XXIV Interdisciplinary
Math-Science Student Conference

SEMPOWISKO

April 23-26 2026

Book of abstracts

UNIWERSYTET
JAGIELLOŃSKI
W KRAKOWIE

SMP

UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE

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SeMPowisko 2026

Book **O**f **A**bstracts

Mathematics and Natural Sciences Students' Association - **KMPSUJ**
Jagiellonian University in Kraków, Poland, Earth

About SMP

Interdisciplinary Studies in Mathematics and Natural Sciences (Studia Matematyczno-Przyrodnicze, SMP) is a modern approach to studying at the Jagiellonian University. It offers 26 different specialisations across 6 faculties.

What makes SMP unique?

Individualised study path: From the very beginning, students work under the supervision of a tutor (academic adviser) and choose courses that interest them from the full range of mathematics and natural sciences departments.

Interdisciplinarity: Students have the opportunity to attend classes across various fields. Candidates choose their leading specialisation at the beginning of the first year of studies and finalise this choice at the end of the second year. Please note that there are some restrictions on the choice of specialisation, as outlined in the announcements of the SMP Programme Council and the SMP Regulations. After completing the first cycle (3 years) of studies, graduates receive a Bachelor's degree in the chosen field. After continuing their studies in the SMP mode at the second cycle (2 years) and completing them, graduates receive a Master's degree in one of the specialisations.

Benefits of SMP: Develops independence and decision-making skills, broadens students' horizons and interests, provides early engagement in scientific research, and prepares students for a successful career and personal life. SMP students are distinguished by their academic achievements, receiving numerous awards and scholarships. The SMP programme has been in operation since 1993/94.

If you are interested in studying mathematics or natural sciences at the Jagiellonian University, SMP is an excellent option for you.

Timetable

Legend

- astronomy
- biosciences
- chemistry
- computer science
- engineering
- geography and geology
- mathematics
- physics
- other

Timetable below can change a bit – in case of doubt check the current version on our website.

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Opening

15:30–15:45 WCh A0-01:
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15:45–17:15 WCh A0-01: Prof. Barbara Gil – workshops
Presentation techniques

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Invited talk: Biosciences

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Excited electronic states of the helium dimer including relativistic, adiabatic, and QED effects PAGE 17

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Presentation techniques

Friday/12:00–12:45 🪨 WCh A0-01: Prof. Bartłomiej Rzonca
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HYADES

Sunday/12:00–13:00 ⚗️ WFAIS A-1-06: Prof. Konrad Szaciłowski
What the Possum Squawks About, or How to Lock Pavlov's Dog and Schrödinger's Cat in a Faraday Cage

More information about invited speakers on the leaflet (you can glue it down here)

Abstracts

Molecular fingerprints are strong models for peptide function prediction

Jakub Adamczyk Field:
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Machine learning (ML) has become an indispensable tool for modern drug design, reducing reliance on expensive and hard wet lab experiments. There is a dynamically growing interest in applying it to not only small molecule drugs, but also biologics, exemplified by peptide therapeutics. Peptides, small proteins of up to 50 amino acids, have become research targets for antibiotics and obesity drugs, among others, with famous successes including Ozempic.

Molecular fingerprints are simple and well-established chemoinformatics feature extraction algorithms for small molecules. In this work, we show that they also give state-of-the-art results on peptide property prediction tasks, resulting in robust, fast, and scalable predictive ML models. Comparisons with Protein Language Models (PLMs), Graph Neural Networks (GNNs), and complex feature engineering pipelines commonly applied in bioinformatics reveal that our approach is superior on a largest to date comparison on 6 benchmarks, 132 datasets, and over 215 thousand unique peptides. Further experiments underscore the robustness of our proposed method to adversarial changes of training data and challenging train-test splits.

Open-Shell Switches: Dimeric Macrocycles for Singlet-Triplet Control

Kamil Banasiuk Field:
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The presence of unpaired electrons in organic molecules changes their physical and chemical properties and increases reactivity, making their synthesis and handling challenging. Diradicals exhibit spin-spin interactions that determine the energetic balance between singlet and triplet states, which is crucial for applications in spintronics and optoelectronics. In this work, a dimeric macrocyclic chromophore was synthesised that upon oxidation produces a heterocyclic quinoidal derivative with probable open-shell character. This compound could display an easily accessible quinoidal state, enabling in situ generation of triplet states. Spectroscopic measurements and single-crystal X-ray diffraction will confirm the molecular structure, and DFT calculations estimate the singlet-triplet energy gap (Δ_{EST}) and spin distribution.

Broad-leaved trees as indicators of past debris-flow activity: evidence from the Vallée de Chaudefour, Massif Central

Łukasz Baran Field:
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Faculty of Geography and Geology, Jagiellonian University in Kraków, Poland

Dendrogeomorphological studies of debris-flow activity have traditionally relied on tree-ring disturbances preserved in conifer species, whereas the potential of broad-leaved trees for such reconstructions has received less attention. This study explores the suitability of using growth disturbances in deciduous species to identify and date past debris-flow events, and to evaluate their usefs hulness for characterizing key geomorphic parameters of mass-wasting processes. The analysis focuses on goat willow, European beech, silver birch, and gray alder affected by debris-flows in the Vallée de Chaudefour (Massif Central, France). A total of 80 increment cores extracted from 34 trees revealed

growth anomalies that enabled the reconstruction of major debris-flow events occurring between 1930 and 2017 AD. These reconstructed events were compared with meteorological observations from the Monts Dore massif and with documentary evidence reporting debris-flow activity in November 1994. The findings highlight the potential of broad-leaved species for dendrogeomorphic analyses and demonstrate their capability to extend debris-flow reconstructions to areas covered with deciduous forest.

The Geometry of Thought: Bridging Phenomenological Psychology and Mathematical Modeling

Bartosz Chmielarski Field:
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The "hard problem" of consciousness remains a central challenge in natural sciences, bridging the gap between biological substrates and subjective experience. This paper proposes a transition from descriptive psychology to a formal framework based on mathematical topology and information theory. We argue that human consciousness is not an amorphous entity but a structured "phenomenal field" governed by specific geometric laws. Drawing on Integrated Information Theory, we explore the concept of "qualia spaces," where subjective experiences are represented as high-dimensional manifolds. This approach allows us to analyze the continuity of perception and the structure of intentionality through the lens of topological constraints. By synthesizing Husserlian phenomenology with the mathematical language of manifolds, we demonstrate that psychological states can be modeled as formal properties of a system's informational architecture. This interdisciplinary perspective provides a rigorous methodology for integrating the study of the mind into the fundamental natural sciences.

The Yoneda Lemma

Piotr Chudzio Field:
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Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland

Modern mathematics has developed various branches that approach problems from different perspective. One of the more interesting ones is category theory. It is a branch of mathematics that provides a unifying language for describing and comparing mathematical structures. Instead of focusing on the internal details of objects, it emphasizes the relationships between them, encoded as morphisms. This shift in perspective allows mathematicians to recognize deep analogies across different fields and to transfer ideas in a systematic way. The Yoneda Lemma is one of the central results of category theory, yet its statement is deceptively simple and its consequences are remarkably far-reaching. This talk presents the Yoneda Lemma from first principles, aiming to make it accessible for everyone, even those without strong mathematical background.

Touching Atoms: An Introduction to Scanning Probe Microscopy

Michał Cyl Field:
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Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

This presentation aims to introduce Scanning Probe Microscopy (SPM), a very important tool of modern nanotechnology, to a broad audience with no prior experience with the technique. It starts with a short overview of the historical development of the field, beginning with the invention of the

Scanning Tunneling Microscope (STM) and the Atomic Force Microscope (AFM). We will discuss the physical principles behind these techniques, including quantum tunneling and interatomic forces, without going into the underlying equations. A large part of the presentation is focused on the diverse applications of SPM in physics, surface chemistry, biology, and geology, highlighting its unique ability to image and manipulate matter at different scales in various environments. Additionally, we will compare SPM to other microscopy techniques and examine its strengths and weaknesses.

All the FUS about water

Artur Czajkowski Field:
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Physics of Life Excellence Cluster, TU Dresden, Germany

The living cell is capable of compartmentalizing without the use of lipid membranes through a process called biomolecular condensation. Formation of biomolecular condensates is typically driven by multivalent interactions between proteins and nucleic acids. At the same time, the desolvation of the biomolecules when they meet provides an entropic addition to the free energy of assembly. Additionally, the behavior of water is coupled to the overall molecular organization within the condensates. How can that environment can be regulated and affected externally? bB means of adding co-solutes, and modifying the protein with posttranslational modifications. The goal of this research is to investigate how those influences map to changes in behavior inside condensates, establishing what role hydration related phenomena play in the regulation of condensation.

Bioinformatics analysis of Hi-C data: selected aspects.

Marianna Dekert Field:
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Faculty of Biochemistry, Biophysics and Biotechnology, Jagiellonian University in Krakow, Poland

The structure of the nuclear genome of eukaryotic cells has been extensively studied for many years. Understanding how genome architecture relates to function is crucial, as chromatin organization and its dynamic changes play an important role in gene regulation. A major breakthrough in this field was the development of high-throughput techniques such as Hi-C, which enable genome-wide analysis of chromatin organization. A Hi-C experiment involves both an experimental component and complex bioinformatics analysis. In this talk, I will discuss selected aspects of Hi-C data analysis and interpretation, including the construction and interpretation of Hi-C matrices and Aggregated Peak Analysis. I will also present the integration of Hi-C data with ATAC-seq and ChIP-seq to identify specific chromatin loops. The presentation is based on results from my own analyses conducted during a research internship.

The impact of gravitational waves on radiation emission

Mikołaj Dettlaff Field:
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Faculty of Physics, University of Warsaw, Warsaw, Poland

We analyze the emission of scalar field quanta by a Unruh–DeWitt detector, with emphasis on the role of the field's initial state. The detector is modeled as a quantum system coupled to a scalar field along a timelike trajectory. For a field in the vacuum state, we derive the expression for the mean number of emitted quanta in a mode. We then generalize the analysis to the case where the field is prepared in a coherent state. In this regime, the field operator decomposes into a classical component and vacuum fluctuations, leading to a separation of the emission into spontaneous, stimulated, and interference contributions. Our results show that a coherent state acts as classical radiation that induces additional emission. In the limit of large mode occupation, the emission is dominated by the stimulated component, recovering the regime characteristic of laser radiation. The presented analysis constitutes a step toward a more general description of quantum detector responses in the presence of nonvanishing field backgrounds and may be relevant for studies of the Unruh effect, radiation in curved spacetime, and semiclassical models of light-matter interaction.

Targeting the activity of a circadian transcription factor with de novo binder design

Joanna Doliwa Field:
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Max Perutz Labs, Vienna, Austria

Circadian rhythms are 24-hour cycles that align physiology and behavior with the day–night cycle. In mammals, these rhythms arise from a transcription–translation feedback loop driven by the CLOCK:BMAL1 complex, which activates Per and Cry genes. The resulting PER and CRY proteins inhibit CLOCK:BMAL1, maintaining rhythmic gene expression. Precise timing depends on dynamic interactions at the BMAL1 transactivation domain (TAD) with coactivators (CBP/p300) and repressors (CRY1). Our work aims to design synthetic binders that selectively interact with the BMAL1 TAD to probe and modulate these interactions.

Rashba metal to insulator transition in a non-symmorphic 2D system

Jakub Domański Field:
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Université Paris Cité / École Normale Supérieure – PSL, France

This work investigates the Rashba metal-to-insulator transition in a non-symmorphic 2D system on a square lattice. Inspired by the $BaNiS_2$ structure, it compares a standard homogeneous Rashba coupling with an unconventional staggered pattern. The study combines analytical derivations of the kinetic and Rashba Hamiltonian terms with a computational treatment of the spin-spin Hubbard interaction.

Using a self-consistent mean-field algorithm, the phase diagrams are generated to illustrate the emergence of paramagnetic, ferromagnetic, and antiferromagnetic phases depending on interaction strength and electronic occupancy. Depending on these parameters certain curious properties are observed, such as pockets of antiferromagnetism inside the ferromagnetic phase, together with particular in-plane and out-of-plane spinor patterns in the Brillouin Zone. The research provides a detailed analysis of band structures and spinor projections, highlighting the delicate energy competition between phases. Ultimately, this shows the complexity of electronic behavior in non-symmorphic crystals and suggests future research directions in this area.

Design of a Compact, Low-Cost Photodiode-Based Radiation Detector

Krzysztof Domański Field:
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Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering, AGH University of Krakow, Poland

X-ray and gamma detectors are widely used in biomedical imaging, particle physics, material and structural science, and environmental radioactivity monitoring. While commercial systems are expensive and often inaccessible to hobbyists and independent researchers, low-cost alternatives based on PIN photodiodes (semiconductor devices commonly used in optical and photonic systems) offer an accessible solution.

In my talk I will present how a PIN photodiode can be used as a simple radiation sensor and showcase an architecture overview of semiconductor radiation detectors. A compact prototype of a photodiode-based detector will be presented along with simulations and measurements that confirm the correct operation of the designed discrete-component readout electronics in the range of 30keV to 1MeV. The presented design and its parameters demonstrate that PIN-based solutions make radiation monitoring accessible for student clubs, hobbyist communities, and independent researchers.

The Biogeochemical Legacy of the Great Oxidation Event

Kamil Drzymała Field:

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Department of Plant Physiology and Biochemistry, Faculty of Biochemistry, Biophysics and Biotechnology, Jagiellonian University in Kraków, Poland

The Great Oxidation Event (GOE), occurring approximately 2,4 billion years ago, fundamentally transformed Earth's biosphere and climate. The accumulation of oxygen produced by cyanobacteria imposed severe evolutionary pressures that drove significant biochemical innovations. Specifically, the chlorophyll biosynthesis pathway bypassed oxygen-sensitive mechanisms by evolving novel, oxygen-dependent and oxygen-tolerant enzymes, reflecting a critical cellular adaptation to increasing oxygen toxicity. On a planetary scale, rising atmospheric oxygen rapidly reacted with and depleted the early methane-based greenhouse effect. This biogeochemical feedback loop led to the Huronian Glaciation, Earth's first "Snowball Earth" scenario. Ultimately, the GOE demonstrates the complex feedback mechanisms between molecular evolution and global climatology, where biological innovation directly drove planetary-scale geological shifts.

Why won't it crash? Mathematical models for server stability under million-user loads

Dmytro Dychenko, Marina Svintsitska Field:

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Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland

How can we guarantee that a server won't "explode" when a million users log in simultaneously? This talk provides an accessible introduction to software performance engineering, demonstrating how applied mathematics predicts application failures before they occur in production. We explore the theoretical foundations of System Design and Modeling, focusing on how abstract user behavior is translated into quantifiable metrics. Specifically, we will briefly introduce key mathematical tools used in performance evaluation, including queuing systems and Markov chains. We will explain the difference between Discrete-Time Markov Chains (DTMC) and Continuous-Time Markov Chains (CTMC), and how they help in modeling discrete-event systems. Additionally, we will explain how these concepts help identify bottlenecks and evaluate system limits.The goal of this talk is to demonstrate that building resilient systems is not just about good engineering practices, but also about understanding and applying the right mathematical models to anticipate problems before they arise.

Excited electronic states of the helium dimer including relativistic, adiabatic, and QED effects

Dawid Dąbrowski Field:

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Faculty of Physics, University of Warsaw, Poland

The helium dimer constitutes a unique system situated at the boundary between few- and many-body physics. All excited electronic states of He_2 are of Rydberg character, making it a candidate for

laser cooling studies. We present highly accurate *ab initio* potential energy curves for the low-lying excited states of the helium dimer utilizing state-of-the-art coupled cluster and full configuration interaction methods. We employ newly developed basis sets reaching up to the cardinal number $X = 10$. To ensure exceptional final accuracy, we incorporate all relevant corrections, including relativistic, QED, adiabatic, and nonadiabatic effects, achieving a theoretical accuracy reaching 1.0 cm^{-1} at the potential energy minima. These results establish a benchmark for calculations in orbital basis sets at the interface of few- and many-body regimes and provide a foundation for guiding spectroscopic experiments and identifying optimal excitation paths.

Ferrocene-Modified Seliciclib Derivatives as Selective CDK Inhibitors: A Novel Approach in Cancer Therapy

Eryk Federyga Field:
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Faculty of Chemistry, Jagiellonian University in Kraków, Poland

Cancer remains one of the leading global health challenges, driving the continuous search for more effective and selective therapeutic strategies. Cyclin-dependent kinases (CDKs) play a crucial role in cell cycle regulation, making them attractive molecular targets in anticancer drug development. Among them, CDK7 has emerged as a particularly promising target due to its dual function in cell cycle control and transcriptional regulation. In this study, we present the evaluation of novel ferrocene-based derivatives of Seliciclib. Their biological activity was assessed in MCF-7 breast cancer cells, focusing on cytotoxicity, intracellular accumulation, and effects on cell cycle progression. Additionally, the selectivity profile toward CDKs was investigated. Our findings highlight the potential of ferrocene-modified CDK inhibitors as candidates for further development in cancer therapy.

The delights and problems of Melanogenesis: browning, tanning- ...cancer?

Natalia Gajewska Field:
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Melanogenesis is the tightly regulated cellular process responsible for the synthesis of melanin, the pigment that underlies visible coloration in human tissues. Way beyond its cosmetic role, melanin exerts significant biological effects, most notably its capacity to absorb ultraviolet (UV) radiation and protect against DNA damage. Upon close inspection, however, these protective properties present a paradox: melanin and its intermediates can also promote oxidative stress, positioning melanogenesis as a double-edged sword for the cell. This tension becomes most apparent when contrasting its roles across various physiological and pathological contexts. In this talk, I will outline what makes melanin a uniquely impactful biological molecule, why its synthesis and regulation thereof warrant close study, and how it can backfire if it does go wrong.

Non-minimal coupling of the Higgs field to gravity: cosmological and astrophysical predictions beyond the Standard Model.

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I consider a modification of the Standard Model in the form of a non-trivial coupling of the Higgs field H to gravity mediated via the Ricci scalar R in a term $\xi R|H|^2$. I present the most relevant results regarding possible explanations of the inflation in the Early Universe and comment on the influence of quantum corrections. Furthermore, I highlight the troublesome aspects of the underlying mathematics and showcase the results of my research group in this matter. This concerns development of a framework for a rigorous analysis of the model, proof of stability on maximally symmetric spacetimes and application to the formation of astrophysical objects such as gravastars.

Stratospheric Aerosol Injection as climate intervention: A solution or a challenge?

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This presentation examines Stratospheric Aerosol Injection (SAI) as a proposed climate intervention aimed at reducing global temperature. It outlines the physical basis of SAI and distinguishes it from other climate mitigation strategies. Selected simulations and experimental studies, such as GeoMIP or ARISE-SAI, are presented to assess its potential impacts on temperature, precipitation patterns and other atmospheric processes. The analysis addresses key uncertainties, possible side effects, and governance challenges. Particular attention is given to the question of whether SAI can be considered a feasible and responsible approach to climate change.

Microfauna of the lower bone-bearing horizon of the palaeontological site in Krasiejów

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Palaeontological site in Krasiejów is considered one of the most important late Triassic outcrops in Central Europe and has been extensively studied, especially regarding vertebrate fauna. The aim of this study was to characterise the microfauna of the lower bone-bearing horizon and to verify the occurrence of previously reported taxa.

The researched material was dominated by calcified oogonia of charophytes (Charophyta), particularly Stellatochara germanica, Stomochara starozhilovae, Stenochara kisielevskyi, and Porochara triassica. Ostracods were rare and represented solely by the genus Darwinula. Previously reported in the literature genus Suchonella was not confirmed. Vertebrate microfossils were also identified. These include few fish teeth (chondrichthyans and actinopterygians) and scales.

The results show relatively low diversity of microfauna of the studied bone-bearing horizon. Methodological limitations may influence the representativeness of the result. Further research including more precise preparation and the examination of the entire profile is needed to provide full understanding of the microfauna and the paleoenvironmental conditions at the Krasiejów site.

Orbit-Finite-Dimensional Vector Spaces

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A vector space is a fundamental concept in mathematic. In particular, vector spaces of finite dimension are robust structures that are useful even beyond mathematics. This raises the question: can some of the advantages of finite dimensionality be extended to the infinite setting? In this talk I will present the concept of orbit-finite-dimensional vector spaces. These are vector spaces spanned by sets that are orbit-finite. Intuitively, an orbit-finite set is infinite, but finite up to symmetries. Reaserch on these vector spaces started in 2021, when Bojańczyk et al. established some of their key properties and demonstrated their applications in automata theory. The study of orbit-finite-dimensional vector spaces is still a young and rapidly developing area.

The Thing About Viruses in the Antarctic

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Viruses, despite having a major role in the ecosystem and proving to be of immeasurable value to modern science, are still greatly underexplored. Not all viruses are accounted for in conducted research, some remain obscure due to their troublesome characteristics or challenging environmental conditions. Additionally, physical constraints limit the possibility of quantifying the effects of viruses as a whole. Consequently, there is insufficient data on the viral impact on the biogeochemical cycling and viruses are still not accounted for in current climate models, despite being a major constituent of the ecosystem. In this talk, I will briefly introduce the contribution of viral communities to the biogeochemical cycling via viral shunt and viral shuttle in the global ocean, touch upon the concept of auxiliary metabolic genes and provide reasons why we should investigate the viral communities of the Antarctic.

Kakeya Sets

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For a finite field $\mathbb{F}$, $\mathcal{K} \subseteq \mathbb{F}^n$ is a Kakeya set, if it contains an affine line in every direction, i.e. $\forall_{y \in \mathbb{F}^n} \exists_{a \in \mathbb{F}^n} \, a + \mathbb{F}y \subseteq \mathcal{K}$. We shall present an elegant proof (Zeev Dvir 2008) for a lower bound for the size of such a set. This is unlike the case over real numbers, where Kakeya sets can have arbitrarily small measure.

Targeted Protein Degradation - Harnessing chimeras for the development of selective drugs

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Human organism is an incredibly complex system where we can think of protein enzymes as fundamental gears within cellular machinery. Consequently, pathological states - whether driven by pathogens, cancers or systemic malfunctions - can often be adrresed by targeting specific enzymatic pathways. Current drug design strategies have relied primarily on the occupation of key protein sites to achieve inhibition. New paradigm has emerged described as Targeted Protein Degradation (TPD). This strategy hijacks the cell's internal recycling machinery utilizing mainly the ubiquitin-proteasome system (UPS) via molecular glues, PROTACs and SNIPERs, as well as the lysosomal degradation pathway via LYTACs. Recent advancements in protein structure modeling enable those more sophisticated approaches to render previously undruggable targets druggable. In this talk I will briefly introduce core principles, discuss the importance of this novel approach, outline main challenges and show some most promising candidates.

Potential reality - on the Aharonov-Bohm effect

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In classical physics, we trust what we can touch or feel—the magnetic field inside a motor or the electric field of a storm. The potentials used to calculate these fields are seen as mere mathematical crutches; they are ambiguous, non-unique, and therefore deemed 'unreal.' This presentation traces the journey of the electromagnetic potential from a useful fiction to a physical necessity through the lens of the Aharonov-Bohm effect. We will explore how quantum mechanics, which governs particles via the wavefunction's phase, fundamentally shifts this ontology. By examining the iconic interference experiment where electrons are affected by a region of zero magnetic field, we see that the potential acts where the force does not. This talk will bridge physics and philosophy, arguing that the Aharonov-Bohm effect—and its analogues in gravity and Berry phases—forces us to reconsider the ontological status of mathematical objects we use and accept that in the quantum world, influence extends beyond the tangible.

Rewriting RNA: smarter aptamers through in silico design

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Aptamers are short, single-stranded RNA molecules. They are capable of specific target binding due to their three-dimensional structure, which makes them promising tools in therapeutic applications. In silico approaches can be used to engineer beneficial modifications by analyzing their impact on an aptamer's structure and binding mechanism. Two aptamers were analyzed: anti-mGP2, targeting glycoprotein 2 (GP2), and HAS15-5, binding to hemagglutinin (HA1) of the avian influenza virus. Sequence truncations and mutations were introduced, followed by prediction of secondary and tertiary structures and molecular docking analysis. For anti-mGP2, shortening the sequence led to minor structural changes but increased hydrogen bonding and electrostatic interactions, suggesting improved binding affinity. In HAS15-5 variants, selected modifications resulted in structural rearrangements and enhanced interaction with the target protein. The conserved sequence motif was found to have limited involvement in binding. These results highlight the utility of bioinformatics tools in aptamer design, although experimental validation remains necessary.

Mesenchymal Stem Cells and Their Secretome: Applications in Regenerative Medicine

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Mesenchymal stem cells (MSCs) are multipotent stromal cells capable of differentiating into various mesodermal lineages and exerting strong immunomodulatory effects. MSCs are widely recognized for their regenerative potential, but beyond direct differentiation, much of their therapeutic activity is driven by the bioactive molecules they release, collectively referred to as the secretome, which includes extracellular vesicles (EVs) among other factors. This presentation explores how MSCs and MSC-derived secretome contribute to tissue repair, inflammation modulation, and the development of cell-free regenerative therapies, along with current clinical applications and translational challenges.

How do folds above faults develop?

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Folds are geological structures that form as a result of deformation without breaking the continuity of rocks. Viscous constitutive equations (both Newtonian and non-Newtonian) are commonly used in mechanical modelling of folding. A more complex viscoelastic rheology can also be utilized. Fold development is often associated with two mechanisms: compression acting parallel to the layering (i.e., buckling) and compression acting normal to the layering (i.e., bending). Viscosity contrasts between layers are essential for buckling. Both buckling and bending components have a major role in the formation of folds in a sedimentary cover above a fault in a rigid basement. Results from a custom Finite Element Method model of viscous folding above a basement fault in three rheological scenarios will be presented: (1) a homogeneous isotropic cover, (2) a heterogeneous cover with alternating isotropic layers, (3) a homogeneous anisotropic cover. The work was supported by the National Science Centre, Poland, under research project "Numerical and field studies of anisotropic rocks under large strain: applying micro-POLAR mechanIcS in structural geology (POLARIS)", no UMO-2020/39/I/ST10/00818.

Synthesis of zeolite Y using sustainable cellulose nanocrystals as templates

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With the increasing use of microporous materials such as zeolites in a wide range of industries, there is an urging need to reduce environmental footprint of producing them, as many of the current methods require usage of highly toxic materials [1]. In response to this problem, it has been found that nanocellulose can be utilized as a template for synthesizing zeolites [2]. In this study cellulose nanocrystals (CNC) were prepared with green chemistry approach by extracting in ionic liquids or reactive eutectic media. Then CNCs were used as template to synthesize zeolites Y. Obtained zeolites were characterized in the matter of structure, porosity and sorption properties. [1] Q. Wu et al., Journal of the American Chemical Society 136, 4019 (2014). [2] S. Abdulridha et al., Green Chemistry 22, 5115 (2020)

Synergistic interaction between EGFR and Aurora A inhibitors in NSCLC cells and their encapsulation in liposomes to enhance therapeutic efficacy

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The aim of our study was to evaluate the cytotoxicity and therapeutic potential of selected FDA-approved drugs in combination therapy of the PC-9 cell line. Cytotoxicity was determined using MTS colorimetric assay after 72 hours of incubation, and IC values were calculated. The strongest synergistic effect was observed for the combination of afatinib and alisertib. To enhance the therapeutic effect, each selected drug was encapsulated in liposomal carriers. The liposome preparation method involved hydration of the lipid film and extrusion. Part of our study was to determine the physicochemical properties of the obtained liposome carriers and their stability in the culture medium and during storage. Finally, PC-9 cells were treated with liposomes loaded with these drugs to assess their

therapeutic effectiveness. Our results indicate that rationally designed combinations of inhibitors of key signalling pathways and drugs affecting cell cycle arrest, supported by liposomal drug delivery systems, may represent a promising therapeutic strategy for the treatment of EGFR-dependent NSCLC.

Are time series proper approach to assess continous-time phenomena? About weak convergence in Skorohod spaces.

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Discrete-time time series models are widely used to describe phenomena that are inherently continuous in nature. We address the question of when a sequence of discrete-time processes faithfully represents a continuous-time limit. The natural framework is the Skorokhod space $D[0,\infty)$ of càdlàg functions, equipped with the J1 or M1 topology. We focus on mixed causal-noncausal VAR processes driven by α-stable innovations, $\alpha \in (0,2)$, where classical Donsker-type invariance principles may fail and J1-convergence breaks down, necessitating the weaker M1 topology. The limiting objects are α-stable Lévy motions and their integrals. We discuss implications for statistical inference and continuous-time approximations in applications such as catastrophe bond pricing.

The unknown potential of the astrocytes

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Astrocytes are glial cells in the central nervous system. Although they were identified over a century ago, their functions have only recently begun to be explored in greater detail. For many years, astrocytes were considered to serve mainly supportive roles for neurons. However, current research indicates that they are highly active cells involved in a wide range of essential processes. Recent findings suggest that astrocytes play a major part in the removal of metabolic waste from the brain, particularly during sleep. This function may be crucial for long-term brain health. Disruption of astrocyte activity has been linked to the development of neurodegenerative diseases, highlighting their potential significance in disease mechanisms. In addition disturbances of the glymphatic system are also observed in psychiatric disorders. During the talk, I will discuss the diverse roles of astrocytes and emphasize their still not fully understood potential. A better understanding of these cells may provide new insights into brain function and contribute to the development of novel therapeutic approaches for neurological disorders.

Phase transitions and nanostructure: an insight into the interplay between friction and domain structure on perovskite ferroelectric crystal surfaces

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Ferroelectric perovskite oxides are a vast group of inorganic, ceramic materials with promising applications in photocatalytic reactions, such as water splitting —- a process of producing hydrogen and oxygen using solar energy.

One of the most promising aspects of this class of materials is the presence of ferroelectric domains. These regions of uniform and spontaneous electric polarization facilitate electron-hole separation and transport, which promises increased efficiency of photocatalytic processes and holds great potential for vast applications in green technologies.

Utilising lateral force microscopy (LFM) – a mode of atomic force microscopy (AFM) – regions with different frictions coefficients were observed on the cleaved perovskite surface. Friction changes were found to be closely linked with the ferroelectric domain structure, imaged using piezoresponse force microscopy. Impact of ferroelectric-paraelectric phase transition on domain-friction interplay was investigated. Along with imaging of the nanostructure on the material's surface, these observations aid in creating full understanding of domain friction imprints.

Experimental Validation of CFD Models for Microfluidic Flow in 3D-Printed Channels

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Microfluidic systems enable precise fluid control at small scales and are widely used in chemical and biomedical applications [1]. Computational Fluid Dynamics (CFD) is commonly applied to support their design; however, its accuracy in microscale conditions requires validation. This study evaluates two CFD approaches, the laminar model and the $k - \omega$ SST turbulence model, for simulating flow in a microfluidic channel fabricated using 3D-VAT photopolymerization (LCD) printing [2]. A CAD-designed geometry was simulated and experimentally tested. Results show that both models yield nearly identical predictions due to low Reynolds numbers, confirming laminar flow conditions. Experimental measurements closely match CFD results, with minor deviations attributed to surface roughness and manufacturing imperfections. These findings confirm that CFD is a reliable tool for predicting flow behavior in additively manufactured microfluidic systems. The research was carried out as part of the Student Research Clubs Creating Innovations project, contract number SKN/SP/630040/2025, financed by the Ministry of Science and Higher Education of Poland.

Large Scale Simulations of Locust Collective Motion based on Behavioral Mechanisms

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Locust outbreaks represent a major threat to food security in many regions worldwide. Accurate modeling of locust swarm formation and behavior is imperative for developing effective prevention and control programs. Traditionally, most methods for modeling collective motion drew from theoretical physics, assuming that individual locusts act as self-propelled particles. Recently, this approach has been challenged, leading to the exploration of alternative models that account for the sensory and cognitive mechanisms of locusts. These models rely on frameworks for decision-making based on a locust's immediate surroundings, offering greater neurobiological accuracy. However, this shift inevitably increases model complexity and the computational demands required to achieve sufficient scale. In this talk, I will present past and current techniques for modeling collective motion in locust swarms and discuss the scalability challenges arising from these increasingly complex biological models.

Computational Electromagnetics in the Cloud: Overcoming Hardware Limitations in FDTD Simulations

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The Finite-Difference Time-Domain (FDTD) method is a cornerstone of electromagnetics, enabling the study of light in complex nanophotonic structures. However, FDTD accuracy is strictly tied to grid density, which demands high computational memory and processing power. Traditionally, these constraints limited simulations to small domains or low-resolution grids. This presentation discusses the transition from local CPU-based computing to cloud-native, GPU-accelerated architectures. By offloading the numerical integration of Maxwell's equations to high-performance computing (HPC) clusters, we significantly reduce computation time while maintaining high fidelity:

$$\nabla \times \mathbf{E} = -\mu \frac{\partial \mathbf{H}}{\partial t}$$

$$\nabla \times \mathbf{H} = \epsilon \frac{\partial \mathbf{E}}{\partial t}$$

The talk analyzes the workflow of large-scale simulations and explores how cloud parallelism provides researchers with advanced computational capabilities without specialized on-site hardware. Finally, the talk concludes by evaluating the impact of these high-throughput methods on the efficiency of the design cycle in modern photonics.

Tracing Water in Comets: Modelling OH, H, and Deuterium in the HYADES Mission

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The talk will focus on the HYADES mission (UJ) and its goal of studying the origin of water in the Solar System using comets. I will briefly introduce how water released from a comet transforms into species like OH, H, and their deuterated counterparts, which carry information about the D/H ratio. The main part will present a numerical model of the cometary coma based on Monte Carlo simulations. By tracking the motion and reactions of particles such as H, D, OH, and OD, we can reconstruct their spatial distributions and predict observable signals

Design and Implementation of a Power System and Electric Motor for a Hydrogen Fuel Cell-Powered USV

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The increasing use of unmanned surface vehicles (USVs) in monitoring, inspection, and surveillance tasks has intensified the demand for compact, efficient, and reliable low-emission power and propulsion systems. This work focuses on the development of a hydrogen fuel cell-based power system together with the design of a PM-assisted synchronous reluctance motor (PMaSynRM) intended for a small underwater thruster. The presented concept addresses the integration of the fuel cell, energy buffer, power electronics, and propulsion unit into a compact onboard architecture. Attention is given to the motor design process and the selection of key parameters required for efficient propulsion in inland-water applications. The motor was designed analytically and verified by FEA, including back-EMF and loss evaluation. The developed concept combines a hydrogen fuel cell-based power system with a dedicated low-voltage propulsion unit for inland-water applications.

This research was funded by the Ministry of Science and Higher Education (Poland) under the programme "Student Scientific Clubs Create Innovations", Grant No. SKN/SP/631410/2025.

Precision measure - a methodology for quantifying the precision of numerical methods.

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The work presents an original concept of the Precision Measure - a function designed to determine the accuracy of numerical methods with a „step-wise" character. This function is used to analyze numerical algorithms involving a step parameter, such as quadratures (where the step is the number of nodes) or equation-solving methods (e.g., Newton's method, where the step corresponds to the number of iterations). In contrast to the classical, widely used approach that focuses solely on the final error (i.e., the error obtained at the n-th step), the proposed Precision Measure incorporates a specific portion of the algorithm's convergence history. It is constructed using nested, generalized means combined with weighing functions. This model is intended to distinguish between algorithms that, despite yielding identical final results, exhibit different stability and convergence dynamics. The work provides a detailed analysis of Precision Measure variants for the arithmetic mean and presents theorems concerning their convergence. The behavior of the Precision Measure is demonstrated using selected numerical quadratures across various test functions in relation to the number of nodes.

Fisher Information from Stimulated Emission in the Unruh-DeWitt Detector in the Presence of a Gravitational Wave

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Gravitational waves - ripples in spacetime first detected in 2015 - are traditionally measured using large-scale interferometers like LIGO. In this talk, I explore a different approach: using a simple two-level quantum system called an Unruh-DeWitt (UDW) detector to sense a passing gravitational wave. The detector is coupled to a scalar quantum field prepared in a coherent state, which drives stimulated emission and absorption processes. When a gravitational wave is present, it distorts the local spacetime geometry and modifies these transition rates. This modification carries information about the wave's amplitude and frequency. To extract it optimally, I apply classical and quantum Fisher information, which quantify how precisely a given measurement can estimate an unknown parameter. Using these tools, I also estimate the minimum number of detectors needed for a statistically reliable detection.

Luminescent materials based on dithiolate-Au(I) coordination systems

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Coordination compounds of gold(I) are well known for their photoluminescent properties, which are related to aurophilic Au(I)··Au(I) interactions giving rise to the formation of efficiently emissive metal-to-ligand charge transfer excited states. The strong affinity of Au(I) centers to soft-donor ligands causes the scientific interest devoted to the combination of these metal ions with thiolate-type organic ligands. The optical properties of dithiolate-Au(I) systems can be effectively tuned through modifications of their structural environments, including incorporation of additional d-block and f-block metal ions, as

well as through external stimuli [1,2]. As a result, such materials are promising candidates for tunable solid luminophores with potential applications in light-emitting diodes, gas sensing, and luminescent thermometry. In this context, we present heterometallic luminescent coordination systems based on $[Au^{I}{}_{2}(i\text{-mnt})_{2}]^{2-}$ (i-mnt = iso-maleonitriledithiolate) and lanthanide ions, which assemble into linear aurophilic chains, as well as three-dimensional assemblies containing related Au(I)-based clusters and Cu(I) complexes.

TCP/IP-based Remote Control and Telemetry System for an Inland-Water Unmanned Surface Vehicle

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The ability to operate Unmanned Surface Vehicles (USVs) safely beyond visual line-of-sight is paramount. A major challenge in this domain is establishing a communication framework that is not only robust enough to handle multiple data streams but also secure for internet-based remote control. This work presents the design and implementation of a comprehensive TCP/IP-based remote control and telemetry system built to address these operational challenges. Rather than focusing solely on basic vehicle telemetry alongside live IP camera feeds, the proposed system integrates a wider suite, aggregating real-time data from the vehicle's power systems, including its hydrogen fuel cell and battery management modules. By encapsulating all communication within a cloud-managed VPN tunnel, the system ensures that the platform can be securely monitored and managed from a remote ground control station. This research was funded by the Ministry of Science and Higher Education (Poland) under the programme "Student Scientific Clubs Create Innovations", Grant No. SKN/SP/631410/2025.

Fantastic Hemp Properties and How to Find Them

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Cannabis sativa is a plant widely praised for its various properties, ranging from nutritional, through psychoactive, medicinal, and analgesic, to antioxidative. In recent years, the popularity of hemp oils as health supplements has surged. But where do the benefits come from and how can one verify them? The sought-after antioxidative qualities of hemp oils stem mostly from the presence of phenolic compounds, tocopherols, and flavonoids. Multiple studies have been conducted on this topic, utilising various methods of measuring antioxidant activity. The total antioxidative power of the sample can be assessed via colorimetric assays - spectrophotometric methods that determine the concentration of an analyte through change in colour. This talk will focus on outlining the desirable properties of Cannabis sativa derivatives and providing an overview of four rapid and practical colorimetric assays commonly used in analytical chemistry research: FRAP, CUPRAC, DPPH, and ABTS - why they work, how they work, and how easy it is to extract data from a little vial of colourful liquid by shining a light at it.

n-Alkyl Xanthic Acids monolayers on Ag(111)

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Self-assembled monolayers (SAMs) are an important method to control the structure and properties of organic-inorganic interface at the nanoscale, which determines the performance of many advanced devices like those related to organic electronics. In this work, SAMs based on xanthate molecules were investigated on Ag(111) substrate, where the molecules bind to the surface by two sulphur atoms. The formation process and structural quality were analysed using infrared reflection-absorption spectroscopy (IRRAS), X-ray photoelectron spectroscopy (XPS), and water contact-angle measurements (CA). It was exanimated how the type of solvent and incubation time affect the structure and stability of the monolayer. Ethanol, isopropanol, and dichloromethane worked best, giving dense and well-ordered layers. On silver, a mixture of sulphur bonding is observed, including atomic sulphur and xanthogenate groups bound to the surface through a single Ag-S bond. These results show that preparation conditions strongly influence SAM structure on silver and are crucial for further studies of their properties.

Remote Sensing for Polar Research: From Google Earth Engine Image Mosaics to Glacial Dynamics

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Satellite remote sensing is a vital tool for observing the rapid changes in the Earth's polar regions. This presentations provides an overview of current satellite methods, focusing on the practical benefits of using Google Earth Engine (GEE). Unlike traditional software, GEE acts as a powerful analysis engine that allows researchers to process massive amounts of data without the need for local storage, while also enabling the creation of image mosaics, which combine several satellite scenes to create one clear, cloud-free image of the Arctic surface. The Vestfonna ice cap on Nordaustlandet, Svalbard, serves as an example to demonstrate how remote sensing methods are used in a practical way to monitor glacier changes.

From Lagrange to Federer - An Analytical Reconstruction of Tennis Serve

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The prevailing paradigm in sports biomechanics focuses on optimizing athletic performance through machine learning and extensive datasets. However, in this talk we propose a return to first-principles modeling to gain deeper causal insights. The presentation aims to optimize the tennis serve using classical Newtonian and Lagrangian mechanics supported by targeted empirical data.

We introduce a model of the human upper body as a kinetic chain consisting of five rigid segments with 12 degrees of freedom (DOF). Using inverse kinematics, we numerically derive coefficients for generalized coordinates across three types of serves, yielding an approximate description of each segment throughout the motion. Internal joint torques are subsequently calculated using the Principle of Virtual Power.

Finally, we discuss how this analytical approach provides physical interpretability for two pillars of sports biomechanics: performance enhancement and injury prevention. Ultimately, we may pose

a broader question: should we aim to mimic the "evolved" techniques of elite players, or can pure physics reveal a more efficient movement yet to be performed?

Can a Tree get a cancer?

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Every year, cancer diseases constitutes a serious public health problem in Poland. According to researchers from University Clinical Center of the Medical University of Warsaw, approximately 170,000 new cases of malignant tumors are diagnosed annually, and over 100,000 people die from them. Furthermore, it also occurs in animals, such as dogs and cats, mice, frogs, tigers, and even elephants. This fact raises the question of whether analogous phenomena occur in the plant world. The purpose of this lecture is to present the current state of knowledge about tree cancers, discussing their types, and discussing the factors that contribute to their development. In addition, similar wood defects and methods for combating the disease will be discussed. Presentation will be enriched with materials collected during research on heaps of uranium mining in Kowary, Lower Silesian Voivodeship.

Role of heuristic models in science development on the example of the metal-organic frameworks

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In my speech, I would like to take a closer look at the role of heuristic (didactic) models in the development of science, using the example of metal-organic frameworks (MOFs). Such models are very common in science, but their role is usually overlooked in everyday's research. For example, this year's Nobel Prize winner in Chemistry, Richard Robson, shows that a critical look at these models may lead to surprising results. He states that creating didactic models gave him the idea for a new class of materials. I will enrich my speech with general reflections on the positive and negative aspects of using heuristic models in scientific and especially chemical way of thinking. For instance, a huge advantage of heuristic models is the opportunity to share ideas and research results with others. However, there is a risk that a model might conceal the underlying problem. To support my considerations, I would like to refer to the thoughts of the Hungarian philosopher Imre Lakatos.

MNPs in neurotoxicity: Complex effects on microglia and brain health

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The escalation of plastic production has led to a global crisis where micro- and nanoplastics (MNPs) now reach the most remote corners of the Earth. As these contaminants permeate ecosystems, there is a growing concern and evidence regarding their systemic toxicity and impact on human health, particularly in the field of neurotoxicity. These particles, of various shapes and sizes, can reach the brain by breaching biological barriers like the blood-brain barrier. Emerging research indicates that the accumulation of MNPs in the brain is not just a passive presence. Instead, they act as catalysts for chronic neuroinflammation by inducing oxidative stress and altering microglial activity. With microglia being the brain's primary immune defense, their functional impairment may serve as an important link to the pathogenesis of neurodegenerative diseases. I will move from the environmental scale to

the cellular level, addressing research challenges and sharing insights from studies I was involved in. Since this issue affects all life forms and continues to grow, it demands a comprehensive approach to how we understand the long-term effects of plastic exposure on human health.

Modeling in the Shades of Grey: A Comparative Analysis of White-, Black-, and Grey-box Approaches for Control Valve Identification

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Modern control engineering and the development of Digital Twins demand high-fidelity models that reconcile theoretical rigor with empirical reality. This presentation explores the "shades of grey" in system identification by comparing three distinct modeling paradigms—white-box, black-box, and grey-box—applied to a nonlinear control valve within a multi-tank laboratory system.

The study demonstrates that while white-box models based on the Torricelli law offer physical interpretability, they often lack the flexibility to capture specific hardware non-idealities. Conversely, pure black-box models derived from closed-loop data prove highly susceptible to measurement noise and hysteresis. As a solution, a grey-box approach is presented, utilizing numerical differentiation of liquid levels to reconstruct flow dynamics. By grounding the model in mass-balance equations while employing polynomial approximation for nonlinearities, a 4-fold increase in accuracy (RMSE) over traditional analytical methods was achieved. The results highlight the necessity of hybrid modeling for reliable real-time simulation and predictive maintenance in industrial automation.

A brief introduction to liquid crystals

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Liquid crystals are mesophases of matter that combine fluidity with long-range orientational order, intermediate between isotropic liquids and crystalline solids, naturally connecting multiple disciplines. They are experimentally attractive because they allow direct observation of ordering and defects using techniques such as polarised light microscopy, while their strong response to external fields enables precise control. Small changes in molecular structure can significantly affect phase behaviour, allowing chemists to design and tune material properties. Many biological systems exhibit liquid-crystalline ordering, including lipid bilayers, DNA, and cytoskeletal filaments. For theoretical physicists and mathematicians, LCs provide a platform to study symmetry breaking, phase transitions, and topological defects within nonlinear field theories. Engineering applications include displays and photonic devices, as well as sensors, tunable optics, and smart materials enabled by their low power consumption and responsiveness.

[1] P. G. de Gennes, J. Prost, The Physics of Liquid Crystals (Oxford University Press, 1993)

Calibration algorithm for the mathematical model of the autonomous boat Barka

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This paper presents the development and application of a calibration algorithm for a mathematical model of a solar-powered boat, with the goal of improving the model's accuracy and reliability in representing real-world behavior. The calibration process focuses on identifying key model parameters that cannot be directly measured but significantly influence the system's dynamics, such as hydrodynamic resistance coefficients.

To estimate these parameters, a numerical algorithm based on the bisection method was developed and extended to handle a multivariate system. Although the classical bisection method is typically applied to single-variable problems, this work adapts the approach to iteratively converge on multiple parameters by decomposing the calibration problem into a set of coupled scalar equations.

The entire method was implemented in the MATLAB Simulink environment, which provides a flexible platform for modeling dynamic systems and integrating custom numerical algorithms. The use of Simulink enables seamless interaction between the physical model of the boat and the calibration routine, allowing for automated simulations and parameter updates.

From Compass to Quantum Physics: A Historical Overview on Magnetic Field Sensors

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Magnetic field sensors play a crucial role in a wide range of modern technologies, including navigation systems, data storage devices, industrial automation, and biomedical applications such as magnetoencephalography. This presentation provides a historical and technological overview of the development of magnetic sensing devices, tracing their evolution from the earliest magnetic compass to state-of-the-art quantum sensors and miniaturized thin-film technologies.

The discussion begins with the compass as the first practical instrument for detecting the Earth's magnetic field, emphasizing its physical principles and historical importance in navigation and exploration. It then follows the transition to electronic magnetic sensing, highlighting the Hall effect sensor as a key milestone in solid-state magnetometry and industrial applications. Further advances driven by spintronics are presented through anisotropic magnetoresistance (AMR), giant magnetoresistance (GMR), and tunneling magnetoresistance (TMR) sensors, which significantly improved sensitivity, scalability, and integration with microelectronic systems.

Quantum Wasserstein GAN enhanced by Hamming geometry

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In this presentation, I discuss the advantages of using the Hamming distance in Quantum Generative Adversarial Networks based on the Wasserstein distance (qWGANs). In the case of pure quantum states, the Wasserstein-based formulation of a Quantum Generative Adversarial Network admits a natural simplification that eliminates the need for an explicitly parameterized discriminator. I begin by introducing key concepts of classical GANs and the classical Wasserstein distance, and then present their quantum counterparts. I introduce the Hamming and Bures distances, discuss their geometric interpretations, and how they act on the computational basis. Finally, I examine how the choice of metric influences the behavior of qWGANs and present numerical results.

A not so deep dive into the world of polymers

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What does DNA have to do with a plastic water bottle? Polymers are silently present in our everyday life. Widely used in medicine, industry and scientific research, they make significant impact on our life. Extreme diversity of polymers makes them irreplaceable materials. This presentation provides a brief introduction to polymerization reaction, process of synthesizing plastics and their further usage, showing examples of biopolymers, modified natural polymers and synthetic polymers.

NaCl thin films engineering on Ge(001) surface

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NaCl thin films have attracted considerable industrial interest in recent years as a substrate for the large-scale growth and processing of a range of compounds (including GaAs and metal nanostructures) or as a component of optical systems. The standard growth method, molecular-beam epitaxy (MBE), offers deposition rates of several nm/min and requires ultrahigh vacuum and lengthy preparation process.

We propose an alternative method for obtaining NaCl thin films on Ge(001) via droplet chemical solution deposition (CSD). This allows for easy coverage of an area of 5-10 mm^2 with a 100 nm thick layer in a few minutes and offers high scalability.

Manipulation of solution parameters and the evaporation rates enables repeatable generation of three different types of homogeneous surfaces, the properties of which will be discussed.

Around Nyquist

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Control theory is a profoundly rich discipline that has evolved from the practical needs of physics and engineering into a rigorous, fully-fledged branch of applied mathematics. Despite its universality, it is often taught with a lack of mathematical rigor at technical universities, while physics curricula frequently overlook it entirely. This presentation aims to demystify control theory, demonstrating its mathematical elegance and broad applicability across a vast spectrum of scientific domains. In essence, the field's interdisciplinary nature can be summarized by the maxim: "Tell me what you want to control, and I will tell you who you are."

The core focus of this presentation will revolve around the Nyquist Stability Criterion for dynamical systems. To establish the necessary foundation, we will first explore the concepts of dynamical systems, feedback control, and Lyapunov stability. Subsequently, a concise proof of the Nyquist Criterion will be presented, rooted deeply in complex analysis - specifically Cauchy's residue theorem. Finally, we will examine practical applications and unravel the geometric origins of the characteristically "twisted" Nyquist plots.

Posters

Copper vanadate as a new promising semiconductor materials in photoelectrochemistry

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Copper vanadates are promising mixed-metal oxides with tunable electronic and redox properties. In this study, thin films with Cu:V ratios of 1:1, 1:2, and 3:1 were synthesized to systematically investigate composition-dependent behavior. FTIR, DRS, SEM, and XPS analyses revealed structural, optical, and defect-related variations, with oxygen vacancies playing a key role in modulating photocurrent response. The films exhibited a band gap of ∼2.3 eV and achieved photocurrent densities up to 4 $\mu A\,cm^{-2}$ under monochromatic illumination. A clear photoelectrochemical photocurrent switching (PEPS) effect was observed over a wide potential range (-500 to 900 mV), showing reversible anodic and cathodic responses corresponding to n-type and p-type behavior, supported by Mott–Schottky analysis. These findings demonstrate that compositional tuning enables precise control over charge transport and photoresponse in copper vanadates.

More Than Correlation: An Introduction to Copula Theory.

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While correlation is one of the standard measures of dependence between random variables, it may fail to capture their full dependence structure. This poster introduces the basic concept of copulas and presents Sklar's theorem, which forms the foundation of copula theory. It also provides examples of copula functions and illustrates how they can capture features such as tail dependence that are not reflected by correlation alone. The poster highlights the usefulness of copulas in modeling complex dependence structures.

Synthesis of alpha-ketoamide pseudopeptides to inhibit HtrA enzyme of Helicobacter pylori

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H. pylori are bacteria colonizing epithelial cells of gastric mucosa, which could lead to chronic gastritis, stomach ulcer or even cancer. One of the virulence factors of H. pylori is HtrA enzyme. It is a protease which cleaves intercellular junction proteins. It makes it possible for bacteria to reach basal side of gastric cells and leads to further infection [1].

Popular strategy in protease inhibitors design is reversible covalent inhibition. These kind of drugs are less toxic than typical covalent inhibitors which could bind irreversibly to off-target proteins. At the same time they still have advantages of covalent bond, such as prolonged duration of action. One of reversible covalent inhibitors' warheads with uniquely great properties are alpha-ketoamides.

The aim of this work was design and synthesis of alpha-ketoamide pseudopeptides to inhibit HtrA enzyme of H. pylori. Alpha-ketoacid building block was synthesized and used in classic solid phase peptide synthesis. Eight pseudopeptides were succesfully obtained and are going to be examined for their influence on H. pylori.

[1] L. Cui, et al., Crystal structures and solution conformations of HtrA from H. pylori reveal pH-dependent oligomeric conversion and conformational rearrangements. Int J Biol Macromol. 243, 125274 (2023).

"The Biggest Ecological Disasters of Our Time - long-term consequences"

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The poster examines the topic of the Chernobyl disaster - a symbol of the dangers associated with nuclear power. It's divided into three parts: "The reactor's anatomy", in which the RBMK reactor's construction will be outlined, "Why it failed", where we find information about xenon poisoning and graphite-tipped control rods, and "What we learned", that contains a comparison with other, safer reactor designs and the later fate of the Chernobyl exclusion zone. Topics will range from the functions of various parts of the system and reactor's internal structure to the tragic circumstances resulting from human–machine miscommunication.

DNA origami - nanostructures of the future

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DNA origami is a nanotechnology technique that enables DNA strands to be folded into designed two- and three-dimensional structures with nanometre precision. The method uses predictable nitrogen base pairing to guide the folding of a long template strand using short helper oligonucleotides. This makes it possible to create objects of virtually any geometry, from simple shapes to dynamic nanomachines. The technology has applications in medicine, biophysics and nanoelectronics. The poster is an overview that presents the methods, discusses its main applications and indicates the prospects and challenges for further development.

In Silico Evolution: The Emergence of Biological Complexity and Speciation Through Simple Algorithms

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How can we understand the origins of biological diversity and speciation without waiting millions of years? This poster provides an accessible introduction to in silico evolution, demonstrating how computer simulations model the emergence of complex biological phenomena directly before our eyes. We explore the theoretical foundations of artificial life, focusing on how abstract evolutionary mechanisms are translated into observable, dynamic ecosystems. Specifically, we will briefly introduce key computational concepts used in evolutionary modeling, including genetic algorithms, fitness landscapes, and the role of neutral DNA segments. We will explain the mechanics of speciation by observing how a homogeneous population of adaptable "universalists" naturally diverges into distinct, highly specialized clusters when competing for different resources in a stable environment. Additionally, we will explain how measuring the genetic distance between these virtual groups helps identify the exact boundary of reproductive isolation. The goal of this poster is to demonstrate that evolution is not just a historical biological process, but a powerful optimization framework governed by strict mathematical rules that can spontaneously generate complexity without any external direction.

Evaluation of the effectiveness of an anticancer drug as a photosensitizer in multicomponent systems for initiating radical photopolymerization processes

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Photopolymerization is a widely used technique in the production of polymer materials, including in 3D printing and biomaterials engineering. It is based on the action of photoinitiators which, upon absorption of UV radiation or visible light, generate reactive radical species that initiate the crosslinking process of monomers and prepolymers. An important direction of research is the development of new photoinitiating systems, particularly those involving biologically active compounds. The aim of this study was to evaluate the effectiveness of an anticancer drug as a photosensitizer in multicomponent systems initiating radical photopolymerization. Its photophysical and photochemical properties were analyzed. Additionally, its biological activity was assessed, including cytotoxicity and antibacterial properties. The obtained results indicate that the investigated compound can effectively initiate photopolymerization in appropriately selected systems and exhibits significant biological activity. This confirms its potential in the design of functional materials for biomedical applications. [1,2]

1] Photoinitiators for Medical Applications—The Latest Advances, Molecules, 2024 [2] Photopolymerization of Bio-Based Polymers in a Biomedical Engineering Perspective, Biomacromolecules, 2021

Effects of colchicine and paclitaxel on the structure of microtubules

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Microtubules, together with actin and intermediate filaments, makes up the main elements of cytoskeleton. They play a key role in many important cell processes, like organelles organization, delivering cargo vescicles or creation of karyokinetic spindle, essential to proper cell division. The structure of microtubules is very dynamic, as they undergo a constant restructuring. Maintaining this balance is crucial to proper cell functioning, and so exploring the effects of selected inhibitors on the spacial structure of mcirotubules is as crucial. The aim of this study is to visually evaluate effects on microtubule spacial structure in NIH3T3 fibroblasts of two chosen inhibitors - Colchicine and Paclitaxel. The cells were incubated in standard conditions (37oC, 5% CO2), and then seeded on fibronectin-coated glass dishes. After 15 min. of incubation, the cells were treated with inhibitors, and then after 1h of incubation the cells were fixed and alfa-tubulin was immunofluorescently stained. Cells imaging was performed using confocal microscope, capturing 3D scans of selected cells. Clear changes in spacial structure of microtubules were observed, including near total depolimerization. Obtained results confirm analyzed inhibitors effects on spacial structure of microtubules and pave the way towards future studies.

PID-based event selection of neutrino interactions in T2K

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An overview of event selection in the neutrino oscillation analysis in the T2K experiment. Focus is on the role of particle identification (PID) in discriminating between different interaction modes as well as various final state topologies. PID distributions for selected neutrino oscillation channels ($\nu_\mu \to \nu_\mu$ and $\nu_\mu \to \nu_e$) after Fully Contained Fiducial Volume and single-ring cuts are examined. Some initial observations on the performance of PID-based selection and its role in signal discrimination are also presented.

GEMAP: Geochemical Analysis of Martian Regolith Using NASA Perseverance PIXL Instrument Data — Implications for Planetary History and Habitability

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This study analyses 103 rock and regolith targets measured by the PIXL instrument aboard NASA's Perseverance rover, spanning Sol 125 to Sol 1481 across Jezero Crater. Data were sourced from the NASA Planetary Data System archive and processed using Python across 13 measured oxides. Results show 82% of targets are ultramafic, iron and magnesium-rich, silica-poor, confirming Mars lacks Earth's granite continental crust. FeO-T is 3.0× Earth levels, MgO 2.78×, and $P_2O_5 5.85\times$. Temporal analysis across the Noachian, Hesperian, and Amazonian epochs reveals declining iron and rising silica, recording Mars's transition from a volcanic, water-rich planet to a cold, dry world. SO_3 peaks at 28.1% confirm Hesperian lake evaporation. A habitability scoring framework identified ten maximum-score targets. Cheyava Falls (Sol 1197) was subsequently confirmed by Nature (2025) as containing potential biosignatures – the closest humanity has come to evidence of life on Mars.

Beer-hemian Rhapsody: Ale-iance of density and sound

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Co-authors: Krzysztof Kryk, Szymon Książek, Mikołaj Lewandowski, Witold Rudziński, Wiktor Sala, Wiktoria Seweryn

Sometimes boredom can push people to explore random ideas. For example sitting at a table someone bored will start playing on wine glasses. After drinking a few sips they may notice that the sound changed slightly. But does the frequency of the sound depend only on the amount of liquid in the glass? To find out how the density and the characteristics of the liquid (in our case, beers - mostly non-alcoholic) affect the sound it makes the densities and frequencies of the sounds were measured. The measurements were carried out using a simple wine glass with thin walls, in the range of 20-90 ml with 10 ml increments. During the measurement audio files were recorded and, at the same time, the sound was analyzed live using the program Friture. Thanks to that, it was possible to analyze the samples in two ways. Using Python libraries such as PyAV and Matplotlib, the results (maximum frequencies depending on volume) were plotted on a combined plot featuring all measured samples.

The Neuroscience of Mindfulness Meditation

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Mindfulness meditation is a mental training practice focused on cultivating present-moment awareness and non-judgmental acceptance. Recent neuroimaging research shows that regular practice can physically reshape the brain through a process called neural plasticity. Studies indicate that meditation increases gray matter density in the prefrontal cortex and hippocampus, areas responsible for decision-making and memory (1). Simultaneously, it decreases activity in the amygdala, which reduces the body's "fight or flight" response to stress. These structural changes improve the communication between brain regions, leading to better emotional control and lower levels of anxiety (2). Ultimately, these findings provide a scientific basis for using mindfulness as an effective tool to enhance mental health and psychological resilience.

Neural Network-Based Estimation of Parameters in a First-Order Time-Varying Autoregressive Model

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We study a first-order autoregressive model with time-varying parameters (TVAR(1)) and propose a deep learning–based approach for estimating its coefficients. The estimation task is cast as an optimization problem within a maximum likelihood framework. The resulting calibrated model is subsequently applied to day-ahead electricity price forecasting. Beyond the conventional assumption of Gaussian noise, we also consider Laplace-distributed noise. Empirical results based on real-world electricity market data show that the method effectively captures time-varying behavior and delivers accurate and reliable day-ahead price predictions.

Neutrons from Deuterium-Tritium Sources for BNCT

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The dose in Boron Neutron Capture Therapy (BNCT) depends on the local boron concentration in tissues, as well as on the energy characteristics and flux of neutrons. Monitoring the BNCT process, particularly based on the emission of gamma radiation with an energy of 478 keV, requires either the use of a large number of detectors operating simultaneously or a sufficiently accurate knowledge of the spatial, energy, and time characteristics of the neutron field I(E, r, t). This poster presents a review of the properties of neutron beams obtained from Deuterium–Tritium–type sources in the context of the CERBER (Compact Emission Reconstruction for BNCT) project, with particular emphasis on the neutron generation mechanism and factors influencing their emission, such as the deuteron accelerating voltage and beam current. The limitations of neutron beam monitoring through the analysis of generator operating parameters are discussed. Attention is drawn to the stability of neutron emission over different time scales, including short-term effects related to operating conditions during a single irradiation, as well as long-term effects resulting from generator use, in particular changes in the properties of the tritium-containing target. The poster is of a review nature and serves as an introduction to further analyses and potential experimental and simulation studies within the CERBER project.

Fabrication of photonic structures using two-photon polymerization technology with new biocompatible photoinitiators

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Two-photon polymerization (TPP) is a specific type of chemical process that uses a laser beam to cure a photosensitive material. Photonic structures are materials with an ordered structure that allows light to pass through in a controlled manner. Their structure also features a photonic bandgap, which enables the selective filtration of light at a specific wavelength. Important aspect aspect of the entire process is the discovery of biocompatible photoinitiators; this is essential in biomedical technologies and in the TPP process itself. In this study, micrometric photonic structures were fabricated using TPP technology, employing methacrylate monomers and new non-cytotoxic initiators that absorb in the 500 nm range

Research funded as part of the activities of the Applied Photochemistry Research Club through participation in the 7th edition of the FutureLab PK Student Project Competition at the Tadeusz Kościuszko University of Technology in Kraków, student project group number 154/2026.

MEMRISTIC BEHAVIOUR IN GRAPHEN OXIDE-BASED ORGANIC THIN FILMS

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Nonvolatile organic memristors have emerged as promising candidates for unconventional electronics, addressing demand for low energy consuming devices. This study aimed to exploit the exceptional electronic and charge-transport properties of graphene and its derivatives to tackle current challenges in electronic – the optimization of computer memory. The results reported herein demonstrate the electric characteristics of thin films formed between electron donor (X) and electron acceptor (GO) through non-covalent bonding of (X:GO)n, whereas X the polyethyleneimine (PEI), poly(diallyldimethylammonium chloride) (PDADMAC), poly(allylamine hydrochloride) (PAH) and cationic chitosan were used. Multilayers structures were fabricated on ITO glass using the Layer-by-Layer (LbL) method where the substrates were dipped into solutions without disturbing the underlying layers. The obtained results indicate that created LbL structures exhibit promising memrsitive behavior.

"Don't Skip Your Cardio" - Beyond the Mechanism of Exercise on the Cardiovascular System

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A closer look at the long-term impact of physical activity on the cardiovascular system reveals it not as an isolated mechanism but as a dynamic and interconnected network shaped by multiple simultaneous influences. This presentation explores how the increase in cardiac output emerges from the combined effects of skeletal muscle activity, venous return, physiological myocardial hypertrophy, and vascular resistance. Rather than acting independently, these factors operate in constant interplay,

where changes in preload, contractility, and afterload are tightly linked and mutually dependent. Small adjustments at one level can influence the whole system, producing a coordinated response that supports the demands of active tissues. By highlighting this integrated perspective, the presentation emphasizes how regular physical activity drives essential cardiovascular adaptations, improving its efficiency and reducing the risk of disease.

How to build a flying boat - Showcasing fluid flow discrepencies between the real world and simulations

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What differences are there between Computational Fluid Dynamics (CFD) simulations and real-world flows? Based on a simulation of an emerging hydrofoil boat designed at AGH Solar Boat Team, I will explain how a simulated flow might behave differently to a real one, as well as the necessary constraints we must apply, even though they partially disconnect the simulated results from reality. This practical approach showcases certain phenomena in an easy-to-understand way for a person without prior CFD knowledge.

Polycyclic radical photoinitiators designed for the production of three-dimensional micrometric polymeric materials using light-induced initiation in two-photon polymerization technology

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Małgorzata Noworyta1, Konrad Cyprych2, Marcin Lindner3, Cina Foroutan-Nejad3, Joanna Ortyl1,4,5 1Cracow University of Technology, Faculty of Chemical Engineering and Technology, Department of Biotechnology and Physical Chemistry, Warszawska 24, 31-155 Cracow, Poland 2Wroclaw University of Technology, Faculty of Chemistry, Department of Soft Matter Optics, Wybrzeze Wyspianskiego 27, 50-370 Wrocław, Poland 3Institute of Organic Chemistry, Polish Academy of Sciences, Marcina Kasprzaka 44/52, 01-224 Warsaw, Poland 4Photo HiTech Sp. z o.o., Bobrzynskiego 14, 30-348 Cracow, Poland 5Photo4Chem Sp. z o.o., Juliusza Lea 114 / 416A, 416B, 30-133 Cracow, Poland joanna.ortyl@pk.edu.pl Nowadays, there are increasing demands for precision in the fabrication of three-dimensional structures using 3D printing methods, including powder, filament, and resin-based technologies. These technologies are used, among other fields, in aviation, medicine, and microrobotics. A particularly promising technique is two-photon photopolymerization, which enables the creation of complex objects with micrometer-scale dimensions. This paper describes new multi-ring radical photoinitiators used in two-photon polymerization. A 1064 nm wavelength laser was used for printing, and the fabricated objects were characterized using SEM imaging. Research funded as part of the activities of the Applied Photochemistry Research Club through participation in the 7th edition of the FutureLab PK Student Project Competition at the Tadeusz Kościuszko University of Technology in Kraków, student project group number 154/2026.

The effect of interactions between latex microspheres and fibroblasts on their actin cytoskeleton

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The aim of this study was to analyze the effect of interactions between latex microspheres and mouse embryonic fibroblasts of the MEF 3T3 cell line on the organization of their actin cytoskeleton. This research constitutes a continuation of the work described in the article [1] Adamczyk et al. (2021), in which the effects of interactions between latex microspheres with a diameter of 2 µm and MEF 3T3 cells on their actin and microtubule cytoskeleton were presented. In the present study, the correlation between microsphere size (0.5 µm; 1 µm; 2 µm) and incubation time (3 h, 12 h, 24 h) on the actin cytoskeleton of MEF 3T3 cells was analyzed. The organization of the cytoskeleton was visualized using confocal microscopy, enabling its three-dimensional imaging. Experiments were conducted on fibroblast cells stained for the following cellular components: nucleus – DAPI, actin – phalloidin labeled with AlexaFluor488. Microspheres with natural fluorescence were used, eliminating the need for additional staining.

Atmospheric Characterization of WASP-39 b from JWST Transmission Spectroscopy

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This study presents an analysis of transmission spectroscopy observations of the exoplanet WASP-39 b obtained with the James Webb Space Telescope. The work focuses on the capabilities of near-infrared spectroscopy in probing the atmospheric composition of exoplanets across a broad wavelength range. Using high-precision data from multiple JWST instrument modes, including NIRSpec, the transmission spectrum of WASP-39 b has been analyzed to identify key atmospheric constituents. The observations reveal the presence of several molecular and atomic species, including water vapor (HO), carbon dioxide (CO), carbon monoxide (CO), sulfur dioxide (SO), as well as sodium (Na) and potassium (K). The results demonstrate a significant improvement in spectral coverage and precision compared to previous observations from the Hubble Space Telescope and Spitzer Space Telescope. The study also highlights the importance of consistent data analysis methods for achieving reliable comparisons between different instrument modes. These findings illustrate the transformative potential of JWST in advancing our understanding of exoplanet atmospheres and their chemical complexity.

Scalable Non-Cleanroom Fabrication of Graphene Flakes for van der Waals Heterostructures

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This work focuses on the fabrication of graphene flakes under non-cleanroom conditions using mechanical exfoliation and transfer techniques. The study compares different source materials (HOPG vs natural graphite) and transfer media (adhesive tapes, viscoelastic substrates, thermal-release tapes) in terms of flake size, contamination level, and reproducibility.

The goal is to identify practical, low-cost methods enabling the production of large, high-quality graphene flakes suitable for further integration into van der Waals heterostructures such as graphene/h-

BN. Optical microscopy (contrast-based identification) and AFM were used for structural verification.

Results show that non-cleanroom approaches can yield sufficiently large and clean flakes for prototyping nanoelectronic structures, while highlighting trade-offs between scalability, contamination, and control over transfer. The work provides a practical pathway toward accessible fabrication of 2D material systems outside specialized facilities.

Characteristics of cellular and crystalline limestones of the Tarnowice Beds based on the Kamień Śląski - Otmice quarry – a complex diagenetic history of carbonate deposits in the youngest Middle Muschelkalk formation in Poland

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The Tarnowice Beds are the youngest lithostratigraphic unit of the Middle Muschelkalk in Upper Silesia, southern Poland. They represent the final stage of one of several marine transgressions onto the Polish part of the Germanic Basin and consequently were deposited in a shallow saline environment. The unit shows a variety of carbonate peritidal lithofacies, including dolomudstones, domal stromatolites, oolites, and crystalline and cellular limestones. The latter two are enigmatic in terms of their origin and thus are the main focus of this study. This poster discusses their characteristics in the most complete section in the Kamień Śląski - Otmice quarry in Upper Silesia. The study utilizes preliminary research conducted as part of a Master thesis of the author, including field analyses and thin-section examination using a polarization microscope. Based on the research four subfacies of crystalline carbonates have been distinguished, including: fine- and coarse-crystalline types without internal structures, fine-crystalline types composed of tabular like forms, and those with an external fine-needle texture.

Blood Cell Genealogy – Understanding Hematopoiesis through Single-Cell Lineage Tracking

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Hematopoiesis is the lifelong production of blood and immune cells driven by hematopoietic stem cells (HSCs). Traditional studies relied heavily on bulk population analyses and transplantation assays. While foundational, these methods place cells in highly stressful, artificial environments, which masks their individual traits and natural behavior in steady-state conditions.

Single-Cell Lineage Tracking (SCLT) overcomes this limitation. Much like researching genealogy to build a family tree, SCLT uses genetic barcodes or naturally occurring mutations to trace the exact descendants of individual HSCs over time. This high-resolution mapping reveals differentiation as a fluid landscape rather than a rigid hierarchy. It uncovers hidden HSC heterogeneity, showing inherent clonal biases and capturing critical aging dynamics, such as declining clonal diversity.

Understanding these cellular histories drives modern precision medicine. SCLT is essential for pinpointing leukemic stem cell origins and investigating clonal hematopoiesis – the risky age-related expansion of mutated clones. Additionally, it holds the potential to enable tracking of drug-resistant cancer sub-clones and monitoring post-transplant immune regeneration, which might ultimately guide targeted therapies and help improve patient outcomes.

Ferrocene-functionalized polymer brushes as memristive devices

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Nowadays, the nanoscale silicon-based electronics are approaching their fundamental physical limits. Furthermore, modern computer architectures are affected by the von Neumann bottleneck, in which the physical separation between memory and processing units, combined with their mismatch in operational speed, leads to significant energy loss during repeated data transfer [1]. To address these challenges, memristors, named after the concept of "memory of resistance," are being intensively investigated due to their potential to function as artificial synapses and to overcome the aforementioned limitations [2]. In this work, a new approach to the fabrication of memristors based on ferrocene-functionalized polymer brushes and their characterization are presented. The active layers are synthesized on indium tin oxide (ITO) glass substrates via the surface-initiated atom transfer radical polymerization (SI-ATRP) method, forming highly ordered macromolecular architectures. Structural and electrical characterizations of the synthesized systems are carried out to investigate their design and resistive switching behavior. Research funded by the NCN SONATA BIS grant 2021/42/E/ST4/00290.

Finding the "Perfect Swish": Using a PINN to Optimise the Physics of a Basketball Shot

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Neural networks have increasingly become crucial to scientific discovery, driving advancements in material synthesis, pharmacology, and meteorological forecasting. Within this domain, Physics-Informed Neural Networks (PINNs) represent a specialized class of machine learning architectures. By embedding physical laws—typically formulated as partial differential equations—directly into the learning framework, PINNs provide a robust approach to addressing complex, high-dimensional real-world challenges. In this study, a PINN architecture was implemented to model the trajectory of a basketball, incorporating aerodynamic drag into the governing physical equations. The model was designed to optimize the initial velocity vector required for a successful shot, given the coordinates of the player on the basketball court. The primary objective of the algorithm was to identify initial conditions for a successful field goal. Beyond accuracy, the model was optimized to maximize the vertical component of the initial velocity—increasing the arc to minimize the probability of a defensive block—while simultaneously minimizing the total velocity magnitude to reduce the required physical effort from the shooter. This work serves as a foundational baseline for the development of more robust kinematic PINN models. Future iterations will integrate player parameters—including height and wingspan—to provide a detailed simulation of energy expenditure in jump-shooting. By coupling biomechanics with physics and machine learning, this research aims to refine sports performance diagnostics and personalized athletic training protocols.

Basics of Algebraic Quantum Field Theory

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Quantum mechanics and special theory of relativity are two, each over a hundred years old, well established physical theories in their own right but if one tries to combine them and one wants to complete this task in a rigorous, mathematical manner, then one numerous problems arise. In my poster I briefly present why the most naive approaches of arriving at the relativistic equations for wave function are inevitable going to fail in describing nature and then show solutions that humanity came up to resolve this issue, namely the quantum field theory(QFT). Next, I present some arguments why naive approaches to QFT are also bound to fail. In response to that I introduce the axiomatic programme for QFT, focusing on the basics of algebraic approach to QFT and discuss algebraic quantum field theory (AQFT) axioms. Then I show simplest example satisfying presented axioms. Lastly, I briefly outline successes and challenges of algebraic approach.

Targeting Cancer Cells: Novel Boron-10 Carriers in BNCT

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Boron neutron capture therapy (BNCT) is one of many radiotherapy approaches currently under development for cancer treatment. It is based on the nuclear reaction between boron-10 and thermal neutrons, which generates an alpha particle and a lithium-7 ion with a range limited to approximately one cell diameter. This reaction enables the selective destruction of tumor cells while minimizing damage to surrounding healthy tissue. The method is currently used in the treatment of recurrent head and neck tumors, and its potential is also being investigated for breast cancer, glioblastoma, and melanoma. One of the key challenges lies in the development of boron-10 carriers that are selective for tumor cells, exhibit low systemic toxicity, and allow therapeutic boron concentrations to be achieved. The two compounds currently used in clinical practice — boronophenylalanine (BPA) and sodium borocaptate (BSH) — have well-documented limitations in terms of selectivity, pharmacokinetics, and homogeneity of intratumoral distribution. Among the candidates for next-generation carriers are nanoparticles, antibody conjugates, liposomes, peptides, and aptamers. This review summarizes current BNCT strategies employing novel boron-10 delivery agents, highlighting their potential to overcome the limitations of clinically established carriers.

Synthesis and Effective Purification of Copper-doped Carbon Dots

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Carbon dots (CDs) are nanoscale structures composed primarily of carbon atoms and rich in functional groups. Thanks to their strong fluorescence, biocompatibility, low toxicity, and good solubility in water, they are widely applied in different fields. In this study, we introduce a straightforward and cost-efficient method for synthesizing copper-doped carbon dots (Cu-CDs), along with an effective purification approach based on membrane dialysis. The chemical composition and optical properties of the obtained Cu-CDs were analyzed using multiple spectroscopic techniques, including fluorescence spectroscopy, liquid chromatography-mass spectrometry (LC-MS), UV-Vis spectroscopy, and FT-

IR microscopy. Acknolwedgments This research was funded by the National Science Centre (NCN, Poland), OPUS, ("Emerging strategy approaches for the design and functionalization of carbon dots as multifunctional, Dynamics, green systems photoinitiators and photocatalysts involved in photopolymerisation processes") Grant No. UMO-2021/41/B/ST5/04533

High-energy collisions of heavy atomic and molecular ions with helium: estimating cross-sections from electronic structure calculations

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Spectroscopic studies of heavy radioactive ions offer unique insights into fundamental physics. This study explains discrepancies in energy loss rates for various radioactive ions colliding with a helium buffer gas. We hypothesize these differences are linked to effective collision cross-sections, which strongly depend on relative ion sizes.

Using ab initio electronic structure theory - specifically the Coupled Cluster method (CCSD(T)) and Gaussian basis sets - we modeled interaction potentials via grid-based calculations, Legendre polynomial expansions, and diatomic system analysis. We constructed and analyzed helium interaction potentials for heavy atomic ions (Cs+, Rb+, Pb+/++, Po+, Rn+, Ra++, Sm++, Xe+, Kr+, Cu+, Ag+, W+, Au+, Ta+, Ho+) and molecular ions (RaF+, PbF+, PbOH+) to correlate an ion's effective size with its energy loss rate.

Analyzing the relationship between ion size, derived from the interaction potential, and energy loss rate provides critical data for interpreting experimental results. Further modeling of these cross-sections will deepen our understanding of the atomic dynamics governing ion-gas interactions.

Animal Models of Schizophrenia: Advantages and Limitations

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Schizophrenia is a chronic mental disorder that significantly impairs functioning. Animal models are essential for understanding its etiopathology and developing more effective treatments [1]. There are three main types of models: pharmacological, genetic, and neurodevelopmental. The models differ in the type of intervention and in the range of symptoms they reproduce, including positive, negative, and cognitive domains, as well as their predictive validity [1]. Pharmacological models, based on dopaminergic or glutamatergic hyperactivity, are useful for studying positive symptoms but lack etiological relevance [3]. Genetic and neurodevelopmental models better reflect underlying mechanisms, although their behavioral effects may be less consistent [2,4]. Importantly, no single model captures the full complexity of schizophrenia. Different models may be useful for different research aims, which highlights the need for a complementary approach.

Breathing life into fluids: the power of leapfrog flow maps

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Preserving vortical structures is a key challenge in Eulerian fluid simulation. Traditional semi-Lagrangian advection is computationally efficient but suffers from high numerical dissipation, rapidly erasing fine-scale turbulent details. Conversely, pure flow-map methods are highly accurate but incur prohibitive computational costs.This study explores Leapfrog Flow Maps (LFM), a hybrid velocity-impulse scheme designed to bridge this gap. By reformulating the Navier-Stokes equations and employing leapfrog integration for midpoint velocities, LFM restricts expensive flow-map calculations to periodic reinitialization steps. We compare LFM's performance against classical advection techniques, demonstrating its superior ability to capture stable, long-lived vortices and complex fluid phenomena without the dissipative energy loss inherent in standard grid-based solvers.

Actin Inhibitor–Induced Cytoskeleton Disruption and Focal Adhesion Changes in NIH 3T3 and U2OS Cells

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The actin cytoskeleton plays a key role in maintaining cell shape, enabling cell migration, and forming adhesion structures. Disruptions in its organization can affect many biological processes. Therefore, it is important to investigate the effects of actin cytoskeleton inhibitors on the structure of actin filaments and adhesion sites. The aim of this study was a visual assessment of changes in the actin cytoskeleton and the number of adhesion sites in U2OS and NIH 3T3 cell lines under the influence of selected inhibitors: (S)-blebbistatin, cytochalasin D, and Y-27632. Cells from both lines were transfected to enable visualization of actin and paxillin. They were cultured under standard conditions (37°C, 5% CO) and then seeded onto fibronectin-coated dishes. After a short incubation period, the cells were treated with inhibitors at specific concentrations and incubated for 1 hour. Live-cell imaging was performed using a confocal microscope, capturing Z-stack images of selected cells. Clear changes in the structure of the actin cytoskeleton were observed, including disrupted formation of stress fibers and a reduced number of adhesion sites to the substrate for all applied inhibitors. These effects were present in both studied cell lines; however, a stronger visual effect was observed in the U2OS cell line. The obtained results confirm that the analyzed inhibitors significantly disrupt the organization of the actin cytoskeleton in U2OS and NIH 3T3 cells and affect adhesion sites. This constitutes an important starting point for further research on the role of cytoskeletal elements and cell adhesion structures in cancer progression, as well as potential directions for anticancer therapies.

A Treatise on Shelling Bananas, or Why One Should Not Leave Antimatter in Gravitational Field

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Does antimatter interact with gravitational field the same way as matter? While ALPHA-g confirmed this for antihydrogen, a purely leptonic system – positronium – remains a compelling target. This poster explores how metastable 2^3S Ps beams and matter-wave interferometry can probe gravitational acceleration on antimatter, and why it does not work.

Epidemics on Networks: Unraveling the Role of Contact Structure in Disease Spread

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Classical epidemiological models typically assume homogeneous mixing of individuals, which leads to

simple descriptions of disease spread and well-defined epidemic thresholds. In reality, contact patterns are heterogeneous and can be represented as complex networks. This poster presents SI and SIS models on networks, focusing on how network structure affects the dynamics of spreading processes. In particular, it compares random and scale-free networks and shows how degree heterogeneity influences the persistence of an epidemic. Numerical simulations are used to illustrate these effects.

Optimization of High-Temperature Properties of Perovskite-Structured Proton Conductors

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The aim of the project was to optimize the content of dopants to build a high-temperature protonic conductor with the structure of perovskite ABO3. A chemical formula Ba Ce0.61 Zr0.3 Yb0.04 Nd0.05 O3 was used. Calculations of the Goldschmidt tolerance factor and free space volume, was said to give a good protonic conduction. In addition, two extreme contents of dopants were made (in range 0-0.1) for better analysis. Calcination, and high-temperature sintering was done. The materials were analyzed by DSC, TG, XRD and EIS methods. As a result of sintering, 1 sample got destructed due to unstable crystal structure, which was predicted by the low Goldschmidt tolerance factor. Other samples were analyzed by spectroscopy impedance (EIS) method in dry and wet air in a range of 800-25C. It showed that types of air had no influence on protonic conductivity. The theory of high conductivity for a big value of free space volume proved effective in the project.

What β-decay secrets we can obtain by MTAS detector?

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Total Absorption Spectrometers (TAS) are designed to measure the true β-decay patterns and energies of unstable neutron-rich nuclei. Many β decays occur at high energies but with low probabilities, populating a large number of nuclear states in regions of high level density. As a result, the emitted γ rays form complex cascades that are difficult to fully detect using conventional β–γ spectroscopy with high-resolution germanium detectors. TAS systems, typically based on large NaI crystals, overcome this limitation by efficiently capturing the total energy released in γ cascades. This provides a more complete and reliable picture of the decay process. During the presentation, I will introduce the design and capabilities of the world's largest Total Absorption Spectrometer — the Modular Total Absorption Spectrometer (MTAS). During its first experimental campaign at Oak Ridge National Laboratory, MTAS was used to measure β-decay schemes of numerous fission products, providing new insights into a wide range of nuclei, including those with relatively long half-lives. I will present the types of spectra obtained and the kind of information that can be extracted using the MTAS system.

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Treat the space above as a Banach space

Figure 1: XXIII SeMPowisko conference, group photo,
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