmenty. Z hľadiska prvkovej analýzy v prípade prvého obrazu najzaujímavejší pigment bol červený, ktorý obsahoval relatívne vyššie množstvo ortuti (14,1 ± 0,7 %). Druhý obraz mal relatívne vyššie koncentrácie bária vo viacerých farbách a ozdobný tanierik zase kobalt v modrom pigmente (0.36 ± 0,06 %) a olovo v glazúre.

ID:88# Fluorescence emission of CO induced by electron impact

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Emission spectroscopy is particularly valuable in space exploration, as it enables remote analysis of planetary atmospheres, cometary comas, and nebulas irradiated mainly by nearby stars. In comets, atomic sulphur can be stored inside the dust grains or as part of volatiles in the form of OCS, H_2S, SO, S_2 or CS_2 [1, 2]. The comet's sulphur inventory is closely linked to the pre-solar cloud and holds important information about the degree of reprocessing of the material in the solar nebula and during comet accretion. Fluorescence emission spectra of CS_2 were obtained after electron impact at several electron energies. The spectrum measured at 100eV shows a prominent emission from the CS_2^+ ($\tilde{A}^2\Pi_u$–$\tilde{X}^2\Pi_g$) emission band. A few features of the CS_2^+ ($\tilde{B}^2\Sigma_u^+$–$\tilde{X}^2\Pi_g$) emission band were detected below 300 nm, and in the near-infrared region, the emission lines of CI, CII, SI, and SII were identified. Meanwhile, the emission spectrum measured at 10eV shows solely the emission from neutral CS_2 ($1\Delta_u$(V1B$_2$)–$X^1\Sigma_g^+$) emission band, which spreads from 320~nm to 800~nm. There is no signal from ionized CS_2^+, as the ionization energy of CS_2 is 10.073eV [3].
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ID:95# Preselection of emission lines for future CF LIBS analysis of the suitable fusion devices first wall material

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CF-LIBS is a proven effective method for elemental analysis of metal alloys. EUROFER97's development began more than 25 years ago as a replacement for radiologically undesired elements like Mo, Nb, Ni and Co with their lower-activation counterparts like Ta, W, Mn, and V. The addition of about 0.2 wt% of V improves creep strength and impact behavior, whereas about 1 wt% of W can acts as strengthening element [1]. The nominal composition is approximately 0.11% C, 9.0% Cr, 1.1% W, 0.4% Mn, 0.2% V, 0.1% Ta, and 89.09% iron (Fe).
EUROFER is the European structural candidate for future fusion devices wall material. Its development included several boundary conditions such as lifetime at operational conditions at elevated temperatures and neutron irradiation, environmental and economic issues. The current EUROFER material development tries to find an optimum temperature by thermodynamically guided alloying, thermal treatment, and microstructural optimization.
This work involves a preliminary evaluation of the emission lines of the elements in the EUROFER. This preliminary evaluation consists of determining the optimal emission lines for studying the concentrations of the elements using the LIBS technique. Their selection was based on the following properties:

The lines must be inferefernce free, uneffected by other emission lines and should not be self-absorbed, which could contribute to an error. The preselection of the suitable lines of the considered elements and degree of ionization for CF-LIBS analysis is crucially important. The emission lines and their parameters were ontained from the NIST LIBS database[2].

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ID:98# Study of Laser-Induced Plasma Dynamics with Rapid Imaging and Shadowgraphy in an Acoustic Levitation System

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Laser-induced breakdown spectroscopy is a well-known analytical technique with a huge potential for characterization of materials in all three states of matter. It enables quick remote analysis without time-consuming sample preparation. The temporal evolution of plasma in liquid samples due to the nature of liquid itself provides further challenges. Plasma produced by a laser pulse (PPL) in liquid samples, unlike the one in solids, exhibits some difficulties during the plasma formation such as splashing, quenching and plasma duration. For solids, plasma created by laser ablation is generated on the surface of a target. However, in the case of a liquid which is usually transparent to the light source, plasma can be formed on the surface and within the liquid. Hence, the dynamic of the plasma in liquids could change depending on the PPL location.

LIBS on liquids using an acoustic levitation system has recently been reported. This device allows droplets to be suspended in the air to perform analytic determinations with LIBS technique. This approach is called LIBS-AL.

To study droplet dynamics the fast-photo and shadowgraphy techniques were integrated into LIBS-AL setup. Temporal evolution of plasma in liquids was recorded for different focal distances. Both techniques employ a secondary fast camera in addition to an spectrometer, with both cameras simultaneously triggered by the laser. Two separate images were captured: one for the shadow of the levitated sample and another for the ablated plasma. The results indicate variations in the ablated material depending on delay time and focal distance (fluence). Delay times corresponding to the maximum ablated mass were identified.

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ID:111# Rapid Degradation of Coumarin via In Situ Hydroxyl Radical Generation Induced by Recycled Gas from a DBD Plasma

Bubble Reactor

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Coumarin, a fluorescent aromatic compound widely used in dyes, pharmaceuticals, and optical brighteners, is frequently detected in industrial effluents and poses ecological risks due to its persistence, phototoxicity, and potential bioaccumulation in aquatic environments 1. This study presents a novel approach for the rapid degradation of coumarin using recycled gas from a dielectric barrier discharge (DBD) plasma bubble reactor. The DBD plasma device consists of a coaxial geometry (150 mm length, 15 mm outer diameter) with two quartz tubes forming a 1.5 mm discharge gap where plasma is generated. The complete experimental setup is shown in Fig. 1(a). The reactor is immersed in water, allowing reactive oxygen and nitrogen species (RONS) to be transferred into the liquid phase via plasma bubbles, while gas-phase species such as ozone are recycled to a secondary reactor containing the pollutant solution. These recycled oxidants, mainly ozone and hydrogen peroxide, react to generate hydroxyl radicals in situ, accelerating coumarin degradation.

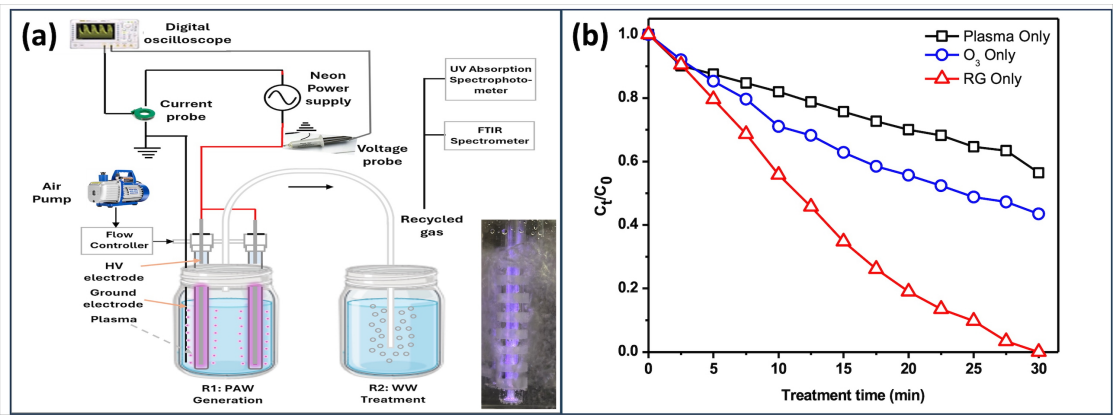

Figure 1: enter image description here

Fig. 1. (a) Complete experimental setup for coumarin degradation, (b) Degradation profile of coumarin under three different treatment conditions.
The performance was evaluated under three conditions: (i) plasma bubbling, (ii) recycled gas treatment, and (iii) ozonation alone. Hydroxyl radicals were quantified in all cases using a terephthalic acid fluorescence probe, revealing that the secondary reactor with recycled gas diffusion produced the highest radical concentration, correlating with the maximum degradation. Among these, the recycled gas system achieved 99% degradation within 25 minutes, demonstrating superior efficiency, as shown in Fig 1(b). The presence of excess nitrogen species in the primary plasma zone reduced degradation efficiency compared to ozone alone, emphasizing the role of optimized gas recycling in enhancing plasma-based oxidation.
This work was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V03-00033 EnvAdwice.
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ID:112# Detection of Indoor Ketones Using Ion Mobility Spectrometry with Air as Carrier Gas

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Indoor air quality is a critical factor in occupant health,safety and building performance, making it a key concern in civil engineering and sustainable construction. Volatile organic compounds (VOCs), particularly ketones such as 2-hexanone, 3-hexanone, 2-heptanone, and 3-heptanone, are commonly emitted from building materials and finishing products.

This study applies Ion Mobility Spectrometry (IMS) with corona discharge ionization (CDI) operated in positive mode for the rapid detection of these ketones. Vapors were generated from the headspace of a small, sealed bottle, diluted into a 1000 mL container, and introduced into the IMS using a syringe pump at a controlled flow rate of 100 $mL \cdot min^{-1}$ with air as the carrier gas. The IMS operated under the following conditions: drift tube length 11.93 cm, electric field intensity 670.6 $V \cdot cm^{-1}$, pressure 621 mbar, temperature 378 K, drift gas flow 600 $mL \cdot min^{-1}$, and shutter grid frequency 16 Hz.

Detection limits were below 50 ppb, demonstrating IMS capability for trace-level monitoring. Compared to chromatographic methods, IMS offers high sensitivity, sub-second response, and minimal sample preparation. These findings support IMS integration into smart building systems for real-time air quality assessment.

Keywords: Ion Mobility Spectrometry, Indoor Air Quality, VOCs, Civil Engineering, Sustainable Buildings.

Acknowledgment
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ID:108# Comparison of two gridded climatological observation-based datasets for use in climate projections development

Author: Nikola Kristekova

Future climate projections are based on future climate simulations by numerical climate models. Model performance is evaluated by comparing historical model simulations against observations. As model simulations are gridded, gridded observation-based datasets are widely used as the evaluation reference. These datasets can be created either by interpolation of station observations, or by using station observations as input into numerical weather prediction models producing reanalyses (simulated gridded 'observations'). Specifics of the method used to create a gridded observation-based dataset (e.g. interpolation method, NWP model) cause individual datasets to differ, leading to uncertainty in climate model evaluation. For credible model evaluation and therefore credible future climate projections, it is important to asses this uncertainty. Additionally, this uncertainty can be reduced by avoiding the use of gridded datasets which show large inconsistencies with station observations.

In this work, two gridded temperature and precipitation datasets available for Slovakia are compared - CARPATCLIM (gridded observations) and ERA5-Land (reanalysis). Furthermore, the two datasets are evaluated against selected Slovak station observations. Results show that there are significant differences between the two datasets, with CARPATCLIM corresponding to station observations to a considerably greater degree than ERA5-Land.

ID:83# Low-energy electrons interaction with acetone $(CH_3)_2CO$ in the UV-Vis spectral region

Author: Gadisa Deme Megersa[1]

Co-authors: Stefan Matejcik [1]; Enmily .L. Garcia Angulo [1]; Országh Juraj [1]; Barbora Stachová [1]

[1] *Fakulta matematiky, fyziky a informatiky (Univerzita Komenského v Bratislave)*

This study investigates electron collisions (10 –100 eV) with molecular species using emission spectroscopy processes that are fundamental to the chemistry of extraterrestrial environments. Electron-induced chemistry, in which low-energy electrons interact with molecules, plays a crucial role in the study of objects in space and has significant implications for astrochemical research. At the Laboratory of Electron-Induced Fluorescence (LEIF), Comenius University in Bratislava, we recorded the optical emission spectra of acetone under 50 eV electron impact 1. Prominent spectral features, namely the hydrogen Balmer series, the Swan system, and the CH ($A^2\Delta$–$X^2\Pi$) emission band, were observed in the 280–950 nm wavelength range. Using electron-induced fluorescence, we analyzed the electronic, vibrational, and rotational states of acetone through its emitted radiation. These measurements also provided insight into dissociation and ionization processes and enabled the determination of emission cross-sections. Given acetone's high abundance in astrophysical environments, where it can form or be modified through electron-driven reactions, our results have important astrochemical relevance. The 380 –445 nm region, identified as the most active part of the spectrum, was recorded at higher resolution and corrected for instrumental sensitivity. Individual rotational transitions from the P, Q, and R branches of CH fragments were clearly resolved.

Acknowledgment
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Reference

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ID:39# Determination of Biogenic Carbon Fraction in Liquid Fuels by Accelerator Mass Spectrometry

Author: Boris Bobal

Co-authors: Ivan Kontul ; Jakub Kaizer [1]; Jakub Zeman ; Miroslav Jeskovsky ; Pavel P. Povinec

[1] *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava*

Reliable quantification of the biogenic carbon content in liquid fuels is needed to satisfy EU renewable-fuel requirements (Directive (EU) 2018/2001). Accelerator-mass spectrometry (AMS) provides a fast, self-consistent, and well-validated approach to distinguishing fossil from biogenic carbon, fully in accordance with ASTM D6866-2024 Rev A and EN 16640 standards.

In this study, we employ a sealed-tube oxidation procedure in which samples are heated to 550℃ in a muffle furnace for 12 hours in the presence of MnO_2, oxidising all presented carbon to CO_2. The produced CO_2 is then cryogenically purified (a water trap cooled to -30℃, followed by a liquid nitrogen trap) while graphite is converted in a catalysed graphitisation reactor.

Our liquid test matrix comprises alcohol (e.g., ethanol and isopropyl alcohol with their blends) for verification of our method. Liquids of purely fossil and purely biogenic origin were used to prepare additional samples with varying proportions of the biogenic component. The samples included commercially available diesel (B7) and petrol (E10), representing different fractions of biogenic carbon

content. Biogenic fractions were determined with respect to a constant-contamination model, and the associated standard deviation was evaluated. The biogenic carbon content in analysed samples ranged from 4.5 ± 0.2 % to 5.7 ± 0.3 %.
The obtained results demonstrate that the sealed-tube MnO_2 combustion method coupled with ^{14}C and ^{13}C AMS analyses delivers a reliable, precision experimental approach for routine certification of biofuel blends, thereby supporting the regulatory compliance and sustainability initiatives in the automotive sector.

Keywords: AMS; ^{14}C; Biofuels; Combustion; MnO_2; Blend-Ratio Determination

Poster session + káva: prezentácie študentov Informatika

ID:86# Analysis of the spaceweathering effect on the surface of satellites and space debris

Author: Katarína Sabolová[1]

[1] *Comenius University in Bratislava*

Space weathering impacts all objects exposed to the space environment, including artificial satellites and space debris. Exposure to high-energy solar particles, micrometeoroids, and atmospheric particles degrades surface materials through oxidation, erosion, and paint peeling, producing wavelength-dependent changes detectable with observations in Johnson-Cousins photometric bands.
These effects were investigated through two observational campaigns targeting artificial space objects. The short-term campaign monitored recently launched CZ-3B rocket upper stages in geostationary transfer orbits over the course of eight months, while the long-term campaign focused on active GEO satellites annually over four years. The two groups differ in both material composition (painted metal vs. multi-layer insulation) and orbital environment.
Results show two distinct color index trends: GEO satellites exhibit darkening and spectral reddening consistent with the aging of multilayer insulation materials (e.g., Kapton, Mylar), whereas CZ-3B upper stages show brightening and spectral bluing, attributed to white paint flaking off and revealing the highly reflective metal surface underneath, accelerated by interactions with atomic oxygen. Differences between the two populations can be attributed to variations in material type, exposure duration, and orbital altitude.

ID:80# Total colouring of (sub)cubic Halin graphs

Authors: František Kardoš; Matúš Matok[1]

[1] *Comenius University, Bratislava*

A Halin graph is a planar graph consisting of a tree and an additional cycle connecting all the leaves in such manner that no two edges are crossing.

Total colouring of a graph is a mapping from the set of vertices and edges to a set of colours such that no two neighbouring objects receive the same colour.

As there were only 4 known cubic Halin graphs with total chromatic index greater than 4, a natural question of whether the number of such graphs is finite had arisen.

We managed to prove that the set of cubic Halin graphs with total chromatic index greater than 4 is finite, containing only the cubic Halin graphs known before-hand. By a slight modification of our approach, we managed to establish similar results for total and also AVD-colouring of subcubic Halin graphs.

ID:44# Usefulness of information for regular languages

Authors: Andrej Ravinger; Vincent Hlaváč

We continue the research of the notion of usefulness of information.
We formalize a problem by a regular language L and we measure its complexity using the state complexity of the minimal automaton A accepting the language L.
A language L_{adv} provides a useful supplementary information about the problem, if it allows us to solve the problem easier, i.e., if it allows us to find an easier problem L_{new} such that $L = L_{adv} \cap L_{new}$. Moreover, we require to check the correctness of supplementary information to be easier than to solve the original problem.
We formalize this concept using the decomposition of the automaton A formed by automata A_{adv} and A_{new} accepting the languages L_{adv} and L_{new}, respectively.
We study the family of all problems for which a given unary language L_A provides useful information.
We also consider decompositions of regular languages bounded by a^*b^* (languages that are a subset of a^*b^*) and we characterize a subclass of these languages upon decomposition.

ID:91# Hybrid Xception-Vision Transformer Model for Automatic Diagnosis and Classification of White Matter Lesions with Explaiable AI Techniques

Author: Fatana Jafari

White matter hyperintensities (WMHs) or lesion in brain MRI are key biomarkers for neurological conditions, but detecting small lesions remains challenging. Existing deep learning models often act as "black boxes,"limiting clinical trust due to lack of interpretability. This study proposes a hybrid Xception-Vision Transformer (XViT) integrated with explainable AI (XAI) methods to enhance small WMH detection and provide interpretable predictions. Preliminary experiments using ResNet50, custom 3D-CNN, and CNN+LSTM models, along with Grad-CAM and LIME for explanation, showed that CNN+LSTM achieved the best performance, offering high accuracy.This work demonstrates the potential of combining advanced DL architectures with XAI to improve small WMH detection and clinical trust.

ID:38# CATS Solver: The Rise of Hybrid Abduction Algorithms

Authors: Jakub Kloc; Janka Boborova; Júlia Pukancová; Martin Homola

The state-of-the-art complete algorithms to solve ABox abduction in DL include the original Reiter's algorithm for minimal hitting sets alongside its more recent updates: Wotawa's HST and Pill and Quaritch's RC-Tree. On the other hand, incomplete methods that quickly find some but not all solutions include Junker's QuickXplain and MergeXplain by Shchekotykhin et al. We present CATS, a new modular ABox abduction solver. It implements all the said algorithms together with the hybrid MHS-MXP, recently introduced by Homola et al., and two new analogous variants: HST-MXP and RCT-MXP, based on HST and RC-Tree, respectively. The user can choose any of the eight algorithms. The solver uses the JFact reasoner as a black box and thus allows any DL expressivity up to $\mathcal{S}, \mathcal{R}, \mathcal{O}, \mathcal{I}, \mathcal{Q}$. The modular implementation served as a test bed for an evaluation and comparison of the implemented algorithms, which we conducted over the LUBM ontology. Out of the complete algorithms, the hybrid ones were proven to find explanations faster, and they were also more memory-efficient.

ID:89# X-MalNet: A Novel Multi-Level eXplainability Framework for Malware Detection Using Matrix Product States (MPS) Tensor Networks

Authors: Peter Anthony[1]; Philip Wilson[2]; Zekeri Adams[1]

[1] *Comenius University in Bratislava*

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We propose X-MalNet, an inherently explainable malware detection framework based on Matrix Product States (MPS) tensor networks. Unlike previous explainability methods that provide fragmented insights, X-MalNet natively generates multi-level explanations from a single coherent architecture. The MPS explicitly learns the joint probability distribution of features and labels, enabling faithful explanations through tensor operations. For binary classification, we model predictions via conditional probability $P(\text{malware}|\mathbf{x})$. From its core tensor decomposition, we derive: (1) exact first-order feature importance scores; (2) second-order feature interactions quantified via the entanglement spectrum from Schmidt decomposition, revealing non-linear logical dependencies; and (3) minimal, precise rule-based explanations extracted analytically by fixing feature values and marginalizing the network. Our preliminary results on the binarized EMBER dataset demonstrate impressive detection performance and capable of providing a holistic suite of faithful explanations without compromising performance.

ID:43# Computational analysis of bacterial plasmids

Authors: Jana Cernikova Bronislava Brejova; Tomas Vinar

Plasmids are small, circular, extrachromosomal DNA molecules commonly found in bacteria. They can be transferred between different bacterial cells through horizontal gene transfer and often carry genes conferring antimicrobial resistance (AMR), making them a critical focus in the study of antibiotic resistance.
The goal of our work is to develop new bioinformatics methods for plasmid detection and comparison, using techniques from machine learning and comparative genomics. We explore computational approaches for classifying plasmid sequences based on high-throughput sequencing data. Using k-mer profiles, various sequence-derived features, and homology-based log-odds scores, we train machine learning models to distinguish plasmid reads from chromosomal ones.
Our dataset, consisting of multiple E. coli isolates, presents significant challenges due to class imbalance – plasmid reads are markedly underrepresented. Experimental results show that data partitioning strategies and isolate-specific differences have a strong effect on classification performance.

ID:99# Stain Busters

Authors: Miriam Grznarova; Zuzana Cernekova; Viktor Kocur; Andrej Ferko; Robert Bohdal; Zuzana Berger Haladova

The preservation of historical documents is a crucial component of cultural heritage protection. One significant threat to these artifacts is the appearance of colored stains, which may originate from biological agents (e.g., fungi, bacteria, insects) or synthetic compounds (e.g., ink stamps, dyes). Currently, conservators rely primarily on subjective visual assessment and invasive analysis to identify the nature of such stains. This poster introduces a novel AI-based solution that utilizes deep neural networks to classify biological and synthetic stains on historical paper with minimal intervention.

ID:100# From Noise to Readable Images: Eavesdropping on Computer Screens via Custom Hardware and Deep Learning Image Reconstruction

Authors: Filip Tuch[1]; Richard Ostertág[1]

[1] *Comenius University*

A computer transmits visual information to a monitor as a continuous stream of RGB pixels, with their intensities encoded as voltage levels in the signal traveling through the video cable. The high-frequency voltage transitions of the signals generate unintentional electromagnetic emissions, which can be intercepted and used to reconstruct the displayed image. Under standard conditions, using conventional software-defined radios with the TempestSDR software, such reconstruction is only feasible at very short distances, typically below one meter. This work presents methods to extend both the range and the quality of these reconstructions. By employing a directional Yagi–Uda antenna, a low-noise amplifier, and a band-pass filter, we increased the effective capture distance to approximately 20 meters. To further enhance image quality, we automated the dataset generation process, creating a large dataset representing typical computer usage scenarios. We trained two image restoration convolutional neural networks, DRUNet and DnCNN, and achieved improvements across all tested image quality metrics. Additionally, we integrated the trained models into TempestSDR, making high-quality image reconstruction easier for users. Our findings demonstrate the potential vulnerability of display devices and emphasize the need for preventive measures to enhance their security.

ID:109# Contrasting Human and Emergent Concepts in Image Classifiers

Authors: Igor Farkaš ; Tamara Bila[1]

[1] *Comenius University Bratislava*

In the age of AI becoming an everyday partner and support tool in both professional and private domains, users and stakeholders are increasingly confronted with the question of interpretability. This work contributes to the search for answers by exploring hidden meanings in the internal layers of convolutional neural networks trained on image classification tasks. Combining supervised concept-based and unsupervised learning paradigms, the goal is to discover semantically meaningful representations that can be contrasted with human-defined concepts (defined once per dataset). More specifically, we extracted layer-wise network-inherent clusters using hierarchical agglomerative clustering. To evaluate their semantic fidelity, we trained auxiliary classifiers on concepts as well as cluster memberships, and evaluated across all layers.
Our experiments reveal a higher classification accuracy for clusters extracted from each layer compared to human-defined concepts, indicating better separability and indication that clusters may capture patterns beyond human labels. Additionally, the classification accuracy increases for both clusters and concepts toward the output layer. Beyond quantitative evaluation, we provide qualitative insights using visualization techniques such as UMAP projections and Concept Localization Maps. Our findings highlight the potential of hybrid approaches for post hoc explainability and point to promising directions in uncovering emergent structures within deep neural networks.

ID:113# Texture-based analysis of mitochondrial microscopy scans

Authors: Jiří Hladůvka; Matúš Kočalka; Viktória Hodorová; Xénia Richnáková

We present a work-in-progress study on mitochondrial fluorescence microscopy scans using classical image-processing techniques. The workflow combines morphological and intensity-based segmentation with the extraction of descriptive textural features that capture structural variability of mitochondria. To identify the most informative characteristics, we apply systematic feature selection and evaluate their ability to distinguish experimental conditions. Reflection-invariant representations, including co-occurrence statistics of local binary patterns (LBP), are further explored to ensure consistent measurements across mirrored or rotated scans. The study aims to develop an interpretable and computationally efficient framework for quantitative assessment of mitochondrial morphology, providing a foundation for future large-scale analyses and methodological comparisons.

ID:17# Examining the legibility of humanoid robot arm movements in a pointing task

Authors: Ana Farič ; Andrej Lúčny[1]; Carlo Mazzola ; Hana Hornáčková[1]; Igor Farkaš ; Kristína Malinovská ; Matilde Antonj ; Michal Vavrecka

[1] *Comenius University*

Human–robot interaction requires robots whose actions are legible, allowing humans to interpret, predict, and feel safe around them. This study investigates the legibility of humanoid robot arm movements in a pointing task, aiming to understand how humans predict robot intentions from truncated movements and bodily cues. We designed an experiment using the NICO humanoid robot, where participants observed its arm movements towards targets on a touchscreen. Robot cues varied across conditions: gaze, pointing, and pointing with congruent or incongruent gaze. Arm trajectories were stopped at 60\% or 80\% of their full length, and participants predicted the final target. We tested the multimodal superiority and ocular primacy hypotheses, both of which were supported by the experiment.

Poster session + káva: prezentácie študentov Didaktika

ID:45# Model rozvoja metakognitívnych zručností žiakov na základe teórie skefoldingu a kognitívnej Rumsfeldovej matice

Author: Mariia Saprykina

Co-author: Peter Demkanin

V práci sa navrhuje konceptuálny model výučby fyziky založený na integrácii teórie skefoldingu a adaptovanej Rumsfeldovej matice. Výskum chápe edukačný proces ako cyklický pohyb žiaka cez štyri kognitívne stavy –od nevedomého nepoznania až k intuitívnemu ovládaniu poznatkov. Model opisuje mechanizmus postupného oslabovania pedagogickej podpory a formovania autonómnych stratégií poznávacej činnosti.
V rámci navrhovaného prístupu sú učebné úlohy štruktúrované tak, aby aktivovali uvedomenie si hraníc poznania, stimulovali kognitívny prechod medzi úrovňami porozumenia a rozvíjali schopnosť pracovať s neistotou ako neoddeliteľnou súčasťou vedeckého poznávania.

ID:54# Analysis of Tasks and Pupils'Solutions at the International Junior Science Olympiad from the Perspective of Cognitive Processes

Authors: Patrik Rezak[None]; Klara Velmovska[None]

The paper presents the results of an analysis of the performance of pupils who participated in the international rounds of the International Junior Science Olympiad (IJSO) in 2023 and 2024 (six pupils each year). The aim of the analysis was to find out how the selected sample of Slovak pupils performed in standardized tests, more precisely –to what extent the pupils lacked the ability to use certain cognitive processes when solving physics problems.

The analysis also aimed to examine the kinds of physics tasks to which the pupils were exposed. Therefore, the paper provides a comprehensive summary of the nature of the tasks given to pupils at the IJSO and how the selected Slovak pupils approached these tasks in 2023 and 2024.

Based on the analysis, Slovak pupils showed relatively consistent performance in tasks requiring the Applying level of cognitive processes; however, they had difficulties with tasks involving higher cognitive processes, such as Analyzing.

ID:74# Úniková hra s grafovými úlohami

Author: Julia Peskova

Co-author: Lucia Budinska

V práci sme sa snažili priblížiť žiakom druhého stupňa základnej školy koncepty teórie grafov pomocou zábavnej formy, únikovej hry. Hra bola určená pre žiakov siedmeho a ôsmeho ročníka základných škôl a realizovaná vo forme pracovného listu, ktorý žiaci riešili bez použitia počítača. Obsahovala sedem úloh, pričom jedna z nich bola bonusová.
Úlohy boli inšpirované úlohami zo súťaže iBobor a prepojené detektívnym príbehom. Žiaci postupným riešením úloh eliminovali počet podozrivých. Únikovú hru sme overili s 20 žiakmi 7. a 40 žiakmi 8. ročníka základnej školy na západe Slovenska. Pri overovaní sme identifikovali niekoľko možných problémov, ich riešenie navrhujeme v časti overenie. Prevažujúca spätná väzba od žiakov aj učiteľov bola pozitívna.

ID:78# Fyzikálna identita študentov fyzikálnych odborov na FMFI UK

Author: Tomáš Rudinský[1]

Co-author: Viera Haverlikova [1]

[1] *Katedra didaktiky matematiky, fyziky a informatiky, Fakulta matematiky, fyziky a informatiky, Univerzita Komenského v Bratislave*

Jedna z mnohých výziev, ktorým čelí slovenské vysoké školstvo, je odliv študentov do zahraničia a dlhodobo klesajúci záujem o prírodovedné a technické študijné programy. Zo študentov, ktorí nastúpili na štúdium fyzikálnych odborov na FMFI UK medzi rokmi 2020 až 2024, ktorí mohli získať bakalársky titul z fyziky do 30. júna 2025, bolo úspešných 33 % študentov v konverznom programe a 41 % študentov v štandardnom bakalárskom programe.
Zámerom výskumu je porozumieť faktorom, ktoré podporujú u nastupujúcich VŠ študentov fyzikálnych odborov voľbu ich študijného zamerania; a faktorom, ktoré ovplyvňujú úspešnosť procesu adaptácie na vysokoškolský systém vzdelávania a úspešnosť študentov počas ich VŠ štúdia fyzikálneho zamerania. Počas 4-ročného výskumu budú formou dotazníkových prieskumov dlhodobo sledovaní študenti bakalárskeho štúdia fyzikálnych odborov na FMFI UK, ktorí nastúpili na štúdium v akademickom roku 2025/2026, s cieľom mapovať vývin ich fyzikálnej identity a proces adaptácie na vysokoškolské štúdium, univerzitné prostredie a príslušnosť k akademickej komunite. Konečným cieľom výskumu je navrhnúť konkrétne príklady intervencie na podporu prehĺbenia fyzikálnej identity študentov fyzikálnych odborov FMFI UK a potenciálnych záujemcov o toto štúdium.

ID:75# Využitie programu Algodoo vo vyučovaní fyziky

Author: Ľubomír Varchol

Co-author: Klára Velmovská

Táto práca sa zameriava na využitie programu Algodoo vo vyučovaní fyziky. Algodoo poskytuje učiteľom fyziky možnosť doplniť experimenty realizované na hodinách fyziky počítačovým modelom alebo, v prípade potreby, niektoré experimenty úplne nahradiť, najmä v oblastiach mechaniky a optiky. Súčasťou práce je vytvorenie konkrétnych modelov a aktivít pre žiakov, ktoré podporujú rozvoj ich zručností a vedú ich k objavovaniu kľúčových fyzikálnych vzťahov a zákonitostí.

ID:35# Analýza algebrického myslenia prostredníctvom úloh zo súťaže iBobor

Author: Dusan Daniel

Cieľom prezentovaného dizertačného projektu je identifikovať úlohy zo súťaže iBobor, ktoré nesú vysokú mieru informácie o algebrickom myslení (AM) a posúdiť ich z hľadiska charakteristiky. Výskum nadväzuje na aktuálne teoretické rámce AM a využíva prístup teórie odpovede na položku (IRT) na modelovanie pravdepodobnosti úspechu žiaka v teste AM na základe jeho výkonu v úlohách zo súťaže iBobor. Na posteri budú predstavené čiastkové výsledky pilotného výskumu vrátane prvých IRT analýz a kvalitatívnych charakteristík skúmaných úloh.

ID:97# Významní fyzici a ich pohľady na poznanie

Author: Ivo Bednář[1]

[1] *Fakulta matematiky, fyziky a informatiky Univerzity Komenského v Bratislave, Odelenie didaktiky fyziky*

V práci sa zaoberáme analýzou diela významných osobností fyziky. Vybrané osobnosti sa okrem známych prínosov vo fyzike venovali aj filozofickým otázkam v oblastiach poznania, učenia sa a využitia získaných vedomostí. Táto práca je východiskom pre analýzu súčasného stavu, akým pristupujú pedagógovia na gymnáziách k fyzikálnemu vzdelávaniu, a filozoficko-psychologickým kontextom, ktoré možno spojiť s obsahom, ale i spôsobom vyučovania kurikula na gymnáziu.

Poster session + káva: prezentácie vedeckých výsledkov FMFI UK Zamestnanci Matematika

ID:24# A Rigorous Approach to Stochastic Dynamics Inference from Tracked Data

Authors: Katarina Bodova[1]; Richard Kollár[2]

[1] *Comenius University*

[2] *FMFI UK*

Advances in experimental biology increasingly provide time-resolved data that capture essential aspects of complex biological dynamics. Yet, uncovering how the underlying components interact remains a challenging inverse problem, requiring the separation of systematic behavior from stochastic fluctuations and measurement noise.

Among existing approaches, the method of Brückner et al. (2020) offers a way to work with smaller datasets. In this work, we present our ongoing work that builds on and extends this approach. Our method rigorously addresses the theoretical gaps and ad hoc assumptions of the original formulation by achieving a higher degree of accuracy, identifying the correct small parameters, and clarifying the conditions for validity. The result is a more efficient and broadly applicable framework for analyzing stochastic dynamics from limited, sparsely sampled data. This is joint work with Richard Kollár.

ID:48# Double Nonlinear Diffusion Equations in a Two-Component Domain

Authors: Jan Filo; Jela Babusikova ; Patrik Mihala

A system of two doubly nonlinear diffusion equations acting on two different rectangles in $\mathbb{R}^2$, connected by nonlinear boundary conditions on the contact line, is studied. The goal is to present numerical simulations of this coupled problem. We use a conservative finite-volume discretization in space and fully implicit time stepping with adaptive step sizes and adaptive damping. The interface condition is approximated by a penalty formulation. The resulting nonlinear system is solved by Newton's method with an analytic Jacobian. The experiments show close agreement with a validated explicit scheme with approximately half the computational time, successful computation of a stiff case that the explicit scheme cannot handle, and long-time relaxation with a stable interface jump.

ID:60# Cancer–immune coevolution dictated by antigenic mutation accumulation

Author: Christopher Morison

We introduce a stochastic model of cancer–immune coevolution, where mutations trigger effector responses. Simulations show that interactions impact outcomes (e.g. suppression), with implications for immunotherapy. We find signatures of selection in sequencing statistics such as the single-cell mutational burden distribution. (based on the paper: https://doi.org/10.7554/eLife.103970.3)

ID:59# Single-cell mutational burden distributions in birth–death processes

Author: Christopher Morison

We introduce a birth–death model of neutral tumour evolution uniting summary statistics via dynamical matrices. We derive and solve recurrence relations to find analytical expressions for expected mutational distributions. We compare to known results and simulated data, validating our predictions. (based on the paper: https://doi.org/10.1371/journal.pcbi.1013241)

ID:28# Existence and uniqueness of periodic solutions of a certain functional differential equation

Authors: julius pacuta ; michal fečkan

We prove the existence and uniqueness of periodic solutions of a first order differential equation

$$x'(t) = f(x(t)) + x(\lfloor t \rfloor)g(t - \lfloor t \rfloor), \quad t \geq 0$$

that contains a piecewise constant term. Such equations admit periodic solutions and hence they can be used for numerical modelling of temperature changes in a space surrounded by environment with different temperature. For some types of functional equations, it is possible to use the comparison principle method of differential equations to obtain existence, uniqueness, and asymptotic stability results.

ID:107# Bridging Math and Practice - Premostenia medzi matematikou a praxou na FMFI UK

Authors: Daniela Majercakova ; Gabor Szucs

Tento konferenčný príspevok je venovaný predstaveniu a zhodnoteniu spolupráce dvoch matematických pracovísk na Fakulte matematiky, fyziky a informatiky Univerzity Komenského v Bratislave (FMFI UK) s praktickou sférou. Katedra matematickej analýzy a numerickej matematiky a Katedra aplikovanej matematiky a štatistiky sú v priamom kontakte s desiatkami spoločností, ktoré pôsobia v rôznych oblastiach finančníctva, bankovníctva a poisťovníctva, v dátovo-analytickom a konzultačnom sektore, ako aj s niektorými štátnymi inštitúciami. Počas uplynulých 10 rokov sme pre študentov FMFI UK zorganizovali množstvo pozvaných prednášok, praktických seminárov a workshopov. Študenti aj prostredníctvom týchto aktivít mohli získať cenné mäkké i tvrdé zručnosti, a tiež vstúpiť do kontaktu so zamestnávateľmi a partnerskými spoločnosťami našich katedier. Naším cieľom bolo prispieť k účinnejšiemu prepájaniu akademickej výuky so súvisiacimi oblasťami národného hospodárstva a v tejto snahe plánujeme pokračovať aj naďalej. Príspevok o vytváraní mostov medzi matematikou a praxou na FMFI UK plánujeme prezentovať formou posteru.

ID:50# Topology of manifolds

Author: Tibor Macko

Co-authors: Ajay Raj ; Marián Poturnay ; Samuel Kalužný ; Serhii Dylda

We present selected results from the work in the topology group at KAG FMFI UK supported by the grant VEGA 1/0425/25. The main focus is on the results of the PhD student Ajay Raj, who defended his thesis in August 2025. His work is located in surgery theory which is a specific way of approaching classification problems of topological and smooth manifolds. His aim was to calculate the so-called surgery structure sets of manifolds which are total spaces of S^{4k-1}-bundles over S^{4k}. The topological structure set classifies topological manifolds equipped with homotopy equivalences to the total space of the bundle up to homeomorphism. The smooth structure set does the same for smooth manifolds up to diffeomorphism. The objective was to calculate the topological structure set and determine which of the elements in it can be realized as such bundles. Furthermore, the forgetful map between smooth and topological versions of structure set was completely determined. We briefly mention other work in the group, some of which will also be presented in other posters.

ID:62# Stationary distributions of iterated function systems

Author: Jozef Kovac[1]

Co-authors: Jan Vesely ; Katarina Jankova

[1] *KAMŠ*

Iterated function systems (IFSs) with probabilities have been investigated in various settings. In the simplest case, they can be interpreted as Markov chains. In this context, it was proved that for every continuous probability distribution μ with support in $\mathbb{R}$, there exists an IFS for which μ is the unique stationary distribution of the associated Markov chain. Moreover, only two functions are sufficient for the construction of such an IFS. In this work, we study a discrete analogue of this problem. Specifically, we show that for almost all discrete probability distributions μ supported on the set $\{1, ..., n\}$, μ is not the unique stationary distribution of the Markov chain corresponding to IFSs generated by $n-1$ (or fewer) functions, while it is trivial to construct IFS generated by n function with μ as its unique stationary distribution for any μ.

ID:52# Quantitative Insights into Personality Psychopathology

Author: Livia Rosova

This presentation provides a statistical analysis of personality data based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-5). Across three independent studies, we examine the psychometric and statistical properties of the instruments used to evaluate personality psychopathology. The first study tests the reliability and validity of the Structured Interview of Personality Organisation using data from addictology students. The second study examines the Level of Personality Functioning Scale –Self Report in patients with substance use disorders, comparing the results with those of the general population and exploring gender differences. The third study provides cut-off threshold scores for the Personality Inventory for DSM-5, based on Czech clinical and non-clinical samples categorised by age and gender. Methods such as correlation analysis, factor analysis, logistic regression and the social relations model are applied across these datasets.

ID:15# Bursty Gene Expression in Single Cells and Expanding Populations: A Discrete Approach

Authors: Iryna Zabaikina[1]; Jakub Poljovka[2]; Pavol Bokes[3]

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Gene expression is inherently stochastic, resulting in **cell-to-cell variability in protein levels**, even among genetically identical cells.
Such **variability plays a crucial role** in such processes as cell differentiation, stress response, and antibiotic tolerance.

- Proteins are synthesized in instantaneous discrete events, **bursts**, each producing a random number of proteins.
- **Protein levels are decreased by dilution** due to active cell growth.
- **Positive feedback on dilution**: an increase in protein levels imposes a burden on the cell, reducing its growth rate and thereby slowing down dilution.

ID:31# 3D Pen-Supported Geometry Teaching

Author: Barbora Pokorna

The study of three-dimensional objects in school mathematics is frequently mediated through planar projections. For many students, however, these two-dimensional representations do not sufficiently support the development of accurate spatial imagery, making it difficult to mentally reconstruct the intended 3D structure. Recent advances in low-cost 3D printing technologies provide new opportunities for teaching three-dimensional geometry. In particular, handheld 3D printing pens enable students to construct spatial models directly and to interact with them in ways that integrate visual and tactile experience. This poster presents research findings indicating that the use of 3D pens in solid geometry instruction can significantly enhance students'spatial understanding and engagement. We also introduce a set of instructional materials designed to support the integration of 3D pen activities into secondary school geometry lessons.

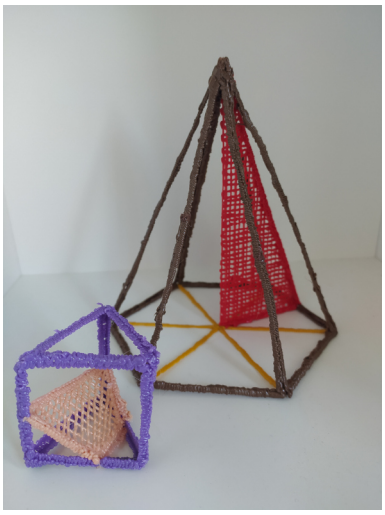

Figure 2: 3D pen models demonstrating the construction of basic solids and the visualization of planar cross-sections

Poster session + káva: prezentácie vedeckých výsledkov FMFI UK Zamestnanci fyzika

ID:11# Preparation of Ti-Fe precursor layers for nanostructured applications using magnetron sputtering

Authors: Leonid Satrapinskyy[1]; Yevhenii Popov

[1] *Fakulta matematiky, fyziky a informatiky, Univerzita Komenského v Bratislave*

Titanium dioxide nanotubes are promising nanomaterials with wide-range potential applications in energy, environmental, and medical fields, driven by their tunable structure and exceptional properties. However, pure TiO2 nanotubes usage is limited by relatively wide energy gap.
The fabrication and oxidation processes of iron-doped titanium nanotubes were investigated. The structural and morphological properties of precursor films prepared by magnetron sputtering was analyzed. Advanced characterization techniques, including scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDS), were used to examine the relationship between the amount of iron and material characteristics. Optimized precursor films were deposited by magnetron sputtering. The as-deposited films were subsequently oxidized in an organic-based electrolyte to obtain an oriented array of Ti-Fe nanotubes. To improve their sensorics properties, the samples were annealed.

ID:119# Unraveling the Plasma–Photocatalysis Process: Coumarin Degradation Using a Modified Fountain DBD System

Authors: Akshara Chithran[1]; Kiran Ahlawat[2]; Mohammed Abdulsalam; Oleksandr Galmiz[3]; Zdenko Machala[1]

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[3] *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava (SK)*

Coumarin is widely used in cosmetics and pharmaceuticals, has emerged as a persistent and potentially toxic contaminant. This study investigates coumarin degradation using a modified fountain dielectric barrier discharge (MF-DBD) plasma reactor, operated alone and in combination with WO_3, WO_3–ZnO, and ZnO catalysts. Under identical conditions (16 mg/L, atmospheric air pressure, 0–65 min), plasma treatment achieved 95% degradation, primarily via •OH-mediated oxidation. Incorporating catalysts significantly enhanced degradation kinetics and mineralization. WO_3 promoted reactive oxygen species (ROS) generation, while ZnO improved pH stability. The WO_3–ZnO composites exhibited composition-dependent synergy, achieving >97% removal efficiency, with Plasma + WO_3 showing the highest performance (99.9% degradation, 84% TOC reduction). The results highlight the strong plasma–catalyst coupling effect and demonstrate MF-DBD plasma systems as efficient, green technologies for treating recalcitrant organic pollutants.

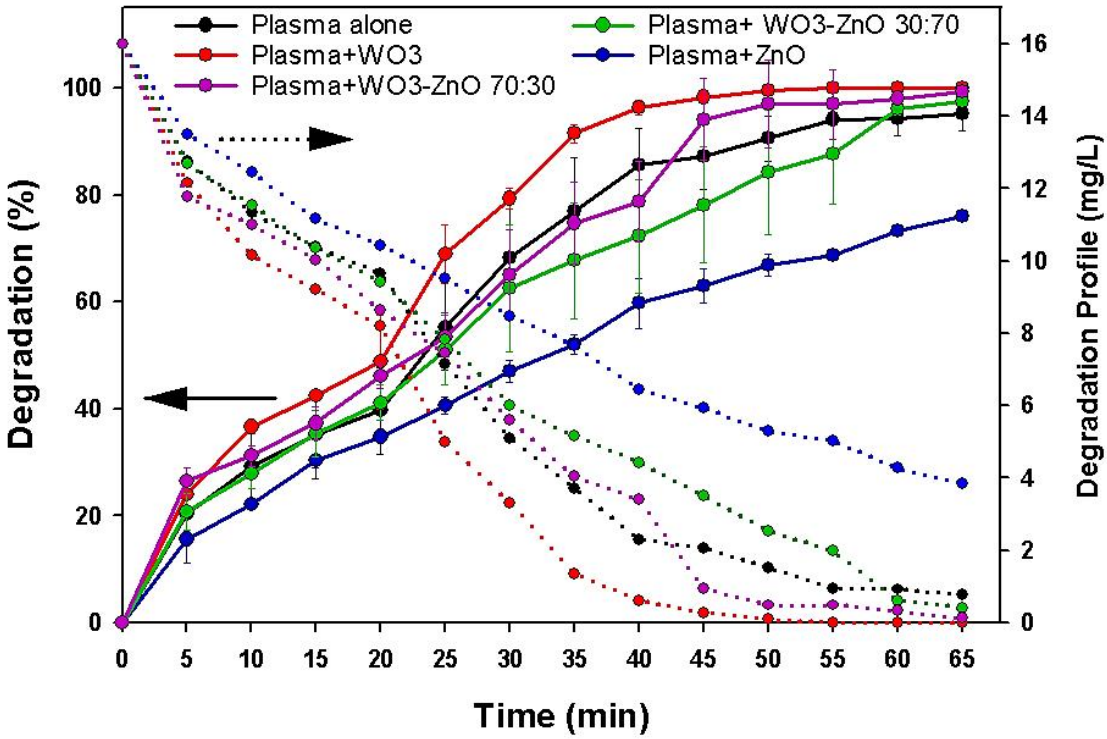

Figure 3:

Keywords:

Dielectric Barrier Discharge; Plasma–Photocatalysis; WO_3–ZnO Composite; Coumarin Degradation; Advanced Oxidation Process

Acknowledgement

Funded by the EUNextGeneration EU through the Recovery and Resilience Plan for Slovakia under project No 09I03–03-V04–00373

ID:106# Large scale air decontamination system using dielectric barrier discharge combined with UV activated TiO_2

Author: Alex Jean Andre Destrieux[1]

Co-authors: Aleksandra Lavrikova [1]; Thomas Vazquez [1]; Zdenko Machala [1]

[1] *Faculty of Mathematics, Physics, and Informatics, Comenius University Bratislava, Slovakia*

Indoor air can be polluted by many different harmful contaminants, such as chemicals, viruses or bacteria, aerosols or fine particles from combustion, among others 1. The recent global pandemic is the perfect example showing how contaminants such as viruses are dealt with. Instead of destroying or inactivating them, physical barriers, i.e. filters, were mostly used. Similarly, current decontamination systems mostly rely on filters (HEPA, mechanical, electrostatic), whatever the pollutant. Such non-destructive methods work but they induce lots of maintenance costs for changing filters, which "store"the pollutants and produce potentially harmful wastes if not handled carefully.
For these reasons, alternative destructive methods have been developed. Among advanced oxidation processes, the combination of cold atmospheric pressure plasma with UV activated photocatalysts is very promising [2]. The plasma generated electrons, ions, reactive oxygen and nitrogen species,

combined with the photocatalyst-generated radicals (OH, O2•−) allow for the oxidation or decomposition of most chemical pollutants, as well as the inactivation of bio contaminants [3].
This work focuses on a large-scale air decontamination system, which combines a volume dielectric barrier discharge (DBD), with a UV-activated TiO2-coated textile as photocatalyst. The latter is activated using UV-C lamps. An important feature of the setup is that it can treat large volumes of air (several hundred L.min-1) in a single pass, making it closer to real applications than typical lab reactors. The efficiency of the system against VOC (formaldehyde) is assessed using FTIR measurements of the outlet gas. The production of ozone is also monitored using UV absorption spectroscopy. To better understand the process, the importance of the different elements (DBD, UV, photocatalyst) are also studied separately. Additionally, the influence of the specific input energy and the distance to the discharge are investigated, giving a better view of the synergetic effects between the discharge and the photocatalytic effect, as well as the fragmentation pathways of the VOC. Finally, preliminary results on the deactivation of E. Coli and S. Aureus by the systems are presented [4].

Funded by the EU NextGenerationEU: Recovery and Resilience Plan of Slovak Republic - 09I03-03-V03-00033 EnvAdwice.
Keywords: Indoor air decontamination; Plasma photocatalysis; FTIR.

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[4] T. Vazquez, A. Lavrikova, et al., J. Electrostat. 138 (2025) 104160

ID:26# Nonlocal Four-Terminal Method for Electrical Measurements

Author: Mykhaylo Bilogolovskyy

The four-terminal measurement technique is a foundational and widely utilized method for determining the electrical conducting characteristics of materials, especially thin films, bulk crystals, semiconductors, and complex nanostructures. By employing four separate electrical contacts - two for current injection and two for voltage measurements - on top of a sample, this methodology effectively eliminates the influence of contact and lead resistance, which can otherwise introduce significant errors in resistance and conductivity measurements. Here, we introduce a through-sample nonlocal four-terminal method based on the Landauer-Büttiker approach relating the electrical resistance to scattering properties of a mesoscopic conductor. The new methodology has been tested on all-metallic hybrid sandwiches composed of two 80 nm thick NbN films and a 50 nm thick core made of three archetypal ferromagnetic materials, F = Co, Ni, or NiCu alloy. Using a simple equivalent circuit model with six resistances connecting the four probes, we have explained some unexpected findings in the normal state and the temperature range corresponding to the normal-to-superconducting transition. Notably, it relates apparent negative resistances of some trilayers above the NbN critical temperature. By comparing NbN and NbN/F/NbN trilayers, we demonstrate that the inclusion of an F interlayer leads to a significant shift in the onset of the superconducting transition, particularly in the near-surface region, and increases the overall transition width. This work provides insights into the delicate interplay between superconductivity and magnetism and opens pathways for engineering interface-sensitive superconducting spintronic devices.

ID:70# OSCAR Benchmark: Single-station Site Characterisation

Authors: Miriam Kristekova; Jozef Kristek; Peter Moczo

OSCAR (One-Station methods for site ChARacterisation) is an international, collaborative benchmark that compares single-station approaches—i.e., methods using a single three-component seismometer—for estimating subsurface structure. Its goal is to provide the missing standardized framework for comparing these increasingly popular methods, which offer low cost and simple logistics at the expense of accuracy and/or reliability of results compared to multi-station methods. Inversions for structure from single station methods lack systematic inter-team validation, transparent

uncertainty quantification, and shared best practices. The benchmark proceeds in three phases: (1) a blind test at six sites without any a priori information; (2) an informed inversion of the same data leveraging other available geological and geophysical data; and (3) scenarios with more complex geological conditions. In our contribution, we briefly present the benchmark framework and our participation in the first phase.

ID:76# Ultra-high-energy cosmic neutrino discovered with KM3NeT neutrino telescope

Authors: Eliška Eckerová[1]; Fedor Šimkovic[1]; Rastislav Dvornicky[1]; Zuzana Beňušová[1]

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KM3NeT collaboration announced an observation of the most energetic cosmic neutrino with energy of 220 PeV on Wednesday, February 12, 2025, by means of a publication in Nature journal. This event, practically near-horizontal muon traversing three-dimensional network of optical modules (photosensors) of the telescope, was registered by the ARCA detector that is located offshore Sicily at a depth of about 3450 m in Mediterranean Sea. Based on high energy of this muon (approximately 120 PeV) and its trajectory, a conclusion has been made that the particle cannot be produced by collisions of cosmic rays in Earth's atmosphere, but it is produced by a cosmic neutrino. This is indeed groundbreaking discovery in the field of astronomy, astrophysics and human knowledge.

ID:115# Quantification of eroded Fe contamination in plasma activated water using Surface Assisted LIBS

Authors: Mario Janda[1]; Matej Veis[2]; Pankaj Pareek[1]; Pavel Veis[2]

Co-author: Sahithya Atikukke [1]

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Cold plasma discharges generate reactive oxygen and nitrogen species (RONS), which can be trapped in the liquid phase to form plasma-activated water (PAW), a chemically rich solution with applications in agriculture, biomedicine, and environmental treatment. When transient spark (TS) discharges are coupled with electrospray (ES) microdroplet generation, PAW production efficiency increases significantly due to the enhanced plasma–liquid interaction area. However, this configuration also leads to electrode degradation and the release of metallic ions and nanoparticles, which can alter PAW chemistry through catalytic or Fenton-type reactions [1, 2].
In this work, we employ surface assisted laser induced breakdown spectroscopy (SA LIBS) [3,4] to detect and quantify the eroded metallic species in PAW produced by the TS–ES system [5]. The PAW samples were dried on polished silicon wafers to form a thin film, providing a stable surface for ablation and minimizing splashing and plasma quenching associated with direct liquid analysis. A tuneable OPO laser (EKSPLA NT342C, 532 nm) was focused onto the dried films to generate laser-induced plasma, and the resulting emission spectra were recorded using an echelle spectrometer (ME5000, Andor) equipped with an iCCD detector (iStar DH743, temporal resolution 5 ns). The quantification was done using Calibration-Free LIBS at different gate timings under air at atmospheric pressure [6].
The SA LIBS approach enabled sensitive detection of metallic contaminants in PAW with improved signal stability and reproducibility compared to direct liquid LIBS. This method demonstrates the potential of SA LIBS for monitoring electrode degradation and metal transport in plasma–liquid systems, offering a simple and efficient route for chemical characterization of PAW.
Acknowledgment:
This work was supported by the EU NextGenerationEU: Recovery and Resilience Plan of the Slovak Republic –09I03-03-V03-00033 EnvAdwice project.
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ID:36# Real Charge Trapping in Hydroxyapatite Thin Films Prepared by Pulsed Laser Deposition

Authors: Ehtsham Ul-Haq; Hema Dinesh Barnana; Magdaléna Poláčková; Maroš Gregor; Tofail Syed; Tomáš Roch; Veronika Hidasi Turinicova; Viktor Šroba

Direct injection of electrons into synthetic bone mineral hydroxyapatite can change its surface potential in thin films prepared by spin coating, reduce bacterial adhesion at the surface of bulk ceramics and impact biological adhesion. To explore this further, we investigate direct electron injection, and trapping of charge in hydroxyapatite thin films produced by Pulsed Laser Deposition (PLD) on sapphire (Al2O3) substrates. The films are characterized by X-Ray Diffraction (XRD) for phase composition and X-ray Photoelectron Spectroscopy (XPS) for surface chemistry. Injection of electrons into prepared samples is conducted using an electron beam within a Scanning Electron Microscope (SEM) capable of electron beam lithography with control over dosage, current, and irradiation area. Monte Carlo simulation estimates the beam/sample interaction volume to be ten times larger than the thickness of the hydroxyapatite thin film. This means that incident electrons should largely transmit through hydroxyapatite thin film, and end up in being trapped in the Al2O3 substrate instead of the hydroxyapatite film. Bulk hydroxyapatite, however, can store excess electric charge of the order of 10-9 C, mainly in oxygen vacancies or other defect centres located within the band gap. Thus, in this study, we quantify the charge trapped in hydroxyapatite thin films using a Pendant Drop in Electric Field Method, compare it with charge trapped in bulk samples, and assess the influence of the Al2O3 substrate on charge storage.

ID:37# Heterostructural decomposition in V1-xWxB2-Δ films induced by B deficiency

Authors: Branislav Grancic[1]; Katarína Viskupová; Tomáš Fiantok

Co-authors: Leonid Satrapinskyy ; Marián Mikula ; Martin Truchlý ; Peter Kúš ; Peter Švec ; Tomáš Roch ; Viktor Šroba

[1] *Center for Nanotechnology and Advanced Materials, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava*

Transition metal borides (TMBy) represent a structurally rich group of materials with attractive physical properties, including high hardness and high melting points, making them promising candidates for applications in extreme conditions. Considerable attention has been paid to overstoichiometric TMB2+Δ films with hexagonal α-P6/mmm structure exhibiting super-hardness attributed to high cohesive strength between excess-boron tissue phase and crystalline nanocolumns. However, positive effects of reducing the boron content in terms of toughness and oxidation resistance have been reported. Lowering the boron to metal ratio can have various effects on structure and stability, depending on the specific diboride system and its affinity to boron vacancies. In this work, we study the influence of boron understoichiometry on structure and thermal stability of vanadium tungsten diboride films. We present results of high-resolution scanning transmission electron microscopy showing that boron deficiency leads to a high density of planar defects, including anti-phase boundaries (APB-2i), the accumulation of which enables the formation of WB-Cmcm areas coherently included in the hexagonal VB2-P6/mmm structure. The observation is supported by density functional theory calculations showing that since the presence of vacancies is favored by the α-WB2 and not convenient for the α-VB2 system, there is an increased probability of decomposition into stoichiometric VB2 and boron deficient WBz<2 products. Additionally, we report on other types of planar defects, such as twinning, and discuss their role in local formation of other boride phases within the Cmcm structure.

ID:81# Matrix Models and Fuzzy Spaces

Authors: Samuel Kovacik[1]; Juraj Tekel[2]; Matej Hrmo; Katarina Magdolenova; Adam Kubis; Patrik Rusnak; Benedek Bukor

[1] *Comenius University*

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We study spaces that don't have to be continuous like ordinary space but can instead be built from matrices that replace the usual notion of points. These matrix spaces allow us to explore what happens when geometry itself becomes quantum. Our work includes well-known examples such as the fuzzy sphere and newer constructions like the fuzzy onion, where several fuzzy layers form a richer internal structure. By choosing different actions, we can define a variety of matrix models with distinct symmetries and dynamics, each revealing different aspects of quantum geometry. On these spaces, we build and analyse field theories to understand how their behaviour depends on the underlying structure and parameters of the model. Combining analytic calculations, bootstrap techniques, and large-scale simulations, we investigate how such quantum spaces behave and how classical geometry might emerge from them—creating a playground where geometry, quantum field theory, and statistical physics naturally meet.

ID:51# Proximity phenomena in heterostructures consisting of superconductor –ferromagnet

Author: Magdaléna Poláčková

Co-authors: Leonid Satrapinskyy ; Maroš Gregor ; Pavol Ďurina ; Tomáš Plecenik

Current demands on computing technologies and storage units, such as speed, low power consumption, and high memory density, are leading to the development of new technologies. One promising area is superconducting cryoelectronics, including qubits, superconducting spintronics, or memory cells. Devices combining two antagonistic phenomena –superconductivity and ferromagnetism –show great potential. Various effects can occur at their interfaces, such as the formation of π-junctions or triplet Cooper pairs, which enable the generation and transport of spin-polarized current. In this work, we report on the fabrication and electrical characterization of superconductor/ferromagnet/superconductor (S/F/S) nanostructures based on NbN superconducting electrodes and ferromagnetic Ni or Co interlayers. Transport measurements revealed that Co layers (20 and 50 nm thick) did not become superconducting via the proximity effect, while structures with similarly thick Ni layers exhibited zero resistance after the superconducting transition. This behavior indicates the possible formation of triplet Cooper pairs, further supported by I-V measurements showing a nearly field-independent critical current, which is characteristic for triplet superconductivity.

ID:53# Plasma-activated water enhances growth, antioxidant activity and sensory quality of hydroponically grown lettuce

Author: Adriana Misuthova[1]

Co-authors: Zuzana Lukačová [2]; Ramin Mehrabifard [1]; Zdenko Machala [1]

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Cold atmospheric plasma generates multiple reactive oxygen and nitrogen species (RONS), which dissolve in water to form plasma-activated water (PAW), resulting in its subsequent chemical modifications. Due to the presence of RONS, PAW shows considerable potential in agriculture, as these species act as signaling molecules in plant metabolic pathways and enhance nutrient availability.

This study evaluates the effects of PAW produced via a transient spark (TS) discharge system on the growth and physiological responses of hydroponically cultivated lettuce (Lactuca sativa). Four experimental treatments were established: (1) a control group grown in ½ Hoagland's nutrient solution; (2) plants from seeds primed in PAW for 1.5 hours, then transferred to Hoagland's nutrient solution; (3) plants from seeds primed in PAW and subsequently cultivated in PAW supplemented with ½ Hoagland's nutrient solution; and (4) plants cultivated solely in PAW enriched with ½ Hoagland's nutrients. Plant development was monitored over a 10-week period. At harvest, central rosette leaves (3–5 per plant) were analyzed for concentration of selected antioxidants, specifically soluble phenols and quercetin from flavonoids. Another important parameter was the activity of several antioxidant enzymes (superoxide dismutase, ascorbate peroxidase, guaiacol peroxidase, and glutathione reductase), which was measured in the mixture of two oldest and youngest leaves of plants. A sensory evaluation involving 15 participants assessed visual appearance, aroma, flavor, and texture. Our results showed that the combination of PAW treatment and seed priming led to increased biomass accumulation and enhanced activity of antioxidant enzymes. These plants also had higher concentrations of key antioxidant compounds. Among these antioxidants, flavonoids (in our case, quercetin) are the most powerful scavengers of free radicals and possess anti-inflammatory, antidiabetic, antiatherosclerotic, antihypertensive, and anti-aging properties. Sensory panel participants consistently rated the PAW-treated lettuce as more appealing and tastier, indicating strong potential for consumer acceptance and commercial application.

Acknowledgement:
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ID:32# Accelerator Mass Spectrometry of Beryllium-10

Author: Miroslav Jeskovsky[1]

Co-authors: Boris Bobal [1]; Jakub Kaizer [1]; Ivan Kontul [1]; Pavel P. Povinec[1]

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Beryllium-10 (^{10}Be) is a long-lived radioactive cosmogenic isotope of beryllium (half-life = 1.387 Ma), primarily produced in the Earth's atmosphere through spallation reactions induced by high-energy cosmic rays. Owing to its extended half-life and β^--decay mode, the quantification of ^{10}Be at ultratrace levels in natural samples is most effectively achieved using accelerator mass spectrometry (AMS). As a robust geochemical tracer, ^{10}Be is extensively utilised for geochronological applications and serves as a valuable tool in diverse fields of Earth and environmental sciences.
The CENTA (Centre for Nuclear and Accelerator Technologies) laboratory was founded in 2013 and is equipped with a 3 MV Pelletron accelerator from NEC (National Electrostatic Corporation, Middleton, USA). The first attempts to measure ^{10}Be in 2015 were done in cooperation with the VERA (Vienna Environmental Research Accelerator) laboratory of the University of Vienna; however, they were limited by insufficient background suppression in the high-energy part of the beamline. A major upgrade of the beam line was implemented in 2023 and allows almost total suppression of interfering ions. To suppress the main isobaric interference of ^{10}Be, the stable isotope ^{10}B, additional methods need to be implemented.
The full suppression of ^{10}B can be achieved by several techniques utilising different energy losses of boron and beryllium in matter. We have adopted the absorption technique, where a stack of silicon nitride foils with a defined areal density is used as an absorber in front of the gas ionisation detector used for the registration of ions. This technique was tested by using a 2+ charge state, for higher transmission and a gas ionisation chamber supplied by NEC was used as the end detector. Standard reference materials with an isotopic ratio of ^{10}Be/^{9}Be ranging from 2.502×10^{-11} to 1.01×10^{-13}, obtained from the University of California, were used for the determination of linearity in this range. When the production of BeH molecules was suppressed by increasing the pressure of the stripper gas in the accelerator, a background level of 5 x 10^{-14} was achieved.

ID:82# Reference laboratory data for astrophysics

Author: Juraj Orszagh[1]

Co-authors: Enmily Loelbis Garcia Angulo [1]; Gadisa Deme Megersa [1]

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Most objects in space are too distant to be studied in situ. Therefore, emission spectroscopy is one of the primary methods used. The generation of excited species responsible for this emission can be induced either by radiation from nearby stars or by collisions with other particles. In our Solar System, planets and small bodies are constantly exposed to photon irradiation from the Sun. These reactions produce a significant number of secondary electrons with relatively low energies, which in turn induce further excitations, ionizations, and dissociations.
Electron-impact excitation reactions provide a valuable remote diagnostic of neutral gases and the physical environments of planetary atmospheres and small bodies in the Solar System [1–2]. The resulting emission spectra strongly depend on both the collision energy and the target molecule [3], and they yield distinct spectral fingerprints across the infrared, visible, and ultraviolet ranges.
The importance of these collisions has been demonstrated in several publications, where they played a crucial role in key discoveries [4–6]. The information encoded in the spectra can reveal properties of the surrounding environment. However, astronomical environments such as atmospheres or comae contain many different species, with multiple excitation–emission processes occurring simultaneously. As a result, astronomical spectra are highly complex. To extract meaningful data, reliable databases of reference emission spectra and emission cross-sections are essential. Laboratory experiments focused on electron-induced fluorescence [2,7] provide such data, as they allow controlled and repeatable studies of individual compounds. Laboratory of Electron Induced Fluorescence at the Department of Experimental Physics is one of a few laboratories in the world able to produce comprehensive data of this type.

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ID:46# Thermal Stability of Magnetoresistive Properties in Permalloy-Copper Alloy Thin Films

Author: Ihor Shpetnyy[1]

Co-authors: Anatolyi Ruban [2]; Leonid Satrapinskyy [3]; Serhij Lyfar [2]; Tetiana Kulyk [2]; Tomáš Plecenik [3]; Uliana Shvets [2]; Vasyl Pak [2]; Viktor Hrebynakha [4]; Yurii Shkurdoda [2]

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Thin-film systems exhibiting magnetoresistive effects have found broad practical application in various industries, including nanoelectronics, automotive engineering, and biotechnology. During the

operation of devices that utilize magnetoresistive elements (e.g., non-volatile magnetic memory such as MRAM, or magnetic field sensors), the materials are subjected to elevated temperatures. The stability of the MR response under thermal exposure is a key parameter determining device reliability. We present a systematic study of the nanostructure, phase state, and magnetoresistive properties in alloy thin films based on permalloy ($Ni_{80}Fe_{20}$) and copper, both as-deposited and after vacuum annealing up to 800 K. The films $(Ni_{80}Fe_{20})_xCu_{100-x}$ with compositions 21 vol. % ≤ x ≤ 73 vol. % and a thickness of 40 nm were prepared by vacuum co-evaporation from two independent sources, enabling precise composition control.
Transmission electron microscopy (TEM) studies revealed that the structural and phase state of the as-deposited samples over a wide composition range was characterized by the presence of FCC-permalloy granules (with sizes ranging from 7 to 15 nm) embedded in an FCC-Cu matrix. The phase composition of the samples remained unchanged after isothermal annealing at 600 K, 700 K, and 800 K. The nanostructure of the films also exhibited high thermal stability. The size of the permalloy granules increased only slightly following heat treatment: 8–16 nm at 600 K, 8–21 nm at 700 K, and 10–22 nm at 800 K. No phase transformations or oxide formation were detected in the crystalline phase. The magnetoresistive effect was isotropic and composition-dependent. The magnetoresistive properties of the thin film samples also remained stable after annealing at 700 K. The highest GMR value of 0.68 % at room temperature in a magnetic field of 15 kOe was observed in the film sample with a permalloy concentration of $x = 50$ vol.%. Low-temperature measurements confirmed superparamagnetic behavior and enhanced spin-dependent scattering. Despite the relatively low GMR value, the system exhibits low coercivity and high sensitivity in weak magnetic fields, making granular alloy thin films based on permalloy and copper promising for use in high-sensitivity magnetic sensors and suitable for applications requiring magnetoresistive stability at elevated temperatures.

Acknowledgments
This work was funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V01-00044.

ID:73# Stability of acrylic acid grafted microporous polymeric membranes in alkaline electrolyte

Author: Michal Stano[1]

Co-authors: Martin Kuťka ; Dušan Kováčik ; Leonid Satrapinskyy ; Anna Zahoranová

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This work is devoted to development and characterization of inter-electrode separators for alkaline water electrolysis (WE) for hydrogen production. The purpose of the separator is to prevent mixing of the produced hydrogen and oxygen, therefore the separator must possess low permeability to these gases under WE conditions. Meanwhile, the separator must be highly conductive to OH- ions to minimize the energy losses. The separator must also possess mechanical strength and chemical stability in alkaline electrolyte.
In our previous work we have shown that separators produced by plasma-initiated graft polymerization of acrylic acid on microporous membranes possess high ionic conductivity and low permeability to hydrogen under WE conditions [1,2]. Nevertheless, the main weakness of this type of separators was insufficient durability in alkaline electrolyte, especially at elevated temperatures. In this work we show that durability of this type of separators can be significantly improved by optimization of conditions of the plasma activation as well as by addition of crosslinking agents during the graft-polymerization process. The improved separators exhibit high stability in 30 wt.% KOH electrolyte at 60℃ for at least 5000 hours.
1 STAŇO Ľubomír, STANO Michal and ĎURINA Pavol. International Journal of Hydrogen Energy, 2020. Vol. 45, p. 80-93.
[2] KUŤKA Martin, STAŇO Ľubomír, KOVÁČIK Dušan, SATRAPINSKYY Leonid and STANO Michal. International Journal of Hydrogen Energy, 2024. Vol. 84, p. 224-234.

ID:49# Designing Quadruple Grating Spatial Heterodyne Spectrometer (QGSHS)

Author: Pavitra Ganapati Bhat

Co-authors: Ardian Gojani ; Igor Gornushkin ; Michal Stano ; Pavel Veis

The versatility and design adaptability of the Spatial Heterodyne Spectrometer (SHS) have proven to be beneficial in various disciplines, including analyses in atmospheric, astrophysical, elemental, and others 1. A hybrid of interferometric and dispersive domains of the spectrometers is implemented in the single SHS spectrometer, providing high throughput and resolutions with design adaptiveness suitable for specific experiments. However, a disadvantage in such spectrometers is the inverse relationship between the wavelength bandwidth and the resolving power of the spectrometer, similar to Czerny-Terner spectrometers. Circumventing this inverse relationship, the current work proposes to partly compensate for the inverse relationship between wavelength bandwidth and the resolving power using a novel SHS design with two gratings in one arm of the SHS interferometer, i.e., Quadruple Grating SHS (QGSHS), providing simultaneous detection of two different regions of the spectrum. Additionally, the proposed work is already realised using a miniature design with maximum dimensions of 110 mm* 100 mm. More on such designs'applicability, in addition to the simulated design results and drawbacks, would be discussed at the conference.

Reference

1 W. Li Zhang et al., Microchemical Journal 166 (2021), doi: 10.1016/j.microc.2021.106228.

Acknowledgement
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ID:94# Nanocomposite coatings with enhanced antimicrobial and antiviral activity based on silver nanoclusters incorporated into hard organosilicon matrix prepared by high target utilization sputtering

Author: Vitalii Izai

Co-authors: Tomáš Fiantok ; Veronika Turiničová ; Leonid Satrapinskyy ; Štefan Nagy ; Tomáš Roch [1]; Martin Truchlý ; Marek Vidiš ; M. Pop ; Miroslav Rajninec ; Marián Mikula

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Silver-containing nanocomposite coatings were deposited using the High Target Utilization Sputtering technique (HiTUS) by simultaneous sputtering of Ag target and polymerization of hexamethyldisiloxane (HMDSO) vapours in the radiofrequency plasma. The presence of silver in the form of nanoclusters with dimensions below 10 nm embedded in an amorphous organosilicon plasma polymer was confirmed by X-ray diffraction and transmission electron microscopy. The silver content in the films under investigation increases with increasing the power applied to the target and decreases with increasing HMDSO monomer partial pressure. Silver is present mostly in the metallic form while the surface of Ag nanoclusters in the vicinity of the films'surface is oxidized. Addition of silver leads to a steep decrease of organosilicon polymer density, decrease of bonded carbon content, and increase of oxygen content bonded in silanol groups (SiOH). Silver incorporation intensifies the fragmentation of polymer matrix on a molecular level and changes the plasma polymerized HMDSO the same way as a transition from "soft"to "hard"plasma conditions. The nanohardness and adhesion of nanocomposite films to the sapphire substrate decrease with increase of silver content. All films under investigation demonstrate high antibacterial, antifungal, and antiviral activity which in some cases exceeds similar effects of pure metallic silver, maintaining at the same time the low level of cytotoxicity in comparison with non-immobilized free-standing silver nanoparticles.

ID:96# Superconducting diode effect in thin films with 100% efficiency

Author: Oleh Turutanov[1]

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[3] *Comenius University, FMFI, KEF*

The term **"superconducting diode effect" (SDE)** was introduced in the context of advancing superconducting quantum electronics. However, the ac rectification was observed in the 1960s in dc SQUIDs caused by asymmetry in their current–voltage characteristics in magnetic fields. Later, similar behavior was identified in wide thin films due to asymmetry in the Bean–Livingston edge barriers.
Visualization of the critical and resistive states in wide tin films with low-temperature laser scanning microscopy 1 shows that the critical current is locally determined at one of the film edges. Externally applied magnetic field induces nonreciprocity in the critical currents of up to 65% [2]. This phenomenon is intrinsic to all superconducting thin film structures and must therefore be considered and excluded when investigating new quantum mechanisms for SDE.
Our experiments demonstrate that this approach is the most effective for implementing SD as a superconducting microbridge controlled by magnetic field and driven by current into a resistive state characterized by phase slip lines. Moreover, when the system is additionally exposed to 10 GHz microwave radiation, the rectification efficiency approaches **100%**.

1 A. G. Sivakov et al., Low Temp. Phys. 44, 226 (2018)
[2] Y. Hou et al., Phys. Rev. Lett. 131, 027001 (2023)

ID:101# Reference data for optical spectroscopy of small molecules

Authors: Peter Čermák[1]; Filip Pastierovic[2]

[1] *KEF FMFI UK, Bratislava*

[2] *Department of Experimental Physics Faculty of Mathematics, Physics and Informatics Comenius University, Bratislava, Slovakia*

In our laboratory, we study the interaction of light with small molecules (such as ammonia or NOx radicals). These particles often play a key role in everyday physical and chemical processes on both terrestrial and cosmic scales. One example is the characterization of exoplanets based on the detection of such molecules in their atmospheres.
Effective analysis of absorption signals requires a very good understanding of the structure of these molecules and their mutual interactions. The most reliable way to obtain such data is through sensitive laboratory measurements, where reference data can be collected under well-defined experimental conditions (unlike in studied astronomical objects, where these parameters must be inferred from observations).
Our work focuses both on the development of new optical detectors (e.g., CEAS and CRDS) and on the processing of spectroscopic data and creation of reference datasets. Most of this year was dedicated to the finalisation of the ammonia dataset for the HITRAN 2024 edition.

ID:103# Geant4 simulation of geomagnetic field

Authors: Jozef Masarik[1]; Robert Breier[1]

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Modern experimental techniques, such as Accelerator Mass Spectrometry (AMS), allow us to analyze environmental samples with high sensitivity and resolution. The concentration of cosmogenic nuclides in these samples is the result of the interplay between three processes: production, transport,

and deposition. The knowledge of involved processes and their simulations allowed us to obtain production rates of various cosmogenic nuclides. The Monte-Carlo method is a very helpful method to understand and simulate such processes. Our model of extraterrestrial production of cosmogenic nuclide was described in 1. This model could be used also for simulation of cosmic rays' irradiation of extraterrestrial and also terrestrial objects. Cosmic rays impacting at the Earth highly depends on modulation with a geomagnetic field. The field simulation is not included in our model yet. This presentation will be dedicated to the description of improved modelling of geomagnetic field effects in our model. Geant4 toolkit is suited to simulation of simple magnetics field. On the other hand, the geomagnetic field is highly non-uniform. Modeling non-uniforms field is possible by definition of many small uniform fields in Geant4. The global field will be modeled using Geant4 routines. The results will be compared with existing published works and existing experimental data. The extension of our model allows the investigation of Earth samples.

1 Čechvala, P., Breier, R. & Masarik, J. Production rates of cosmogenic nuclides in extraterrestrial material using GEANT4 software. J Radioanal Nucl Chem 332, 4403–4411 (2023). https://doi.org/10.1007/s10967-023-09135-5

ID:105# Study of laser ablation of Cu as a material suitable for thermonuclear reactor walls

Author: Vladyslav Kysil

Co-authors: Daniel Haško [1]; Matej Veis [2]; Pavel Veis [2]; Sahithya Atikukke [2]

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This study investigates laser ablation of materials relevant for thermonuclear reactor walls under various laser irradiation conditions. Copper was selected as the target material due to its high thermal and electrical conductivity and relevance in fusion technology. The study is focused on laser ablation processes using a EKSPLA NT342C laser system operating at a wavelength of 532 nm with nanosecond laser pulses energies set to 25 mJ and 35 mJ. The experimental setup also includes a diffuser and a UV-quality plano-convex fused silica lens to focus the laser on the sample. The optical emission spectroscopy (OES) signal from the laser-generated plasma is analyzed using an echelle spectrometer (ME5000, Andor Tech) and an iCCD camera (iStar DH743, Andor Tech) with a time resolution of 5 ns. The study aims to understand the ablation mechanisms and optimize the laser settings to increase the ablation efficiency and enhance the accuracy of depth analysis. Through a series of kinetic studies with different numbers of pulses (80, 40, 20, 10, 5, and 1), the ablation rate is calculated and the characteristics of the craters are analyzed using Keyence VK-X scanning confocal microscopy. Plasma parameters, including electron temperature, are determined using Boltzmann plots. The results show a clear influence of self-absorption on spectral lines, with visible changes in intensity and width at higher plasma densities. In addition, the depth of the craters increases with the number of laser pulses and the energy of the laser pulse which is then visualized through 3D reconstructions of craters created the aforementioned energies.
In conclusion, this work provides a comprehensive analysis of laser ablationon copper sample, offering valuable insights for optimizing material processing techniques for applications in thermonuclear reactors. The findings emphasize the importance of precise control of laser parameters to achieve the desired ablation results,and thereby advancing materials for fusion technologies. Further studies could include research on the influence of different laser wavelengths and pulse frequencies on ablation efficiency and a more detailed investigation of thermal effects on material surfaces.

ID:116# Research on historical earthquakes in Eastern Slovakia

Author: Robert Kysel

Co-author: Sebastián Ševčík

On Monday, October 9, 2023, 20:23 CEST, an earthquake with a local magnitude of 4.9 occurred in Eastern Slovakia with an epicenter near the village of Ďapalovce. The epicentral macroseismic intensity reached 8° EMS-98. It was the strongest earthquake on the territory of Slovakia in more than 100 years (since earthquake on the night of January 9-10, 1906 near the municipality Dobrá Voda, nowadays Trnava region). The macroseismic effects were reported from more than 540 municipalities and damage was verified to 80 sites.

Looking at the earthquake catalogue for the territory of Slovakia, the location of the epicenter and the magnitude of October 9, 2023 earthquake are not surprising in terms of the historical seismic activity of the Vranov nad Topľou and Humenné regions (a series of three earthquakes between 1778-1779 with a magnitude of around 5.0, earthquakes in 1885, 1890, 1893, 1914, 1932, 1941 with magnitudes between 4.5 and 5.0). The 2023 earthquake undoubtedly contributed to the increased interest in studying the historical and recent seismic activity of eastern Slovakia and raised the need to update the seismic hazard map of the territory of Slovakia.

ID:110# Reflection-enhanced gain in traveling-wave parametric amplifiers and plasma oscillation phase matching

Author: Emil Rizvanov[1]

Co-authors: Samuel Kern [1]; Pavol Neilinger [1]; Miroslav Grajcar [1]

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Traveling-Wave Parametric Amplifiers (TWPAs) are essential tools for ultra-sensitive measurements, particularly in quantum systems. Their performance, however, is often limited by challenges in impedance and phase matching. Conventional phase-matching techniques, such as periodic impedance modulation or the use of resonators and phase shifters, complicate circuit design and increase impedance mismatch. We show that reflections caused by such mismatches significantly alter both gain and phase-matching conditions in TWPAs 1. To capture this behavior, we extend standard coupled-mode theory, which typically assumes only forward-propagating waves, by including reflected waves. This leads to a corrected gain formula that more accurately reflects real device performance. To overcome these limitations, we propose a simpler and more integrated solution: leveraging tunable dispersion in a Josephson junction array waveguide [2]. The desired dispersion is engineered through a metamaterial structure, achieved by periodically adding a parallel capacitor to every n-th Josephson junction. This design enables efficient phase matching in the three-wave mixing regime. Our analytical framework is supported by numerical simulations that account for the complex nonlinear dynamics present in realistic devices

ID:118# Non-Thermal Plasma-Assisted VOC Decomposition: Influence of Catalyst Type, Electron Energy, and Gas Residence Time

Author: Ramavtar Jangra[1]

Co-authors: Gokul Selvaraj [1]; Karol Hensel [1]

[1] *Comenius University Bratislava*

Volatile organic compounds (VOCs) such as toluene are major air pollutants, contributing to photochemical smog and posing severe environmental and health risks. Conventional abatement methods often require high operating temperatures or show poor efficiency for intermittent emissions. In this study, non-thermal plasma (NTP) assisted VOC decomposition was investigated using a dielectric barrier discharge (DBD) reactor integrated with different catalyst materials (TiO_2, Ag/TiO_2, $BaTiO_2$, and γ-Al_2O_3). The effects of discharge characteristics, gas residence time, and catalyst type on toluene degradation, energy efficiency, and by-product formation were systematically examined. Experiments were performed in an N_2/O_2 (50:50) atmosphere at applied voltages of 12 - 16.5 kV and flow rates of 0.5 - 2.0 L min^{-1}. Infrared spectroscopy analysis identified CO_2, CO, HCOOH, and O_3 as

major oxidation products, indicating partial mineralisation of toluene. Among the tested catalysts, $BaTiO_3$ exhibited superior degradation performance and energy efficiency at lower specific input energy (SIE), emphasising the role of high-dielectric materials in enhancing plasma–catalyst interactions. The Ag/TiO_2 catalyst demonstrated further improvement in mineralisation efficiency due to enhanced electron transfer and plasmonic activity of Ag nanoparticles, facilitating deeper oxidation of intermediate species. Additionally, the mean electron energy and reduced electric field (E/N) were calculated for different plasma-catalyst combinations, revealing that plasma-only conditions exhibited higher values compared to plasma-catalyst configurations, consistent with the voltage distribution and energy dissipation across the dielectric materials. These findings provide valuable insights into optimising plasma-catalyst systems for energy-efficient VOC abatement and highlight their potential for scalable, low-temperature air purification applications.

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ID:29#Towards the minimal effective theory for leptogenesis, dark matter, and neutrino masses

Authors: Tomáš Blažek[1]; Peter Maták[1]; Ján Ramaj[1]; Martina Sabová[1]

[1] *Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava*

We present a bottom-up approach to an effective theory that simultaneously explains the matter–antimatter asymmetry via leptogenesis, the dark matter relic abundance via freeze-in or freeze-out mechanisms, and neutrino masses via the Weinberg operator. We show that, in the minimal scenario, only two new particles and a single portal operator coupling the visible and dark sectors are sufficient beyond the Standard Model. This contribution is primarily based on arXiv:2504.15164.

ID:55#The study of nuclear structure in collaboration with ISOLDE

Author: Jozef Mist

Co-authors: Boris Andel ; Stanislav Antalic

The ISOLDE facility at CERN is one of the world's leading centers for the investigation of exotic nuclei and their structure. Thanks to large production yields and element-selective laser ionisation, ISOLDE provides access to a broad range of radioactive isotopes far from stability. Various experimental techniques, for example, laser or decay spectroscopy, are used to probe properties of these nuclei, including their shapes, the presence of isomeric states, or rare decay modes, such as the process of β-delayed fission. In this contribution, we present recent results obtained through a collaboration between a local research group specializing in nuclear structure studies and the ISOLDE facility.

ID:25#Robust edge states in stacked Al/Ni-based multilayers

Author: Olena Zhytlukhina[1]

[1] *Centre for Nanotechnology and Advanced Materials, Faculty of Mathematics, Physics and Informatics, Comenius University Bratislava*

Topological phases emerge from the global properties of electronic band structures, stabilized by time-reversal or mirror symmetries. Their hallmark is the presence of gapless boundary states that are robust against perturbations and enable charge transport without backscattering. To realize a

non-trivial conducting state, we adopted a stacking strategy by fabricating a superlattice composed of nominally trivial metallic layers, which were formed by 3.1 nm-thick aluminum films alternated with ultrathin (1.3 nm) nickel layers that mediate intermediate coupling between adjacent Al films. The goal of this stage of the research was to test for the presence of highly conductive quantum channels in a multilayered $(Al/Ni)_{10}$ structure, providing compelling evidence for topologically protected transport modes. To this end, we employed our previously developed technique for probing normal–superconducting hybrid sandwiches using nonlocal four-terminal electrical measurements. Remarkably, the phenomena observed in the $(Al/Ni)_{10}$ superlattice bear a strong resemblance to behaviors reported in topological systems hosting higher-order edge modes, despite the constituent metals being topologically trivial in their intrinsic band structure. While a definitive topological interpretation requires further experimental and theoretical validation, the results obtained suggest a novel route for engineering exotic edge transport modes in hybrid multilayered metallic systems. These findings open promising directions toward realizing low-dissipation quantum devices based on technologically accessible, structurally tunable materials.

ID:120#Student Scientific Conference

Author: Juraj Tekel[1]

[1] *Comenius University, Bratislava*

The Student Scientific Conference is an annual showcase of scientific and professional works by students of bachelor's, master's and doctoral studies from all fields of mathematics, physics, computer science and didactics of these disciplines. All contributions are assessed by a scientific committee, the best of them are awarded as winners or laureates of the ŠVK, or nominated for other special awards. The most successful participants will have the opportunity to represent the Faculty at the relevant Czech-Slovak competition. Abstracts of the works, or their extended versions, are published annually in the proceedings of the conference.

Poster session + káva: prezentácie vedeckých výsledkov FMFI UK Zamestnanci informatika

ID:85# Can Full Set-Theoretical Subsumption Semantics in Metamodelled Description Logics Be Captured Within Decidable FOL Fragments?

Authors: Ján Kľuka; Martin Homola; Zekeri Adams[1]

[1] *Comenius University Bratislava*

Metamodelling in ontologies enables the structured representation of complex domains by defining relationships between concepts across multiple levels of abstraction. Subsumption, a core relation in hierarchical reasoning, provides a strong foundation for organizing ontological knowledge. In this work, we build on an extended form of higher-order description logic, denoted $\mathscr{HIIRS}*(\mathscr{L})$, which supports metamodeling through two semantically fixed roles: instanceOf and subClassOf. These roles explicitly enforce meta-level constraints, allowing for a richer and more expressive representation of both hierarchical and meta-level concepts. While the logic has four known variants with three shown to be decidable, the decidability of the full set-theoretical semantics of the subClassOf relation for all concepts remains open. This work investigates the decidability of the full set-theoretical semantics of the subClassOf relation for all concepts, denoted as $\mathscr{HIRSSA}(\mathscr{L})$ for arbitrary base DL, $\mathscr{L}$ by seeking to align it with well-established decidable fragments of first-order logic.

ID:13#Modeling Security Under Partial Observability

Authors: Aliyu Tanko Ali; Damas Gruska[1]

[1] *Comenius University, FMPH*

Attack Trees (ATs) are a widely adopted formalism for modeling security threats. However, their conventional use relies on an unrealistic assumption of perfect knowledge, where the system's entire state and all adversarial actions are fully known. Real-world security interactions are characterized by limited visibility and finite resource constraints for both the attacker and the defender.

To address this gap, we introduce Supervised Attack Trees (SATs), a novel framework that extends ATs to explicitly model the strategic, resource-constrained interaction between an attacker and a defender under conditions of partial observability. In our SAT model, each agent possesses a distinct, limited view of the system's nodes. The defender (supervisor) can dynamically allocate a finite budget to delay ongoing attacks, while the attacker expends a separate budget to compromise nodes.

We formally define the notion of a consistent observation, which represents a partially visible snapshot of the system state, and provide an algorithm for verifying its validity against the underlying SAT structure. Furthermore, we demonstrate that critical security decision problems, such as determining the minimum budget required to guarantee a successful attack and verifying the existence

of a purely observation-based defense strategy that perpetually prevents the root compromise, can be systematically reduced to tractable model-checking problems.

ID:72#Noncanonical chromosomal-end-specific telomeric arrays in naturally telomerase-negative yeasts

Authors: Bronislava Brejová[1]; Jozef Nosek

Co-authors: Viktória Hodorová ; Hana Lichancová ; Askar Gafurov ; Dominik Bujna ; Filip Brázdovič ; Filip Červenák ; Tomáš Petrík ; Eva Hegedűsová ; Michaela Forgáčová Jakúbková ; Martina Neboháčová ; Ľubomír Tomáška ; Matthias Sipiczki ; Tomáš Vinař

[1] *KI FMFI UK*

In most eukaryotes, chromosomal DNA terminates with tandem repeats of a short G-rich motif, such as the canonical TTAGGG sequence. Here we report that nuclear chromosomes of several basidiomycetous yeasts classified into the order Microstromatales carry unusual telomeres. We demonstrate that instead of TTAGGG-like repeats these telomeres are composed of unique tandem arrays which are in most cases specific to a particular chromosomal end. In contrast to other basidiomycetes, the Microstromatales genomes lack orthologs coding for the telomerase catalytic subunit Est2 and a shelterin component Tpp1 indicating that noncanonical telomeric arrays are maintained by a telomerase-independent mechanism. We hypothesize that in a common ancestor of Microstromatales the loss of telomerase and Tpp1 was compensated by activation of an ALT mechanism, which promoted amplification of various motifs and formation of distinct telomeric arrays at most chromosomal ends. In this poster, we will show various bioinformatics analyses applied to explore sequencing data from these species.

ID:21#Explainable Malware Analysis

Authors: Martin Homola; Štefan Balogh[1]; Ján Kľuka[2]; Daniela Chudá[3]; Iveta Bečková; Jaroslav Kopčan[3]

[1] *FEI STU*

[2] *FMFI UK*

[3] *KInIT*

Malware analysis increasingly relies on machine learning classification. In this mission-critical domain, analysts require deeper insights that justify the classification results and help them understand how the results were reached. In the project EMA (NextGenerationEU/Recovery and Resilience Plan project No. 09I05-03-V02-00064), we focus on applications of eXplainable (XAI) methods that enable such insights. We develop suitable datasets, select the most promising XAI methods, and also focus on the presentation of the justifications/explanations to the user.

ID:27#Teaching software development in MSc. courses: Cooperation of FMFI UK with IT industry

Author: Lubor Sesera[1]

[1] *assistant professor, DAI FMFI UK,*

ACM and IEEE Curricula for Computing science defines seven disciplines of computing. One of the disciplines is Software engineering which deals with development of complex software systems. Software engineering is the important discipline as, according to U.S. Bureau of Labor Statistics, 42% of 'computer and Information technology jobs'are software developers and testers. The issue, however, is how to teach Software engineering at universities. ACM and IEEE curricula specifies main knowledge areas of Software engineering but does not go into details. Moreover, software

development has changed significantly since the era Software engineering was coined. Last but not least, universities lack experts on Software engineering as most of them work in industry due to high salaries. This paper describes a successful project in FMFI UK in teaching Software engineering in cooperation of FMFI UK with IT industry. The project includes six courses which join university knowledge on how to organize university education with practices of modern software development in IT industry.

ID:69#Cross-Domain Synthetic Data Generation: From Avatars to Real-World Applications

Authors: Martin Halaj; Lukas Gajdosech[1]; Martin Madaras

[1] *Comenius University, FMFI, Bratislava*

The growing demand for large, diverse datasets in AI and machine learning is often limited by the cost, privacy, and complexity of real-world data collection. Synthetic Data Generation offers a powerful alternative-creating realistic, controllable datasets through computer graphics, generative models, and physics-based simulations.

This approach enables precise control over environments, lighting, and object diversity, while producing data that can match or exceed real-world complexity. In particular, realistic 3D human avatars support applications in computer vision, virtual reality, and ergonomics, providing rich and ethical training data. Beyond human modeling, synthetic data drives progress in robotics, automation, and quality control.

Ultimately, it represents a shift toward scalable, ethical, and customizable data creation-enhancing AI robustness and accelerating innovation across industries.

ID:87# Kuriatko alebo pes?

Author: Andrej Lucny

Jedným zo spôsobov, akým dokáže systém umelej inteligencie pomenovať predmet na obraze je spriahnutie extraktora príznakov z obrazu s extraktorom príznakov textu. V takomto spoločnom priestore obrazových a textových príznakov je potom pre príznaky obrazu hľadať akým príznakom textu sú podobné. Robí to takto napríklad model CLIP, pričom používa kosínusovú podobnosť medzi príznakovým vektorom textu a klasifikačným príznakovým vektorom obrazu. Tento prístup je pomerne ľahké pomýliť, napríklad keď modelu prezentujeme obrázok kuriatka a pod ním text "pes", povie, že na obrázku je pes. Pritom ako vedľajší produkt vzniká mapa príznakov jednotlivých regiónov obrazu. Naším vkladom do problematiky je nový algoritmus, ktorý túto mapu dokáže rozložiť na časť, ktorá zodpovedá kuriatku a časť, ktorá zodpovedá nápisu "pes". Takáto bipartícia je v princípe NP-ťažký problém, pre ktorý navrhli Shi a Malik v roku 2000 približný algoritmus, kvadratický od počtu regiónov. Prerobili sme ho na lineárny a dali mu podobu, v ktorej môže byť zabudovaný priamo do neurónovej siete. Vďaka bipartícii obrázka je potom možné použiť pôvodný model, aby jednu časť pomenoval správne: "kuriatko" a druhú správne: "pes".

ID:117#Optimizing hyperparameters of a novel bio-inspired neural network via interpretable meta-modeling

Authors: Kristina Malinovska[1]; Miroslav Cibula

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Artificial neural networks are currently at their prime, mainly due to the bloom of deep learning. Despite their inspiration from brain processes, learning in such systems, based on error backpropagation (BP), is only loosely inspired by the actual neural mechanisms. Learning in the brain is local

and makes use of the bidirectional flow of information. Our Universal Bidirectional Activation-based Learning (UBAL) model extends the existing work on bio-inspired alternatives to BP based on the so-called contrastive Hebbian-anti-Hebbian learning principle. Introducing more brain-related properties, it implements two mutually dependent yet separate weight matrices for different activation-propagation directions and a so-called echo component that allows the network to learn from its own internal representations. At its core, UBAL performs heteroassociative learning via a novel learning rule with special hyperparameters that enable our model to master qualitatively different tasks, such as auto-encoding, denoising, and classification, all with a single learning rule. In a good hyperparameter setup, UBAL achieves performance comparable to a standard multi-layer perceptron as well as to related biologically motivated state-of-the-art models. Due to its heteroassociative nature, it is able to generate images of the learned classes as an emergent phenomenon, without being explicitly trained to do so, and this is also dependent on the setup of the special new hyperparameters. As it is vital yet difficult to find an optimal setup of the beta and gamma hyperparameters, we have focused on well-interpretable and effective methods for finding these values. Here, we present our chosen analytical method that reveals the individual effects of given hyperparameters on the performance of our model as a form of meta-modeling the model's performance as a function of the hyperparameter configuration. Namely, we utilize a multi-layer perceptron, which learns to predict the model's performance as a function of a hyperparameter setup and the SHAP method to reveal the feature importance of the novel hyperparameters of the UBAL model. Our proposed method helps us to further explore their function and relative importance in a particular machine learning task.

ID:57# Pangenome-based characterization of novel genetic variants

Authors: Luca Denti[1]; Paola Bonizzoni[2]; Rayan Chikhi[3]; Thomas Krannich[4]; Tomas Vinar[1]; Bronislava Brejova[1]; Fereydoun Hormozdiari[5]

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Pangenomes are becoming increasingly popular data structures for genomics analyses due to their ability to compactly represent the genetic diversity within populations. Constructing a pangenome graph, however, is still a time-consuming and expensive process. A promising approach for pangenome construction consists in progressively augmenting a pangenome graph with additional high-quality assemblies. Currently, there is no method for augmenting a pangenome graph with unassembled reads from newly sequenced samples without first aligning the reads to a reference genome and performing variant calling and genotyping on the new individuals. In this work, we present the first assembly-free and mapping-free approach for augmenting an existing pangenome graph using unassembled long reads from an individual not already present in the pangenome. Our approach consists of finding sample specific sequences in reads using efficient indexes, clustering reads corresponding to the same novel variant(s), and then building a consensus sequence to be added to the pangenome graph for each variant separately. An additional advantage of our approach lies in its capability to collect and characterize variants specific to new individuals while performing updates to the graph topology. However, as we will demonstrate, evaluating the accuracy of this characterization presents several challenges that render the task particularly complex. Using simulated reads and real pangenome graphs provided by the Human Pangenome Reference Consortium (HPRC), we demonstrate the effectiveness of the proposed approach. Software and code is freely available at github.com/ldenti/palss and github.com/ldenti/svbench-fw.

ID:90#Circular chromatic index

Author: Jan Mazak

Circular colourings are a relaxation of proper graph colourings where we allow real numbers as colours. They serve as a model for scheduling problems in which we have arbitrary starting times instead of aligned slots. We provide an overview of computational methods we successfully used to

determine circular chromatic index of small graphs and discuss recent results related to the Upper Gap Conjecture which asserts that certain "high" values of circular chromatic index are not attainable by any graph. In particular, we determine the circular chromatic index of small graphs with maximum degree 4, 5, 6 and refute certain variants of the conjecture.

ID:84# Explainable Malware Detection via Relational Graph Neural Networks with Bidirectional Relations

Author: Monday Onoja[1]

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Graph Neural Networks (GNNs) are increasingly applied to cybersecurity tasks such as malware detection, intrusion detection, and program analysis, as they can model structured program representations and capture relational dependencies beyond flat feature vectors. However, their black-box nature poses challenges in security-critical do- mains, where analysts and stakeholders require explanations for trust and forensic analysis. This has motivated growing interest in explainable GNNs (XGNNs), which aim to provide interpretable insights into model decisions. In this work, we investigate Relational Graph Convolutional Networks (R-GCNs) for ontology-based malware detection. We introduce a proof-of-concept framework that incorporates bidirectional relations through edge reversal to strengthen semantic representation.
Experimental results on the numeric subset of the Ontology–Knowledge Graph EMBER dataset (1,000 binaries) show that bidirectional relations substantially improve performance: R-GCN with edge reversal (RGCN2) achieved 98% accuracy and true positive rate (TPR), compared to 67% in baseline models, and delivered 87% fidelity with the Captum explainer. These findings demonstrate the effectiveness of relational GNNs in leveraging semantic structures for robust and interpretable malware detection.

ID:102#Three-view Focal Length Recovery From Homographies

Authors: Jian Yang; Qianliang Wu; Shen Cai; Viktor Kocur[1]; Yaqing Ding; Zuzana Berger Haladova; Zuzana Kukelova

[1] *Comenius University*

In this paper, we propose a novel approach for recovering focal lengths from three-view homographies. By examining the consistency of normal vectors between two homographies, we derive new explicit constraints between the focal lengths and homographies using an elimination technique. We demonstrate that three-view homographies provide two additional constraints, enabling the recovery of one or two focal lengths. We discuss four possible cases, including three cameras having an unknown equal focal length, three cameras having two different unknown focal lengths, three cameras where one focal length is known, and the other two cameras have equal or different unknown focal lengths. All the problems can be converted into solving polynomials in one or two unknowns, which can be efficiently solved using Sturm sequence or hidden variable technique. Evaluation using both synthetic and real data shows that the proposed solvers are both faster and more accurate than methods relying on existing two-view solvers.

ID:66# MACKO: Sparse Matrix-Vector Multiplication for Low Sparsity

Authors: Vladimir Boza[1]; Vladimir Macko

[1] *Comenius University*

Sparse Matrix-Vector Multiplication (SpMV) is a fundamental operation in the inference of sparse Large Language Models (LLMs). Because existing SpMV methods perform poorly under the low and unstructured sparsity (30–90%) commonly observed in pruned LLMs, unstructured pruning struggled to deliver real memory reduction or speedup. We propose **MACKO-SpMV**, a GPU-optimized format and kernel co-designed to reduce storage overhead while preserving compatibility with the GPU's execution model. This enables efficient SpMV for unstructured sparsity without specialized hardware units (e.g., tensor cores) or format-specific precomputation.

Empirical results show that at sparsity 50%, MACKO is the first approach with significant $1.5\times$ memory reduction and 1.2
$textup--1.5\times$ speedup over dense representation. Speedups over other SpMV baselines: 2.8
$textup--13.0\times$ over cuSPARSE, 1.9
$textup--2.6\times$ over Sputnik, and 2.2
$textup--2.5\times$ over DASP. Applied to Llama2-7B pruned with Wanda to sparsity 50%, it delivers $1.5\times$ memory reduction and $1.5\times$ faster inference at fp16 precision. Thanks to MACKO, unstructured pruning at 50% sparsity is now justified for practical deployment in real-world LLM workloads.

ID:71# Addition is almost all you need: Compressing neural networks with double binary factorization

Author: Vladimir Boza[1]

Co-author: Vladimir Macko

[1] *Comenius University*

Binary quantization approaches, which replace weight matrices with binary matrices and substitute costly multiplications with cheaper additions, offer a computationally efficient approach to address the increasing computational and storage requirements of Large Language Models (LLMs). However, the severe quantization constraint (± 1) can lead to significant accuracy degradation.
In this paper, we propose Double Binary Factorization (DBF), a novel method that factorizes dense weight matrices into products of two binary (sign) matrices, each accompanied by scaling vectors. DBF preserves the efficiency advantages of binary representations while achieving compression rates that are competitive with or superior to state-of-the-art methods.
Specifically, in a 1-bit per weight range, DBF is better than existing binarization approaches. In a 2-bit per weight range, DBF is competitive with the best quantization methods like QuIP\# and QTIP. Unlike most existing compression techniques, which offer limited compression level choices, DBF allows fine-grained control over compression ratios by adjusting the factorization's intermediate dimension. Based on this advantage, we further introduce an algorithm for estimating non-uniform layer-wise compression ratios for DBF, based on previously developed channel pruning criteria.

Poster session + káva: prezentácie vedeckých výsledkov FMFI UK Zamestnanci didaktika

ID:16#Challenge-based education

Author: Mária Slavíčková[1]

Co-author: Klara Velmovska

[1] *KDMFI*

In our contribution, we present the introduction of Challenge-based Education (CBE) in lower-secondary mathematics and sciences as a means to enhance pupils'scientific competences and engagement. We described the design and implementation of activities that apply CBE principles to connect curricular content with real-world challenges. This approach supports the development of collaboration, communication, critical thinking, and creativity, while strengthening cooperation between schools and universities through joint work of teachers, researchers, and students. The expected outcomes include deeper conceptual understanding, improved teaching practices in mathematics and physics, and increased pupil motivation for further study in STEM fields.

ID:22#Edukačné prostredia a didaktické materiály na výučbu programovania pre nevidiacich žiakov

Author: Ludmila Jaskova

V našej prezentácii uvedieme prehľad programovacích nástrojov a edukačných materiálov na výučbu programovania pre nevidiacich žiakov rôznych vekových kategórií od prvého ročníka základnej školy až po maturantov.
Pre žiakov prvého stupňa ZŠ sú to robotické hračky Bee-Bot alebo Blue-Bot v kombinácii s tabuľkou Tactile Reader. Ďalej sa zmienime o fyzickom programovacom jazyku Code Jumper.
Pre žiakov druhého stupňa ZŠ sú to textové programovacie prostredia, ktoré vytvorili naši študenti aplikovanej informatiky. Ide o aplikácie na programovanie hudby Musik, zvukových príbehov Alan a na programovanie pohybu virtuálneho objektu po ozvučenej mriežke –Coshi a Coshi 2.
Pre nevidiacich žiakov vyššieho sekundárneho vzdelávania predstavíme voľne dostupné a prístupné programovacie prostredia využívajúce jazyk Python (NVDA Python konzola, Visual Studio Code, Google Collaboratory, Jython Music) a edukačné materiály adaptované pre týchto študentov.

ID:34#Comparison of manually created and ai-generated mind maps: insights from preservice teachers

Author: Maria Cujdikova

Our study explores how preservice teachers perceive the process of creating mind maps manually compared to generating them with artificial intelligence (AI). Over two academic years, 34 preservice

teachers enrolled in the course Software for the Modern Teacher were tasked with creating mind maps on the theme of software and education. Initially, they constructed their mind maps using Coggle, incorporating multimedia elements such as YouTube videos. Subsequently, they created mind maps on the same theme using AI tools available in Miro. After completing the tasks, the students documented their experiences and reflections on their personal course webpages. In our research we analyze these reflections to understand how students evaluated the usability of the tools, the differences they perceived between manually created and AI-generated maps, and their overall satisfaction with both approaches. The findings highlight key advantages and limitations identified by the students, including the perceived structure, coherence, and relevance of the AI-generated maps compared to their manually created counterparts.

ID:42#Innovative Approaches to Teaching Probability in Secondary Schools

Authors: Michaela Vargova; Peter Vankus

In this paper, we present innovative approaches to teaching probability that were developed as part of the KEGA 037UK-4/2024 project Innovative learning technologies in the preparation of future mathematics teachers and the project Digital Transformation of Education and Schools (DiTEdu, code ITMS2014+: 401402DVR6). These approaches aim to foster a deep conceptual understanding of probabilistic concepts through their gradual constructivist development, with an emphasis on visualization, manipulative activities, and experimentation. The topics covered include conditional probability, geometric probability, and expected value.

ID:41#Súťaž Informatický bobor

Author: Monika Tomcsanyiova

Súťaž Informatický bobor vznikla v roku 2004 v Litve. Jej myšlienka sa odvtedy rozšírila do ďalších európskych aj mimoeurópskych krajín. Jej hlavným cieľom je podporiť záujem žiakov, učiteľov a rodičov o informatiku a rozvoj digitálnych zručností u všetkých žiakov. Súťaž chce posilniť v mladých ľuďoch záujem o intenzívne a inovatívne používanie moderných digitálnych technológií pri učení sa.
Súťaž kladie dôraz na šírku záberu –jej cieľom je osloviť desaťtisíce žiakov –chlapcov a dievčat a ukázať im úlohy, pri ktorých riešení má šancu na úspech –aspoň čiastočný –každý z nich.
Sekundárnym cieľom súťaže iBobor je poskytovanie atraktívneho priestoru pre šírenie osvety o tom, čo považujeme za súčasť modernej školskej informatiky. Toto posolstvo sa vďaka atraktivite úloh dostáva nielen k samotným žiakom, ale aj k ich učiteľom a rodičom.

ID:40#Informatics in the new curriculum reform

Author: Lubomir Salanci

In our presentation, we focus on the ongoing curriculum reform, the results of analyses of current trends in education in the field of school informatics, aspects of the process of creating a national document, such as the relationship between digital literacy and informatics or the role of artificial intelligence in education. The new legislation brings several changes, not only in the subject of computer science. We focus on the most significant ones and compare them with the previous situation.

ID:30#Hands-on Physics Education for Developing Scientific and Critical Thinking in Primary Schools

Author: Klára Velmovská

Co-authors: Alena Opálková Šišková [1]; Martin Nosko [1]

[1] *Ústav materiálov a mechaniky strojov SAV*

The Creative Science project, developed with the Slovak Academy of Sciences, promotes experiential learning in physics and technical education. Using custom-made experiment kits and a methodological guide, the project aimed to boost pupils'scientific and critical thinking and interest in science. A pilot study with 42 schools showed that pupils exposed to hands-on physics lessons achieved better results in scientific reasoning and physics knowledge. The poster will present the project's core ideas, the design of the experimental kits, and selected findings from the pilot study. While the focus is on physics and technical education, the interdisciplinary nature of the kits also touches on biology and chemistry. The results suggest that hands-on, methodologically guided science education can foster deeper understanding and enthusiasm for science among young learners.

ID:68#Applications of the learning sciences to the theory of physics education

Author: Peter Demkanin[1]

Co-authors: Dasa Cervenova [1]; Diana Demkaninova [2]; Fatema Ashoori [1]; Marek Kralik [1]

[1] *FMFI UK*

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In the past decade, several research teams have investigated the bio-psycho-social aspects of students and analyzed the basic principles of personality theory, taking into account genetic mapping. Recently developed medical brain imaging techniques, combined with investigations into the fundamental connections between learning theories that encompass psychological, social, and biological aspects, have yielded new insights into learning theories. Our contribution to this research direction is focused in particular on one neurocognitive theory, the Five Pillars of Mind Theory, formulated by Professor Tokuhama-Espinosa in 2017. Five years of research applying this theory to physics education has yielded promising results. In our poster, we present an example of how this theory and other knowledge from contemporary learning sciences are applied to the design of a high school physics final exam.

ID:65#WILMA.sk ako aktívna podpora učiteľov matematiky

Author: Emilia Mitkova

Co-authors: Dusan Daniel ; Jana Havlickova ; Monika Dillingerova

Stránka WILMA.sk vznikla na Oddelení didaktiky matematiky FMFI UK s cieľom ponúknuť učiteľom matematiky rôzne inšpirácie a materiály priamo na výučbu, no aj na mimoškolskú činnosť. Na základe spätnej väzby od učiteľov vieme, že v období pred prázdninami si nami pravidelne vytvárané a publikované materiály nachádzajú u učiteľov obľubu. Zohľadňujúc túto skutočnosť, bol v júni 2025 na stránke WILMA.sk uverejnený materiál Leto s Wilmou 2025, ktorý v rámci poster session ponúkneme ako konkrétnu ukážku aktivity. Predstavíme tiež niektoré publikačné výstupy, ktoré vznikli v nedávnom období v súvislosti so stránkou WILMA.sk.

ID:33# EcoMystery

Authors: Katarina Kaluzna; Maria Cujdikova; Peter Vankus

Interactive Escape Rooms for Climate Crisis Awareness and Civic Engagement in School Education. International Erasmus+ project with Greece, Italy, Portugal and Romania.
EcoMystery project aims to integrate innovative educational methodologies with pressing environmental challenges to enhance the school community's awareness of the climate crisis and strengthen civic engagement. Utilising the compelling experience of escape rooms, we seek to create an immersive, interactive learning experience that engages young minds in understanding and addressing the climate crisis. In detail, the project will produce a relevant needs analysis, ready-made educational

resources for teacher training and a variety of educational activities for students, as well as an innovative platform with thematic escape rooms. Thus, project funding is crucial to fill the gaps in school education on climate change mitigation practices, while enhancing civic engagement, thus achieving multiplier positive results at a community level.

ID:79#Activities focused on the Challenge-based education method

Author: Tünde Kozánek Kiss[1]

Co-authors: Klara Velmovska ; Viera Haverlikova [2]

[1] *Oddelenie didaktiky fyziky, Katedra didaktiky matematiky, fyziky a informatiky*

[2] *Katedra didaktiky matematiky, fyziky a informatiky, Fakulta matematiky, fyziky a informatiky, Univerzita Komenského v Bratislave*

Challenge-based Education (CBE) is an innovative educational approach that engages pupils in solving real-world problems through active learning, collaboration, and the integration of knowledge across different subject areas. In this paper, we present a set of activities designed to implement the CBE method, aimed at lower secondary school pupils. We also discuss the results of the pilot testing and outline the next steps of our research.