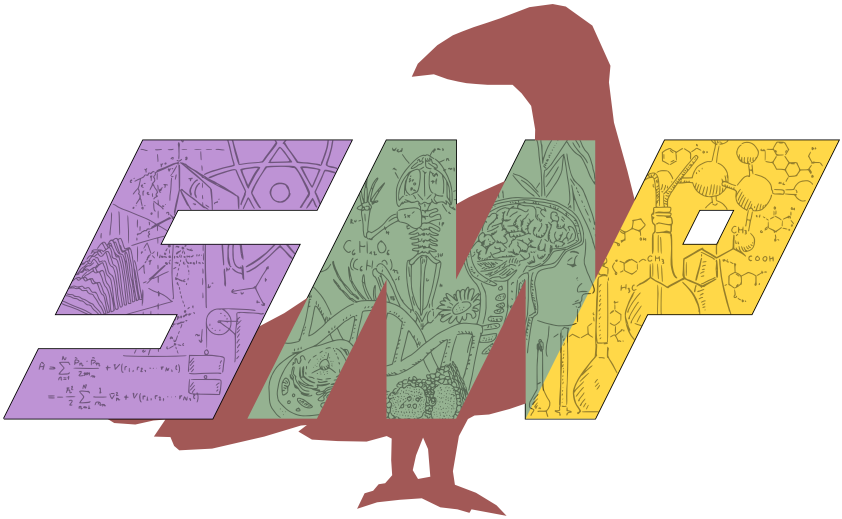
SEMPOWISKO

Interdisciplinary math-science student conference

18-21 April 2024
30-year anniversary of SMP

Book of Abstracts

UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE



About SMP

Interdisciplinary Studies in Mathematics and Natural Sciences (*Studia Matematyczno-Przyrodnicze, SMP*) is a modern approach to studying at the faculties of mathematics and natural sciences at the Jagiellonian University. It offers 26 different specializations, including:

- Applied Computer Science
- Astronomy
- Advanced Materials and Nanotechnology
- Biochemistry
- Bioinformatics
- Biotechnology
- Biology
- Biophysics
- Chemistry
- Computer Science
- Computer Science of Video Games
- Computer Mathematics
- Geography
- Geography and Spatial Planning
- Geology
- Machine Learning
- Mathematics
- Medical Chemistry
- Molecular Biotechnology
- Molecular and Cellular Biophysics
- Neurobiology
- Physics
- Physics for Business
- Spatial E-Planning
- Sustainable Chemistry
- Theoretical Computer Science

What makes SMP unique?

Individualized study path: From the very beginning, students work under the supervision of a tutor (academic advisor) and choose courses that interest them from the entire range of mathematics and natural sciences faculties.

Interdisciplinarity: Students have the opportunity to attend classes from various fields. Leading specialization: Students choose their leading specialization (one of 21) at the end of the first year of studies and finalize it at the end of the second year. Please note that there are some restrictions on the choice of specialization, as outlined in the announcements of the SMP Program Council and the SMP Regulations. Degrees: After completing the first level (3 years) of studies, graduates receive a Bachelor's degree in the chosen field. After continuing their studies in the SMP mode at the second level (2 years) and completing them, graduates receive a Master's degree in one of 22 specializations.

Benefits of SMP: Develops independence and decision-making skills. Broadens students' horizons and interests. Provides early engagement in scientific research. Prepares students for a successful career and personal life. SMP students are distinguished by their academic achievements, collecting numerous awards and scholarships.

The SMP program has been operating since 1993/94.

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

Timetable

Thursday, April 18th

(12:00 - 12:20) How to study Martian winds? – the overview of aeolian landforms on Meridiani Planum

– Presenter: MOL, Szymon – Page: 24

(12:20 - 13:50) The long way from SMP and back after 30 years: reflections on science and scientific careers

– Presenter: LAGISZ, Malgorzata – Page: 41

(16:40 - 17:05) A brief introduction to single-molecule magnets

– Presenter: BONAREK, Paweł – Page: 11

(17:05 - 17:20) On The Red Dwarf - Bee Hive Correspondence

– Presenter: UNGEHEUER, Franciszek – Page: 33

(17:20 - 17:40) SHERLOCK and the Oder River disaster - using synthetic biology to detect algal blooms

– Presenter: URBANELIS, Katarzyna – Page: 37

(17:40 - 17:55) On CP violation in K-meson and B-meson systems

– Presenter: JOSHI, Ramkrishna – Page: 33

(17:55 - 18:25) Coffee break

(18:25 - 18:40) Magnetochiral dichroism: what do optical activity and magnetism have in common?

– Presenter: RZEPKA, Katarzyna – Page: 30

(18:40 - 19:00) Down the rabbit hole with hierarchical autoregressive neural networks

– Presenter: WINIARSKI, Mateusz – Page: 17

(19:00 - 19:15) Detector and physics simulation using heavy ion collisions at NICA-SPD

– Presenter: PANDEY, Rishav – Page: 16

(19:15 - 19:30) Stochastic Resetting

– Presenter: ŻBIK, Bartosz – Page: 37

Friday, April 19th

(10:15 - 10:55) Ru(II) polypyridyl complexes – potential inhibitors of metastasis development

– Presenter: BRINDELL, Małgorzata – Page: 36

(10:55 - 11:15) X-ray magnetic circular dichroism spectroscopy as an advanced tool for studying magnetic materials

– Presenter: DZIERŻEK, Dominik – Page: 45

(11:15 - 11:30) Concentration of chemical elements and key substances in infusions of commercially available teas as a determinant of their quality

– Presenter: POLOCZEK, Patrycja – Page: 15

(11:30 - 12:00) Coffee break

(12:00 - 12:20) Evaluation of the effect of Ruxolitinib on neoplastic cells with the use of Raman imaging paired with machine learning.

– Presenter: STAWOSKI, Kacper – Page: 17

(12:05 - 12:30) Twin Paradox and Chaos

– Presenter: OSĘKA, Julia – Page: 43

(12:20 - 12:40) Raman molecular probes: selectivity of cellular structures and improved imaging quality

– Presenter: FIRLEJ, Jakub – Page: 35

(12:30 - 12:45) The recent cosmological measurements vs $f(R)$ theory

– Presenter: LENART, Aleksander – Page: 42

(12:40 - 13:05) Strategies for optical thermometry based on lanthanide single-molecule magnets

– Presenter: ZAKRZEWSKI, Jakub J. – Page: 38

(12:45 - 13:05) Dark matter perturbations in ΛeDM model and their impact on cosmological tensions

– Presenter: BOCHNAK, Magdalena – Page: 15

(13:05 - 14:05) Lunch break

(14:05 - 14:25) Cerium oxide nanoparticles – influence of synthesis method on characteristics

– Presenter: WÓJTOWICZ, Andrzej – Page: 14

(14:05 - 14:25) Library of Spectroscopic Reporters as a Tool for Studies of Biological Systems

– Presenter: SIĄKAŁA, Kacper – Page: 28

(14:25 - 14:45) Nongenetic functions of the genome

– Presenter: DEKERT, Marianna – Page: 32

(14:25 - 14:45) Exploring Fluid Dynamics: Simulation of Navier-Stokes Equation in a Rotating Cylinder using Finite Difference Method

– Presenter: ZAPOLSKI, Dawid – Page: 19

(14:45 - 15:10) Graph theory in food web analysis

– Presenter: WÓJTOWICZ, Magda – Page: 22

(14:45 - 15:10) Single Molecules and Light Microscopy: Breaking Boundaries in Molecular Biology Research

– Presenter: RZECZYC, Aleksandra – Page: 37

(15:10 - 15:35) Mathematics of Calabi-Yau Threefolds

– Presenter: RYBALKA, Aliaksandr – Page: 30

(15:10 - 15:35) Luminescent thermometry in multifunctional materials

– Presenter: DZIEŁAK, Hubert – Page: 29

(15:35 - 16:05) Coffee break

(16:05 - 16:25) Unrolling tape sound effect

– Presenter: YUSHCHUK, Anastasiya – Page: 44

(16:05 - 16:20) Exploring novel sampling ideas in NeRF

– Presenter: KĄDZIOŁKA, Marcin – Page: 19

(16:20 - 16:40) Optimization of the housing of the adjustable hydrofoil mount

– Presenter: ZAJĄC, Kamil – Page: 34

(16:25 - 16:45) Introduction to Electrogenetic Gene Expression Systems

– Presenter: DOLIWA, Joanna – Page: 26

(16:40 - 17:05) The 3+1 formalism for Maxwell's equations – a concise introduction

– Presenter: DORUCHOWSKI, Paweł – Page: 39

(16:45 - 17:05) Lactoferrin: Properties and Potential for Medical Research

– Presenter: FEDERYGA, Eryk – Page: 28

(17:05 - 17:25) Matrix models which counts graphs

– Presenter: HONTARENKO, Mykhailo – Page: 31

(17:05 - 17:25) Visual Snow Syndrome - Rare or Not So Rare Disorder?

– Presenter: KOŚCIUK, Zuzanna – Page: 45

(17:25 - 17:55) Coffee break

(17:55 - 18:20) Deuteron production in a combined thermal and coalescence framework for heavy-ion collisions in the few-GeV energy regime

– Presenter: WITKOWSKI, Nikodem – Page: 16

(17:55 - 18:10) Analysis of proliferation and migration of glioblastoma cells in various oxygen conditions

– Presenter: STALICKA, Magdalena – Page: 12

(18:10 - 18:30) Numerical functional analysis for ODE's

– Presenter: CZWÓRNÓG, Jakub – Page: 33

(18:20 - 18:40) Exactly solvable Quantum spin-1/2 models in 2D

– Presenter: SOKOLOV, Ihor – Page: 18

(18:30 - 18:50) Harmonic functions and their properties

– Presenter: KSIĄŻKIEWICZ, Maria – Page: 23

(18:40 - 19:00) Parametric Resonance in Energy Harvesting

– Presenter: ZANTOWICZ, Wiktor – Page: 34

Saturday, April 20th

(09:00 - 10:00) Registration

(10:00 - 10:40) Otwarcie ceremonii jubileuszu [po polsku]

(10:40 - 11:40) Rozmowa o interdyscyplinarności [po polsku]

(11:40 - 12:10) Coffee break

(12:10 - 12:35) Molecule.one brief intro: our journey on automatization of chemistry

– Presenter: JASTRZĘBSKI, Stanisław – Page: 32

(12:35 - 12:55) Introduction to Chaos Theory in Discrete Dynamical Systems

– Presenter: OCHĘDZAN, Konrad – Page: 26

(12:55 - 13:20) WChUJ

– Presenter: NOGA, Marek – Page: see online version

(13:20 - 13:40) Uniquely oriented crystals of metal-organic frameworks

– Presenter: KOWACZ, Gabriela – Page: 44

(13:40 - 14:40) Lunch break

(14:40 - 15:05) WBBiB

– Presenter: KAMIŃSKA, Marta – Page: see online version

(15:05 - 15:25) Time-Travelling Proteins: Unraveling Biochemical Evolution through Ancestral Sequence Reconstruction

– Presenter: LUTEREK, Marta – Page: 43

(15:25 - 15:50) Microbial symbionts as drivers of insects' adaptation to the changing world

– Presenter: ŁUKASIK, Piotr – Page: 31

(15:50 - 16:10) How traumatic and stressful events affect our brains?

– Presenter: CZERNIAK, Gabriela – Page: 24

(16:10 - 16:40) Coffee break

(16:40 - 17:05) Geography and location factors of new working spaces

– Presenter: MICEK, Grzegorz – Page: 21

(17:05 - 17:25) An insight into the principle of uniformitarianism

– Presenter: KACZMAREK, Krzysztof – Page: 11

(17:25 - 17:50) Tidal Phenomena

– Presenter: CIESIELSKI, Adam – Page: 42

(17:50 - 18:10) Optical tweezers: a statistical approach

– Presenter: RASZ, Monika – Page: 34

(18:10 - 18:30) Coffee break

(18:30 - 19:10) Poster session

Sunday, April 21st

(10:00 - 10:40) From SMP to Theories of Extreme Matter

– Presenter: HELLER, Michał P. – Page: 21

(10:40 - 11:00) The reachability problem for Petri nets.

– Presenter: KAMIŃSKI, Łukasz – Page: 41

(11:00 - 11:25) The Kakeya problem

– Presenter: MANDLA, Izabela – Page: 40

(11:25 - 11:55) Break

(11:55 - 12:20) Persistent Homology - gently introduction

– Presenter: MAZUR, Jakub – Page: 35

(12:20 - 12:40) Topological analysis of literature

– Presenter: GRABKA, Magdalena – Page: 43

(12:40 - 13:00) Iris-ML: Neural Density Estimation for the Spectral Energy Distribution fitting.

– Presenter: KAPUSTA, Mateusz – Page: 27

(13:00 - 13:20) Exploring the Kelly Criterion

– Presenter: GAPPA, Mateusz – Page: 20

(13:20 - 14:20) Lunch break

(14:20 - 14:40) Lapunov exponent, the old way of measuring the chaos

– Presenter: SOWIŃSKI, Adam – Page: 29

(14:40 - 15:05) Proof of the Nielsen-Schreier Theorem via graph theory

– Presenter: KRYSIAK, Michał – Page: 35

(15:05 - 15:25) CFD optimization of a 6-series NACA profile for a solar-powered hydrofoil race boat.

– Presenter: GERAS, Paweł – Page: 13

(15:25 - 15:45) Adhesive joints technology and investigation of the impact of different surface roughening level on the adhesion strength.

– Presenter: GRODECKA, Magdalena – Page: 11

(15:45 - 16:15) Coffee ending

List of posters

Analysis of the optical and radio properties of various types of radio sources

– Presenter: SZKODZIŃSKA, Agata – Page: 12

Examination of the pigment makeup of a heat-resistant cyanobacteria strain: Thermostichus lividus PCC6715 cultivated under various temperature conditions.

– Presenter: ZIĘBA, Jakub – Page: 13

Experimental approaches in differentiating between Idiopathic Pulmonary Fibrosis (IPF) and Nonspecific Interstitial Pneumonia (NSIP)

– Presenter: RYBAK, Maria – Page: 18

Free probability

– Presenter: GORCZYCA, Łukasz – Page: 20

Freeze, fight or flight – the impact of the endogenous opioid system on the stress response

– Presenter: STEC, Agnieszka – Page: 20

Fruit fly as a schizophrenia model

– Presenter: NOWALIŃSKA, Karolina – Page: 21

GO-a-GO: Functional Annotation of Genes in Chromatin Contact Pairs

– Presenter: YAKYMENKO, Daryna – Page: 22

Growth kinetics of random sequential adsorption packings built of two-dimensional shapes with discrete orientations

– Presenter: ZANTOWICZ, Wiktor – Page: 23

How to become SHERLOCK with a 3D printed device?

– Presenter: CZECHOWSKA, Iga – Page: 24

Influence of posttranscriptional modifications on RNA structures: crystallographic and thermodynamic analysis

– Presenter: GONET, Antonina – Page: 25

Investigation into the Characteristics of Asymmetric substituted 4,5-Dialkoxy-2-Nitroanilines Using Spectroscopic and Theoretical Approaches

– Presenter: SYNOWIEC, Karina – Page: 26

Lorentz Transformation in Relativistic

– Presenter: KUCIĘBA, Franciszek – Page: 29

Study of high-energy photons polarization in Compton scattering using the J-PET detector system

– Presenter: KASPERSKA, Kamila – Page: 38

Synthesis and study of the properties of new derivatives of tetraazacyclophanes

– Presenter: ADAMSKA, Maria – Page: 39

The Prospects of Gravitational Waves Astronomy

– Presenter: RUDKA, Dominik – Page: 40

Here you can draw your favourite presentation

Abstracts

A brief introduction to single-molecule magnets

Author: Paweł Bonarek[None] (pawel.bonarek@student.uj.edu.pl)

Single-molecule magnets (SMMs) form a class of chemical systems in which magnetic memory effect can be achieved at the molecular level. These materials discovered nearly 30 years ago are still delivering outstanding results. Firstly, they may be an answer to the on-growing need for high-density data storage units. On the other hand, their development provides fundamental information for emerging fields of spintronics and quantum computing. Moreover, due to weak absorption, they are an excellent platform for studying magneto-optical interactions via luminescence spectroscopy. However, as the relaxation of magnetization mechanisms are present at the atomic scale, the use of SMMs is currently limited to cryogenic temperatures. In my presentation, I will introduce to the audience the field of molecular magnetism from the perspective of lanthanide-based compounds. The talk aims to introduce the origin of SMM behavior and the related relaxation mechanisms using an idealized case, as well as briefly pass through the history up to current challenges in the field.

Adhesive joints technology and investigation of the impact of different surface roughening level on the adhesion strength.

Author: Magdalena Grodecka[None] (magda.grodecka57@gmail.com)

Adhesive joints are presently widely used in both industry and everyday life applications. Adhesives popularity stems from the possibility to create joints without breaking the material structure, the possibility to create joints flexible to a certain extent, and the high aesthetics of the joints. Proper adhesive joint design requires consideration of both the properties of the surfaces to be joined and the adhesive, as well as the external factors influencing the manufacturing process. Surface modification processes, including physical (mechanical) and chemical modification, play a key role in ensuring the desired adhesion of the adhesive to the materials. Physical surface modification is recommended for practically all materials and is observed to have a beneficial effect on the strength of the joints regardless of the chemical nature of the material, while the choice of chemical modification method is strictly dependent on the type of materials being joined. In the talk I will provide a brief introduction to adhesive joints technoly and present an example of how different level of roughening affects the joint strength in conducted lap shear strength test.

An insight into the principle of uniformitarianism

Author: Krzysztof Kaczmarek[1] (krzysztof.kaczmarek@student.uj.edu.pl)

[1] *Faculty of Geography and Geology, Jagiellonian University in Kraków, Poland*

"The present is a key to the past" (Charles Lyell, 1797 – 1875). Geology students learn that quote at the first lecture. It summarizes the principle of uniformitarianism, which assumes that we can reconstruct the formation of geological features and past events by observing the present processes which lead to similar results. However, that simple rule demands proper understanding as erroneously used may lead to misinterpretations of past Earth history events. My talk will be a basic introduction to the one of the fundamental assumptions used in geology. I am going to briefly outline the theory of uniformitarianism proposed by Charles Lyell in 1830. Moreover, I will explain some changes which occurred in the interpretation of that theory since 20th century when research proved that some phenomena occurred contrary to the then assumptions of the principle of uniformitarianism. As over the years some research findings seemed to be contradictory to the then interpretations, some adjustments were made to the understanding of the principle of uniformitarianism in order to explain the geological history of Earth more precisely.

Analysis of proliferation and migration of glioblastoma cells in various oxygen conditions

Author: Magdalena Stalicka[1] (magdalena.stalicka@student.uj.edu.pl)

[1] *the Faculty of Biochemistry, Biophysics and Biotechnology of the Jagiellonian University*

Glioblastoma, ranked among the most aggressive types of neoplasms of the central nervous system, is characterized by very high mortality rate. The understanding of such processes constitutes a key step in the development of innovative, effective strategies of treatment to improve the prognosis of this devastating condition.
Three different glioma cell lines were chosen–human LN229, U87 and murine GL261 and microscopic images were taken continually during the cell growth (for the period of one week, using JuLI™ Stage Real-Time CHR). Using advanced imaging analysis, cells were automatically counted and their morphology was analyzed.
The automatic collection of images during growth enabled continuous monitoring of cell proliferation and migration. In a hypoxic environment, cells exhibit a greater degree of elongation and enhanced substrate adhesion, thus categorizing them as more flattened in morphology. This analysis reveals subtle differences in the rates of cell proliferation among the examined cell lines. LN229 and U87 exhibit comparatively shorter doubling times than GL261, implying a potential for higher proliferative activity within these specific lines.

Analysis of the optical and radio properties of various types of radio sources

Author: Agata Szkodzińska[1] (agata.szkodzinska@student.uj.edu.pl)

[1] *Astronomical Observatory, Jagiellonian University in Kraków*

An active galaxy is a galaxy that has an active nucleus. It consists of a supermassive black hole, and the emission is related to the accretion processes. When an active galaxy is emitting large amounts of radiofrequency radiation (it is radio-loud), jets—streams of matter released from the active nucleus—can be observed. Strong interaction between jets and the interstellar medium may result in a widening of emission lines' profiles in the spectra of these galaxies. The aim of the work is to study the kinematic properties of gas and, on this basis, the interaction of jets with the interstellar medium. 32616 objects have been analysed, and from them, as a result of a multi-stage selection, the final sample of 6 objects was extracted, in which a significant widening of the emission lines was observed. Moreover, it was found that in three radio sources, this broadening was large enough to observe the separation of the line into two components. Therefore, the course of the function was adjusted to the appropriate lines, and the results allowed us to determine the velocity of the related outflows and discuss possible causes.

Examination of the pigment makeup of a heat-resistant cyanobacteria strain: Thermostichus lividus PCC6715 cultivated under various temperature conditions.

Author: Jakub Zięba[None] (jakub99.zieba@student.uj.edu.pl)

Co-authors: Przemysław Malec[1]; Anna Klepacz-Smółka[2]

[1] *FBBiB, UJ*

[2] *Faculty of Process and Environmental Engineering, Lodz University of Technology*

Cyanobacteria are one of the main groups of photosynthetic organisms. Thermophilic representatives of this group have considerable biotechnological potential due to the potentially useful substances they produce. These substances include carotenoids, which have antioxidant properties. A subclass of carotenoids particular to cyanobacteria are myxoxanthophylls (carotenoid glycosides). Due to the modest state of knowledge about the response of thermophilic cyanobacteria to temperature changes, we analyzed the pigment composition of Thermostichus lividus PCC6175 cultured at different temperatures. Spectroscopic, HPLC and LC-MS techniques were used. The analysis showed the accumulation of myxoxanthophylls at low temperatures and increased production of β carotene and its hydroxylated derivatives at higher temperatures

CFD optimization of a 6-series NACA profile for a solar-powered hydrofoil race boat.

Author: Paweł Geras[None] (pawelgeras6@gmail.com)

Airfoils, an invention known since the 19th century, are among the most crucial structures discovered by humans. Besides their obvious presence in aircraft wings, airfoil profiles are also used in the design of fans, drone propellers and helicopter blades, and even in foiling motorboats. The physical principles of a wing are fundamentally simple: lift force is generated through pressure differences between the upper and lower surfaces of the wing.

In this study, an investigation was conducted on the NACA 64A-715 airfoil, which is part of the 6-digit NACA profiles. Numerical analysis was performed using Computational Fluid Dynamics (CFD) for both 2D and 3D geometries. An iterative numerical refinement of the geometry was carried out to enhance lift force and increase lift to drag ratio, comparing the results with the original profile. Additionally, the winglets were analyzed to minimize energy losses caused by turbulent eddies. The hydrodynamic properties were examined in relation to the wing's angle of attack. The received data resulted in the creation of high-quality hydrofoil design for solar powered race boat "Celka".

Cerium oxide nanoparticles – influence of synthesis method on characteristics

Author: Andrzej Wójtowicz[None] (andrzej.wojtowicz@student.uj.edu.pl)

Cerium oxide (ceria) has recently brought extensive interest due to its possible applications in numerous fields, e.g. drug delivery and biomedical applications, photocatalysis and environmental catalysis (air purification, water cleansing, etc.). Specific redox properties together with high specific surface area make ceria nanoparticles promising catalysts for oxidation reactions. Cerium dioxide may be synthesised from various precursors and using different methods, e.g. thermal decomposition, hard or soft template synthesis, sol-gel method, sonochemical or hydrothermal synthesis. In the research a series of ceria samples and their modifications with cobalt was synthesised using various methods. The materials were characterised with X-ray powder diffraction, transmission electron microscopy (chosen systems) and tested as catalyst in the reaction of model soot (Printex U) combustion. All samples were active in the investigated reaction, with temperature of 50% soot conversion not exceeding 400^{o}C in tight contact mode. The catalytic performance highly depended on morphology of ceria, as well as on differences in cobalt dispersion.

Cisplatin as an anti-tumor drug

Author: Uladzislava Yarmosh[None] (u.yarmosh@student.uw.edu.pl)

Cisplatin represents a renowned drug for diverse human cancers, including those affecting the head, bladder, lung, and testes. Its therapeutic efficiency spans a spectrum of cancer subtypes, such as carcinomas, lymphomas, and sarcomas.
At the molecular level, cisplatin exhibits a capacity for forming crosslinks with purine bases situated within the DNA structure, disrupting essential DNA repair mechanisms, consequently instigating genomic damage. The accumulation of DNA lesions precipitates apoptosis, or programmed cell death, within afflicted cancer cells, thereby impeding tumor progression.
However, despite its therapeutic efficiency, the clinical utility of cisplatin is marred with challenges, notably the emergence of drug resistance and a spectrum of adverse effects. Hence, alternative platinum-containing drugs such as carboplatin and oxaliplatin have gained widespread adoption.
Furthermore, combination therapies integrating cisplatin with other drugs containing platinum have emerged as a promising strategy to enhance therapeutic outcomes while reducing toxicity and overcoming drug resistance. Such approaches hold considerable potential in optimizing cancer treatment regimens.

Concentration of chemical elements and key substances in infusions of commercially available teas as a determinant of their quality

Author: Patrycja Poloczek[1] (ppoloczek@student.agh.edu.pl)

[1] *Faculty of Management, AGH University od Cracow*

Black tea the world's second most consumed beverage,numerous studies confirm its health-promoting effects on the human body.Its infusion contains essential macronutrients like sodium, potassium, calcium and magnesium, which help reduce the risk of strokes, heart disease and hypertension, while also maintaining electrolyte-water balance. Caffeine boosts alertness, concentration and lowers the risk of Parkinson's and Alzheimer's. However, excessive consumption poses risks including insomnia, increased cholesterol and potential harm to cardiovascular and digestive systems. Additionally, trace amounts of heavy metals like lead or cadmium, found in black tea may lead to kidney failure or nervous system dysfunction.
The study of tea infusions of different quality was carried out in three stages: quantitative determination the content of elements and chemical compounds using the: voltammetric method, Atomic Absorption Spectrometry and flame photometry. The results made it possible to evaluate the quality of the studied black tea infusions and the relationship between the price of the products and their impact on the quality, health improvement and toxicological risks of their consumption.

Dark matter perturbations in ΛeDM model and their impact on cosmological tensions

Author: Magdalena Bochnak[None] (magdalena.bochnak@student.uj.edu.pl)

Perturbations of matter are fundamental in the process of structure formation in the Universe, playing a pivotal role in the evolution of cosmic structures from small-scale fluctuations to the large-scale distribution of matter. Understanding the behavior of these perturbations is crucial for mechanisms driving the formation of galaxies and galaxy clusters.

The ΛeDM (Λ-evolving Dark Matter) model offers a new perspective by introducing an evolving equation of state for dark matter. This dynamic approach allows for a more comprehensive understanding of the role of dark matter in structure formation and cosmological evolution. In this presentation, I delve into the perturbations of dark matter within the ΛeDM framework and explore their implications for H0 and $\sigma 8$ tensions, which appear between observed and derived values in ΛCDM model.

Detector and physics simulation using heavy ion collisions at NICA-SPD

Author: Rishav Pandey[1] (rishav160999@gmail.com)

[1] *Larsen and Toubro Limited, India*

The space-time picture of hadron formation in high-energy collisions with nuclear targets is still poorly known. The tests of hadron formation was suggested for the 1st stage of SPD running. They will require measuring $\pi\pm$ & $p\pm$ spectra with precision better than 10%. A research has been carried out to check feasibility of such studies at SPD. In this work, C-C and Ca-Ca heavy ion collisions at COM energy of 11 AGeV were simulated using the SMASH. Firstly, the generator-level events were studied. The distribution of track multiplicities and momentum spectra of different types of charged particles were obtained. Secondly, the generated events passed through the full reconstruction using the SpdRoot framework. At this stage particles were identified using dE/dx measurement and TOF information. It allowed us to estimate charge track multiplicities in the tracking system and purities of charge particles spectra. The results on multiplicity are important to estimate occupancies in the tracking system, while the results on $\pi\pm$ & $p\pm$ spectra show that PID should be acceptable for validation of hadron formation models. This is the 1st study of moderate ion collisions for the SPD Collaboration.

Deuteron production in a combined thermal and coalescence framework for heavy-ion collisions in the few-GeV energy regime

Author: Nikodem Witkowski[None] (nikodem.witkowski@student.uj.edu.pl)

A recently formulated thermal model for hadron production in heavy-ion collisions in the few-GeV energy regime is combined with the idea that some part of protons and neutrons present in the original thermal system forms deuterons via the coalescence mechanism. Using realistic parametrizations of the freeze-out conditions, which reproduce well the spectra of protons and pions, we make predictions for deuteron transverse-momentum and rapidity spectra. The best agreement with the experimentally known deuteron yield is obtained if the freeze-out temperature is relatively high and, accordingly, the system size at freeze-out is rather small. In addition, the standard Gaussian distribution of the relative distance between nucleons is replaced by the distribution resulting from their independent and approximately uniform production inside the initial thermal system.

Down the rabbit hole with hierarchical autoregressive neural networks

Author: Mateusz Winiarski[1] (mateusz.m.winiarski@student.uj.edu.pl)

[1] *Faculty of Physics, Astronomy, and Applied Computer Science, Jagiellonian University, Kraków*

Neural networks are used for many applications: from generating funny images, through helping students with their homework, to allowing scientists to handle their data.
In this talk, I will explain what are neural networks, what are autoregressive neural networks, what are hierarchical neural networks, and how to combine them all to solve some $O(2^{N^3})$ problems in statistical physics using algorithms with $O(N^6)$ time complexity.

This abstract was written without help of any kind of artifical intelligence.

Evaluation of the effect of Ruxolitinib on neoplastic cells with the use of Raman imaging paired with machine learning.

Author: Kacper Stawoski[1] (kacper.stawoski@student.uj.edu.pl)

Co-authors: Adrianna Adamczyk[1]; Anna M. Nowakowska[1]; Justyna Jakubowska[2]; Marta Ząbczyńska[2]; Agata Pastorczak[2]; Kinga Ostrowska[2]; Wojciech Młynarski[2]; Katarzyna Majzner[1]; Małgorzata Barańska[3]

[1] *Jagiellonian University in Kraków, Faculty of Chemistry, Department of Chemical Physics, Kraków, Poland*

[2] *Department of Pediatrics, Oncology and Hematology, Medical University of Łódź, Łódź, Poland*

[3] *1.Jagiellonian University in Kraków, Faculty of Chemistry, Department of Chemical Physics, Kraków, Poland, 2.Jagiellonian University in Kraków, Jagiellonian Centre for Experimental Therapeutics (JCET), Kraków, Poland*

Acute lymphoblastic leukemia (ALL) is caused by an abnormal proliferation of immature B-cells or T-cells and occurs mainly in children.[1] Among various subtypes of ALL, some are characterized by the overactivation of the JAK-STAT signaling pathway. In such cases,

treatment may include JAK inhibitors e.g. ruxolitinib.[2] The aim of this study was to evaluate the biochemical changes of B-ALL cells, treated with ruxolitinib, with the use of Raman imaging paired with machine learning statistical analysis methods. We used in vitro models of B-ALL cell lines that harbor (MUTZ5) or lack JAK mutation (SEM). Spectroscopic markers of biochemical changes were defined with the use of supervised (PLS) and unsupervised (PCA) chemometric analysis methods. MUTZ5 cells treated with ruxolitinib showed an increased content of lipidic structures and proteins compared to their untreated counterparts, while no similar effect was observed for SEM cells.
The „Label-free and rapid optical imaging, detection and sorting of leukemia cells" project is carried out within the Team-Net programme of the Foundation for Polish Science co-financed by the EU.

Exactly solvable Quantum spin-1/2 models in 2D

Author: Ihor Sokolov[1] (ihor.sokolov@student.uj.edu.pl)

[1] *Jagiellonian University, Institute of Theoretical Physics*

Quantum spin-1/2 systems in two dimensions offer a rich and fascinating arena for theoretical and experimental exploration in condensed matter physics. In this presentation, we will delve into these quantum systems in 2D. Starting with the Kitaev model, we will discuss one of the analytical approaches to solving such models, using the Jordan-Wigner transformation and Bogoliubov rotations. Additionally, we will explore several other exactly solvable models, such as the Ising model (Onsager's solution), free fermion models, and certain limits of the Hubbard model. Through these examples, we will emphasize the crucial symmetries and integrability properties that facilitate exact solvability.

Experimental approaches in differentiating between Idiopathic Pulmonary Fibrosis (IPF) and Nonspecific Interstitial Pneumonia (NSIP)

Author: Maria Rybak[None] (maria.rybak@student.uj.edu.pl)

During the study of lung diseases, researchers face numerous impediments, representing common challenges in advancing research. One such problem involves the identification of cells associated with two diseases: idiopathic pulmonary fibrosis (IPF) and nonspecific interstitial pneumonia (NSIP), which differ significantly in severity, with one being easily treated and the other fatal.
To address these challenges, various experiments involving alterations in the cell environment are carried out, such as the addition of biomolecules (e.g., proteins) or modification of the substrate structure. This requires the use of various intriguing techniques, such as culturing on glass substrates that resemble the 3D structure of the lungs. Utilizing several microscopy

techniques, such as fluorescence microscopy or atomic force microscopy, enables effective visualization of changes in the culture. Such actions allow us to gain insights into the cell properties, representing a significant step towards understanding them and thereby improving accuracy in distinguishing between these two types of diseases.

Exploring Fluid Dynamics: Simulation of Navier-Stokes Equation in a Rotating Cylinder using Finite Difference Method

Author: Dawid Zapolski[1] (dawid.zapolski@student.uj.edu.pl)

[1] *Jagiellonian University in Kraków*

Understanding the intricate dynamics of fluid flow in rotating environments is crucial in various scientific and engineering fields, from meteorology to aerospace engineering. In this study, we delve into the simulation of the Navier-Stokes equation within a rotating cylinder using the finite difference method. The Navier-Stokes equation serves as the fundamental governing equation for fluid flow, encompassing the conservation of mass and momentum.

The rotational aspect introduces complexities that significantly influence the flow patterns and behaviors within the cylinder. Through computational simulations, we explore the effects of rotation on fluid motion. The finite difference method provides a numerical framework for discretizing the Navier-Stokes equation, enabling us to solve for the velocity field within the rotating cylinder. The important aspect of the work is the art of simplification within a framework of fluid dynamics.

Exploring novel sampling ideas in NeRF

Author: Marcin Kądziołka[None] (marcin.kadziolka@student.uj.edu.pl)

Representing scenes as neural radiance fields (NeRF) for view synthesis has taken the world of computer vision by storm. Unlike traditional approaches, NeRF learns to directly encode 3D scenes within neural networks, enabling seamless generation of novel views with high quality. Its efficiency in synthesizing new views from a limited set of input images showcases its potential to revolutionize various applications in computer vision and graphics. Ray tracing in NeRF involves casting rays from camera positions and then using networks to estimate the color and opacity of objects along these rays. Originally this is done by taking initial points throughout the rays, to gather information for second, more precise sampling. This two-stage approach is effective, but slow. Proposed possible improvements include a novel sampling network that takes advantage of extra data, such as camera origins and view directions, via an MLP for direct sample generation on rays. This and other ideas are broad and exciting.

Exploring the Kelly Criterion

Author: Mateusz Gappa[None] (mateusz.gappa.ma@gmail.com)

Kelly Criterion, helps answer a crucial question: how do we decide the right amount of money to invest to maximize our profits? By looking closely at different angles of this issue, I'll point out where its assumptions might fall short in real-world financial situations. I'll also talk about the risks involved and the temptation to blindly trust this formula. Plus, I'll stress the importance of adapting to market changes and competitive pressures when using the Kelly Criterion.

Free probability

Author: Łukasz Gorczyca[1] (lime.pss@gmail.com)

[1] *Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland*

Free probability theory is a relatively young field of mathematics. It is nearly 40 years old and is a connection between random matrices and von Neumann algebras. In the poster, I will present the basic definitions of this theory, in particular the concept of freeness and its properties. I will also present elements of combinatorial theory of freeness, where Catalan numbers, well-known in discrete mathematics, appear. The poster will also make room for a presentation of the free equivalent from classical probability theory for the central limit theorem.

Freeze, fight or flight – the impact of the endogenous opioid system on the stress response

Author: Agnieszka Stec[1] (astec102@gmail.com)

[1] *Faculty of Management and Social Communication, Applied Psychology, Jagiellonian University in Kraków, Poland*

Two biological systems are involved in the stress response - the sympathetic nervous system and the hypothalamic-pituitary-adrenal hormonal system (HPA axis). The intensity and duration of the HPA axis activation translates into the intensity of the stress reaction.(1) Endogenous opioids inhibit the HPA axis, and naloxine, as an opioid receptor antagonist, inhibits their effect (2). An important element of stress response studies in animal models is the selection of a mouse strain with specific sensitivity to stress.

In the discussed work, two inbred strains of laboratory mice, C57BL/6J and SWR/J, were studied. Each strain was characterized by a different phenotype and consequently, a different post-stress response. The C57BL/6J strain exhibits a passive style of coping with stress, which includes high conditioned fear and a frezzing reaction to a threatening stimulus. The

SWR/J strain shows an active style of coping with stress, which is characterized by low conditioned fear and a strategy of active escape from a threatening situation. SWR/J mice also show greater activity of genes encoding opioid peptides (Penk, Pdyn, Pomc), which could explain their stress resistance.(2)

From SMP to Theories of Extreme Matter

Author: Michał P. Heller [1] (Michal.P.Heller@UGent.be)

[1] *Ghent University*

Table top experiments on cold atomic gases and ultrarelativistic nuclear collisions at RHIC and LHC accelerators probe novel forms of matter far from equilibrium. I will describe some of my favourite result on this topic and their connections to being a SeMP between 2003 and 2007.

Fruit fly as a schizophrenia model

Author: Karolina Nowalińska[None] (kar.nowalinska@student.uj.edu.pl)

Schizophrenia is characterized by a range of symptoms, both physical, psychological and cognitive. The etiology of the disease remains elusive. It does not have a characteristic marker and varies greatly among patients.

There are many animal models of schizophrenia, some aimed at verifying the impact of DNA mutations on disease occurrence, disrupted neurotransmission or neurodevelopment – majority of them are rodent models, but there are also studies conducted on other species, among them - on the *Drosophila melanogaster* commonly known as the fruit fly.

Among the advantages of the fruit fly as a model organism, one can enumerate, a fully sequenced genome, numerous innovative genetic engineering methods dedicated to it, small size and the ability to collect data from many individuals. All of this facilitates research on genes and proteins that correlate with schizophrenia in humans.

I will discuss research on the molecular basics of schizophrenia, involving genes associated with the development of schizophrenia in humans, as well as proteins. I will also debate the advantages and disadvantages of this model and whether it is worth using in studying such complex diseases.

Geography and location factors of new working spaces

Author: Grzegorz Micek[1] (grzegorz.micek@uj.edu.pl)

Co-author: Karolina Kapustka[1] (karolina.kapustka@doctoral.uj.edu.pl)

[1] *Faculty of Geography and Geology, Jagiellonian University in Kraków*

Over the past few years, as a result of changes brought about by technological advances and more recently by the COVID-19 pandemic, the form and location of work provision has changed significantly. The presentation aims to deliver recent research on the spatial distribution and location factors of new workspaces (mainly coworking spaces and makerspaces) in Poland and abroad. While coworking spaces clearly relate to the settlement hierarchy and, to a greater extent, to the hierarchy of the country's economic centres, the location of makerspaces is more complex. This is due to the slightly different location factors of these two types of new workspaces. In the case of coworking spaces, good transport accessibility, the presence of accompanying amenities (cafés, restaurants, etc.) and the co-presence of creative and advanced business services companies are often emhpasized. The location factors of makerspaces are not yet fully recognised, although the role of representatives of the maker movement and local leaders is more often indicated here.

GO-a-GO: Functional Annotation of Genes in Chromatin Contact Pairs

Authors: Aleksander Jankowski[1] (aleksander.jankowski@uw.edu.pl); Daryna Yakymenko[2] (daryna.yakymenko@student.uj.edu.pl); Teresa Szczepińska[3] (teresa.szczepinska@pw.edu.pl)

[1] *Faculty of Mathematics, Informatics and Mechanics, University of Warsaw*

[2] *Faculty of Biochemistry, Biophysics and Biotechnology, Jagiellonian University of Cracow*

[3] *CEZAMAT, Warsaw University of Technology*

Analysis of overrepresentation of Gene Ontology (GO) terms in a set of differentially expressed genes is a standard approach to investigate functional associations of gene expression changes. We developed GO-a-GO tool to be able to analyze functional terms that are overrepresented in a set of gene pairs. This provides the opportunity to see which functions are associated with gene pairs from a selected group of chromatin contacts, such as cell type specific contacts. We used GO-a-GO to analyze GO terms enriched in top 5% of differential contacts (at distances up to 5 Mb) in mouse embryonic stem cells and neocortical neurons measured using Hi-C genome architecture mapping (Bonev et al., 2017). The analysis revealed several enriched functional terms associated with both genes in contact pairs. In summary, we developed a promising tool to study the function of chromatin three-dimensional structural contacts, which can be used independently on the type of experimental method used to measure the contacts and on the nature of contacts (e.g. loops or spatial gene clusters).

Graph theory in food web analysis

Author: Magda Wójtowicz[1] (magda.1.wojtowicz@student.uj.edu.pl)

[1] *Faculty of Mathematics and Computer Science, Jagiellonian University in Kraków, Poland*

Food webs are not just a topic for elementary school lessons; they are an interesting example of a discrete mathematical model, ideally represented through directed graphs. In my talk, I will cover the key concepts of graph theory necessary to analyze food webs. Then, I will explain how to apply them to model the relationships between predators and prey, determine the trophic levels and status of different species within a web. Additionally, I will introduce the concept of a competition graph corresponding to the food web (a graph where each vertex represents a species, and there's an edge between two species if they share a common prey) and explore its connections to interval graphs, which are intersection graphs of a family of intervals on a real line.

Growth kinetics of random sequential adsorption packings built of two-dimensional shapes with discrete orientations

Author: Wiktor Zantowicz[None] (wiktor.zantowicz@student.uj.edu.pl)

Co-authors: Michał Cieśla ; Piotr Kubala

We studied random sequential adsorption packings constructed from rectangles, ellipses, and discorectangles, where the orientations of constituent shapes were picked from discrete sets of values with varying spacing. It allowed us to monitor the transition between the two edge cases: the parallel alignment and the arbitrary, continuous orientation of the shapes within the packing. The packings were generated numerically. Apart from determining the kinetics of packing growth in low- and high-density regimes, we analyzed the results in terms of packing density and probed the microstructural properties using the density autocorrelation function.

Harmonic functions and their properties

Author: Maria Książkiewicz[1] (maria.ksiazkiewicz@student.uksw.edu.pl)

[1] *Uniwersytet Kardynała Stefana Wyszyńskiego w Warszawie, Wydział Matematyczno-Przyrodniczy. Szkoła Nauk Ścisłych, Naukowe Koło Matematyczne Inny Wymiar*

We present harmonic functions and their basic properties such as their connection with holomorphic functions, The Mean-Value Property and The Maximum Principle. Then we will tell about practical application of these functions. This presentation is based mainly on "Harmonic Function Theory" by S. Axler, P. Bourdon and W. Ramey as well as on the lecture by M. Majchrowski in Warsaw University of Technology.

How to become SHERLOCK with a 3D printed device?

Author: Iga Czechowska[1] (iga.czechowska@student.uj.edu.pl)

[1] *Faculty of Chemistry, Jagiellonian University*

In recent years, there has been a significant advancement in the field of 3D printing technology. Researchers have utilized it to fabricate cost-effective mobile detection devices aimed at enhancing the rapid diagnosis of biological samples. This research has significantly contributed to the development of a 3D printed device tailored for the swift detection of golden algae (*Prymnesium parvum*) in environmental samples. At the core of this detection system lies a CRISPR-based diagnostic platform known as Specific High Sensitivity Enzymatic Reporter UnLOCKing (SHERLOCK). Leveraging the potential of machine learning algorithms, the device seamlessly translates signals captured from fluorescent probes in images into concentrations of *Prymnesium Parvum* DNA. This innovative device was developed as part of the iGEM (International Genetically Engineered Machine) 2024 competition, where the iGEM JU 2024 team focuses on creating an efficient diagnostic tool for detecting golden algae in natural environments.

How to study Martian winds? – the overview of aeolian landforms on Meridiani Planum

Author: Szymon Mol[None] (szymon.mol@student.uj.edu.pl)

Although Mars is the best explored planet (except Earth) in the Solar System, there are few results from direct measurements of wind parameters on the surface of Mars. However, because wind can interact with loose sediment, it is possible to infer the wind direction from observations of aeolian (wind-related) landforms. It is crucial to distinguish between landforms that show some changes with respect to the season of the year and those that do not show any activity. The former are shaped by current winds and they are called active bedforms, while the latter are related to past winds. Visible from orbit aeolian landforms on the surface of Meridiani Planum include: wind streaks (darker or brighter than surrounding terrains), coarse-grained ripple fields, and large dark dunes. Only wind streaks are active, and their orientation is usually distinct from all other mentioned landforms. It suggests that current wind patterns are different from those of the past.

The work was funded by the Anthropocene Priority Research Area budget under the program 'Excellence Initiative – Research University' at the Jagiellonian University.

How traumatic and stressful events affect our brains?

Author: Gabriela Czerniak[1] (gabriela.czerniak@student.uj.edu.pl)

[1] *Department of Neurophysiology and Chronobiology*

Stress affects both physiological and psychological processes, including brain function and memory. The hippocampus, which is pivotal for memory, is particularly vulnerable to stress. The relationship between stress, the hippocampus, and memory is complex and varies depending on the stress level.
Neurobiological research focuses mainly on the hypothalamic-pituitary-adrenal (HPA) axis and the release of glucocorticoids in response to stress. Although acute stress can enhance cognition, chronic stress can dysregulate the HPA axis, harming the structure and function of the hippocampus. Studies investigating the effects of chronic stress have demonstrated changes in hippocampal morphology and synaptic plasticity. Chronic stress is consistently associated with dendritic atrophy, reduced spine density, and synaptic remodelling in the hippocampus, particularly in the CA1 region.
It is crucial to understand the neurobiological mechanisms underlying stress-induced hippocampal dysfunction to develop therapeutic interventions that mitigate the cognitive consequences of chronic stress and promote resilience in vulnerable populations.

Influence of posttranscriptional modifications on RNA structures: crystallographic and thermodynamic analysis

Authors: Antonina Gonet[1] (antgon3@st.amu.edu.pl); Martyna Mateja-Pluta[2]; Magdalena Bejger[2]; Agnieszka Kiliszek[2]

[1] *Faculty of Biology, A.Mickiewicz University, Poznań, Poland*
[2] *Institute of Bioorganic Chemistry, Polish Academy of Sciences, Poznań, Poland*

The ubiquity of the RNA's functions comes from its structural richness derived from four nucleotides (A, C, G, U) and their canonical pairing. Posttranscriptional modifications of nucleotides expand RNA folding possibilities, and thus the spectrum of structural variations. Among modifications, pseudouridine (Ψ) is the most abundant across all RNA classes and three domains of life[1]. The N1-methylpseudouridine (m1Ψ) has been identified in eucaryotic rRNA, and in archaeal tRNA and rRNA[1]. It has also been incorporated into COVID-19 mRNA vaccines to improve their efficiency[2]. Comparison of the 3D models of modified sequences to their 'native' counterparts can help describe the impact of the modification on RNA structure and function. Hence, more crystallographic studies on RNA molecules is crucial, especially given their limited number.
Here, we present the crystallographic and thermodynamic analysis of unmodified RNA model structures (RNA1-U;RNA2-U;RNA3-U), which serve as references for modified (RNA1-Ψ;RNA2-Ψ;RNA3-Ψ;RNA1-m1Ψ;RNA2-m1Ψ;RNA3-m1Ψ) crystal models. Moreover, the UV-melting analysis and DSC were employed to calculate the thermodynamic parameters of native RNA duplexes.

Introduction to Chaos Theory in Discrete Dynamical Systems

Author: Konrad Ochędzan[None] (konrad.ochedzan@student.uj.edu.pl)

In the 19th century, Henri Poincaré endeavored to answer King Oscar II of Sweden's question, "Is the Solar System stable?" Concurrently, Jacques Hadamard was studying the behavior of billiard balls. Both mathematicians, independently of each other, observed peculiar behaviors in the systems they were investigating. As it turns out, both gentlemen stumbled upon chaos.

In my presentation, I will discuss chaos in the sense of Devaney, the most commonly used definition of chaos in discrete dynamical systems. I will specifically talk about examples of chaotic functions, as well as those that do not fully satisfy Devaney's definition. Additionally, I will mention interesting research findings that allow us to simplify this definition. Due to the interdisciplinary nature of the conference, I will also highlight applications of chaos theory.

Introduction to Electrogenetic Gene Expression Systems

Author: Joanna Doliwa[1] (joanna.doliwa@student.uj.edu.pl)

[1] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University*

The ability to convert ionic modalities to electrical signals has transformed our comprehension of biological phenomena, ranging from electromyography to recording postsynaptic potentials using the patch clamp technique. With the ongoing development of synthetic biology a variety of inducible gene expression systems have been engineered with possible applications in biosensors or inputs for genetic logic circuits. Such systems consist of a promoter and its cognate transcription factor that can either activate or repress the expression of its downstream genes in response to external stimuli like light, magnetism or osmolarity. Electrogenetic circuits transmit electronic information to engineered bacterial cells using redox molecules. The signal then controls the transcription from a simple synthetic gene circuit. The most commonly studied systems are based on the native transcriptional regulator SoxR and transcription from the PsoxS promoter which allows for a quick and scalable cell response. Furthermore, it presents with a variety of possible applications being able to induce bacterial motility and cell-to-cell communication.

[1] https://doi.org/10.1126/sciadv.abm5091

Investigation into the Characteristics of Asymmetric substituted 4,5-Dialkoxy-2-Nitroanilines Using Spectroscopic and Theoretical Approaches

Author: Karina Synowiec[1] (karina.synowiec@interia.pl)

[1] *Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387, Krakow, Poland*

This study aims to synthesize and explore the physicochemical properties of two distinct constitutional isomers of 4,5-dialkoxy-2-nitroanilines, wherein each isomer is asymmetrically substituted with an ethoxy group and an isobutoxy group.

By synthesizing the isomers and subjecting them to spectroscopic analysis, the study focuses on explaining the nature of electron and oscillatory transitions, providing insight into the complex relationship between molecular structure and spectroscopic properties.

There are no significant differences between the experimental and theoretically calculated infrared spectra. From the comparison of infrared spectra, we can conclude that hydrogen bonds are present in the crystal structure, as quantum mechanical calculations considered one molecule and molecular dynamics considered the elementary cell of the compounds studied. By calculating the energies of successive singlet states, analyzing the calculation results in detail, and visualizing the orbitals, it was possible to describe the HOMO orbitals from which the transitions come and the corresponding LUMO orbitals.

Iris-ML: Neural Density Estimation for the Spectral Energy Distribution fitting.

Author: Mateusz Kapusta[None] (mr.kapusta@student.uw.edu.pl)

Markov chain sampling is a versatile algorithm used in modern astronomy for inference tasks. Unfortunately, it is not always suitable for large inference tasks where the evaluation of the likelihood function is computationally expensive. Here, an alternative approach is presented which uses neural networks to tackle the Spectral Energy Distribution fitting problem. Basic idea for this type of analysis is to uncover true physical properties of objects by fitting complicated physical model to broadband brightness measurements. Mastering analysis of the photometric data is essential for modern astronomical research. Based on the transformer architecture for the preprocessing, the proposed model greatly accelerates the sampling process, allowing for the analysis of huge datasets in a relatively short time. Such models are a great step forward compared to the usually used MCMC and will become more influential, as the next generation of astronomical surveys will produce unprecedented amounts of data.

Library of Spectroscopic Reporters as a Tool for Studies of Biological Systems

Author: Kacper Siąkała[1] (kacper.siakala@student.uj.edu.pl)

Co-authors: Anna Nowakowska[1]; Anna Pieczara[2]; Barbara Orzechowska[1]; Małgorzata Barańska[3]; Wiktoria Korona[4]

[1] *Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387, Krakow, Poland*

[2] *Jagiellonian University in Kraków, Doctoral School of Exact and Natural Sciences, 11 Lojasiewicza St., Krakow, Poland; Jagiellonian University, Jagiellonian Centre for Experimental Therapeutics (JCET), Bobrzynskiego 14, 30-348 Krakow, Poland*

[3] *Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387, Krakow, Poland; Jagiellonian University, Jagiellonian Centre for Experimental Therapeutics (JCET), Bobrzynskiego 14, 30-348 Krakow, Poland*

[4] *Jagiellonian University, Faculty of Chemistry, Gronostajowa 2, 30-387, Krakow, Poland; Jagiellonian University in Kraków, Doctoral School of Exact and Natural Sciences, 11 Lojasiewicza St., Krakow, Poland*

Raman (RS) and infrared (IR) spectroscopy are used as versatile tools for examination of biological systems, that can be conducted in two ways – in a label-free or labelled manner. The second approach uses specific chemical compounds, called spectroscopic reporters. They contain chemical moieties (alkyne, nitrile, or C-D bonds) that are active in Raman and/or IR and exhibit bands in the so-called silent region. Spectroscopic tags, due to the special chemical group, bind to a target organelle or enter specific metabolic pathways.

In our studies, we developed the library of spectroscopic reporters by performing molecular characterization (RS, IR and partially UV) of the most promising compounds for further applications in bio-imaging: EdU (nucleus); MitoBADY (mitochondria); dPA and dOA (lipids metabolism); 3-OPG and d7-glucose (glucose metabolism). The proposed library of reporters is a convenient set of targeting molecules that allow for a detailed in vitro examination of metabolic processes with development potential.

This research was funded in whole or in part by the National Science Center Poland (NCN), Maestro 2022/46/A/ST4/00054 to Malgorzata Baranska.

Lactoferrin: Properties and Potential for Medical Research

Author: Eryk Federyga[1] (eryk.federyga@student.uj.edu.pl)

[1] *KMPS UJ, WCh, Faculty of Chemistry, Jagiellonian University in Kraków, Poland*

Lactoferrin is a protein that occurs in milk and other mammalian secretions. As a member of the transferrin family, it is responsible for binding and transporting iron. However, this is only a small fraction of its functions. Many other bioactivities have been identified, including antibacterial, antiviral, antifungal and even anticancer properties. This protein is therefore extremely promising due to its multiple functions and non-toxicity. Therefore, in recent years many researchers have focused on exploring and developing potential uses of lactoferrin. The aim of this speech is to provide the role that lactoferrin plays in protecting human organism at all stages of life, its multipotentiality as well as outline application of this protein and its modifications in medicine.

Lapunov exponent, the old way of measuring the chaos

Author: Adam Sowiński[None] (a3sow220@gmail.com)

A system is said to be chaotic if a small change in initial conditions leads to significant differences in its evolution. Based on this definition, we can ask how to quantify this level of chaos. Given two systems, how can we determine which one exhibits greater chaos? To answer this question, we will introduce the concept of the Largest Lapunov Exponent, an idea proposed in the late 19th century by the mathematician Alexander Lapunov.

Lorentz Transformation in Relativistic

Author: Franciszek Kucięba[None] (franek.kucieba@gmail.com)

The poster will present methods of deriving the Lorentz transformation and a number of thoughts experiments which will result in the conclusion about the non-simultaneity of events in various reference systems..

Luminescent thermometry in multifunctional materials

Author: Hubert Dziełak[1] (hubert.dzielak@student.uj.edu.pl)

[1] *Faculty of Chemistry, Jagiellonian University in Kraków, Poland*

Thermometry in general has variety of applications in our daily lives and is well known concept - its uses range from calibration and maintenance of most intricate electronic devices to determining if weather outside is suitable for Your attire. Luminescent thermometry is technique that uses light to read out temperature, which means no direct contact is required between probe (luminescent material) and detector. It allows for use in conditions where most other sensing strategies fail such as inside living cells, in corrosive conditions and fast moving objects.

That being said, what can be considered especially exciting is introduction of luminescent thermometry to already functional materials such as catalysts, gas sensors or magnets. Combination of multiple useful properties may help with miniaturisation of devices, creation of more responsive systems and reduction of noise during measurement.

I would like to introduce base concepts of luminescent thermometry, show and explain examples of successful combinations with other properties and briefly communicate my own work in the field.

Magnetochiral dichroism: what do optical activity and magnetism have in common?

Author: Katarzyna Rzepka[None] (k.rzepka010@gmail.com)

With a rapidly growing demand for new data storage devices a group of molecular materials which exhibit magnetic memory effect along with optical transparency seems to be a promising candidate. Having in mind the future applications, a reproducible method of synthesis and detailed investigation of their properties is mandatory. Magnetochiral dichroism spectroscopy (MChD) developed for the characterisation of a second order effect arising from the combination of magnetic properties and optical activity in a single compound, stands out as one of the most interesting yet still underexplored techniques. As there are no commercially available spectrometers designed for this measurement, construction of such setups requires deep understanding of the underlying phenomenon and technological issues. This appears to be even more challenging as there are only few people with extensive experience in this field and the number of already investigated compounds is scarce. All this makes MChD and synthesising the relevant chiral molecular magnets even more captivating.

Mathematics of Calabi-Yau Threefolds

Author: Aliaksandr Rybalka[1] (aliaksandr.rybalka@student.uj.edu.pl)

[1] *Faculty of Physics, Astronomy, and Applied Computer Science, Jagiellonian University, Krakow*

In this talk, I will introduce the concept of Calabi-Yau manifolds, which are known from superstring theory. While computing the Hamiltonian of the model, we conclude that the dimension of our space-time is forced to be 10 to preserve physical symmetries, which looks like nonsense. But we know, as in quantum mechanics, that small scale can look different, like A4 piece of paper, which is a 3-dimensional object, but at first sight it is "flat" and two-dimensional. So we compactify our known 4-manifolds (Minkowski as an example), and we could create a new theory with "hidden" dimensions. In superstring theory, we use a mathematical object called Calabi-Yau 3-fold, which is the aim to be discussed in this talk. All mathematical tools from differential and algebraic geometry as manifolds, vector bundles, connections etc. would be presented

Matrix models which counts graphs

Author: Mykhailo Hontarenko[1] (mgontarenko72@gmail.com)

[1] *Jagiellonian University*

In this talk, I will present a brief introduction to matrix models[2], which
naturally arise if we work in the context of interacting QFT, as ϕ_4^4 model, constructing graphs we make perturbation expansion, where arise graphs made of vertexes and edges [1]. The goal of talk to show how combinatoric factors of graphs and maps could be calculated using Gaussian integrals or it's generalization. Matrix models arise in different fields of Quantum gravity, string theory, and different CFT-s, and have deep geometric background.
References
[1] D Bessis, C Itzykson, J.B Zuber "Quantum field theory techniques in graphical enumeration". In: Advances in Applied Mathematics 1 (1980), pp. 109–
157. doi: 10.1016/0196-8858(80)90008-1.
[2] A. Zvonkin. "Matrix integrals and map enumeration: An accessible introduction". In: Mathematical and Computer Modelling 26 (1997), pp. 281–
304. doi: 10.1016/S0895-7177(97)00210-0

Microbial symbionts as drivers of insects' adaptation to the changing world

Author: Piotr Łukasik[1] (p.lukasik@uj.edu.pl)

[1] *Institute of Environmental Sciences, Faculty of Biology, Jagiellonian University in Kraków*

Insects, the most diverse animal group on the planet, play a wide range of ecological roles essential for the functioning of ecosystems and the well-being of humans. However, this has been possible, at least partly, through the contributions of bacteria and fungi that inhabit insect bodies. We know that such microbial symbionts have enabled the emergence and evolutionary success of entire insect clades. Also, there is growing evidence that symbionts may be essential for insects' ecological and evolutionary responses to rapid environmental changes, including those that drive the current biodiversity declines. During this talk, I will explain how we can combine international fieldwork, cutting-edge sequencing technologies, and custom bioinformatics to understand these fundamental processes.

Molecule.one brief intro: our journey on automatization of chemistry

Author: Stanisław Jastrzębski[1]

[1] *Molecule.one*

Small molecule drug discovery relies on synthesizing massive amounts of chemical compounds. Currently, synthesis is slow and expensive. This puts a limit on human innovation by constraining drug hunters to the cheapest subset of the whole chemical space. However, the tides are changing due to the concurrent advances in automatization of chemistry, general robotics, and AI. Thanks to the rapidly growing ability to build massive chemistry datasets, and encoding them in robotic workflows, we face the prospect of making compounds massively cheaper and faster. In this short talk, I will introduce this problem more generally and then briefly share the journey of Molecule.one (from 2018 to now) on automating chemistry by building high-throughput laboratory and AI-based software.

Nongenetic functions of the genome

Author: Marianna Dekert[None] (marianna.dekert@student.uj.edu.pl)

The primary function of the genome is to store DNA and express the genetic information contained within it. However, the genome also serves nongenetic functions within the cell, as one of its essential structural components [1]. The structural organization of chromatin (including the degree of its condensation) influences processes like postmitotic nucleus reassembly [2] and mechanoresponses, especially during cell migration [3]. Chromatin, due to its structural properties, serves as a binding platform for many proteins, including regulators of the cell cycle [4]. The organization of chromatin within the nucleus also influences physiological processes, such as vision in nocturnal animals [5]. In my presentation, I will elucidate the mechanisms of the processes mentioned above, along with examples of experiments confirming their nongenetics origin.

Numerical functional analysis for ODE's

Author: Jakub Czwórnóg[None] (kuba.czwornog@gmail.com)

I am going to present new functional analysis approach for solving differential equations. The main idea is that we can treat problem of solving initial condition as a problem of finding zero of some infinite dimensional operator. With this idea we can extend Newton's method to solve such equation rigorously.

On CP violation in K-meson and B-meson systems

Author: Ramkrishna Joshi[1] (ph23mscst11029@iith.ac.in)

[1] *Indian Institute of Technology Hyderabad*

The CPT symmetry is one of the most fundamental symmetries observed in nature. This symmetry is observed in the most basic building blocks of the universe, subatomic particles. CPT invariance forms basis of all the fundamental theories that underlie the nature. This symmetry facilitates our understanding of particles and their antiparticles. Behavior of fundamental particle interactions under CPT symmetry reveals a lot about the observational evidence of the universe that we have long gathered. However breaking of these fundamental symmetries probes new insights into matter-antimatter asymmetry. In this paper, I explore CP violation in K-meson and B-meson system. I provide an overview of the mathematical formalism of CP violation and it's physical interpretation through aid of CKM matrix. I conclude with Sakharov conditions for matter-antimatter asymmetry and their correlation to CP violation phenomenon.

On The Red Dwarf - Bee Hive Correspondence

Author: Franciszek Ungeheuer[None] (franciszekungeheuer@gmail.com)

Co-author: Aleksander Lenart (aleksander.lenart@student.uj.edu.pl)

Over the years, researchers found that many exotic physical systems are reflected in nature. We aim to study the similarities between the low mass, main sequence stars (red dwarfs) and a hibernating bee hive. Although the sizes of those systems are different by 8 orders of magnitude, we believe that some characteristics are similar. We will introduce the topic and present some of the most basic simulations.

Optical tweezers: a statistical approach

Author: Monika Rasz[None] (monikarasz22@gmail.com)

Optical tweezers have emerged as a powerful tool for manipulating microscopic particles with precision and control, finding applications across various fields, such as nanotechnology and life sciences. In this talk, I will derive the statistical description of the particle dynamics inside the optical trap, as well as methods that can be used to recover trap parameters from experimental data.
Alongside the mathematical description, I will present the results of Monte Carlo simulations illustrating the probabilistic nature of particle trapping and allowing for a more qualitative understanding of the discussed phenomena.

Optimization of the housing of the adjustable hydrofoil mount

Author: Kamil Zając[1] (kamilzajac60@gmail.com)

[1] *Faculty of Mechanical Engineering and Robotics, AGH University of Krakow, Poland*

At AGH University in Krakow, I am part of the student organization AGH Solar Boat focuses on building Solar-powered electric hydrofoil boats. The most efficient way of increasing the lift force of a hydrofoil is by changing the angle of attack of the whole foil. To obtain it regulation is necessary. Our adjustment mechanism has large dimensions compared to the competition and poorly matched shapes which causes great resistance to the movement of the boat. To avoid that problem, designing casing with better, more hydrodynamic shapes would be an appropriate solution. After designing several CAD models, CFD research has been carried out. From the results of simulations, there were selected most required models, mounted on the mechanism.

Parametric Resonance in Energy Harvesting

Author: Wiktor Zantowicz[None] (wiktor.zantowicz@student.uj.edu.pl)

With the growing popularity of miniature devices, the issue of their power supply arises. Batteries require replacement and have low energy density, while conducting electrical connections can be problematic or impossible.

One solution could be the implementation of Energy Harvesters, devices that harness vibrations from the environment or electromagnetic fields from other devices for power. This could enable the powering of wearable devices, the utilization of numerous sensors, for instance, in bridges for monitoring strength, or in miniature biomedical devices.

This presentation will focus on Vibrational Energy Harvesters and the application of Parametric Resonance as a means to increase harvested energy.

My talk is based on Caldwell, Nicholas B., "Exploiting the Principal Parametric Resonance of an RLC" Circuit for Vibratory Energy Harvesting"" (2016).
All Theses. 3041.
https://tigerprints.clemson.edu/all_theses/3041

Persistent Homology - gently introduction

Author: Jakub Mazur[None] (mazur.jakub05@gmail.com)

The talk will introduce the concept of homology groups in the context of data analysis. In particular, I'll focus on presenting intuitive notions of cycles, boundaries and homology groups in simplicial complexes. Then I'll introduce the theory of persistent homology, in particular filtration of simplicial complexes and calculating persistent birth-death diagram, followed by some examples on a simple data set.

Proof of the Nielsen-Schreier Theorem via graph theory

Author: Michał Krysiak[None] (michalkrysiak99@gmail.com)

The Nielsen–Schreier theorem states that a subgroup of a free group is itself a free group, giving also a formula for the number of generators of the subgroup when its index is known and finite. While the first statement sounds somewhat obvious, it is not completely straightforward to show. Moreover, the second part shows that subgroups of free groups can have arbitrarily many generators. In this talk I wish to present a non-advanced and, hopefully, intuitive proof of the above theorem.

Raman molecular probes: selectivity of cellular structures and improved imaging quality

Author: Jakub Firlej[1] (jakub.firlej@student.uj.edu.pl)

Co-authors: Krzysztof Brzozowski[2]; Anna Pieczara[3]; Malgorzata Baranska[2]

[1] *KMPSUJ*

[2] *Jagiellonian University*

[3] *Jagiellonian Centre for Experimental Therapeutics*

Raman scattering is mainly associated with label-free bioimaging, but the presence of specific measurement and experimental conditions may significantly increase the intensity of registered signals, and therefore image quality. One way to enhance the signal coming from the subcellular structure of choice is the introduction of a special probe molecule into the cell, which exhibits different oscillations from those of endogenous biomolecules. In this case, bands specific for the reporter are usually observed in the so-called silent region of the Raman spectrum. Another approach includes taking advantage of the energy transfer mechanism to enhance the signal of substances that can be normally found in the cell.

Preliminary research of near field energy transfer was carried out using stimulated Raman scattering (SRS). A group of dyes dissolved in dimethyl sulfoxide (DMSO) was studied. The studies focused on comparing stimulated Raman loss (SRL) values at 2766 cm^{-1} and 3100 cm^{-1} where DMSO does not absorb energy with the SRL signal at 2916 cm^{-1} and 3001 cm^{-1} where the DMSO absorption bands are located. A comparison between pure DMSO and DMSO dye solutions was made.

Ru(II) polypyridyl complexes – potential inhibitors of metastasis development

Authors: Małgorzata Brindell[1] (malgorzata.brindell@uj.edu.pl), Olga Mazuryk[1], Ilona Gurgul[1], Ewelina Janczy-Cempa[1], Przemysław Gajda-Morszewski[1]

[1] *Department of Inorganic Chemistry, Faculty of Chemistry, Jagiellonian University*

Most of the compounds tested for anticancer properties act as cytotoxic agents and vast majority of studies focus on evaluation their influence on primary tumors. However, the biggest problem in the treatment of cancer is the development of metastases. It is estimated that over 90% of deaths due to cancer are associated with metastases. Combating metastasis formation and growth is the key to successfully treating cancer and traditional growth control approaches are inadequate. It is believed that an essential precondition for successful clinical development requires targeting the correct portions of the metastatic cascade.

For many years the coordinatively saturated polypyridyl Ru(II) complexes were investigated as potential anticancer agents and in vitro studies were focused on their cytotoxic activity. In our studies we have showed that in addition to cytotoxic properties Ru(II) polypyridyl complexes had an impact on cancer cell detachment, migration and adhesion as well as on endothelial cell angiogenesis. Based on these findings we made a hypothesis that this group of ruthenium complexes might be a good candidate for searching effective anti-metastatic agents. The modification of the tumor microenvironment by ruthenium polypyridyl complexes will be discussed.

SHERLOCK and the Oder River disaster - using synthetic biology to detect algal blooms

Authors: Katarzyna Urbanelis[1] (katarzyna.urbanelis@gmail.com); Marta Luterek[1]; Nina Kurowska[1]

[1] *Faculty of Biochemistry, Biophysics and Biotechnology, Jagiellonian University in Kraków, Poland*

Prymnesium parvum, the so-called "golden algae", is an algal species responsible for the 2022 disaster in the Oder River. Despite the serious threat that it poses, the methods of its detection are still time-consuming, tedious and ineffective. As a member of a team set to participate in the 2024 iGEM competition, I will present the results of our work, leading to the development of a more accurate technique. Centred around an innovative synthetic biology tool - the SHERLOCK (specific high-sensitivity enzymatic reporter unlocking) system - our test will make preventative monitoring of regions susceptible to algal blooms easier and more efficient.

Single Molecules and Light Microscopy: Breaking Boundaries in Molecular Biology Research

Author: Aleksandra Rzeczyc[1] (aleksandra.rzeczyc@student.uj.edu.pl)

[1] *Jagiellonian University*

In recent years, light microscopy has emerged as a powerful tool in molecular biology research, facilitating the observation of structures at the level of single molecules. In my presentation, I will delve into the advantages and limitations of traditional light microscopy and modern techniques such as confocal microscopy, STED (STimulated Emission Depletion), and STORM (STochastic Optical Reconstruction Microscopy).

I will emphasize the significance of these methods in investigating DNA damage, such as strand breaks, in cells and tissues. Furthermore, I will illustrate how modern light microscopy techniques enable real-time observation of single DNA molecules, opening new avenues for understanding the dynamics of biological processes at the molecular level.

By critically analyzing the advantages and limitations of various microscopy techniques and presenting specific examples of their application in biological research, my presentation aims to shed light on the evolving role of light microscopy in molecular biology and its importance for driving future scientific discoveries.

Stochastic Resetting

Author: Bartosz Żbik[None] (bartosz.zbik@student.uj.edu.pl)

Stochastic resetting is a broad concept referring to restarting a (stochastic) process anew. It can be used to understand or optimise various problems related to first passage dynamics not only in physics but also in computer science (Monte Carlo algorithms), biology (search strategies) or chemistry (reaction kinetics). Despite the verity of systems which may be studied, processes under stochastic resetting share universal properties [1,2]. One of which is a sufficient condition under which the process ends (on average) faster than without resetting. The power of this criterion comes from the fact that it's based only on studies of a process without resetting.

[1] https://doi.org/10.1103/PhysRevLett.118.030603
[2] https://doi.org/10.1103/PhysRevLett.121.050601

Strategies for optical thermometry based on lanthanide single-molecule magnets

Author: Jakub J. Zakrzewski[1] (j.zakrzewski@uj.edu.pl)

Co-authors: Junhao Wang[2] (wang.junhao.gb@u.tsukuba.ac.jp); Mikolaj Zychowicz[1] (mikolaj.zychowicz@uj.edu.pl); Pawel Bonarek[1](pawel.bonarek@uj.edu.pl); Shin-ichi Ohkoshi[3] (ohkoshi@chem.s.u-tokyo.ac.jp); Szymon Chorazy[1] (simon.chorazy@uj.edu.pl)

[1] *Faculty of Chemistry, Jagiellonian University*

[2] *Faculty of Pure and Applied Sciences, University of Tsukuba*

[3] *Department of Chemistry, School of Sciences, The University of Tokyo*

For two decades, anisotropic lanthanide(III) complexes stay at the forefront of research devoted to molecular objects called single-molecule magnets (SMMs), showing magnetic memory effect at the single-ion scale.[1] Nevertheless, the main issue to address for SMMs lies in the temperature working range, with the record held by an organometallic Dy(III) complex, operating up to 80 K.[2] As it is well established, to implement SMMs into novel devices some competitive factors have to be met,[3] we and others focused on luminescence originating from Ln(III) f-f electronic transitions, hard to achieve for classical ferromagnets. We discovered, that the optical signal in the vis or NIR emission ranges can be employed to follow the temperature of Ln(III)-based SMMs, parameter which is crucial in terms of the magnetic memory effect.[4] Here, the different strategies to achieve optical thermometers and their advantages will be presented.

[1] *J. Am. Chem. Soc.* **2003**, *125*, 8694. [2] *Science* **2018**, *362*, *1400*. [3] *Chem. Rev.* **2013**, *113*, 5110. [4] *J. Am. Chem. Soc.* **2020**, *142*, 3970; *Chem. Sci.* **2021**, *12*, 730; *Angew. Chem. Int. Ed.* **2023**, *62*, e202306372.

Study of high-energy photons polarization in Compton scattering using the J-PET detector system

Author: Kamila Kasperska[1] (kamila.kasperska@student.uj.edu.pl)

[1] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University*

The purpose of this work is the study of the high-energy photons polarization in Compton scattering using the Jagiellonian Positron Emission Tomography scanner (J-PET), more specifically finding the distribution of an angle between incoming and scattered photons polarization planes which opens the door for the polarization studies. Although polarization itself is a well studied phenomenon, until now it was only possible to investigate it in a narrow range of energies, using optical methods. J-PET detector, due to its unique construction, allows the registration of high-energetic gamma quanta emitted by the radioactive source and coming from the electron-positron annihilation and also their multiple scatterings. It enables to determine the direction of photons momentum vectors, thus the directions of their polarization. Future measurements of the polarization will allow deeper understanding of the other phenomena, such as quantum entanglement or testing discrete symmetries in the leptonic sector.

Synthesis and study of the properties of new derivatives of tetraazacyclophanes

Author: Maria Adamska[1] (maria.adamska@student.uj.edu.pl)

[1] *Faculty of Chemistry, Jagiellonian University in Kraków, Poland.*

Azacyclphanes, also known as macrocyclic oligoaryl amines, are a group of compounds combining the electrodonor and acid-base properties of nitrogen heterocycles with the properties of cyclophanes. The Buchwald-Hartwig reaction, catalyzed by palladium, is commonly used for the synthesis of such compounds
The aim of the study was to develop a synthesis path for a tetraazacyclophane derivative and investigate the properties of the transitional macrocycles. The most challenging part of the research was to adjust the cyclization reaction conditions to obtain more than trace amounts of the product and attempt to increase the efficiency of individual steps.
A synthesis of a new, previously unreported in the literature, tetraazacyclophane derivative based on the Buchwald-Hartwig amination reaction was described, and two effective synthetic paths were established. During the study, a three-step reaction path was modified and optymalized. Moreover the choice to synthesize the compound using an alternative four-step method was made. Additionally, modifications introduced in the second reaction step allowed for a twofold increase in yield on a larger scale.

The 3+1 formalism for Maxwell's equations – a concise introduction

Author: Paweł Doruchowski[1] (pawel.doruchowski@gmail.com)

[1] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland*

The 3+1 formalism is a method commonly used in numerical general relativity, based on a decomposition (foliation) of spacetime into a one-parameter family of spacelike hypersurfaces, which turns out to be possible for a wide class of spacetimes. This technique is very useful as it allows one to write equations that need to be solved (e.g. the Einstein equations) in a form convenient for computer treatment.

In my talk I will briefly describe the concept of foliation on the example of electrodynamics in axisymmetric spacetimes. In particular, I will show how from the Faraday tensor one can construct the electric and magnetic fields which live on the hypersurfaces and obey Maxwell's equations. This picture leads, when combined with the plasma part, to the famous Grad-Shafranov equation, governing magnetohydrodynamical equilibria in accretion disks around rotating black holes.

The Kakeya problem

Author: Izabela Mandla[None] (s36imand@uni-bonn.de)

Let's think about a puzzle. Take a needle (yes, the same one you normally use to sew holes in your socks) and draw a random shape on paper such that the needle fits inside. The question is: can you rotate the needle in such a way that it will not go outside of the lines at any moment? No? Try to draw another shape. Yes? That's great. Now do it again, but this time let it be smaller. The idea is to find the smallest possible shape in which this rotation would be possible. Seems hard? Because it is. But I will not say anything more now. I will cover the topic of this problem, known as the Kakeya problem, as well as its connections to harmonic analysis during my talk.

The Prospects of Gravitational Waves Astronomy

Author: Dominik Rudka[1] (dominik.rudka@student.uj.edu.pl)

[1] *FAIS, UJ*

After first direct detection of gravitational waves (GWs) in 2015 the new window for studying the cosmos is open. New branch of astronomy using the GWs is capable of analysing the strong dynamical regime of gravitational field in order to probe the new and old physical theories and may be able to address the fundamental questions in astrophysics such as:

evolution of binary systems (BSs) consisted of black holes (BHs) or neutron stars (NSs), the inner structure of neutron stars, the physics of the early universe, the nature of dark energy and many others. Below I present the most important information about physics behind the GWs and about detectors LIGO and Virgo worth to know. Next, the chosen problems in astrophysics which can be addressed through gravitational-wave observations are explained in more detail. Finally, plans for the KAGRA and LIGO-India detectors are discussed.

The long way from SMP and back after 30 years: reflections on science and scientific careers

Author: Malgorzata Lagisz[1] (m.lagisz@unsw.edu.au)

[1] *University of New South Wales Sydney, Australia*

In this talk I will briefly introduce my scientific pathway – starting from the first cohort of SMP students, then shifting between different countries and research topics, to the current joys of doing cross-disciplinary collaborative meta-research at a global scale. I will try to convince you that meta-research is a little known but rapidly growing field of research of critical importance (and super-interesting too). Because, if we (as individual researchers or research-related organisations) do not know how well (or bad) we are doing, where there the problems are, and what works – how can we improve? This applies at all scales. From a perspective of individual scientists, paying attention to the studies investigating research-related institutions and processes can help you to understand and better navigate this wicked system. In my talk, I will provide some engaging examples from research of my colleagues and my own. So, if you heard about research bias, research waste, or reproducibility crisis in science – this talk is for you. If you have not heard about any of these – you should definitely listen to it.

The reachability problem for Petri nets.

Author: Łukasz Kamiński[1] (l.kaminski5@uw.edu.pl)

[1] *University of Warsaw*

A *Petri net* is a mathematical modeling language, which is used mainly for verification of concurrent programs, but it also can model processes in economy or even in biology and chemistry. One of the advantages is the simplicity: a Petri net consists of a set of places on which we can put tokens, and a set of transitions i.e. rules according to which we can add and remove tokens from places. The reachability problem is to decide whether for a given Petri net and two configurations one is reachable from the another. This problem was shown to be decidable (i.e. there is an algorithm that solves it) over 40 years ago, but

until 2021 the exact computational complexity was not known! The reachability problem is Ackermann-complete, which means that its complexity is so huge, that it cannot be bounded by any elementary function. In my talk I will explain what is a Petri net using examples and mini tasks that I hope will be fun. Then I will define the Ackermann complexity class, convince you that it is really big, and at the end I will talk shortly about the history and open questions.

The recent cosmological measurements vs $f(R)$ theory

Author: Aleksander Lenart[1] (lenart.a.lenart@gmail.com)

[1] *Astronomical Observatory, Jagiellonian University in Kraków*

The recent high z measurements of Quasars and Gamma-ray attenuation constrained a matter density parameter Ω_M at 0.23 and 0.20, respectively. Given that the low-z measurements with SNe Ia converge around $\Omega_M = 0.3$, a question arises: is there a new tension in cosmology? The community is very early in this investigation, but surprisingly, a long-known model could account for such a phenomenon. The $f(R)$ gravity reconstructs both low and high-distance measurements. I will present an overview of the recent measurements and the $f(R)$ correction derivation. I will compare the traditional ΛCDM model with the one obtained for $f(R)$ gravity.

Tidal Phenomena

Author: Adam Ciesielski[1] (adam.ciesielski@igik.edu.pl)

[1] *Institute of Geodesy and Cartography in Warsaw*

Gravity is a fundamental interaction that causes mutual attraction between all objects with mass. Despite being the weakest of the known fundamental forces, it is the most significant one between macroscopic objects, determining the motion of celestial bodies. While the common description assumes point-mass objects, celestial bodies such as the Earth are not. As a result, the gravitational attraction from an external body on an extended body is not uniform, which is a reason for tides.

Astronomy and planetary sciences have a strong interest in the tidal deformation, disruption, or dismantling of all kinds of celestial bodies, such as planets, comets, stars, or even whole galaxies. On Earth, which is of particular interest to geophysicists, tides are primarily generated by two bodies: the Moon and the Sun. They manifest as well-known ocean tides - the rise and fall of sea levels, frequently referred to as simply “tides”. These tides play a major role in shaping our climate, and they influence marine ecosystems. However, they also exist as solid Earth or crustal tides, sometimes named Earth body tides. The Earth’s body deforms because it is elastic (like a ball); therefore, the repetitive smooth displacement of the solid surface - with semidiurnal amplitude even up to 50 cm - takes place all the time. These tides interrupt geodetic measurements and geophysical exploration. Both ocean tides

and body tides are still not well investigated, making them difficult to predict accurately, despite the tidal force being well understood in celestial mechanics (astronomy).

I will introduce you to tides and show their power in the universe. I will demonstrate what tides cause on Earth and explain in detail the complexity they bring. To sum up, the applications of tides, tidal analysis, and gravimetry will be unveiled.

Time-Travelling Proteins: Unraveling Biochemical Evolution through Ancestral Sequence Reconstruction

Author: Marta Luterek[1] (marta.luterek@student.uj.edu.pl)

[1] *Jagiellonian University in Krakow*

One of the central goals in biochemistry is to reveal the relationships between sequence, structure, and function within protein systems. One way to accomplish this is through a vertical evolutionary approach using Ancestral Sequence Reconstruction (ASR). This method relies on a computational inference of an ancestral protein sequence, followed by an experimental workflow that aims to dissect the protein molecular evolution. This talk will delve into the workflow of such an analysis, highlighting its advantages and notable examples. Additionally, it will explore a specific research case, in which ASR was employed to resurrect ancestral features of a cell division system in Archea, in an effort to trace its biochemical evolution.

Topological analysis of literature

Author: Magdalena Grabka[None] (magdalena.grabka000@gmail.com)

This talk introduces the fascinating intersection of topological data analysis (TDA) and literary studies, offering a novel perspective on understanding complex textual structures. I begin by unraveling the intuitive principles behind TDA, emphasizing its ability to capture essential features and relationships within intricate datasets.

Then, I showcase how TDA techniques can be effectively applied to analyze and interpret literary texts. By constructing topological representations based on textual elements, I unveil hidden patterns that transcend traditional approaches.

This interdisciplinary exploration highlights the collaborative potential between mathematics, computer science, and humanities fields.

Twin Paradox and Chaos

Author: Julia Osęka[1] (julia.oseka@student.uj.edu.pl)

[1] *Obserwatorium Astronomiczne Uniwersytetu Jagiellońskiego*

I would like to present a research on the twin paradox for chaotic geodesics. The phenomenon is analysed in the Einstein-Rosen class of spacetimes. The two twins start to fall freely from adjacent positions. Nevertheless, they separate due to the presence of standing gravitational waves. After some time they reunite and notice that they aged differently. The age difference is deterministic yet practically unpredictable in a sense of deterministic chaos.

Uniquely oriented crystals of metal-organic frameworks

Author: Gabriela Kowacz[None] (gabriela.kowacz@student.uj.edu.pl)

Metal-organic frameworks (MOFs) are a subclass of coordination polymers (CPs), distinguished by porosity, applicable in many areas of industry, such as catalysis, gas storage and separation, energy storage or drug delivery. MOFs crystallize in various forms, derived from the structure of the unit cell, internal forces within the structure and other factors.
MOFs can form single crystals as well as more complicated structures, containing multiple single crystals oriented towards one another in a specific way, forming superstructures. Those aggregates can have one- or three-dimensional orientation, influencing some properties of the material, which allows their modification by forming superstructures. One of the 3D-oriented crystals are radially oriented crystallite rods, called spherulites. Those forms can be recognized by a distinctive Maltese cross when observed under polarized light.
Spherulites are mainly formed by polymers, but recently formation of these superstructures was observed in MOF-74. In this talk, a novel isoreticular MOF-74 material forming spherulite superstructures and its potential functionalization by post-synthetic modifications will be presented.

Unrolling tape sound effect

Author: Anastasiya Yushchuk[1] (8225373@gmail.com)

[1] *Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University in Kraków, Poland*

Ever wondered why unrolling adhesive tape can be so surprisingly noisy? Let's dive into the physics behind this seemingly mundane effect together! This talk, inspired by a problem statement from the International Physicists' Tournament 2024, seeks to provide you with both theoretical analyses and practical experiments, exploring the mechanisms behind tape noise generation and ways to maximize and minimize the sound.

Visual Snow Syndrome - Rare or Not So Rare Disorder?

Author: Zuzanna Kościuk[None] (zuzanna.kosciuk@student.uj.edu.pl)

Visual Snow Syndrome is a neurological condition characterised by the persistent presence of a visual disturbance that covers the entire field of vision. The disorder mainly consists of the presence of small flashing dots in the visual field, some of which are darker than the background, while the rest are lighter. This phenomenon is compared to the snowing present in analogue television. Visual snow is equally often accompanied by symptoms such as palinopsia (persistence or recurrence of an image after the original image has been removed), photophobia (sensitivity to light), entopic phenomena (visual effects derived from within the eye) or nyctalopia (impaired night vision). It is considered a rare condition, but estimating the number of people affected is difficult. Interestingly, it is not a disease related to the visual apparatus, but a disturbance of the activity of the brain itself. Research to date is scarce and the greatest interest only began at the beginning of this decade. The purpose of this report is to discuss the symptomatology, diagnosis, pathophysiology and therapies, based on the latest scientific research, in order to raise awareness of Visual Snow Syndrome.

X-ray magnetic circular dichroism spectroscopy as an advanced tool for studying magnetic materials

Author: Dominik Dzierżek[1] (domos445@gmail.com)

[1] *Jagiellonian University Faculty of Chemistry*

Started by Michael Faraday in 1845, the studies on numerous magneto-optical phenomena, i.e. changes in the interactions between electromagnetic radiation and matter provoked by the presence of a magnetic field in a material, played a key role in understanding the quantum nature of light and matter. To this day, the implementation of research techniques deeply embedded in the relationship between magnetic field and light results in advancements and broadening the understanding in many key fields including astrophysics or electronics. Furthermore, X-ray magnetic circular dichroism (XMCD) is particularly useful in studying magnetic materials. It enables an unambiguous determination of the spin and orbital contribu-tions to the magnetic moments of specific elements.[1] This capability proves particularly valua-ble in the field of molecular magnetic materials and photomagnets, which show promise as candidates in emerging advanced technologies such as magneto-optical ultra-high density data storage.

The presentation will introduce XMCD spectroscopy as a tool for studying magnetic materials and will cover its fundamentals as well as some specific applications.

Acknowledgements

Organizers

⊗ Coordinator: Aleksander Lenart, Bartosz Żbik

⊗ Co-organizers: Gabriela Kowacz, Mateusz Winiarski

⊗ Technical support: Mateusz Winiarski, Maciej Ziobro, Hubert Hermann

⊗ Graphic project: Maria Rybak, Jakub Wida

⊗ Overwhelmers: Marianna Dekert, Joanna Doliwa, Dominik Piasecki, Magdalena Stalicka

⊗ Special thanks to all the members of KMPSUJ association

Honorary Committee

⊕ Joanna Grabocińska, Office of Mathematical and Natural Sciences Studies

⊕ Prof. Ewa Gudowska-Nowak, Dean of Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University

⊕ Prof. Romuald Janik, Director of Mathematical and Natural Sciences Studies

⊕ Prof. Leszek Motyka, Chairman of the Advisory Board of Mathematical and Natural Sciences Studies

⊕ Prof. Andrzej Siódmok, Representant of SMP graduates

⊕ Prof. Jakub Zakrzewski, Supervisor of Jagiellonian University Mathematics and Natural Sciences Students' Organization

⊕ Prof. Karol Życzkowski, Chairman of Krakow Branch of the Polish Academy of Sciences

Honorary Patronage of the Rector of the Jagiellonian University

Sponsors and Partners

Centre for Interdisciplinary Individual Studies in Mathematics and Natural Sciences

Jagiellonian University units:

- Faculty of Physics, Astronomy and Applied Computer Science of Jagiellonian University
- Faculty of Chemistry
- Faculty of Biochemistry, Biophysics and Biotechnology
- Faculty of Mathematics and Computer Science
- Faculty of Biology
- Faculty of Geography and Geology
- Institute of Theoretical Physics
- Student's Council at the Faculty of Physics, Astronomy and Applied Computer Science

Jagiellonian University Council of Student Circles

The Foundation of Students and Graduates of the Jagiellonian University "Bratniak"

Copernicus Center for Interdisciplinary Studies of the Jagiellonian University

Polish Academy of Sciences, branch in Kraków

Julia Programming Language

JuliaHub

Polish Children's Fund

Planetarium – Silesian Science Park

MyGen Students Association of Jagiellonian University

Jagiellonian University Scientific Association of Astronomy Students

The Zaremba Society of Mathematicians - Students of the Jagiellonian University