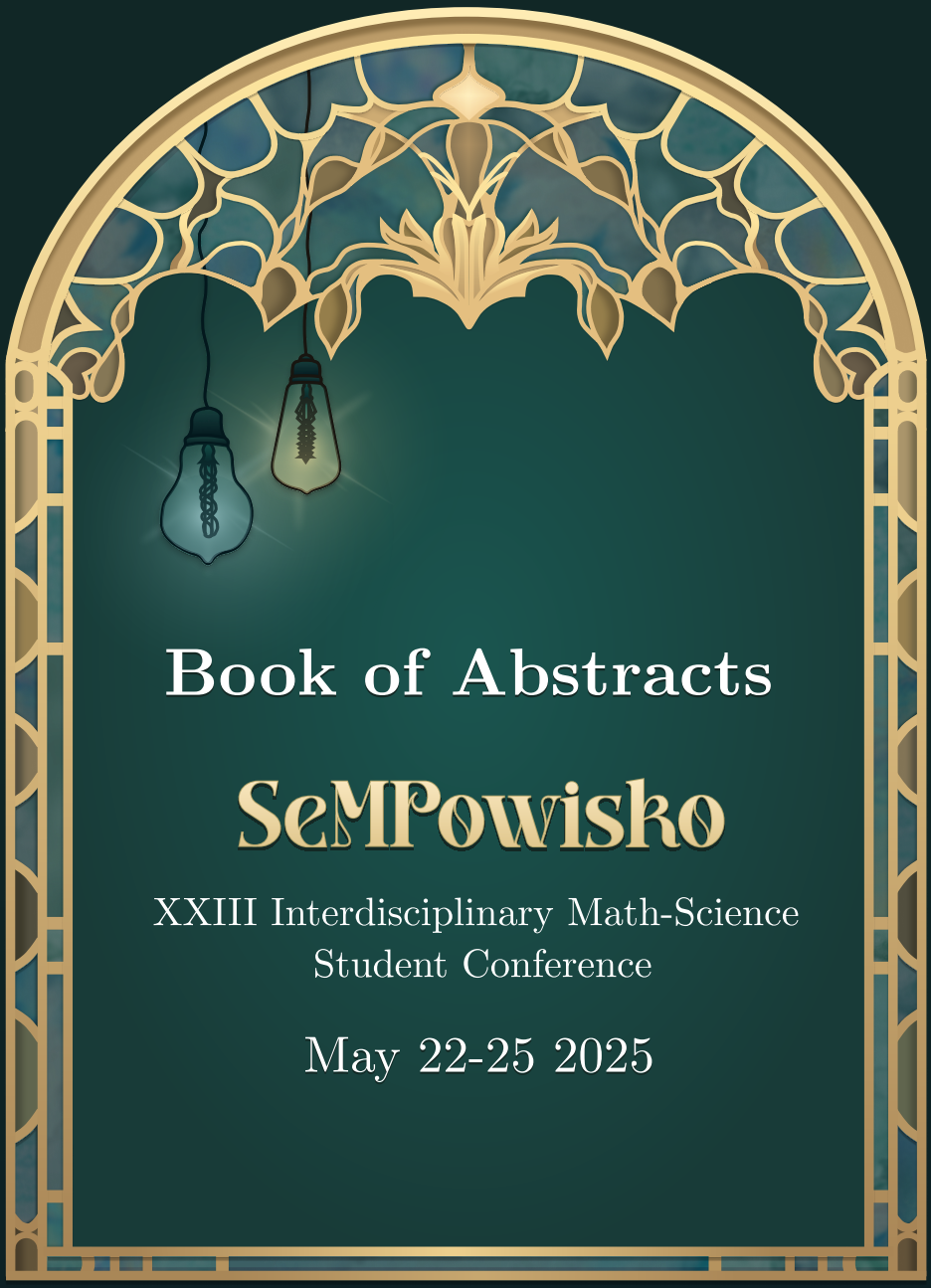

Book of Abstracts

SeMPowisko

XXIII Interdisciplinary Math-Science Student Conference

May 22-25 2025

UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE

SMP

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SMPowiśle 2025

Book Of Abstracts

Studies in Mathematics and Natural Sciences - **SMP**
Jagiellonian University in Kraków, Poland, Earth

Timetable

Legend

- 💡 physics and astronomy
- 📈 mathematics
- 🖥️ computer science
- ⚗️ chemistry
- 🍍 biosciences
- ⚙️ engineering
- ⛰️ geography and geology
- ❔ other

Thursday, May 22nd

10:00–12:00 Solaris: Synchrotron tour

12:00–13:00 WCh hall: Registration

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13:45–14:10 💡WCh A0-01: Kacper Nowak
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14:10–14:35 💡WCh A0-01: Rafał Bistroń
Benchmarking quantum devices beyond classical capabilities PAGE 11

14:35–15:05 WCh A0-01: Coffee break

15:05–15:30 ⚗️WCh A0-01: Marta Niemiec
Photoluminescent metal organic frameworks for optical sensing PAGE 23

15:30–15:50 ⚗️WCh A0-01: Gabriela Kowacz
The iEDDA reaction to the rescue: introducing 'difficult' functional groups into a new metal-organic framework (JUK-74) PAGE 19

15:50–16:15 ⚗️WCh A0-01: Wiktor Wolański
High temperature photomagnetic sponge based on $[Mo^{III}(CN)_7]^{4-}$ PAGE 32

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Biological studies on ferrocene derivatives of cyclin-dependent kinase inhibitor PAGE 14

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17:05–17:25 🍍WCh A0-01: Kacper Siąkała
A Novel Vitamin E-Based Raman Probe for Selective Imaging of Lipids and Mitochondria PAGE 28

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Optimal order execution via Markov Decision Process PAGE 15

17:50–18:10 📈**WCh A0-01: Marta Kosz**
The House Always Wins – Use of Probability in Gambling Strategies PAGE 19

18:10–18:35 ⚗️**WCh A0-01: Joachim Grzybowski**
Theoretical studies on electronic structure and intermolecular interactions in selected supramolecular systems PAGE 16

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Alice, Bob and Pan Tarhei: about quantum, thermodynamics and flow PAGE 9

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Fossil electric wires PAGE 9

11:30–12:00 WMiI 1101: Coffee break

12:00–12:45 🪴**WMiI 1093: prof. Martyna Elas**
Oxygen imaging in preclinical tumors PAGE 10

12:45–13:10 💡**WMiI 1093: Filip Kowalski**
Spectral triples on graphs PAGE 20

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14:50–15:10 🖥️**WMiI 1093: Łukasz Gorczyca**
Interval arithmetic for robust continual learning models PAGE 16

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Symmetries and gravitational memory PAGE 11

15:30–15:50 💡**WMiI 1093: Daniel Kessler**
Gravitional wave scattering from the Sun and planets PAGE 18

15:50–16:20 WMiI 1101: Coffee break

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Oxidation, Etching and Degradation of MoS2 and CrSBr Crystals. PAGE 10

11:45–12:15 WFAIS A-1-04: Coffee break

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Reprogramming Tumor-Associated Macrophages via Plant-Derived mtDNA Nanovesicles PAGE 13

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Freudenthal's Suspension Theorem: Spaces, and Other Things You Shouldn't Try at Home. PAGE 25

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What black holes are there? (theoretically) PAGE 31

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3D Printing to Fight Bacteria: A Look at Metal-Enhanced TPU Materials PAGE 29

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14:00–15:00 WFAIS A-1-04: Lunch break

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Debate: Compartmentalizing Science – A Path to Progress or Decline?

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Invited Speakers

Zeolitic Imidazolate Framework Bio-composites

prof. Paolo Falcaro Field: ⚗️

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Institute of Physical and Theoretical Chemistry, Graz University of Technology

In aqueous systems, the presence of biomacromolecules can trigger the rapid self-assembly of 2-methylimidazole and Zn(II) into Zeolitic Imidazole Frameworkbased materials. The building blocks of these frameworks can be arranged in different topologies (e.g. sodalite, diamondoid, and katzenite) and diverse crystalline phases with distinct chemical compositions (e.g. ZIF-C, ZIF-EC1). These different spatial arrangements and chemical compositions lead to different functional properties. Here we illustrate the research progress mainly focusing on the contribution of our group to this research field with a focus on potential application to biomedicine.

- Coord. Chem. Rev., 2021, 429, 213651
- Chemistry of Materials, 2018, 30, 1069–1077
- Chemical Science, 2020,11, 3397-3404
- Angew. Chem. Int Ed., 2021, 60,11391–11397
- Biomaterials Advances, 2023, 149, 213420
- Advanced Materials, 2022, 34, 2106607

Alice, Bob and Pan Tarhei: about quantum, thermodynamics and flow

dr Jakub Czartowski Field: 💡

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Heat has accompanied humanity ever since the first bonfire lit up the night, marking our discovery of the power of flame. Its role gained new significance with the invention of the steam engine and the formalization of the relation between heat and work—what we now call thermodynamics. Much later, this same discipline sparked a crisis known as the ultraviolet catastrophe, inadvertently paving the way for one of the most successful theories in physics: quantum mechanics. A century on, thermodynamics and quantum theory meet again as we strive to understand how the smallest—quantum systems—interact with the large and complex, for which thermodynamics was originally devised. In this lecture, I will offer an accessible introduction to select topics at the intersection of quantum theory, thermodynamics, and their unifying language: quantum resource theories. Along the way, we'll follow Alice and Bob—our iconic quantum duo—as they attempt to escape their entangled daily struggles at the house of Pan Tarhei, only to find that in a world where everything flows, quantum weirdness still finds a way to stay.

Fossil electric wires

prof. Mariusz Kędzierski Field: ⛰️

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The trace fossil Trichichnus is proposed as an indicator of fossil bioelectric bacterial activity at the oxic–anoxic interface zone of marine sediments. This fulfils the idea that such processes, commonly found in the modern realm, should be also present in the geological past. Trichichnus is an exceptional trace fossil due to its very thin diameter (mostly less than 1 mm) and common pyritic filling. It is ubiquitous in some fine-grained sediments, where it has been interpreted as a burrow formed deeper than any other trace fossils, below the redox boundary. Trichichnus, formerly referred to as deeply burrowed invertebrates, has been found as remnant of a fossilized intrasediment bacterial mat that is

pyritized. As visualized in 3-D by means of X-ray computed microtomography scanner, Trichichnus forms dense filamentous fabric, which reflects that it is produced by modern large, mat-forming, sulfide-oxidizing bacteria, belonging mostly to Thioploca-related taxa, which are able to house a complex bacterial consortium. Several stages of Trichichnus formation, including filamentous, bacterial mat and its pyritization, are proposed to explain an electron exchange between oxic and suboxic/anoxic layers in the sediment. Therefore, Trichichnus can be considered a fossilized "electric wire".

Ref.: Kędzierski et al., 2015. Biogeosciences. 12(8):2301–2309. doi: 10.5194/bg-12-2301-2015

Oxygen imaging in preclinical tumors

prof. Martyna Elas Field:

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EPR oximetry, enabling oxygen concentration and hypoxia studies has been a prominent application in preclinical biomedicine. Recent advances in EPR technology and spin probes make it possible to obtain fast and accurate 3D oxygen images with a wide range of possible applications, including cancer. Solid state oximetric probes, such as LiPc or Oxychip may be used to follow oxygenation over time in a chosen area of the tumor volume. Another option is a soluble probe, e.g. OXO71, providing a 3D image and enabling visualization of the pO2 distribution within the tissue. Our goal was to map the oxygenation in a wide range of tumor types and monitor the effects of therapeutic interventions.

Tumor oxygenation was measured using EPR (Jiva-25, O2M Technology or Bruker E540L, Bruker Biospin). Ultrasound and Doppler ultrasound were used to determine tumor anatomy and vascular structure (Vevo2100 or Vevo F2, FujiFilm Visual Sonic). Syngeneic tumor models were grown either ectopically (murine glioma GL261, human glioma LN229) or orthotopically (4T1 breast carcinoma).

In small tumors (<50ul), high pO2 was found, between 10 and 50 mmHg. As expected, the hypoxia level was much higher in older and larger tumors (>250 ul), and pO2 values were between 1-20 mm Hg. The lowest pO2 was found in orthotopic glioma, where it could be as low as 3-5 mm Hg. Oxygen bubbles increase pO2 for appr. 20 min and lead to tumor radiosensitization.

The oxygenation changes significantly during tumor growth and following treatment with either chemotherapy or oxygen nanobubbles. Fast and effective tumor oxygen measurements are a very important tool for future therapy monitoring and understanding tumor hypoxia. Combined with anatomic ultrasound imaging and Doppler imaging of the vasculature EPRI provides insight into tumor microenvironment dynamic changes.

Oxidation, Etching and Degradation of MoS2 and CrSBr Crystals.

prof. Robert Szoszkiewicz Field:

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Laboratory of Physicochemistry of Materials, Biological and Chemical Research Centre, University of Warsaw

Thin MoS2 crystals became indeed a nodal point in flexible nanoelectronics, but their usage extends as well into novel generation of chemical sensors and catalysts for important reactions, such as hydrogen evolution reaction. All these phenomena depend critically onto chemical stability of thin MoS2 crystals. In this talk I will concentrate on our selected research efforts into understanding of local mechanisms for oxidation and etching of the MoS2 crystalline surfaces as well as formation of originating MoOx nanometric and sub-nanometric clusters together with their interesting electrical properties. Then, I will also extend this methodology and show some related results for another interesting 2D material: CrSBr. Time permitting, I will also say a few words about other research in my laboratory, pertaining to measurements of internal friction of peptides and proteins at the single molecule level.

Abstracts

Symmetries and gravitational memory

Szymon Bagiński
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Field: 💡

The mathematical description of gravitational waves has become very important in recent years due to relevant past and future experiments. One way to describe gravitational radiation is by studying the asymptotic symmetries of spacetimes. This particular approach demonstrates an exciting interplay between physics and mathematics. In my talk, I will briefly introduce the concept of conformal compactification of a spacetime and the Bondi–Van der Burg–Metzner–Sachs (BMS) group as the group of transformations preserving its structure. Then, I will present how these mathematical constructs may be used to describe the so-called gravitational memory effect.

Fluvial dendro-zoo-geomorphology: beavers' role in the modeling of river valleys

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Faculty of Geography and Geology, Jagiellonian University in Kraków, Poland

Field: ⛰️

Since the emergence of beavers in the late Miocene (about 12-10 million years ago), they have become crucial in altering river environments across Eurasia and North America. The extant species, European beaver (Castor fiber) and North American beaver (Castor canadensis), are two of the most important agents in modifying geomorphological features, nutrient cycling, and vegetation in many river valleys, as well as chemical composition of water. These mammals can also reshape river channels, considerably influencing sediment transport and discharge regime. In this talk, I will outline how dams built by these rodents can impact the modeling of valley floors upstream and downstream, and why their tree cutting plays a significant role in weakening the stability of slopes.

Benchmarking quantum devices beyond classical capabilities

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

Field: 💡

Rapid development of quantum computing technology has led to a wide variety of sophisticated quantum devices. Benchmarking these systems becomes crucial for understanding their capabilities and paving the way for future advancements. The Quantum Volume (QV) test is one of the most widely used benchmarks for evaluating quantum computer performance due to its architecture independence. However, as the number of qubits in a quantum device grows, the test faces a significant limitation: classical simulation of the quantum circuit, which is indispensable for evaluating QV, becomes computationally impractical. In this talk I'll present modifications of the QV test that allow for direct determination of the most probable outcomes (heavy output subspace) of a quantum circuit, eliminating the need for expensive classical simulations. This approach resolves the scalability problem of the Quantum Volume test beyond classical computational capabilities.

Effects of the diamagnetic matrix on the magnetic relaxation pathways of single-molecule magnets.

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Faculty of Chemistry, Jagiellonian University in Kraków, Poland

Single-molecule magnets (SMMs) are a class of compounds in which a magnetic memory effect can be achieved at the molecular level. They are now extensively studied and deliver promising results regarding future applications in spintronics, quantum computing and high-density data storage. For a given system, one of the established ways to improve its performance is to dilute the paramagnetic centres in an isostructural diamagnetic matrix, as the resulting separation usually increases the magnetization lifetime. Plentiful diamagnetic ions can fulfil this role. The go-to approach is to use one closest in size to analysed paramagnetic centre. Here I present a study shifting from that paradigm. The magnetic proprieties of Dy3+ and Tb3+ are measured and studied in detail in three paramagnetic matrices of La3+, Y3+, and Lu3+. The results are interpreted as functions of both molar mass and ionic radii of the diluting ion, proving that either can be effectively used to tailor the magnetic relaxation pathways of lanthanide-based SMMs.

On the Convergence in Spaces of Character Smaller than $\mathfrak{p}$

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Instytut Matematyczny, Wydział Matematyki i Informatyki Uniwersytetu Wrocławskiego

In topology—the branch of mathematics concerned with the shape, size, and continuity of spaces—we often seek to understand how ”closeness” behaves without relying on distances. One powerful way to study this is by analyzing convergence: when and how sequences of points settle toward a limit. But not all convergence is created equal. Sometimes, the structure of the space itself, particularly how rich its collection of neighborhoods is, can dictate what kinds of convergence are possible. This talk explores a beautiful connection between convergence in topological spaces and a mysterious object from set theory known as the pseudo-intersection number, denoted by $\mathfrak{p}$. Though originally defined in the abstract world of infinite sets, $\mathfrak{p}$ turns out to control the behavior of sequences in certain spaces. Specifically, we consider topological spaces where a point has fewer than $\mathfrak{p}$ many neighborhoods—what mathematicians call a space of character less than $\mathfrak{p}$—and show that such a space must contain a non-trivial convergent sequence. To make this result accessible, I will first introduce the audience to the key set-theoretic notions.

Standing waves in physics

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Standing waves in physics are well-known and precisely described phenomena, yet their nature can sometimes be surprising. Starting with a one-dimensional standing wave model, such as that of a guitar string, and progressing to two-dimensional models like Faraday waves, one can see how something seemingly simple can become complex and unpredictable. The patterns formed by 2D standing wave models remain both mysterious and inspiring to physicists. The next possible frontier may be standing gravitational waves.

Reprogramming Tumor-Associated Macrophages via Plant-Derived mtDNA Nanovesicles

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The ecosystem surrounding cancer cells within a tumor is known as the tumor microenvironment (TME). It consists of extracellular matrix components as well as non-cancerous cells. One type of cells present in the TME is the tumor-associated macrophages (TAMs). Although macrophages are generally expected to fight with cancer cells, TAMs often exhibit a pro-tumor phenotype (M2), and their presence significantly hinders effective therapy. However, it has been shown that these macrophages can be reprogrammed back to an anti-tumor phenotype (M1), which supports disease regression. This reprogramming can occur through activation of the cGAS-STING pathway, which is involved in detecting double-stranded DNA molecules in the cytoplasm. In my talk, I will discuss one method of activating the cGAS-STING pathway using nanovesicles loaded with mtDNA, derived from the plant *Artemisia annua*. This example is intriguing not only because it offers hope for future therapeutic strategies, but also because it represents one of the first documented inter-kingdom interactions of this kind between plants and animals.

Bekenstein-Hawking entropy from Bogolyubov transformatiom

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The goal of this presentation is to introduce the participants of the conference to the Bogoliubov transformation, a crucial concept in quantum field theory that allows one to transition between inertial and non-inertial reference frames. The transformation also plays a key role in understanding phenomena such as the Unruh effect. According to Einstein's strong equivalence principle, an observer accelerating in a vacuum is locally equivalent to an observer at rest relative to a gravitational field source. In particular, the Bogoliubov transformation is used to describe how a quantum field, which appears in the vacuum state in one reference frame, may appear to contain particles when viewed from a different reference frame. This leads directly to the Unruh effect, where an accelerating observer detects thermal radiation. In my presentation, I'd like to focus on extending Stephen Hawking's groundbreaking work from his 1974 paper "Black Hole Explosions?" to demonstrate the entropy of black holes.

3D Printing to Fight Bacteria: A Look at Metal-Enhanced TPU Materials

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Metal powders, such as silver and copper, exhibit strong biocidal properties due to their high surface area-to-volume ratio, which enables effective antimicrobial activity at low concentrations. The resulting composite was based on thermoplastic polyurethane (TPU) with the addition of silver and copper nanopowders, produced using selective laser sintering (SLS) technology without the need to modify printer settings. The obtained material is characterized by enhanced mechanical strength, corrosion resistance, and significantly improved antibacterial properties, making it attractive for medical, filtration, and public space applications. Antibacterial properties of TPU composites with metal

nanoparticles were evaluated using the OECD protocol based on the ISO 22196 method. The protocol allows quantitative assessment of Escherichia coli and Staphylococcus aureus viability after 24 h exposure to the material surface. We observed a significant reduction in colony-forming units even at low metal nanoparticle content, suggesting strong antibacterial activity of TPU composites.

Octacyanoniobate(IV) as an electronic spin qubit

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The rapidly developing field of quantum information processing strives to enhance the usability of qubit systems for potential practical applications.[1] Molecular qubits based on metal complexes constitute a promising approach for the construction of electron spin-based quantum computing devices due to their chemical tunability, ease of manipulation with microwave pulses and high operation temperatures.[2] Building on prior research on S = ½ systems [Mo(CN)8]3- and [W(CN)8]3-,[3] which both show long relaxation times and the potential for geometry control in cyanide-bridged frameworks, we performed an extensive pulse EPR study of a single crystal of K4[Nb0.001Mo0.999(CN)8] · 2H2O where the octacyanoniobate(IV) qubit is diluted in its isostructural diamagnetic molybdenum(IV) analogue. The photomagnetic properties of the diamagnetic matrix could be used as a way of controlling the qubit behaviour of the studied system.[4]

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Photoswitchable materials

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Light is a convenient stimulus able to influence matter - it is easily accessible, and the development of optics provided us with very precise ways of utilizing it. While usually light-matter interactions are limited to reflection, scattering, and absorption, which than results either with emission, heating, or a photochemical reaction that is often irreversible and unfavorable (photodegradation), some specifically designed materials can reversibly change their properties - we call them photoswiches. Those photoswitches are promising candidates for use in analog encoding, optical memories, photo-influenceable magnets, and many more specific applications. In this talk, I would like to present and explain the most ingenious examples of such materials and introduce my own work related to this topic.

Biological studies on ferrocene derivatives of cyclin-dependent kinase inhibitor

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Cancer remains one of the most significant health challenges of the modern world, prompting the search for innovative compounds with potential anticancer activity. This study focused on evaluating the biological activity of a cyclin-dependent kinase inhibitor, seliciclib, and its novel ferrocene-containing derivatives. The research included stability testing of the compounds in aqueous solutions, as well as in vitro analyses using MCF-7 breast cancer cells. These included assessments of cytotoxicity, oxidative properties, intracellular accumulation, and effects on the cell cycle. The tested derivatives

demonstrated greater biological activity than the parent compound, with the ML-402 analog showing particularly promising results. The results obtained indicate the need for continued research on these compounds and the reasonability for further structural modifications to enhance their anticancer efficacy.

Not Just Colour - How pigmentation of melanoma affects responsiveness to treatment

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Uveal melanoma is a rare intraocular cancer which remains difficult to treat over the long term, particularly following metastasis. A characteristic trait of melanomas is their dark pigmentation; melanogenesis often becomes dysregulated in malignant melanocytes, which results in highly pigmented tumors. This heavy pigmentation is absent in amelanotic uveal melanomas, which lack this overabundance of melanin and remain light in color. Current research suggests this difference is a factor in patient outcomes, as protective properties of melanin are known to interfere with available therapies, mainly radiotherapy, photodynamic therapy and chemotherapy. This presentation aims to systematically review studies on the topic to compare pigmented and amelanotic uveal melanoma in order to investigate how pigmentation affects responsiveness to treatment and prognosis.

Optimal order execution via Markov Decision Process

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In financial markets, executing large orders efficiently is a complex challenge due to market impact and volatility. This presentation explores optimal order execution using Markov Decision Processes (MDPs), a mathematical framework for decision-making under uncertainty. We will model the execution process as an MDP, define states, actions, and rewards, and show how reinforcement learning and probability distributions—such as Gaussian or discrete sampling—can improve execution strategies and reduce trading costs.

Photoluminescent composites based on rhenium(V) complexes and organic diblock copolymers

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The construction of novel functional materials with increasing applicative potential stands out as one of the primary goals of today's materials sciences. Interdisciplinary strategy often opens up new pathways of development and extends previously encountered limits. An example of this approach is turning towards the design of organic-inorganic hybrid materials, which often significantly uplifts the natural limits of the studied systems. In this context, this work focused on exploring the benefits that come from combining strongly photoluminescent [ReV(CN)4(N)]2- complex (where N3- stands for nitrido ligand), which is a lesser known molecular functional unit, previously exploited in the context of optical thermometry, phase transitions and volatile organic compounds (VOCs) sensing[1] with organic polystyrene-block-poly(4-vinylpyridines) (PS-b-P4VPs), which represent a well-studied class of amphiphilic block copolymers, known for their ability to self-assemble and act as templates for functional units.[1] Special attention has been devoted to the characterization of micellar nanostructures

formed by the composites, as their key functionalities including making Re(V) complexes emissive in solution and offering the ability to explore these systems as super-sensitive environment sensors based on luminescence quenching are intrinsically related to this form of aggregation. [1] (a) Inorg. Chem. 2012, 51 (22), 12065–12074; (b) Angew. Chem. Int. Ed. 2023, 62 (41); (c) Inorg. Chem. Front. 2024, 11 (22), 8047–8069 [2] Mai, Y.; Eisenberg, A. Self-Assembly of Block Copolymers. Chem. Soc. Rev. 2012, 41 (18), 5969–5985

Interval arithmetic for robust continual learning models

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Traditional deep neural networks exhibit catastrophic forgetting and sensitivity to minor input perturbations. Existing solutions typically address these issues in isolation. I will present novel method, which integrates hypernetwork-based continual learning with interval arithmetic to tackle both challenges concurrently. Framework employs a hypernetwork to map task-specific embeddings to the weights of dedicated target models, enabling dynamic instantiation of subnetworks per task. The hypernetwork captures cross-task information, ensuring knowledge retention. Each target model consumes input intervals and leverages hypercubic representations to compute output bounds, providing formal guarantees against adversarial perturbations within the interval domain. This approach simultaneously ensures robustness and mitigates forgetting in a principled manner.

Theoretical studies on electronic structure and intermolecular interactions in selected supramolecular systems

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Supramolecular systems based on 1,4,5,8,9,12-hexaazatriphenylenehexacarbonitrile (HAT(CN)6) and phloroglucinol (H3PG) are the object of scientific interest as they can be used for molecular recognition due to non-covalent interactions, namely anion-π and hydrogen bonding [1,2]. Recently, supramolecular architectures based on both H3PG and HAT(CN)6 and halide anions (and thus creating a possibility for an increased number of non-covalent interactions) have been obtained and their photophysical properties have been experimentally studied. The goal of the presented theoretical studies was to characterise (using density functional theory and its time-dependent variant calculations) the electronic structure the aforementioned newly-synthesized compounds, describe the intermolecular interactions present in these systems as well as model their photophysical properties. The research included calculations of the interaction energies between systems components within models taken from the crystal structures and their analyses employing the ETS-NOCV method along with simulations of the UV-vis spectra, which suggested additivity of the interactions rather than their (anti)cooperativity.

Reimagining Spectroscopy: The Capabilities of ZULF NMR

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Nuclear Magnetic Resonance (NMR) is one of the key spectroscopic methods used in chemistry, biology, and physics. Traditional NMR requires strong magnetic fields, which involve high costs and complex equipment. An alternative is Zero- to Ultralow Field (ZULF) NMR, which enables recording nuclear

magnetic resonance signals in almost zero magnetic fields. ZULF NMR eliminates the need for strong magnets and uses precise control of weak fields along with detection via sensitive magnetometers, such as optical magnetometers or SQUID devices. This allows spectroscopy in conditions previously inaccessible to traditional NMR. In ultralow fields, resonance signals are recorded based mainly on spin coupling between nuclei. A key feature of ZULF NMR is its ability to study spin couplings without the dominant influence of external fields. Due to the lower cost of equipment and potential for miniaturization, ZULF NMR is an attractive alternative to conventional systems. Development of this technology could expand NMR applications in fields previously limited by technical and financial barriers.

The state of the climate system in 2024: A multi-scale perspective

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The year 2024 was the warmest on record — the average global annual air temperature was 1.55°C ± 0.13°C higher than for the reference period (1850–1900). Thus, for the first time, this anomaly exceeded 1.5°C, meaning that to achieve goals of the Paris Agreement the average annual temperature would need to begin declining in the coming years in order to keep long-term global warming below 1.5°C. At the same time, other indicators, such as rising sea levels or increasing atmospheric concentrations of greenhouse gases, also point to progressive changes in the climate system. The aim of this talk is to present changes in these climate indicators to assess the rate and magnitude of environmental changes. An attempt has also been made to compare the changes observed in 2024 with those of previous years to evaluate the feasibility of meeting the objectives outlined in various policy documents, as well as the effectiveness of actions taken to mitigate climate change. The analysis has been conducted across different spatial scales — from global, through European and national level, down to the local scale, with Kraków as a case study.

Krasiejów - a glimpse into a Triassic ecosystem

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The paleontological site in Krasiejów, Silesia was discovered in 1993. Since then, it has been a subject of extensive research focused especially on late Triassic vertebrates representing a diverse land ecosystem. Additionally, poorly preserved plant remains, calcified charophytes and freshwater invertebrates preserved in different forms and conditions were discovered in Krasiejów. The occurrence of the Fossillagerstätte in Krasiejów was possible thanks to specific semi-arid climate and fluvial environment in this area in the late Triassic period. However, the exact interpretation of the environment is still controversial. In this talk I will describe the geological context of the Krasiejów site, environment, climate and location of the studied area around 220 million years ago. I will concentrate on the late Triassic organisms found there, namely plants, invertebrates, and vertebrates. I will highlight the most crucial implications of the evolutionary history of dinosaurs derived from the organisms discovered in Krasiejów. I will also briefly outline the aim of my research focused on the analysis of micropaleontological data around the bone-bearing bed in Krasiejów. As well as I will describe the previous results of similar research and what results I expect.

At the edge of decidability in first-order logic

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How wonderful would it be to have a machine that could answer any question about natural numbers! Of course, this is only a dream that can never be fulfilled. Mathematically speaking, it is well known that the theory of natural numbers with addition and multiplication is undecidable. In other words, there is no algorithm that, given a first-order sentence with the predicates $+$ and $\cdot$, can determine whether it is true in the natural numbers. But is there any hope? Yes! A famous result by Mojżesz Presburger states that the theory of natural numbers with addition (but without multiplication) is decidable. Similarly, Skolem arithmetic, i.e. the theory of natural numbers with multiplication is also decidable. But how far can we go? Can we add new predicates to these theories while preserving decidability?

In my talk, I will briefly introduce first-order logic and take you on a journey through decidable theories. But beware, undecidability lurks around every corner!

Gravitional wave scattering from the Sun and planets

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General relativity predicts the existence of gravitational waves—perturbations in time and space that travel with the speed of light. These waves were first detected nearly ten years ago and are now observed around one hundred times per year, primarily from the merger of binary black holes billions of light-years away. The next generation of gravitational wave experiments is expected to detect the mergers of supermassive black holes, which produce gravitational waves with much larger wavelengths than those observed so far. As these waves pass through the Solar System, they would scatter from the curved spacetime created by the Sun and planets, producing briefly delayed "echoes" that may be detectable and could affect the accuracy of future observations if not properly understood. In this talk, I will present current predictions for gravitational wave scattering within the Solar System and discuss open questions regarding its magnitude and significance.

Probing the evolution of Long GRB properties through their cosmic formation history

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The astrophysics of Long Gamma-Ray Burst (LGRB) progenitors, as well as possible cosmological evolution in their properties, still poses many open questions. Previous studies suggest that the LGRB rate density (LGRB-RD) follows the cosmic star formation rate density (SFRD) only at high-z and attribute this to the metallicity evolution of progenitor stars. For low z, opinions differ on whether the uptick in the LGRB-RD is due to a distinct class of low-luminosity GRBs or perhaps even a different progenitor subclass. To investigate these questions, we utilize the Neil Gehrels *Swift* Observatory and ground-based observatories (redshift) data. To test the hypothesis that the observations can be mapped (with/without evolution) to the well-established cosmic SFRD, we consider three cases: no evolution, beaming angle evolution, and a simple power-law evolution. The comparison shows that the 'no evolution' case can be ruled out. Our study highlights that the beaming angle evolution or the simple power law evolution is also not sufficient to obtain a good match between the LGRB-RD and SFRD. Rather, the inclusion of multiple evolving properties of LGRBs in combination appears to be required to match the two rate densities in their entirety.

Space Radiation Environment and Electronics Testing

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Understanding the space radiation environment is essential for the reliable operation of electronic systems in space. Unlike on Earth, where the atmosphere and magnetic field provide substantial shielding, electronics operating in space are exposed to a variety of high-energy radiation sources that can degrade performance or even cause failures. Accurate knowledge of this environment is therefore critical in the design, testing, and deployment of spacecraft systems.

The space radiation environment is composed of several distinct sources, each with unique characteristics and effects on materials and electronics. This talk will introduce the primary sources of space radiation, including the solar wind, galactic cosmic rays (GCRs), solar particle events (SPEs), and trapped radiation within Earth's magnetosphere (commonly known as the Van Allen belts). Moreover, some basic concepts connected to testing electronic components will be described.

The House Always Wins – Use of Probability in Gambling Strategies

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Unfortunately, many people lose their entire fortunes gambling, either because they don't understand or deliberately ignore the math behind the games they're playing. Probability theory can take the "luck" out of casinos and help us understand why certain events occur the way they do.

During this short talk, I will introduce basic probability concepts such as random variables and expected value, and then I'll proceed to talk about the relatively simple Martingale strategy, the Gambler's Fallacy (misunderstanding of probability theory common not only in gambling), and the St. Petersburg paradox – a theoretical game where a player can win an infinite amount of money!

Warning: By listening to this talk you will by no means become qualified to go even near a casino without losing all of your money. After all, the house always wins.

The iEDDA reaction to the rescue: introducing 'difficult' functional groups into a new metal-organic framework (JUK-74)

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Metal-organic frameworks (MOFs) represent a class of porous materials employed in diverse applications ranging from gas storage and separation, chemical sensing, catalysis, to drug delivery. Their functionality often derives from the metal centers, organic ligands, or guest molecules within the pores. Recently, an increasingly prevalent strategy for tailoring the properties of MOFs is post-synthetic modification, which targets either metal clusters or organic linkers.

Covalent post-synthetic modification of incorporated organic linkers within the framework offers a powerful route to introduce a diverse range of functional groups. This approach proves particularly valuable for introducing functional groups selectively or under mild conditions after framework formation. One such reaction is the inverse electron-demand Diels-Alder (iEDDA) reaction, which can be performed on a tetrazine moiety.

In this presentation, the synthesis, structure and post-synthetic modification of a novel tetrazine-based metal-organic framework, JUK-74, via the iEDDA reaction will be discussed.

Spectral triples on graphs

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Development of quantum mechanics stimulated a need to develop the new framework of theory of operators, mostly due to von Neumann. Nowadays, we stand in front of the task of quantizing gravity. There are numerous propositions and theories on how to do that. One of them is so called noncommutative geometry. I will try to introduce some of its very basic concepts, especially focusing on its applications on graphs.

Endogenous Cytoplasmic DNA: Implications for Inflammation and Age-Related Diseases

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DNA, the fundamental carrier of genetic information, is typically confined to the nucleus and mitochondria, where its double-helical structure ensures stable storage and replication of genetic code. However, recent discoveries reveal that when DNA appears in the cytoplasm, it can act as a potent danger signal, triggering immune responses. Endogenous cytoplasmic DNA (cytoDNA)—arising from genomic instability, mitochondrial damage, or retroelements—can act as a inflammatory agent. These DNA fragments are diverse in origin and structure, but share the ability to activate innate immune sensors like cGAS-STING, contributing to chronic, sterile inflammation, which is linked with autoimmunity, cancer, neurodegeneration, and age-related diseases. This talk will explore ways of cytoDNA formation, it's inflammatory properties, and how its persistent presence is linked to aging and age-associated diseases. Understanding these mechanisms opens the door to new therapeutic strategies aimed at regulating inflammation from within.

The Claustrum Revisited: A Forgotten Structure in the Psychedelic Renaissance

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The claustrum is a thin but highly interconnected subcortical structure. Despite its small size, it maintains reciprocal connections with nearly all cortical areas, suggesting an integrative role in coordinating cortical activity. Recent theories have proposed that the claustrum may contribute to the synchronization of large-scale neural networks involved in consciousness, multisensory integration, and stress modulation.

This talk will explore the claustrum's anatomical and functional characteristics, drawing from both historical insights and contemporary findings. Special emphasis will be placed on its dense expression of serotonin 5-HT2A receptors, making it a prime candidate for mediating the effects of serotonergic psychedelics such as psilocin and LSD. I will discuss theoretical models that position the claustrum as a key node in the neural mechanisms underlying psychedelic-induced alterations in consciousness, with possible relevance for the therapeutic effects in psychiatric disorders. Ultimately, this exploration aims to situate the claustrum at the intersection of basic neuroscience, altered states of consciousness, and the clinical application of psychedelic compounds.

How looking at stars gave us rumble strips

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Because astronomy often seems like a very abstract science, some people assume all of its discoveries to be abstract as well. While it's true that some findings are difficult to comprehend or connect to everyday life, there are many tangible and widely innovations. From cleanroom technology and PET scans to Wi-Fi and video enhancement software, astronomy has helped shape the modern world. In this talk, I will explore the impact of astronomical research and challenge the idea that astronomy is a waste of money and resources.

How your favourite snacks sabotage your meds: food – drug interactions.

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Field: 🪴

Can a glass of grapefruit juice turn your medicine into a danger? Or French fries decrease effectiveness of your pill? Food-drug interactions are more common – and more serious – than many realize. While food and medications are typically considered independently, their interactions can significantly impact drug pharmacokinetic properties and pose major health risks. Our presentation focuses on exploring the mechanisms underlying food-drug interactions at different stages of drug processing. ADME (Absorption, Distribution, Metabolism and Elimination) serves as the foundation around which the presentation is built. It's a key concept in pharmacokinetics which describes the journey of the drug through the body. Based on this framework, we explain, using examples, how certain foods interact with different drugs. Our aim is not only to share some science-related curiosities but also to raise awareness and emphasize the importance of reading drug leaflets carefully and following healthcare professionals' advice when taking medications.

Shine bright like a black hole: Powering the most luminous explosions in the Universe

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Field: 💡

I will present a recent theoretical model describing Gamma-ray Bursts (GRBs)—intense explosions associated with the deaths of very massive stars. In this scenario, the collapse of the stellar core leads to the formation of a black hole. Conservation of angular momentum causes the newly formed black hole to rotate at high speeds while the magnetic field of the progenitor star is dragged inward by the collapsing material. The resulting system acts like a cosmic dynamo, where the magnified magnetic field lines generate strong electric currents near the poles and launch powerful, highly collimated jets of radiation. This framework successfully accounts for key observational features of GRBs, including the shape of their light curves, the anti-correlation between luminosity and duration, and the total energy output of the explosion.

Finding holes and branches in the data

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In the age of Big Data, scientists often deal with systems generating large amounts of data. Understanding shape of this data can be a big help both in data processing and in extracting valuable information about the underlying system. In this talk I will introduce the idea of persistent homology, computationally efficient topological method that can tell us something about the amount and dimensions of holes in the dataset of interest. Then I will show how to use it to detect clustering of points and branching.

Love letter to Leibniz notation and a quick trip to curved spaces

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Leibniz notation is itself a powerful tool that encodes geometric meaning, simplifies calculations, and generalizes elegantly to advanced mathematics.

We begin in flat Euclidean spaces, revisiting fundamental calculus theorems (e.g., the chain rule and Jacobi matrix properties) to demonstrate how naturally they appear in Leibniz's language of differentials dx and derivatives $\frac{dy}{dx}$.

Transitioning to curved spaces, we introduce manifolds and their locally linear structure. Vectors become directional derivatives, while covectors and tensors emerge naturally through differentials. The notation's power lies in its compatibility with infinitesimal reasoning - since manifolds are locally flat, dx maintains its intuitive interpretation as an infinitesimal displacement.

We examine key tools including the metric tensor and differential forms, showing how Leibniz notation simplifies calculations in curved geometry. Finally, we apply this formalism to electromagnetism by expressing Maxwell's equations covariantly and presenting Stokes' theorem as a unifying principle.

Seasonality of wind streaks on Meridiani Planum, Mars

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Meridiani Planum (MP) is an equatorial region on Mars. MP landscape comprises desert plains with multiple impact craters and the abundance of aeolian landforms. Their orientation allows us to infer on the direction of formative winds. Wind streaks can be formed behind topographic features such as crater rims or dunes. Wind streaks related to 48 craters on MP and 10 dunes in Endeavour crater were analyzed in almost 200 orbital images acquired by CTX and HiRISE instruments between Martian years 28 and 36 (Earth years 2002-2024). In the studied period there is a seasonality of wind streaks and formative wind directions. The results showed that the formative wind directions are: NW, SE and E. The NW winds occur in all seasons except for summer when the SE winds are dominant. In winter wind directions are the most diverse. No straightforward correlation between the activity of wind streaks and dust storms was found. Also, the total disappearance of some dunes due to the process of deflation was observed.

Eccentric Gravitational Waves: Whisper from Exotic Compact Binaries

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Gravitational waves offer a new way to explore the nature of black holes and other dense objects in space. According to Einstein's theory, a black hole's shape is fully determined by its mass and spin—a concept known as the "no-hair" conjecture. This means other features, such as its quadrupole moment, can be predicted. However, more exotic objects—such as neutron stars or boson stars—may not follow this rule.

In this work, we explore how to test this idea using compact binary systems—two dense objects in an eccentric orbit, rather than a perfectly circular one. We examine how future gravitational wave detectors can help us distinguish black holes from other exotic objects by identifying spin-related features and eccentricity in the signals. New future detectors, such as the Einstein Telescope and Cosmic Explorer, which are more sensitive to lower frequencies, will significantly enhance our ability to run such tests.

Photoluminescent metal organic frameworks for optical sensing

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In the last decades, an increase in scientific interest devoted to functional materials based on metal complexes has been observed. Among them, a widely explored group of materials are metal-organic frameworks (MOFs). Their scientific appeal is a result of porosity and stability, often combined with biocompatibility, great tunability, and responsivity to external stimuli. In particular, photoluminescent MOFs (PL MOFs) deserve recognition in the field of sensing, as their emission characteristics can exhibit sensitivity to temperature, relative humidity or chemical stimuli.

The talk will consist of a brief introduction to the field of photoluminescent functional MOFs, then followed by the case study of original scientific work, in which we present a family of MOF materials based on Sr^{2+} or Ba^{2+} ions, 4,4'-bipyridine N,N'-dioxide (4,4'-bpdo) and $[M^{III}(CN)_6]^{3-}$ species. Among them, the air-stable phase of $\{[Sr^{II}(4,4'\text{-bpdo})_{2.5}(NO_3)][Sr^{II}(4,4'\text{-bpdo})_{2.5}(H_2O][Cr^{III}(CN)_6]\}$ (**1a**) deserves special recognition due to the fully reversible water vapor sorption properties and dual luminescence. The presented MOF can serve as a platform for luminescent sensing of both relative humidity and temperature, thus being a great example of a multifunctional luminescent sensor.

AI revolution in climate modeling

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Traditional climate models face prohibitive computational costs, limiting their ability to simulate complex Earth system interactions and explore uncertainties. The HClimRep project pioneers an AI-driven paradigm shift by developing a foundation model for climate science, building on the success of AtmoRep—a transformer-based model for atmospheric dynamics. HClimRep integrates multi-scale atmospheric, oceanic, and sea ice data, leveraging GPU-optimized architectures and diffusion techniques to emulate physics-based simulations at a fraction of the computational expense. This enables efficient generation of large ensembles for seasonal-to-decadal projections, uncertainty quantification, and "what-if" scenario analysis. Key innovations include extending AtmoRep to stratospheric tracers, creating OceanRep for ocean dynamics, and coupling multi-resolution inputs for holistic Earth system modeling. Three downstream applications demonstrate HClimRep's transformative potential: predicting

stratospheric ozone changes, simulating counterfactual marine heatwaves, and enhancing hydrological cycle downscaling for extreme event forecasting. By collaborating with Helmholtz institutes, ECMWF, and CERN, and utilizing Europe's exascale supercomputing infrastructure, HClimRep bridges AI advancements with climate science, offering policymakers and researchers a robust tool to address climate challenges.

Multidimensional modelling in drought assesment problem.

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Drought is a complex and multidimensional natural phenomenon that significantly impacts agriculture, water resources, ecosystems, and socioeconomic systems. Traditional drought assessment methods often rely on single indicators or univariate analyses, which may not fully capture the intricate interactions and temporal-spatial variability inherent in drought processes. This presentation explores the role of multidimensional modelling in enhancing drought assessment by integrating diverse datasets, such as meteorological, hydrological, agricultural, and remote sensing indicators. We discuss various modelling approaches, including multivariate statistical techniques, machine learning algorithms, and spatial-temporal models, emphasizing their advantages and challenges. Case studies, including data from weather stations for Poland, demonstrating the application of these models in different climatic and geographic contexts are presented, highlighting improvements in drought detection, characterization, and forecasting. The findings underscore the potential of multidimensional approaches to support more accurate, comprehensive, and proactive drought management strategies. It is also a breakthrough in actuarial mathematics related to insurance and obligations pricing.

Direct Observation of Perovskite Ferroelectric Domains by Scanning Electron Microscopy

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Ferroelectric perovskite oxides are a vast group of 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 are regions of uniform electric polarization, analogous to ferromagnetic domains in magnets. Ferroelectric domains aid in charge carrier separation and transport, which promises increased efficiency and enhances applications of these materials in green technologies. To take full advantage of the outstanding properties of this group of materials, it is crucial to develop techniques for characterizing these domains.

We present a novel technique for characterizing ferroelectric domains in $KNbO_3$ using a scanning electron microscope (SEM). By collecting data on angle-dependent channeling contrast and correlating it with simulated dependencies, it is possible to obtain crystal orientation information. Through the direct correspondence between crystal orientation and intrinsic polarization direction, full information about the ferroelectric domains can be obtained.

Electrically Charged Black Holes

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In lectures on general relativity, students encounter the analysis of geodesics in Schwarzschild spacetime. In this presentation, I want to demonstrate a fully analytical method for analyzing geodesics in a more general case — Reissner-Nordström spacetime — that is, to discuss the motion of test particles around an electrically charged black hole. I will address how the contribution from the electric charge affects the geometry of spacetime and whether it is meaningful to study such a case in practice.

Freudenthal's Suspension Theorem: Spaces, and Other Things You Shouldn't Try at Home.

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Freudenthal's Suspension Theorem is a gem of algebraic topology, revealing how the homotopy groups of a space relate to those of its suspension. Established by Hans Freudenthal in the 1930s, it states that for an $(n-1)$-connected space X, the suspension map

$$\pi_k(X) \to \pi_{k+1}(\Sigma X)$$

is an isomorphism for $k < 2n-1$ and a surjection for $k = 2n-1$. The theorem is notable not only for its theoretical beauty but also for its practical implications in topological classification and computation. It has applications in the study of spheres, manifolds, and various geometric objects, where understanding the relationships between homotopy groups is essential for solving many problems in algebraic topology. This presentation will introduce the theorem accessibly, starting with a brief overview of homotopy groups and the suspension construction. We will focus on the theorem's intuitive geometric basis: how suspending a space "shifts" its homotopy groups, preserving structure in a predictable way. By exploring the case of spheres, we will illustrate the theorem's power in computing specific homotopy groups, such as those of

$$\Sigma S_n,$$

making abstract ideas concrete.

Crater, Delta, and Evaporites: The Martian Jezero Crater from a Geological Perspective

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Jezero Crater, located on the western edge of the Isidis impact cratering basin, is a scientifically valuable site with high geological and astrobiological significance. Updated age estimates based on impact cratering counts suggest that the Jezero region may have formed as early as 3.1 billion years ago – earlier than previously assumed – which has implications for reconstructing the evolutionary history of both Mars' surface and interior. This area serves as a key focus of the Mars 2020 mission due to its well-preserved fluvio-lacustrine facies and potential to reveal past environmental conditions on Mars.

The low-angle strata characteristic of deltaic bottomsets (<2°) and the steeper foreset layers (2-9°), along with the presence of clay minerals typical of distal sediments, support the interpretation of a delta formed in a body of stagnating water with architecture analogous to terrestrial river deltas. A high-resolution photogeologic map of the Perseverance rover landing site enabled the detailed identification of surface and bedrock units.

Collected samples – from the older Séítah formation to the younger, heavily cratered Máaz unit – contain mafic igneous minerals (pyroxene, olivine, feldspar) as well as sedimentary products of aqueous alteration (carbonates, sulfates, smectites, iron oxides). These minerals indicate varying degrees of hydrothermal alteration and past water activity. Analysis of these deposits and the crater's structural

context will deepen our understanding of Martian magmatism, aqueous processes, and the potential presence of organic compounds.

Together, these data will support reconstruction of Jezero's geological history and its habitability potential, making it one of the most promising sites for the search for past life on Mars.

Search for optimal quantum chemistry methods for the simulation of optical characteristics related to metal-centered electronic transitions in molecular luminophores

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From the perspective of an intensively evolving field of advanced luminescent materials, there is a growing demand for theoretical support to complement and rationalize experimental observations[1]. Addressing this challenge requires the development and application of theoretical methods that combine precision and reliability with reasonable cost and accessibility. In this study, computational strategies for simulating various types of optical spectra were developed and evaluated, with particular emphasis on lanthanide- and transition-metal-based complexes. For lanthanide systems, where f–f transitions are dominant, the CASSCF method proved to be both robust and versatile[2], especially when supplemented with Second Order Perturbation Theory corrections. In the case of transition metal complexes, notable improvements were achieved through periodic geometry optimizations and by extending the active space to include ligand-centered orbitals. In the broader context of theoretical investigations, it is essential not only to explore the applicability and strengths of different methods, but also to identify their inherent limitations, enabling a more informed and critical interpretation of the computational results. [1] Qiao, Y. S.; Sergentu, D. C.; Yin, H. L.; Zabula, A. V.; Cheisson, T.; McSkimming, A.; Manor, B. C.; Carroll, P. J.; Anna, J. M.; Autschbach, J.; Schelter, E. J. J. Am. Chem. Soc. 2018, 140, 4588– 4595 [2] Helmich-Paris, B., J. Chem. Phys. 2019, 150, 174121

Exploring DNA Mismatch Repair Mechanisms using Atomic Force Microscopy

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In science, we use a wide variety of microscopes. Most of them allow us to observe structures at the microscopic level, which is usually sufficient for imaging entire cells. However, cells are incredibly complex structures, and to better understand many processes, we need to dive much deeper. To overcome some of the limitations of optical microscopy, physicists came up with an alternative approach, based on detecting the interactions between a sample surface and a probe. That led to the development of atomic force microscopy (AFM), enabling the analysis of matter at the nanoscale. Using AFM is valuable for studying cellular mechanisms, including mismatch repair (MMR), which is necessary to maintain the stability of our genome. Ideally, the DNA sequence follows strict pairing rules: cytosine with guanine and adenine with thymine. But as in life, mistakes happen. The MutS protein plays a crucial role by detecting mismatches in the sequence, which are regions of the DNA, where one nucleotide is paired incorrectly. This step triggers a cascade of events involving other proteins, which together form a complex that is capable of correcting the mistake. Gaining knowledge about the initiation of repair processes is important in many fields, including medicine, as it enables the study of diseases such as hereditary nonpolyposis colorectal cancer, which is linked to the defects

in mismatch repair pathways.

A brief introduction to spinor bundles

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Spinor bundles play a fundamental role in modern differential geometry and mathematical physics, providing a natural generalization of spinor fields from quantum physics to the setting of differentiable manifolds. From a physical perspective, spinors arise as representations of the Lorentz group and provide the appropriate language to describe fermions in Minkowski space, where the Dirac operator captures both their quantum behavior and relativistic dynamics. In this talk, I would like to introduce the essential concepts related to the construction of spinor bundles on spin manifolds and their interplay with Riemannian geometry. Particular emphasis will be placed on spectral geometry, where geometric and topological properties of manifolds are studied via the spectrum of differential operators. Applications in noncommutative geometry, as well as connections to modern models in mathematical physics will also be discussed.

Quantitative Assessment of Endogenous Single-Strand Breaks in Muscle Tissues

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As a carrier of genetic information, DNA is commonly perceived as a stable molecule, but in fact the molecule is susceptible to damage. It is caused by both endogenous and exogenous factors, and its stability comes from continuous repair. Therefore, it may be assumed that eucaryotic cells have their base level of DNA damage.

In this study we employed the STRIDE (SensiTive Recognition of Individual DNA Ends) technique, which enables the direct visualisation of single-strand breaks (SSBs) in fixed cells and tissues. Combined with fluorescent confocal microscopy, this method allowed the quantitative assessment of endogenous DNA damage in cells that had not been exposed to additional mutagenic factors.

The aim of this study was to determine whether skeletal, cardiac, and bladder muscle tissues, representing smooth muscle, exhibit comparable levels of endogenous SSBs. The findings gathered offer information that could serve as a foundation for additional research into the tissue-specific characteristics of DNA damage and its connection to metabolic activity.

Solving sine-Gordon equation through Bäklund transformation

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Solitons are waves created in nonlinear mediums that play an important role in many areas of physics such as condensed matter physics, nuclear physics, Bose-Einstein condensates, nonlinear optics, cosmology and elementary particle physics. Kinks are one of the simplest topological solitons appearing in many field theories , among others in sine-Gordon model, Christ-Lee model and abelian Higgs field. During my presentation I will discuss different types of solitons using the example of solutions of sine-Gordon equation and I will present the way of receiving these solutions by using Bäklund transform and Bianchi diagram. In particular, I will focus on kink/antikink and breather solutions,

and then on ways of using them to generate more complicated solutions like wobbler, composition of kink and breather, or two breather solution. Families of solitons generated this way, from simple kinks and breathers, are one of the key tools for describing solitons in non-integrable models.

A Novel Vitamin E-Based Raman Probe for Selective Imaging of Lipids and Mitochondria

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Examining biological systems by Raman microscopy can be conducted in either a labelled or non-labelled manner. The labelled approach employs specific compounds called Raman probes, which consist of targeting and spectroscopically active (characterized by high Raman cross-section) moieties. The usage of Raman probes enables biorthogonal imaging at the subcellular level. One of the most important subcellular structures are biomembranes, their proper construction and protection is provided by 'vitamin E' - a family of eight structurally related lipid-soluble molecules possessing antioxidant activity [1]. In our work, a polyene-modified derivative of vitamin E (α-tocopherol form – poli-Vit.E-probe) was tested on live HAEC cells. Our research demonstrates that, depending on the concentration and incubation time, the poli-Vit.E probe can exhibit two distinct bands (2235 cm^{-1} and 2260 cm^{-1}) in the 'silent region.' The ratio of these two bands is closely correlated with the degree of unsaturation within the cell, while the 2260 cm^{-1} band alone can be used to visualize mitochondria. Therefore, this compound holds promise for assessing cellular lipid profiles and detecting mitochondria.

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[1] Schneider, C. (2005). Chemistry and biology of vitamin E. Molecular Nutrition & Food Research, 49(1), 7–30. https://doi.org/https://doi.org/10.1002/mnfr.200400049

Aurophilic interactions in heterometallic lanthanide(III)–containing molecular materials

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Metallophilic (aurophilic, argentophilic, etc.) interaction is a non-covalent attraction that occurs between closed-shell metal centers of a d8 or d10 electron configuration. They play an important role in the arrangement and stabilization of crystal structures based on metal complexes. They induce and influence many physical properties, including photoluminescence, electron conductivity, and magnetic properties. A special interest was given to Au(I)-Au(I) interactions, which often lead to bright photoluminescence sensitive to small changes in the structural environment. It can be used in optical applications in lightning, sensors, etc. Hence, materials based on Au(I) complexes have gain broad interest in materials chemistry and many systems have been synthesized, both homo- and heterometallic. When combined with lanthanides(3+) ions, Ln3+, they may create systems based on aurophilic interactions, revealing strong luminescence and diverse magnetic properties. In our work, we focused on luminescent gold(I) iso-maleonitriledithiolate (i-mnt) complexes, [AuI2(i-mnt)2]2-, which in combination with Ln3+ form emissive coordination systems bearing Au(I)· · ·Au(I) interactions, [LnIII(DMF)8]2[AuI2(i-mnt)2]3, which were investigated using X-ray diffraction and spectroscopic techniques.

3D Printing to Fight Bacteria: A Look at Metal-Enhanced TPU Materials

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Metal powders, such as silver and copper, exhibit strong biocidal properties due to their high surface area-to-volume ratio, which enables effective antimicrobial activity at low concentrations. The resulting composite was based on thermoplastic polyurethane (TPU) with the addition of silver and copper nanopowders, produced using selective laser sintering (SLS) technology without the need to modify printer settings. The obtained material is characterized by enhanced mechanical strength, corrosion resistance, and significantly improved antibacterial properties, making it attractive for medical, filtration, and public space applications. Antibacterial properties of TPU composites with metal nanoparticles were evaluated using the OECD protocol based on the ISO 22196 method. The protocol allows quantitative assessment of Escherichia coli and Staphylococcus aureus viability after 24 h exposure to the material surface. We observed a significant reduction in colony-forming units even at low metal nanoparticle content, suggesting strong antibacterial activity of TPU composites.

Experimental evaluation of molecular filters

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We study the effectiveness of filters commonly used in chemoinformatics for molecular screening. Filters are rule-based tools, based on physicochemical descriptors or sustructural patterns, used to preprocess molecular datasets and remove unwanted compounds, e.g. potentially toxic. Despite their widespread use, there is a lack of quantitative evaluation of those methods, and even experimental procedures for such evaluation. To remediate this, we assess over thirty common filters across a number of molecular datasets.

We compare physicochemical and substructural filters on various tasks. Proposed validation procedure compares the efficiency in removing unwanted compounds and ability to keep bioactive compounds, where there is typically a tradeoff between the two. Results indicate redundancy of some of the filters and rather weak evidence for superiory of more complex designs. We conclude that while molecular filters offer a computationally inexpensive and interpretable tool for molecular dataset curation, there is still room for improvements in this space.

An investigation of Abacavir-induced biochemical alterations in endothelial cells utilizing Raman spectroscopy

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Nucleoside reverse transcriptase inhibitors (NRTIs), including Abacavir (ABC), are key drugs in HIV therapy. Combination antiretroviral therapy (cART) has improved and extended patients' lives, but the use of NRTIs comes at a cost. HIV-positive people are twice as likely to develop cardiovascular diseases (CVDs) as the healthy population.[1] Endothelial cells, lining blood and lymphatic vessels, have been reported to exhibit vulnerability to NRTI-induced oxidative stress and mitochondrial dysfunction.[1,2] This endothelial impairment has been linked to the development of atherosclerosis and CVDs.[2] Presented study evaluates the biochemical alterations in human aortic endothelial cells (HAECs) exposed to varying concentrations (1 µM, 10 µM, and 50 µM) of ABC, employing Raman imaging techniques. Average single-cell spectra of whole cells and lipid classes were obtained from hyperspectral images. Unsupervised chemometric analysis (PCA) indicated a concentration-dependent

separation of data into control and ABC-treated groups, suggesting changes in lipid, protein, and nucleic acid content. Moreover, PLS-R analysis verified a linear concentration-dependent response of HAECs to ABC exposure.

In vitro or in silico - machine learning in chemistry

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Drug design and testing is a process that in standard laboratory conditions may take years or even decades. The introduction of machine learning and in silico testing accelerated this immeasurably, but how does it even work? In my talk, I'll provide an overview of how to transform a compound into code, how programs recognise chemical properties, and most importantly how ML and AI aid drug discovery in pharma.

Why galaxy groups are interesting objects to study

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In my presentation, I will discuss galaxy groups. I will highlight their defining characteristics compared to other astrophysical structures, for example their role in cosmic structure formation and galaxy evolution processes. I will also present current research topics related to them, in particular focusing on studies of radio emission.

Oxazaborolidines based on terpene-derived amino alcoholis as catalysts in asymmetric Diels-Alder reactions

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Previous studies have established chiral oxazaborolidines as effective Lewis acid-type catalysts for asymmetric Diels-Alder reactions. Although there have been many examples of oxazaborolidines based on amino acid-derived amino alcohols, there are limited studies on oxazaborolidines with different carbon frameworks. In this work, we present the use of terpene-derived amino alcohols and various boronic acids in the synthesis of chiral oxazaborolidines. We have observed a relationship between structural and electronic features of amino alcohols and boronic acids, and the stereochemical outcomes of the tested reactions. In our most successful aproach, we have achieved 80% yield with 79% ee. in the Diels-Alder reaction between ethyl acrylate and cyclopentadiene.

The Genetic Portrait: Forensic DNA Phenotyping and Facial Feature Prediction

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In recent years, significant advancements have been made in predicting human facial features using DNA. Researchers have extensively studied the genetic influences on these features, including the role of epigenetic factors on an individual's phenotype. Forensic DNA Phenotyping (FDP) employs bioinformatics algorithms to analyze genetic variations, primarily single nucleotide polymorphisms

(SNPs), to predict externally visible characteristics (EVCs) such as eye and hair colour, skin pigmentation, as well as certain facial traits. In my talk, I will discuss these recent advancements and explore future prospects for enhancing the application of human face prediction in forensic and medical contexts.

Dark Legend of Polish Uranium Mining

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Hair and teeth falling out, skin peeling off in patches, acute cases of respiratory diseases: this is the image of miners working in uranium mines in Poland in the 1950s that developed among many residents of Lower Silesia. The People's Republic of Poland was forced to participate in the Soviet Atomic Program, for which uranium ore was extracted. The entire operation was of course secret, which is why many myths and legends have grown around this part of Polish mining history (and much more people have no idea that such exploitation even took place). During my lecture, I would like to briefly present the history of Polish uranium ore mining and processing, as well as describe the actual consequences of this exploitation.

Search and observations of asteroids in citizen science projects

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Citizen science is a form of participation and collaboration that actively involves non-scientists in the scientific research. It is used in a wide range of areas, including ecology, medicine and astronomy. In recent years, citizen science has emerged as a powerful tool in astronomical research, enabling people from all over the world, irrespective of their age, nationality or gender, to contribute to real scientific discoveries. In the field of asteroid search and observation, citizen scientists can currently help professional astronomers in three projects: International Astronomical Search Collaboration (IASC), The Daily Minor Planet (TDMP), and Come on! Impacting ASteroids (COIAS). This talk is an attempt to analyze these projects from the perspective of an active participant involved in each of them. The work presents my observations, research and discoveries of minor planets as a citizen scientist. This presentation will cover different types of asteroids, including Main-Belt Asteroids, Near-Earth Objects, Jupiter Trojans and Trans-Neptunian objects.

What black holes are there? (theoretically)

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I will talk about the theoretical background behind the black hole theory. I will try to explain what mathematics has to say about black hole types and how it connects to observations. In the end we will conclude with maybe not so famous no-hair theorems. All will be done in mathematical relativity manner with (I hope) not much of overcomplicated and scary mathematics.

Talking with the Satellites: Building a Low-Cost Ground Station with SatNOGS

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It's not spying if it's open-source and in low Earth orbit.

Satellites in low Earth orbit (LEO) continuously transmit a variety of signals — from simple CW beacons to structured telemetry frames — offering valuable opportunities for passive observation and analysis. In this presentation, we explore the reception of such signals using a simple, fixed ground station based on the open SatNOGS infrastructure. The setup, consisting of an RTL-SDR receiver and a homemade turnstile antenna, was used to monitor VHF and UHF transmissions from multiple satellite missions.

By capturing transmissions from a variety of LEO satellites – including telemetry beacons, amateur radio payloads, and weather satellites – we demonstrate how even small-scale stations can contribute to distributed scientific data collection. The system enables reproducible RF measurements that support both educational and research efforts in the study of the near-Earth space environment.

This project was co-funded by Garage of Complexity.

High temperature photomagnetic sponge based on $[Mo^{III}(CN)_7]^{4-}$

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Polycyanometallates are known as building blocks for the construction of coordination frameworks which show magnetic or photomagnetic behavior. In particular, coordination networks based on MnII and [Mo(CN)7]4- were among the first molecular magnets that could be analyzed in the form of single crystals. Herein, I will present a new system: $\left\{[Mn^{II}(H_2O)_2][Mn^{II}(imidazole)_2][Mo^{III}(CN)_7]\cdot H_2O\right\}_n$ (1), which upon dehydration undergoes reversible single-crystal to single-crystal transformation to $\left\{[Mn^{II}(imidazole)]_2[Mo^{III}(CN)_7]\right\}_n$ (2). Interestingly, both the hydrated and the anhydrous system show long range magnetic ordering and it was discovered that upon 405 nm irradiation the magnetic ordering temperature (Tc) increases from 49 to 79 K in 1, and from 53 to 110 K in 2.. The underlying photoswitching mechanism is associated with the photodissociation of one of the cyanide ligands from the low-spin $[Mo^{III}(CN)_7]^{4-}$ followed by the formation of a high spin $[Mo^{III}(CN)_6]^{3-}$. This research was funded by the European Research Council (ERC) under the EU Horizon Europe research and innovation programme, project LUX-INVENTA, grant agreement no 101045004.

Paper as a circular saw blade: Physical conditions for cutting

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I will present an exploration of the conditions under which a rotating sheet of paper can act as a cutting tool. Although paper is a soft material, its thinness and microscopic edge serrations allow it to concentrate force effectively. When rotated at high speed, it can cut through certain solids due to increased rigidity and localised stress. I will introduce a simplified physical model describing the critical velocity needed for cutting, based on energy arguments, and briefly discuss material properties that influence the process. The talk will also touch on possible ways to enhance the cutting capabilities of paper.

Does VR interfere with EEG signals? Experiment, preliminary results, blunders and tips from ongoing research

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Event-related potentials (ERPs) are brain responses to stimuli recorded via EEG, commonly measured in controlled lab settings with static 2D computer screens. However, such artificial conditions may limit ecological validity of the reserch. Integrating virtual reality (VR) into EEG/ERP research can enhance realism while preserving control. Yet, VR head-mounted displays (HMDs) may affect EEG signal quality due to their electronic and physical interference. The present study examines the impact of VR HMDs on the P3 ERP component (linked to attention), using a 32-channel EEG system (ANT Neuro). Preliminary results show that P3 was reliably elicited in both standard and VR conditions with comparable amplitudes and latencies, supporting the feasibility of EEG/VR setups. The presentation will also cover practical insights and lessons learned during the study in such areas as scenario programming, participant recruitment and preparation, equipment setup, and managing unexpected issues—aiming to foster discussion on the practical side of neurocognitive research.

Optimalisation of DELTA solar racing boat drive unit housing

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Currently, renewable energy sources are becoming increasingly introduced into the energy infrastructure, which is causing the development of modern solutions in this field. Means of transport powered by electricity are also becoming popular. Vehicles powered by photovoltaic panels are also increasingly being developed. In the AGH Solar Boat scientific group, we design highly efficient solar boats that take part in races, e.g. in Monaco, Sardinia or the Netherlands. Our new DELTA vessel was designed with the lowest possible energy consumption in mind. The most attention was paid to reducing energy losses in the boat's drive. A number of geometric, hydrodynamic and mechanical analyses were performed to optimize the drive unit.

How to Choose the Right Strategy? Simple Introduction to Markov Decision Process

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When modelling various systems, one frequently comes into a problem when the evolution of the system can be influenced by taking different actions. For example, a bee foraging for nectar can gather the nectar from the current flower patch or try to find something better, risking losing time and energy. The question is which decision will yield the highest reward? During my talk, I will show how to tackle such problems using the theory of Markov decision processes. Despite avoiding complicated maths, the presented formalism has a broad range of applications.

Proca Theory as a Modification of Classical Electrodynamics

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In this presentation, I examine how adding a mass term to the electromagnetic field Lagrangian alters the structure of classical electrodynamics. This modification may be captured by the Proca Lagrangian, which incorporates a photon mass. I begin by briefly introducing the Lagrangian structure of electrodynamics, without assuming prior familiarity with this theory. I then introduce the Proca Lagrangian as a natural modification that explicitly breaks gauge symmetry. From this, I present the resulting field equations and discuss their structural and physical consequences. In particular, I show how the electrostatic potential becomes Yukawa-type rather than Coulombic, and how light propagation in vacuum becomes dispersive. Special attention is given to the connection between gauge invariance and charge conservation, and to how this relationship changes in the presence of a massive photon: while charge conservation is preserved, it is no longer guaranteed by symmetry alone and must be imposed as a consistency condition. The focus remains on constructing the theory from fundamental principles and identifying how targeted modifications affect its structure and predictions.

Posters

Photographing Comet C/2023 A3 Tsuchinshan-ATLAS from Kraków

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On October 17, 2024, I observed and photographed Comet C/2023 A3 Tsuchinshan-ATLAS using a budget-friendly Lumix camera from two locations in Kraków: my home closer to the city center and Kopiec Pitsudskiego for lower light pollution point. From my home, high light pollution and obstructing trees limited visibility, allowing only the faint tail of the comet to be captured. By contrast, the elevated view point and reduced light pollution at Kopiec Pisudskiego resulted in significantly clearer images, the faint coma and tail distinctly visible. For further comparison, I reference images taken by phone camera on October 21, 2024, during observations on Maksutov telescope at UJ observatory, taken by Weronika Skrobacz

"Mapping Oxytocinergic Innervation in the Rat Ventral Hippocampus"

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Oxytocin is a neuropeptide known for its pivotal role in regulating social behavior, emotional processing, and stress modulation. Given the ventral hippocampus's involvement in emotional regulation it was hypothesized that oxytocinergic fibers might project to this region, potentially influencing hippocampal functions. The ventral hippocampus itself expresses oxytocin receptors and previous studies have shown that oxytocin can affect neurons in this area, indicating a functional oxytocinergic influence. A range of experiments including immunohistochemical staining using antibodies against oxytocin, as well as enzyme-based histochemical techniques were carried out. Despite the use of sensitive and well-established protocols, results did not reveal any oxytocinergic innervation within the rat ventral hippocampus. These findings suggest that, contrary to some expectations, the ventral hippocampus is not directly targeted by oxytocinergic fibers. This results suggest different pathways through which oxytocin is released and highlights the need for further studies exploring indirect mechanisms of oxytocin action in the brain.

The impact of selected osteogenic factors on adipose-derived stromal vascular fraction cell differentiation

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Adipose-derived stem cells (ADSC) are isolated from stromal vascular fraction (SVF) of adipose tissue. They have emerged as a source of multipotent stem cells potentially useful in tissue regeneration therapies due to their accessibility and high proliferative capacity. However, cells isolated from adipose tissue SVF often display heterogeneity and the effective methods for their osteogenic differentiation are still in high demand. In this study, we have analyzed differentiation potential of rat ADSC derived from SVF of subcutaneous adipose tissue (AD-SVF). We stimulated AD-SVF cells with different combinations of osteogenic factors (i.e. ascorbic acid, dexamethasone, beta-glycerophosphate, rhBMP-2). Additionally, we pretreated AD-SVF cultures for 7 days to obtain preadipocytes, followed

by their stimulation with above-mentioned osteogenic factors. Such preadipocytic cells treated for 7 days with rhBMP-2 in osteogenic medium displayed increased bone sialoprotein (BSP) mRNA levels, similar to rhBMP-2 treated AD-SVF cultures.

Thus, our results suggest that both rat AD-SVF cells as well as preadipocytes obtained from their adipogenic stimulation, demonstrate the ability to differentiate into osteoblasts when stimulated with selected combination of osteogenic factors. We have also observed in the above-mentioned cultures the intense mineralized matrix deposition (Alizarin Red S staining), characteristic for osteoblastic cells.

Overall, we show that rhBMP-2-supplemented osteogenic medium effectively promotes osteogenesis in both rat AD-SVF cells and preadipocytes. Thus, the presence of preadipocytes in SVF fraction should not be an obstacle to apply this heterogenous AD-SVF cell population in potential bone tissue-related therapies.

The treatment of β-thalassemia with CRISPR-Cas through different methods

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Poster describes the use of CRISPR Cas method in the treatment of Beta-thalassemia. The CRISPR-Cas9 system is a naturally occurring immune system used by unicellular bacteria and several other prokaryotic organisms. B-thalassemia is an inherited blood disorder which occurs due to the mutation or deletion of the HBB gene found on chromosome 11. This mutation causes a reduced (beta+) or absent (beta0) synthesis of beta-globin chains, which are components of hemoglobin - protein respnosible for transportation of oxygen in humans.

Exploring the Roles of Flv2 and Pgr5 Proteins in Photosynthesis

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Photosynthesis involves the coordinated action of many genes encoding proteins responsible for various functions, such as electron transport, pigment binding, water molecule splitting, and maintaining the structural integrity of photosystems. In our project, we focus on two such genes – sll0219 and ssr2016 – which encode the Flv2 and Pgr5 proteins, respectively. Flv2 is a flavoprotein involved in the electron transport chain and photoprotection of photosystem II (PSII), while Pgr5 plays a role in cyclic electron flow and the protection of photosystem I (PSI). Both proteins contribute to the optimal functioning of photosynthetic apparatus.

A common approach to studying gene function is the construction of knock-out mutants that lack the genes of interest. These mutants can be generated using model organisms such as a cyanobacterium Synechocystis sp. PCC 6803, a well-established model in phototrophic research.

In this project, we aim to generate two Synechocystis sp. PCC 6803 double knock-out mutants, each lacking either the flv2 or pgr5 gene in the background of a psaL deletion strain. By characterizing these mutants, we seek to gain a deeper understanding of the specific roles of Flv2 and Pgr5 in fine-tuning the light-dependent phase of photosynthesis in response to environmental conditions and the cell's metabolic status.

Breathing on the Red Planet–Review on NASA'S MOXIE

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NASA's MOXIE demonstrates oxygen extraction technology from Mars atmosphere. Perseverance rover which reached Mars included MOXIE as one of its components.The purpose is to establish methods for astronauts to create oxygen for breathing and rocket fuel during Martian travel without having to bring these supplies from Earth. MOXIE uses solid oxide electrolysis to break 95 percent carbondioxide composition to produce oxygen and carbonmonoxide. The gases require heating to 800°C along with electrical energy input to initiate the reaction. MOXIE demonstrated its functionality successfully by producing 10 gms of oxygen/hour to support one's breathing for 10 minutes. This paper reviews MOXIE's operational principles and its scientific importance while outlining how it supports future human exploration missions on Mars. The paper stresses the importance of using in-situ resource utilization which allows astronauts to access resources already present on other planets. This system promises to make space exploration missions more secure and economical by reducing the need to transport large quantities of oxygen from Earth. The project represents the initial phase of transforming Mars into a place where humans can live. This demonstrates how science fiction concepts have been transformed into scientific achievements.

Luquid biopsy in cancer diagnosis

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Cancers remain one of the major global health challenges, contributing significantly to morbidity and mortality rates worldwide. Rapid diagnosis and the implementation of therapies tailored to the individual characteristics of a tumor are crucial for improving patient outcomes and quality of life. Liquid biopsy represents a modern, minimally invasive diagnostic tool based on the analysis of tumor-derived genetic material circulating in the bloodstream, such as circulating tumor DNA or circulating tumor cells. This technique is applicable in early cancer detection, assessment of treatment efficacy, qualification for targeted therapies, and monitoring of disease recurrence. Unlike conventional tissue biopsy, it does not require the excision of tumor fragments, thereby increasing patient comfort and reducing risks. The aim of this paper is to present the current applications of liquid biopsy and highlight its role in the personalization of cancer treatment. S. Alimirzaie, et al., „Liquid biopsy in breast cancer: A comprehensive review", Clinical Genetics. 2019;95:643–660 I. Martins, et al., „Liquid Biopsies: Applications for Cancer Diagnosis and Monitoring", Genes 2021, 12(3), 349

Applying small-scale chemistry in investigations

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The application of chemistry in mini-scale chemical experiments plays an important role in helping us understand the world. Chemistry is used in many branches of industry, where large amounts of reagents are consumed daily. This can have a negative impact on both the environment and human health. I aim to demonstrate that some chemical reactions can be studied on a small scale — in a safer and more environmentally friendly way — while still being engaging and scientifically valuable.

Synthesis of biofuels from various types of oil

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Biodiesel has become a significant part of the automotive industry in recent years. It was popularised

by the worldwide efforts to switch to renewable sources of energy and is getting more and more widely used today. Biodiesel is synthesised through a process called transesterification, which involves reacting methanol with vegetable oil in the presence of a catalyst and requires intense heat to proceed successfully. The reaction produces biodiesel and glycerine. Glycerine is a major by-product of the reaction. If cleared of impurities, biodiesel-derived glycerine could be used in various industries such as pharmaceuticals, cosmetics, food, etc. Due to the high demand for biodiesel in the world, it is important to find a way to synthesise the most efficient one. The aim of this study is to find the type of biodiesel which produces the most energy upon combustion. The following types of vegetable oil are examined: sunflower oil, rapeseed oil and olive oil. The efficiencies of different types of biodiesel were compared through a comparative calorimetry experiment.

Genetic identification based on biological traces in the Małopolska province in 2020-2024

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The poster presents the process of genetic identification based on biological traces secured in the Małopolska region between 2020 and 2024. It includes key stages of DNA analysis, statistics on genetic expert reports, and examples of the application of genetic research in the identification of individuals. Graphics and charts illustrate the importance of this method in the work of law enforcement agencies.

Spectroscopic imaging and analysis of medicinal plant tissues

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This poster explores the application of Fourier Transform Infrared (FT-IR) spectroscopic imaging combined with chemometric analysis for the spatial and chemical characterisation of tissues from Japanese knotweed, a medicinal plant known for its production of bioactive secondary metabolites such as resveratrol. Cross-sections of leaf, stem, and root tissues were analysed using FT-IR microscopy in the spectral range of 900-3800 cm-1. Key vibrational bands associated with polysaccharides, proteins, phenolic compounds, lignin, and lipids were identified and spatially resolved. K-means clustering (KMC) was employed as the primary chemometric tool due to its clear segmentation and computational efficiency. Comparative analysis between control and UVC-treated sampled revealed tissue-specific biochemical responses, including increased phenolic compound accumulation in epidermal and vascular tissues, consistent with stress-induced metabolic pathways. These findings highlight the utility of FT-IR imaging as a non-destructive, label-free method for monitoring biochemical composition in plant tissues, supporting its potential use in pharmaceutical research and plant stress physiology.

The influence of the type of metal on the potential difference in a galvanic cell

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When my team considered areas in chemistry that seemed unexplored to us and raised questions, we identified galvanic cells as a topic of interest. As we expanded our knowledge in this area, we noticed

that several factors could influence the potential difference in a functioning galvanic cell. We decided to investigate how both the type of metal and the concentration of the electrolyte affect the cell's potential.

Synthesis of tetrahydroisoquinoline derivatives for application in cancer therapy based on PD-L1 protein interaction

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The PD-1/PD-L1 immune checkpoint plays a key role in maintaining immune homeostasis by suppressing overactive T cell responses. Tumor cells can exploit this pathway by overexpressing PD-L1, allowing them to evade immune detection and continue proliferating. As a result, blocking the PD-1/PD-L1 interaction has become a critical strategy in cancer immunotherapy. While monoclonal antibodies targeting this axis have shown clinical success, they possess inherent limitations, including high manufacturing costs, intravenous administration, and poor tissue penetration. These challenges have prompted growing interest in small-molecule inhibitors as a complementary or alternative therapeutic approach. Among emerging structural classes, tetrahydroisoquinoline (THIQ)-based compounds have attracted attention. These scaffolds, found in numerous natural products and drug candidates, offer structural rigidity and tunability, making them attractive for modulating protein–protein interactions such as PD-1/PD-L1. Recent literature reports demonstrate that small molecules containing THIQ frameworks can inhibit PD-L1 function by disrupting its interaction with PD-1. These compounds often incorporate hydrophobic cores and polar substituents, designed to optimize binding affinity and pharmacokinetic profiles. This poster focuses on synthetic methodologies employed to construct N-aryl-substituted THIQ derivatives designed to inhibit PD-L1 function. Several approaches have been described in recent studies, namely Buchwald–Hartwig amination, Ullmann-type couplings, Chan–Lam coupling and nucleophilic aromatic substitution. Beyond direct N-arylation, de novo construction of the THIQ ring system has been explored, enabling the synthesis of structurally diverse analogs.

Time Delays in κ-Deformed Special Relativity

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Most scientific hypotheses aiming to unify quantum theory with general relativity assume the existence of an additional energy parameter. Introducing such a parameter leads to predictions that deviate from both well-established theories. A "bottom-up" approach to constructing hypotheses that incorporate such an intrinsic energy parameter—without requiring a complete theory—can thus lead to testable predictions. One such proposal is Deformed Special Relativity, which is based on Special Relativity. One of its predictions is that the speed of particles, including massless ones, depends on their energy—something that can be experimentally tested as time delays between different photons. In our poster, we present various aspects of time delays in this model.

How aging affects Hematopoietic Stem Cells

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Hematopoietic stem cells (HSCs) are unique cells found primarily in bone marrow that can develop into all types of blood cells — red cells, white cells, and platelets. They are essential for forming and replenishing the blood and immune system throughout life. Hematopoietic stem cells lose their self-renewal and regenerative capacity with age, resulting in a number of hematological disorders. This decline is driven by intrinsic mechanisms such as DNA damage and epigenetic changes, as well as extrinsic mechanisms of the aging niche. Older HSCs become more heterogeneous, skewed towards myeloid lineage, and exhibit clonal hematopoiesis, with specific HSC clones expanding. Uncovering and understanding these processes can provide the basis for therapeutic strategies to enable healthy aging.

What can the morphology of hematopoietic stem cell colonies tell us about cell diversity?

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Hematopoietic stem cells (HSCs) can differentiate into all cells of the blood-forming system. Under physiological conditions, a single HSC divides asymmetrically, giving rise to one differentiating cell and one cell that retains stem cell characteristics. Initially, the differentiation process follows a common pathway, which at the progenitor cell level splits into two main developmental lineages: myeloid and lymphoid. Mature cells derived from the myeloid lineage among others include monocytes, granulocytes, and erythrocytes, while B cells, T cells, and NK cells originate from the lymphoid lineage. Due to the difficulty in culturing mature lymphoid cells - which require specific environmental conditions and carefully selected media - standard cultures are usually dominated by immature cells and cells from the myeloid lineage.

However, the morphology of colonies derived from individual HSCs may suggest that their appearance correlates with the dominant cell type. Colonies vary significantly from compact and homogeneous to dispersed and heterogeneous. One proposed method to validate this relationship is to stimulate HSCs with specific growth factors (e.g., G-CSF, M-CSF, EPO), which direct differentiation toward specific cell types. This would allow an assessment of whether a predominance of a given cell type is associated with a particular colony morphology.

With the rapid development of machine learning and artificial intelligence methods, there is a prospect that in the future, appropriately trained algorithms will be able to predict the cellular and quantitative composition of colonies based on their images. Further research into the relationship between HSC colony morphology and their cellular composition could significantly improve in vitro culture analysis.

Experimental evaluation of molecular filters

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We study the effectiveness of filters commonly used in chemoinformatics for molecular screening. Filters are rule-based tools, based on physicochemical descriptors or sustructural patterns, used to preprocess molecular datasets and remove unwanted compounds, e.g. potentially toxic. Despite their widespread use, there is a lack of quantitative evaluation of those methods, and even experimental procedures for such evaluation. To remediate this, we assess over thirty common filters across a number of molecular datasets.

We compare physicochemical and substructural filters on various tasks. Proposed validation procedure compares the efficiency in removing unwanted compounds and ability to keep bioactive compounds, where there is typically a tradeoff between the two. Results indicate redundancy of some of the filters and rather weak evidence for superiory of more complex designs. We conclude that while molecular filters offer a computationally inexpensive and interpretable tool for molecular dataset curation, there

is still room for improvements in this space.

Neurobiological correlates of psychopathy

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Psychopathy is a personality disorder characterized by affective deficits, impulsivity, and antisocial behaviour. Since psychopathy is a burden to society due to elevating crime and incarceration costs, scientists try to find causes and correlates of this disorder. Neuroimaging technology is especially helpful in understanding neurobiological changes in a brain. Studies link psychopathy to abnormalities in brain structures involved in emotional regulation, impulse control, and decision-making. Reduced amygdala volume and activity impair fear processing and empathy (2). Dysfunction in the prefrontal cortex contributes to impulsivity and poor moral judgment, aggravating antisocial tendencies (1). Disruptions in amygdala-prefrontal connectivity further weaken emotional regulation, increasing aggression and risk-taking. Additionally, hyperactivity in the striatum, a key region in reward processing, leads to heightened sensation-seeking and reduced sensitivity to punishment (3). These findings provide insight into the neurobiological underpinnings of psychopathy and its behavioral manifestations.

Application of ordinal regression to ML-assisted RPG game design

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Predicting ordinal variables is a common challenge in various real-world scenarios—a task well-suited for ordinal regression methods. These include classical regression models with rounding, as well as specialized approaches designed specifically for ordinal data. This talk provides an overview of ordinal regression, its methodologies, and evaluation strategies.

One of the many possible applications of these methods is determining the challenge levels of monsters in pen & paper RPG games. Selecting monsters of appropriate level is essential for preparing encounters that are both challenging and winnable for players. Therefore, accurately determining a monster's level is crucial for effective encounter design. Since monsters are described using numerical statistics, this is a natural task for ML-based solutions. Currently, there are no competitive methods for automatically determining a monster's level. The only existing approaches rely on manual testing, which is time-consuming, and expert assessment, which may be inaccurate due to human error. The use of ordinal regression can help reduce costs for publishers during the design process.

I will show results of our experiments, highlighting the potential of these methods to support game design processes. I will also introduce a human-inspired solution based on knowledge shared among players and compare it to ordinal regression models.

Targeted Gene Therapies:RNA-Based approaches, Viral Vector's and CRISPR/Cas9

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Gene therapies are revolutionizing modern medicine by offering targeted interventions at the genetic level. This poster presents an integrated overview of emerging strategies utilizing RNA molecules, viral vectors, and CRISPR/Cas9 techniques to correct or modulate gene function. RNA-based therapies, including small interfering RNA's (siRNA's), antisense oligonucleotides (ASO's), and therapeutic mRNA's, allow for transient, reversible modulation of gene expression. These approaches have shown

great success in silencing pathogenic genes or restoring deficient protein production, with several therapies now approved for clinical use. Viral vectors, particularly adeno-associated viruses (AAVs), remain the gold standard for stable and efficient gene delivery. Advances in vector engineering have improved tissue specificity, transduction efficiency, and safety, minimizing immune responses and off-target effects. Introduction of CRISPR/Cas9 genome editing has further expanded the therapeutic possibilities. CRISPR/Cas9 enables permanent correction of disease-causing mutations by precisely targeting DNA sequences. Combining CRISPR with viral or non-viral delivery systems, such as lipid nanoparticles, holds promise for treating a wide range of genetic disorders, including those previously considered incurable. Integrating these technologies allows for tailored treatment strategies depending on disease characteristics, target tissues, and therapeutic goals. Ongoing preclinical and clinical studies continue to refine these approaches, focusing on maximizing efficacy while minimizing risks. In conclusion, the synergy between RNA-based tools, advanced viral vectors, and CRISPR/Cas9 editing represents a major step toward personalized, curative therapies for genetic diseases.

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