ICPS 2024

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Free University of Tbilisi

Report of Abstracts

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What is gravity?

Author: Gia Dvali[None]

Black holes are the most compact objects of nature exhibiting properties that for a long time were viewed as mysterious. However, it has been understood recently that these features emerge from certain universal phenomena and are fully shared by a large class of objects. This understanding has a wide range of implications for fundamental physics, cosmology and quantum information. We review the subject and discuss applications for the primordial black holes as dark matter and cosmology.

Student Lectures (Computational Methods for Physics Applications) / 23

Mobility dynamics during the SARS-COV-2 pandemics across different levels of imposed measures

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The onset of the SARS-COV-2 pandemic has drastically changed the everyday lives of people, communities, and countries. Humans quickly adapted work methods for productivity, while mobility and social life underwent dramatic transformations. In this work, we study how the mobility patterns between administrative regions changed during two years of the pandemic. Specifically, we are focused on the change in the network structure of mobility between regions, both in topology and intensity. We obtained data from the Data For Good initiative about mobility between regions in four countries: Italy, Sweden, Great Britain, and Brazil. We map this data onto binary and weighted networks and measure how they change with time, focusing on their differences. Specifically, we study how the difference between successive networks, daily networks, and weekly networks change with time during a two-year period by using network portrait divergence as measure of change. We create a time series of divergence for three types of binary networks, adjacent, daily, and weekly, and therefore weighted networks for each country. We study the multifractality of these time series, the temporal patterns for each time series, and trends.
Our results show that the average differences are increasing with the time window size between the two compared networks, with adjacent networks being the most and weekly networks being the least similar. The average difference is changing between countries, with Brazil showing the most stable mobility networks, both binary and weighted, and Great Britain having the highest average difference for both types of networks. While one would expect more stable, predictable, and less variable signals for countries with strict rules, such as Italy and Great Britain, our results show that this is not the case.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 4

Photocenter shifts caused by magnetic activity

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Stellar activity phenomena, such as stellar spots, flares, coronal mass ejections are manifestations of the underlying magnetic dynamo, thus studying them is an important input for theoretical models. Doppler imaging is an extensively tested and used spot modeling technique. We utilize this technique to derive Doppler images of well-known active stars (young solar type stars as well as giants, including EK Dra, II Peg, V815 Her, V889 Her, DI Psc) using spectral time series from Piszkéstető observatory from 2022 and 2023. Stellar activity tracers, mostly stellar spots can cause the photocenter of the star to shift from the geometric center. Since spot distributions are non-uniform and active stars rotate rapidly, this photocenter shift can vary over time with the rotation of the star. We use our Doppler maps to calculate the photocenter shifts of these stars caused by the joint effect of rotation and stellar spots and measure its change during a single rotation to estimate the possible effect of this phenomenon on the precision of parallax measurements to see whether it is comparable to the precision of Gaia. Moreover, comparing these shifts on different types of stars could prove an insight into the different types of dynamos working on different stars.

Student Lectures (Computational Methods for Physics Applications) / 33

Deciphering Complexity: Machine Learning Insights into Chaotic Dynamical Systems

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We introduce new machine-learning techniques for analyzing chaotic dynamical systems. The primary objectives of the study include the development of a new and simple method for calculating the Lyapunov exponent using only two trajectory data points unlike traditional methods that require an averaging procedure, the exploration of phase transition graphs from regular periodic to chaotic dynamics to identify "almost integrable" trajectories where conserved quantities deviate from whole numbers, and the identification of "integrable regions" within chaotic trajectories. These methods are applied and tested on two dynamical systems: "Two objects moving on a rod" and the "Henon-Heiles" systems.

Student Lectures (Optics and Lasers) / 103

Trapping light at the nanoscale with 2D materials

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Have you ever wonder why we can't see atoms with our own eyes? Is there anything new or interesting in this tiny scale? This talk uncovers the world of polaritons, quasi-particles from light-matter interaction, as well as some of the latest advancements in Nano-optics, both from a theoretical and experimental perspective. Said researches have great impact in modern chip-on technologies and quantum computing.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 11

Orbital dynamics in galactic potentials subjected to parameter drift

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Context. Time-dependent potentials are common in galactic systems that undergo significant evolution, interactions, or encounters with other galaxies, or when there are dynamic processes like star formation and merging events. Recent studies show that an ensemble approach along with the so-called snapshot framework in dynamical system theory provide a powerful tool to analyze time dependent dynamics.
Aims. In this work, we aim to explore and quantify the phase space structure and dynamical complexity in time-dependent galactic potentials consisting of multiple components.
Methods. We apply the classical method of Poincaré-surface of section to analyze the phase space structure in time-dependent Hamiltonian systems. This, however, makes sense only when the evolution of a large ensemble of initial conditions is followed. Numerical simulations explore the phase space structure of such ensembles while the system undergoes a continuous parameter change. The pair-wise average distance of ensemble members allows us to define a generalized Lyapunov-exponent, that might also be time dependent, to describe the system stability.
Results. We revise the system parameters for the Milky Way and provide a comprehensive dynamical and stability analysis of these systems under circumstances where linear mass transfers undergo between the disk and bulge components of the models.

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Synchronization of Oscillators in a Fluid

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Rich nonlinear dynamics can emerge from hydrodynamic interactions between particles in a fluid. One problem of interest is synchronization in biological flows at the micrometer scale, such as the synchronization of bacterial flagella and the transport of organelles in living organisms by cilia. In this project, we will investigate how oscillating particles in a fluid synchronize due to hydrodynamic interactions. The lattice-Boltzmann method (LBM) will be used to solve fluid dynamics and fluid-solid interaction. We will measure the characteristic time that oscillators take to synchronize as a function of system parameters such as distance, viscosity, and frequency and compare it with predictions from a simple effective model, the Kuramotto model.

Student Lectures (Optics and Lasers) / 142

Preparation and Characterization of Gold Nanoparticles Using Nanosecond Laser Ablation at Different Wavelengths

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In this study, the characterization of the gold nanoparticles (AuNP) produced by exposing 1 g gold bulk in deionized water to the nanosecond laser was made and investigated. The nanoparticles produced with the help of the panel controlled by the servo motor controller, which are moved at same velocities in the optical setup, were examined. Gold nanoparticles (AuNP) are produced using a Q-switched Nd:YAG laser in deionized water via 266 - 355 - 532 - 1064 nm nanosecond laser ablation. Gaussian and Bessel Beams were generated using a convex lens with a focal length of 200 mm and axicon with a base angle of 1°, respectively. It was aimed to characterize and compare the nanoparticles produced at different wavelengths by creating Gaussian and Bessel Beams. SEM and Particle Size Analyzer (Zetasizer) images are used to verify AuNP size distributions. The absorbance is also investigated by UV-Vis Spectrometer. Numerous enhancements about the results from previous study and more detailed comparison is added.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 13

Nanosecond time synchronization of distributed detectors

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The study of cosmic rays –charged particles that traverse the universe at nearly the speed of light –is an important domain within astrophysics. When a cosmic ray particle interacts with an air nucleus in the Earth's upper atmosphere, it induces a so called Extensive Air Shower (EAS).

At the Pierre Auger Observatory, the surface detector stations used to detect and measure these cosmic-ray air showers are placed in a triangular ground pattern with a 1500 m spacing, covering a total area of about 3000 km². Naturally, the need arises to wirelessly synchronize the clocks of each station with one another. Current synchronization methods rely on Global Navigation Satellite Systems (GNSS), like GPS, which typically achieve a relative time synchronization accuracy of 10 to 15 ns.

However, time synchronization with 1 ns or even sub-ns accuracy between these detector stations is a very challenging technological problem. Such wireless time synchronization technology would offer exciting possibilities for advancing the precision of cosmic ray air shower measurements. This extends to various applications within the field, including the utilization of radio-interferometric analysis techniques. More precise measurements would help resolve many outstanding mysteries, such as the composition of Ultra High Energy Cosmic Rays (UHECRs), the identification of their sources, and the understanding of their acceleration mechanisms.

This talk will report on recent findings regarding the capabilities of the latest multi-band GNSS receivers, which implement correction techniques to combat the challenges ordinary GNSS receivers are faced with, as well as report on recent findings concerning the limitations of another promising synchronization technique, the so-called radio beacon reference transmitter, which is deployed at the Auger Engineering Radio Array (AERA), a sub-array of the Pierre Auger Observatory.

Student Lectures (Computational Methods for Physics Applications) / 81

Improving MCMC sampling efficiency with normalizing flows

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The Bayesian data analysis approach combines prior knowledge and observed data to derive information about the parameters of a model. Typically, numerical sampling methods are required for performing Bayesian inference due to the complexity of the models and the high-dimensional parameter spaces involved, as is usually also the case in particle physics applications. Markov Chain

Monte Carlo (MCMC) methods are commonly used to generate samples that approximate the posterior distribution. Machine learning techniques have the potential to enhance MCMC methods by improving the exploration of complex parameter spaces, leading to more accurate results. This talk focuses on normalizing flow models, which allow to transform a complex distribution into a simpler one, thereby improving the sampling efficiency of MCMC algorithms. This presentation introduces an implementation of a normalizing flow enhanced MCMC ensemble algorithm currently being integrated into the Bayesian Analysis Toolkit (BAT.jl). Initial studies on the performance of this new algorithm are presented.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 67

Identifying mass transfer stars from age abundance outliers

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The early universe was composed primarily of hydrogen and helium, and over time, nucleosynthesis led to the formation of other heavier metal elements. Therefore the detailed abundance patterns within stars are indicators of their ages. Using a dataset of 6613 stars from APOKASC, their abundance ratios and asteroseismic ages, we implemented a K-dimensional tree to match each star with another star with the most similar abundance and effective temperature data. By using the median age of the star's neighbors, we predicted its asteroseismic age. If the difference between the predicted and measured asteroseismic ages was substantial, we labeled the star an outlier. Through this process we found 66 outliers whose asteroseismic ages do not match their surface abundances, suggesting mass transfer. Identifying these stars is a step towards better understanding stellar histories and how binary systems can change observed surface compositions of stars. Research into the kinematics and UV fluxes of these stars could confirm the presence of binary interactions.

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Ultrafast pulses and time-resolved spectroscopy of molecular crystals

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Time-resolved spectroscopy has attracted a lot of attention in the last years. Judging by the Physics nobel prizes in 1999, 2018 and 2023, ultrafast techniques based on femtosecond lasers are also still very much on the cutting edge of research. I will present the basics of femtosecond pulse generation. Crucial applications taking advantage of the highly nonlinear processes possible with high-intensity pulses will be explained. A special focus will be laid on our own research involving the workhorse of ultrafast dynamics, the pump-probe technique. We apply it, in the form of transient absorption microscopy, to look into the time-dependent behavior of strongly coupled Squaraine molecular crystals in excited states. This research involves tunable light sources, fast broadband detection and

polarization-, temporally and spatially resolved measurements. A short outlook into the theory of excitonic systems will complement this experiment-focused presentation.

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Detecting Moon and Sun Shadows in Cosmic-Ray Muons: KM3NeT/ORCA's Observational Breakthrough

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This report presents the initial observation of Moon and Sun shadows in the sky within the cosmic-ray induced muon distribution detected by the KM3NeT/ORCA detector. The data were collected from February 2020 to November 2021, during which the detector operated with 6 Detection Units deployed at the seabed of the Mediterranean Sea, each comprising 18 Digital Optical Modules. The shadows cast by the Moon and the Sun were precisely identified at their expected positions, with statistical significances of 4.2 σ and 6.2 σ, respectively. The detector achieved an angular resolution of σres = 0.49° and σres = 0.66° for the Moon and Sun shadows, respectively, consistent with the simulated prediction of 0.53°. This early report confirms the effectiveness of detector calibration in time, position, and orientation, as well as the accuracy of event direction reconstruction. Additionally, it highlights the detector's performance and competitiveness in terms of pointing accuracy and angular resolution.

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Thermodynamic theory of multimoded nonlinear photonic systems

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Lately there has been a renewed interest in studying nonlinear multimoded optical systems, namely optical systems consisting of thousands of optical fibers such as high-speed communication structures. The complexity of interactions in these systems is the reason to numerous exceptional optical effects. This somewhat chaotic process has led to several theoretical challenges which we aren't capable of overcoming by using classical approaches. This work starts by deriving the discrete Schrödinger equation for such systems. Followed by a thermodynamic framework capable of describing the intricate behavior of such photonic configurations. New physical observables like the "Internal Energy" (the mean value of the propagation constant) and the "Optical Entropy" are defined. A new equation of state analogous to that of the conventional thermodynamics is obtained. It is also shown that the optical power together with the "Internal Energy" always flow with respect to the second law of thermodynamics. Lastly, laws of isentropic processes are obtained and the possibility of realizing processes similar to the Carnot Cycle in such photonic systems is presented.

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Time-Reversal Symmetry-Breaking in Charge-Ordered Kagome-Lattice Systems Probed with Muon Spin Rotation

Author: Zurab Guguchia[None]

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Space weather predictions: state of the art and challenges

Author: Stefaan Poedts[None]

Student Lectures (Condensed Matter and Solid State Physics) / 47

Lissajous figures in a quantum walk on a lattice

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The dynamics of a quantum particle on a square lattice subjected to an external constant force is numerically studied. In one dimension, it is well known that if the wave packet is wide enough, the average position over time will evolve in an oscillatory manner, while the shape of the wave packet is preserved. This phenomenon is known as Bloch oscillations and is characteristic for particles moving in periodic systems with a constant gradient. Additionally, in the case of a narrow wave packet, the position of the center does not change over time, but periodic changes in shape are observed. Such behavior is often referred to as the breathing mode. Eventually, we can observe two competing effects, where oscillations dominate for wide wave packets and breathing dominates for narrow ones. We show that for a certain class of initial states, the problem of time evolution of the two-dimensional system can be treated as two independent one-dimensional problems. We mainly focus on showing that it is possible through a combination of Bloch oscillations in both directions to obtain trajectories of a wave packet center analogous to classical Lissajous figures. Visuaization of obtained results can be found here RESULTs.

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Long-time Analysis of High Energy Gamma Ray Signals from Active Galactic Nuclei Jets with the MAGIC Telescopes

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The dynamics and processes of acceleration of photons to very high energies in the jets of Active Galactic Nuclei (AGNs) is an ongoing topic of research in Astroparticle Physics. Time sensitivity and fluctuation in the high-energy photon flux of these AGNs can offer insights into the concept behind the acceleration. Thus, approaches are made to analyze long-time data of AGN sources probing theoretical concepts for the explanation of the acceleration mechanisms.

For the analysis, data from the MAGIC telescopes will be used and the automatation tool autoMAGIC will be utilized enabling structured and fast analysis of long-time data.

Student Lectures (High Energy Physics) / 30

CFL quark stars as a candidate for the HESS J1731-347 object with a trace anomaly and GW190814 bound implementation

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A recent analysis on the central compact object within HESS J1731-347 suggested unique mass and radius properties, rendering it a promising candidate for a self-bound star. In this present study, we examine the capability of quark stars composed of color-flavor locked quark matter to explain the latter object by using its marginalized posterior distribution and imposing it as a constraint on the relevant parameter space. The latter space is further confined due to the additional requirement for a high maximum mass (M_{TOV} ≥2.6 M), accounting for GW190814's secondary companion. Critical emphasis is placed on the speed of sound and the trace anomaly which was proposed as a measure of conformality [Y. Fujimoto et al., Phys. Rev. Lett. 129, 252702 (2022).]. We conclude that color-flavor locked quark stars can reach high masses without violating the conformal or the $\langle\rangle$ 0 bound ($\langle\rangle_B$ being the non-normalized trace anomaly at vanishing temperatures), provided that the quartic coefficient $_4$ (a crucial parameter accounting for pQCD corrections in the matter's thermodynamic potential) does not exceed an upper limit which depends on the established M_{TOV}. For M_{TOV} =$2.6M$, we find that the limit reads $_4$ 0.594. Lastly, a final investigation takes place on the agreement of color-flavor locked quark stars with additional astrophysical objects including the GW170817 and GW190425 events, followed by some concluding remarks.

Student Lectures (Condensed Matter and Solid State Physics) / 57

NV-diamond based wide-field camera and physics-informed neural network approach for analysing biomagnetic sources

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Sensing magnetic fields with nitrogen-vacancy (NV) centers in diamonds promises spatial, temporal and field resolution particularly suitable for biological measurements. The DiaQNOS consortium 1 utilizes diamonds with NVs as a stable and biocompatible platform to create a neurosurgical tool for diagnostics of cancerous cells in brain *in vivo*.

For that, we combine a microwave (MW) free imaging device, leveraging the ground state level anti-crossing (GSLAC) feature in NV centers [2], with a novel tool that employs physics-informed neural networks (PINNs) to analyze the obtained magnetic field distributions. The GSLAC-based tool can be used in environments where MW delivery is complicated or can be harmful to studied objects, such as biological cells. Whereas PINNs enable reconstruction of source distributions, such as currents in biological membranes or other conductive materials [3], vortices in superconductors [4] or magnetization textures [5]. Using neural networks mitigates the challenages posed by the ill-posed nature of the This advancements combined enhance the sensitivity limit of the underlying source distribution, moving towards the development of a biocompatible sensor capable of measuring neuron activity.

1 https://diaqnos.de/
[2] A. Wickenbrock et al., "Microwave-free magnetometry with nitrogen-vacancy centers in dia-

mond,"Appl. Phys. Lett., vol. 109, no. 5, p. 053505, Aug. 2016, doi: 10.1063/1.4960171.
[3] J.-P. Tetienne et al., "Apparent delocalization of the current density in metallic wires observed with diamond nitrogen-vacancy magnetometry,"Phys. Rev. B, vol. 99, no. 1, p. 014436, Jan. 2019, doi: 10.1103/PhysRevB.99.014436.
[4] Y. Schlussel et al., "Wide-Field Imaging of Superconductor Vortices with Electron Spins in Diamond,"Phys. Rev. Appl., vol. 10, no. 3, p. 034032, Sep. 2018, doi: 10.1103/PhysRevApplied.10.034032.
[5] A. E. E. Dubois et al., "Untrained Physically Informed Neural Network for Image Reconstruction of Magnetic Field Sources,"Phys. Rev. Appl., vol. 18, no. 6, p. 064076, Dec. 2022, doi: 10.1103/PhysRevApplied.18.064076.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 40

Investigating the Formation of Heavy Elements in Neutron Star Collisions and Rapid Neutron Capture Process

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The collision of neutron stars and the subsequent rapid neutron capture process serve as the origin of kilonovea radiation, playing a fundamental role in the production of elements heavier than iron in the cosmos. In this paper, we aim to model the kilonovea light curve and the mechanisms of heavy element formation within it. Finally, through comparing observational data with the semi-analytical Arnett model and simulations obtained from the Metzger model, we delve into the details of the models and the exploring parameters governing the temporal evolution of kilonovea light curves.

Student Lectures (High Energy Physics) / 50

The effect of axion exchange on the energy of multi-charged ions

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Axions arise in the context of solving the strong CP - problem in the Peccei-Quinn (PQ) theory, where an additional global U(1) symmetry is introduced in the SM QCD Lagrangian and is spontaneously broken, leading to the appearance of a pseudoscalar pseudo-Nambu-Goldstone boson known as the axion. The dark matter problem is another important challenge in modern physics, and its composition remains uncertain. Axions stand out among several potential candidates for cold dark matter. The role of the axion in solving the strong CP problem and its connection to dark matter make it an interesting object of study.
This study examines the contribution of axion interaction to the energy transitions of lithium-like ions. Precision atomic spectroscopy methods have proven exceptionally effective for testing the Standard Model and detecting deviations from its various modifications. Axion exchange can cause shifts in energy levels in the compounds under consideration. This study involves measuring these energy shifts. The data obtained will help establish constraints on the axion interaction constant.
In our work, a universal expression for the axion reduced matrix element has been obtained. This

matrix element is similar to the Breit part of the photon matrix element, which leads to the investigation of systems where the Breit contribution is prominently expressed. Such systems typically involve heavy charged ions, meaning that the probability of detecting axion contributions is high. The plan for future research includes searching for specific systems in which the Breit contribution is well-expressed.

Student Lectures (Condensed Matter and Solid State Physics) / 70

Nanowire-based Single Photon Sources

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Single-photon sources are crucial components in quantum photonics applications, such as quantum communications or computing. Ideally, these sources emit one photon at a time, are highly efficient, and can be integrated into photonic circuits for complex quantum system designs. Various platforms have been explored to achieve such sources, with semiconductor quantum dots being particularly attractive. Specifically, quantum dots embedded in III-V semiconductor nanowires have demonstrated high performance and practicality in fabrication and integration. In this talk, I aim to explain the applications of single photon sources, their theoretical physical principles, their strengths and challenges associated with their practical usage, the advantages and fabrication process of nanowire-based single photon sources and this technology's state-of-the-art.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 53

Anomalies of the Earth's magnetic field caused by meteorite impacts

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As part of the research into Earth's magnetic field conducted by the Faculty of Physics at the University of Warsaw, studies are being carried out on magnetic anomalies caused by meteorite impacts. These celestial objects, upon striking the Earth's surface, have left distinct traces by disrupting the magnetic field values. The research focuses on the most significant impact craters in Europe, including those in Poland, the Baltic countries, and the Scandinavian countries. During the upcoming conference, the presentation will feature the measurement results from the Morasko crater in Poland and possibly other craters, depending on the project's progress by the time of the conference. Additionally, there are plans to investigate sites in Italy and Greece that may potentially be impact craters, although their origin as meteorite impacts has yet to be confirmed.

Student Lectures (High Energy Physics) / 173

Opening up baryon number violating operators

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Baryon number violation is our most sensitive probe of physics beyond the Standard Model. Its realization through heavy new particles can be conveniently encoded in higher-dimensional operators that allow for a model-agnostic analysis. The unparalleled sensitivity of nuclear decays to baryon number violation makes it possible to probe effective operators of very high mass dimension, far beyond the commonly discussed dimension-six operators. To facilitate studies of this ginormous and scarcely explored testable operator landscape we provide the exhaustive set of UV completions for baryon-number-violating operators up to mass dimension 15, which corresponds roughly to the border of sensitivity. In addition to the known Standard Model fields we also include right-handed neutrinos in our operators.

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Extended XY model with n-(n+3) interaction

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We delve into the extended XY model with an n-(n+3) interaction, inspired by the research of Titvinidze and Japaridze in 2003, which introduced the XY model with an n-(n+2) interaction term. First, we investigate the isotropic case, when Jx = Jy. Subsequently, we extend our exploration to include anisotropic considerations. This study aims to elucidate the distinctive characteristics of both isotropic and anisotropic configurations within the extended XY model framework.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 15

Measuring Fast Radio Burst (FRB) Scintillations Using CHIME Catalog1 Data

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Fast Radio Bursts (FRBs) are millisecond-duration bursts of radio waves that mostly originate from outside our galaxy. Although their exact causes remain uncertain, astronomers are now beginning to use these bursts as tools to probe the cosmos. One of the remarkable properties of these radio transients are their scintillations, which are variations in brightness caused by the scattering due to the irregularities in the intervening medium. These scintillations can be used as a tool to study the properties of the intervening medium and the FRB source itself.

We develop a pipeline to measure the scintillations for some of the brightest FRBs using CHIME Catalog1 Data. The result are then compared with the scintillation model in the Milky way and constrain the origin of the scattering of FRBs.

Student Lectures (High Energy Physics) / 102

The Quark Propagator for Timelike Momenta

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The fully dressed quark propagator describes the behavior of strongly interacting quarks inside hadrons. Because of their strong coupling, in the low-momentum domain this propagator can be calculated only nonpertubatively, using either lattice or functional methods. The latter method leads to the quark Dyson-Schwinger equation, a nonlinear integral equation which is self-consistent in the quark propagator. Solving it for timelike quark momenta gets challenging as poles and cuts arise, either from the quark propagator itself or from the gluon propagator coupled to it. To handle them, methods such as contour deformation or the Cauchy method have to be employed at several stages of the calculation.

Student Lectures (Condensed Matter and Solid State Physics) / 88

Extended XY model with four-spin interaction

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This poster delves into the extended XY model with an n-(n+3) interaction, inspired by the research of Titvinidze and Japaridze in 2003, which introduced the XY model with an n-(n+2) interaction term. First, we investigate the isotropic case, when $J_x = J_y$. Subsequently, we extend our exploration to include anisotropic considerations. This study aims to elucidate the distinctive characteristics of both isotropic and anisotropic configurations within the extended XY model framework.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 73

The Effects of Ultra-Light Axions on Cosmological Structure Formation

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The details of cosmological structure formation has attracted a vast amount of interest from both theoretical and observational perspectives; Especially in recent years due to the computational advancements in simulation methods. The ΛCDM model has been realized as the standard cosmological scenario to date which attempts to explain the observations of our universe from small to large scales. However, it faces some inconsistencies interpreting small scale structures and the late time expansion of the cosmos, which has opened the door for new physical models. Ultra-light axion-like (ULAL) particles are proposed as a viable candidate for dark matter and it is of great interest to consider the ingredients induced by these particles on cosmological evolution and its structure formation. In this talk, I intend to review the standard cosmological perturbation theory used to model the growth and formation of structure of our universe, then investigate the new imprints of ULAL particles in this scenario. Next, I'm going to use a semi-analytical method to display the consistency of ULAL with ΛCDM in large scales, and introduce its new predictions for small scales and its deviation from the ΛCDM model.

Student Lectures (High Energy Physics) / 145

Electron motion and Landau levels in Dirac monopole magnetic fields

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In this thesis, we study the landau levels of electrons moving in a magnetic field with spherical symmetry produced by a Dirac monopole. The Electrons in this study are considered to move on the surface of a sphere—traditional approaches to solving this problem mostly involve solving Schrödinger' s equation. However, in my work, we find eigenfunctions using group theory. We construct ladder operators with angular momentum operators, which also simplifies computational processes. By repeatedly applying the ladder operator to the lowest Landau level function, specifically when the quantum number $m = -\ell$, we derive the general solution for the eigenfunctions.

My research further extends to examining the behavior of electrons in a cylindrical magnetic field, where the magnetic flux emerges from a cylindrical surface. In this case, finding the wavefunctions by solving Schrödinger's equation in a cylindrical coordinate system is simpler. Additionally, we present an alternative method of obtaining the same result by solving the problem in 2D, where the magnetic field is in the z-direction. To match the results obtained in the cylindrical geometry, we use the Landau gauge and restrict the y-dimension to $0 < y < L$, with the periodicity condition applied.

To sum up, this work provides important new understandings of quantum dynamics in non-traditional magnetic fields. This thesis provides a strong basis for future research and development in this important area by thoroughly examining electron behavior in unique magnetic field configurations.

Student Lectures (Condensed Matter and Solid State Physics) / 202

Enhancing properties of rare-earth-based double perovskites (R2NiMnO6, R = Er, Nd) through synthesis procedure optimization

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Double perovskites have gained some ground on research studies, once we can replace half of the B-site cations with other B' cations and achieve rock salt ordering between them, exhibiting extraordinary properties compared to the simple perovskite structure. 1

Rare-earth-based double perovskites, Er2NiMnO6 and Nd2NiMnO6, were prepared by solid-state reaction [2], where a synthesis optimization was performed (decreasing the number and temperature of the annealing), and where Manganese content was studied. Structural analysis was conducted with room temperature X-ray diffraction (XRD), and magnetic measurements were taken to analyze

their field and temperature dependence. Morphological characterization using scanning electron microscopy (SEM) was performed to characterize the grain size distribution of the particles.

Results show that the XRD pattern obtained is consistent with the conventional powder XRD pattern, showing a decrease on the intensity of the impurity phase peak [3] with the addition of Manganese oxide and further annealing. Magnetic measurements show the same behaviour seen in literature [2], exhibiting PM-FM and FM-AFM transitions. For the Nd2NiMnO6 sample, an impurity second-phase transition is still present in our results, although we expect that a final annealing at a higher temperature will remove it. [3] The magnetocaloric effect shows promising results demonstrating the potential for high efficiency magnetic refrigeration.

Acknowledgments: This work was performed within the IFIMUP group and supported by the projects UIDB/04968/2020, UIDP/04968/2020 and FCT/EME-TED/3099/2020 from Fundação para a Ciência e Tecnologia (FCT). GNPO acknowledges a contract with reference 10.54499/DL57/2016/CP1454/CT0021; J.H. Belo acknowledges FCT for his contract with reference 10.54499/DL57/2016/CP1454/CT0013.

References
1 DOI: 10.1021/acs.inorgchem.5b01951
[2] DOI: 10.1088/0022-3727/44/24/245405
[3] DOI: 10.1016/j.ssc.2016.04.020

Student Lectures (Astrophysics, Astronomy, Cosmology) / 157

Maximal Energy of Centrifugally Accelerated Electrons Near Primordial Black Holes

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The electrons are assumed to be attached to the magnetic field lines of low mass black holes (10^(-3) – 1 Solar Mass). Their acceleration by relativistic centrifugal force is studied. The main factors limiting their maximal energies are considered to be the Inverse Compton effect, Larmor radiation and the inability of low magnetic field to hold high energy electrons. These effects are numerically analysed and based on that the behaviour of an electron with certain initial conditions is studied.

Workshops / 200

Journey towards the Sun: how modern space missions are revolutionising solar physics

Author: Adam J. Finley[None]

Tutorials / 58

I want to break symmetry

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Symmetries turn out to be a very useful concept in physics again and again - especially when describing the smallest particles. That's what the Standard Model of particle physics is based on. But what if math deserts you and you cannot use your theory to calculate the quantities you're interested in? Go effective! This tutorial will outline how to find an effective field theory describing the interactions of the lightest hadrons at small energies, based on symmetry considerations. We will give a short introduction into symmetry groups and some of the fundamental building blocks of the field theories involved. Then we will derive step by step the emergence of chiral perturbation theory, introducing important physical relations along the way. But be aware - during this journey, some of our symmetries might break!

Table of contents
- symmetries, group theory, continuous groups
- QCD and the QCD Lagrangian, colours and flavours
- QCD at low energies: confinement and breakdown of perturbation theory
- effective field theories, pertinent degrees of freedom
- chirality as a symmetry of the massless QCD Lagrangian
- decomposition of the symmetry group, Wigner-Weyl vs Nambu-Goldstone mode
- spontaneous symmetry breaking and the Goldstone theorem
- the chiral Lagrangian at lowest order from symmetry considerations
- explicit symmetry breaking through the mass term
- low energy constants and higher-order terms

Tutorials / **66**

Mastering Professional Tools for Physicists: CVs, Cover Letters, and LinkedIn Optimization

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Abstract:
In today's competitive job market, having a well-crafted CV, a compelling cover letter, and a professional LinkedIn profile is essential for any aspiring physicist. This tutorial will provide a comprehensive guide to creating these crucial professional documents. We will cover the fundamental principles of writing an effective CV tailored to physics-related roles, composing persuasive cover letters that highlight your strengths and achievements, and optimizing your LinkedIn profile to attract potential employers and collaborators. Through interactive discussions and hands-on exercises, participants will learn practical tips and strategies to enhance their professional presence and increase their chances of success in the job market.

Table of Contents:

1. Introduction to Professional Documentation (5 minutes).
2. Crafting an Effective CV (15 minutes).
3. Writing a Persuasive Cover Letter (15 minutes).
4. Optimizing Your LinkedIn Profile (15 minutes).
5. Interactive Workshop and Q&A (10 minutes).

Tutorials / **25**

Taming systematic uncertainties in experimental physics analyses.

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Evaluating systematic uncertainties takes a significant amount of time and effort in many physics analyses. During their lab courses, many students learn to identify possible sources of systematic uncertainties and how to quantify them. However, they are usually not exposed to handling them using statistical methods. In this tutorial, I will offer a brief overview on parameter estimation with fits and show how this can be implemented using Python. Next, I will explain how systematic uncertainties can be incorporated to a model using nuisance parameters and other methods. Using simple examples from particle physics ,such as counting experiments and a signal plus background fit, I will illustrate how the final uncertainties on a parameter of interest change when we follow these procedures and how to estimate their effect on a measurement.

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Solving Differential Equations Using Lie Groups

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This tutorial will teach about using Lie group theory to solve differential equations. Point transformations will be introduced. The theoretical framework involves defining one-parameter groups of point transformations and their associated infinitesimal generators. We demonstrate the utility of this approach through examples, highlighting how symmetry conditions can simplify the resolution of complex differential equations. The concept of prolongation is introduced to extend transformations to higher-order derivatives, allowing for the comprehensive handling of differential systems. Practical applications are provided, showcasing the effectiveness of Lie symmetries in reducing the order of differential equations, thus facilitating their solution. We will use Mathematica for ease of calculations.

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Vitals for the young scientist

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Our team, within the framework of the tutorial, offers to get acquainted with the basic software skills for any student who wants to successfully integrate into the scientific environment. We will talk about CV, cover letter, motivational letter and personal statement, showing differences between these kinds of papers. We offer a short guide on writing them, in which we will look at some of the pitfalls. Next, we will look at the techniques of nonviolent communication and, perhaps, try them in practice in the context of a small interactive. The main part of the narrative will be concluded with tips on the theme, everyone has ever thought about: "How to combine science and personal life?". At the end of our speech, we would like to share the experience of students' integration into the scientific environment in our country and mention several international cooperation programs in which students can participate.

Poster Sessions (Quantum Technology) - Board: `QT-P-05` / **90**

Towards quantum many-body physics with highly magnetic atoms of Dysprosium

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Ultracold quantum gases achieve exquisite platforms to explore few- and many-body phenomena with extreme control. Being the most magnetic element of the periodic table, dysprosium presents strong interatomic dipole-dipole interactions. Contrasting with the standard contact interactions, the dipolar interactions are long-range and anisotropic.
The relative strength between both types of interactions can be tuned via modification of the scattering length near Feshbach resonances. Within the last years, these properties led to exciting novel discoveries. Some of these arising exotic phenomena are supersolidity, topological ordering and the formation of droplets or droplet crystals.

This experiment aims in particular to a reduction of the dimensionality of the dysprosium quantum gas by restricting it to two dimensions. For this, an accordion lattice for tailorable quasi 2D traps and an objective setup to probe and perturb the atomic cloud with sub-micron resolution are currently being implemented.

The overall goal is to explore and understand not only which exotic phases form in quantum gases under the influence of dipolar interactions in lower dimensional space, but also: How these orders arise? What are the underlying phase transitions and how do the states evolve dynamically when crossing them? How do these states behave far from equilibrium? How do they equilibrate? And with particular interest: What is the role of the topological defects that the exotic states can host in the various aspects of these behaviors?

With the poster "Towards quantum many-body physics with highly magnetic atoms of Dysprosium" we give an overview over the current implementations into the experimental setup and a perspective regarding the exotic phases that are soon being experimentally investigated in lower dimensions.

Poster Sessions (Nuclear Physics) - Board: `NP-P-01` / **76**

Study of the effects of multiple Coulomb scattering in a system of proportional chambers in an experiment on precision measurement of the proton radius in ep-scattering

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Since the 2010 the Proton Radius Puzzle appeared and many groups all around the world are trying to solve it. There are two main ways to solve it - hydrogen spectroscopy and muonic hydrogen spectroscopy.
Scientists of Petersburg Institute of Nuclear Physics are constructing the new experimental setup to measure the proton radius via hydrogen spectroscopy. The experiment is called PRES and is already at the implementation stage.
Before the launch of the setup it is very important to calculate all the possible deviations in the

theory and expected results. So as the proportional counters are used in the setup, which electrons are scatter through, all possible physical effects must be taken into account.
So, the purpose of the work was to study the effects of multiple Coulmb scattering of electron in the system of proportional chambers in elastic ep-scattering for PRES experiment. Software packages based on Monte-Carlo method were used. The GEANT4 software was used to make a model of the setup with the needed physical features and parameters. The resulting statistical data from the model was written and further explored with the help of ROOT program software.
As the result of this work the effects of multiple Coulomb scattering of electrons for PRES experiment are studied and possible deviation in experimental data is predicted.

Poster Sessions (Biophysics) - Board: `Bph-P-04` / **94**

Plastic Waste & Human Health

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How micro/nanoplastics affect human health is the topic of my Bachelor's thesis that I'm just starting. Since I'm at the beginning of research and writing, the topic may become more specific during the process, e.g. how plastic waste affects the respiratory system or neurology.

Poster Sessions (Quantum Technology) - Board: `QT-P-03` / **52**

Generation of Non-classical States Using Optomechanics

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This project aimed to generate nonclassical states among micro and macro-objects. For this, we considered a cavity with perfectly reflecting mirrors where one of the mirrors was oscillating. Our desired outcome was to show that we can entangle classical macro-objects with micro-objects, such as a mechanical mirror and a photon, using quantum optics. The entanglement of classical objects would be a very interesting result, as commonly entanglement was only known to be applicable to microscopic particles. Further, we used our results to generate the non-classical Schrodinger Cat States of the cavity field. Finally, we applied this optomechanics in a Mach Zehnder interferometer and studied the effect on path knowledge and fringe visibility.

Poster Sessions (Earth Sciences) - Board: `ES-P-01` / **86**

ANALYSIS OF PARTICULATE MATTER PM2.5 AND PM10 OVER DIFFERENT REGIONS OF NEPAL

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Particulate matter (PM) pollution, a global environmental and public health challenge, necessitates a detailed analysis of PM2.5 and PM10 levels across diverse regions of Nepal. Study of how PM2.5 and PM10 levels vary across different regions of Nepal and over different human intervention is crucial for a comprehensive analysis. A spectral analysis, including the application of Continuous Wavelet Transform (CWT), has been used to examine the temporal and geographical dynamics of PM2.5 and PM10 over the course of a year. Our study reveals that the Himalayan region exhibits consistently low maximum pollution levels due to highly sparse population distribution. Particularly noteworthy is the Terai region, where PM levels surpass those in the Hilly region despite comparable population density. The spectral analysis using CWT shows a subtle yet recurring annual periodicity in PM variations, marked by varying intensities each year. This comprehensive analysis enhances our understanding of air quality dynamics in Nepal, offering valuable insights into localized variations and seasonally influenced pollution patterns. The findings hold significance for environmental management and public health policies, emphasizing the need for tailored interventions considering regional and temporal aspects in PM influenced pollution.

Keywords: Particulate Matter, PM2.5, PM10, Continuous Wavelet Transform (CWT), Air pollution.

Poster Sessions (Interdisciplinary/Other) - Board: `ID-P-02` / **122**

A Novel 3D Printed Anatomical Prostate Phantom for Investigating Advanced Imaging in Radiotherapy

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Background
CT images are required to create a radiotherapy treatment plan. Metal hip implants can cause streaking and distortions in CT images, which can lead to inaccuracies in dose calculation and cause difficulties in visualising the target area. Iterative metal artefact reduction (iMAR) is a sophisticated algorithm designed to reduce the negative impact of metal artefacts and improve the qualitative and quantitative information gained from CT imaging. The aim of this work was to investigate the effect of different preset types of iMAR on the assignment of accurate Hounsfield Units (HUs) , spatial resolution and contrast resolution using a commercial image quality phantom and a bespoke 3D-printed pelvic phantom with a single metal hip or bilateral metal hips.
Methods
The commercial image quality phantom was setup within the 3D-printed anatomical pelvic phantom and scanned using a Siemens CT scanner for three setups including a single metal hip, bilateral metal hips and no metal hips. The images were analysed using ImageJ to explore the effects of iMAR on CT image quality.
Results
The Hip iMAR protocol, designed by Siemens, was effective in improving the accuracy of the HUs assigned to materials; for example when looking at the HU assigned to a 3D-printed replica of the prostate and bladder, the streaking caused by the bilateral metal hips had significant impact on the bladder and prostate with both being assigned significantly lower HUs values than expected of -88±64HU and -65±76HU respectively. When the Hip iMAR was introduced, the prostate and bladder values were -10±7HU and 53±8HU which are in line with the expected values of 2±9HU and 63±10HU.
Conclusion
From this investigation, it was established that iMAR is a useful and effective tool for reducing the negative effects of metal artefacts caused by metal hip implants when the Hip iMAR protocol is used.

Poster Sessions (Earth Sciences) - Board: `ES-P-03` / **34**

Geophysical Investigations of Mining Waste Heaps in the RAF Project

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The geophysical-geological component of the RAF (Radagost Astral Forge) analog space base project aimed to investigate anomalies in the Earth's magnetic field. Mining waste heaps presented particularly intriguing research subjects due to spontaneous combustion, which caused magnetic anomalies and the formation of new minerals. These heaps had been insufficiently studied thus far, and this project sought to enhance understanding of the occurrence of minerals that disrupt the magnetic field.

A magnetometer was used to measure the Earth's magnetic field in the locations of mining heaps. In our studies, the magnetometer needed to be placed on a special frame made of non-magnetic materials such as aluminum. Astronauts themselves were highly magnetic and therefore had to avoid direct contact with the magnetometer probe.

During our mission, we gathered rock samples to later examine their magnetic properties. Studies of these samples complemented field magnetometer measurements. The samples were analyzed using a rotational magnetometer, and the results were compared with the Earth's magnetic field values to identify the presence of minerals with ferromagnetic properties on the heaps.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `AAC-P-03` / **2**

A Study of the Connection Between the Redshift Distribution of Long GRBs and the Star Formation Rate

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It has been more than 50 years since the discovery of Gamma-Ray Bursts (GRBs). Yet, there are many mysteries surrounding them. One of the biggest questions we have regarding GRBs is their origin. Many astronomers theorize that Long GRBs (those with duration $T90 > 2s$) come from core-collapse of massive stars while Short GRBs (those with duration $T90 < 2s$) come from mergers of compact objects. Hence, there should be a correlation between the occurrence rate of GRBs and the Star Formation Rate (SFR). In this study, several proposed models have been used to test this relation. Monte Carlo simulations have been carried out to fit the proposed models with the SFR. It was found that the SFR fits with the GRB distribution at high redshifts, but requires an evolution term at low redshifts.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: AAC-P-05 / **107**

Exoplanets: The Astronomy Revolution

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Are there other planets like the Earth in the universe? 30 years ago, this question seemed only another example of some of the oldest, unsolvable questions of humanity. However, today, we are privileged to, for the first time in history, state that there are other planets orbiting distant stars.

Exoplanets are planets outside the solar system. So far, more than 5600 of them have been discovered –in fact, this number has experienced an exponential growth during the last decades. One of the main peculiarities of extrasolar planets is the huge diversity of worlds that exist, ranging from lava planets to super-Earths or hot Jupiters. Actually, planets of the solar system fall into a poor exoplanet population region regarding their period-radius relation.

For instance, most extrasolar worlds have sizes bigger than the Earth and smaller than Neptune, this is, without anything similar in our own system. These planets lead to degeneracies and contradiction regarding their compositions –they may even be ocean worlds! Therefore, they are key to understanding planetary formation and evolution.

Exoplanets are usually first spotted by space telescopes, such as Kepler/K2 and TESS, when they transit, this is, pass between the observer and their host star, producing changes on its flux. Secondly, follow up observations are made using ground-based telescopes to validate transits and obtain parameters such as the radius or the orbital period of the planet.

Next, thanks to methods such as radial velocity, based on gravitational interactions between a star and an exoplanet, the mass of the latter can be precisely measured, leading to estimations of its planetary density. Finally, the latest technological developments, such as JWST, allow to study exoplanetary atmospheres, detecting hazes, winds and even molecules such as biomarkers, this is, gases that may potentially be a consequence of the presence of life.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: AAC-P-11 / **51**

The stellar populations trapped at the L4/L5 Lagrange (corotation) points of a bar

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Bars are prevalent features in disc galaxies and play an important role in driving secular evolution, especially through resonances. Stars at corotation resonance with the bar are known to librate around the stable Lagrange points (L4, L5). Here, we investigate the properties of corotating stars by performing an orbital frequency analysis on a subsample of stars in an N-body+SPH galactic simulation to obtain corotating and non-corotating subsamples. Trends in variation of ages and metallicities are investigated by sectioning the galactic plane into radial and azimuthal bins, and comparing the properties of both categories of stars within each bin, using a K-S test to check statistical significance. We confirm the existence of important systematic differences between the distributions of the ages and metallicities of the corotating stars with respect to the surrounding non-corotating stars. Trends in age are found to vary radially and suggest that corotating stars are dragged away from the corotation radius in both directions, whereas the metallicities of stars in corotation are found to be distinctly higher.

Poster Sessions (Interdisciplinary/Other) - Board: `ID-P-04` / **110**

Features of monitoring the state of liquid flow by nuclear magnetic resonance using the modulation technique to record the NMR signal

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The main problem in development of devices for express control is that the measurement methods used in them should not make irreversible changes to the structure and chemical composition of the medium under study. The most mobile among NMR relaxometers are devices in which a modulation technique is used to register the NMR signal.
When measuring the time of longitudinal relaxation T1 using the modulation technique, a number of problems arise that are related to the relationship between the modulation frequencies of the constant magnetic field in the NMR signal recording zone. They are related to the following phenomenon, which is obtained from solutions of the Bloch equation to determine T1. NMR signals are recorded, relaxation times exist, and it is not possible to determine T1 by the equation. Therefore, it is necessary to investigate this phenomenon and develop a solution to this problem. One of the possible options is presented in our work.

Poster Sessions (Earth Sciences) - Board: `ES-P-05` / **19**

Machine Learning for natural dangerous event evaluation in certain region of Georgia

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The monitoring methods, prediction drought and precipitation distribution, the possibilities of their application in Georgia are used in proposed work. Standardized Precipitation Index (SPI) was selected as the research parameter because it better expresses the pronounced drought trends than the Standardized Precipitation Evapotranspiration Index (SPEI). Using prediction model and algorithm, drought-vulnerable areas in Kakheti region were identified. By analyzing the station data on the territory of Georgia and satellite sources, it was determined that using the regression method of machine learning, it is sufficient to evaluate the data of 1960-2000 period for learning and the data of 2001-2022 period for training. SPI-3 three-month standardized precipitation index was selected as training object. R-instat software was used to calculate Pearson's correlation and other statistical parameters. During the creation of the model process various learning algorithms were trained (SVM, Regression Trees, Linear regression Models). The best result was shown by Bagged Trees. The training time of Bagged Trees Optimized Algorithm was recorded as 326.21 sec, prediction speed ~ 7900obs/sec, RMSE - 0.5046, R2-0.64, MSE-0.25466, MAE-0.38065, training process minimum leaf size 19, and 40 iterations are assigned for optimization. CHIRPS satellite data were taken for next generation of the model. The missed stations data that were used during the training period were filled with CHIRPS satellite data. For prediction, it was necessary to calculate a linear regression equation for each station. In the first case of forecast scenario, the amount of precipitation was determined

from 0 cm to 10 cm. Gurjaani was highlighted, where forecast showed SPI value from -0.008 to -0.901, and Kvareli, SPI value from -0.002 to -0.138. Use of the presented ML model and algorithm for the analysis of precipitation distribution, drought monitoring and prediction is appropriate both in Kakheti and other regions too, in conditions of proper observation database.

Poster Sessions (Optics and Lasers) - Board: `OL-P-03` / **146**

We want to build optical senses for brain imaging

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Introduction
Photoacoustic tomography (PAT) has the potential as a method for measuring the oxygen saturation of the blood in the human brain. Therefore, ultrasensitive detectors are needed to measure ultrasound signals through the human skull. The aim of this work is to investigate and optimise the sensitivity of plano-concave optical sensors. It should be clarified whether the Gaussian beam width has an influence on the phase sensitivity of optical sensors.

Method
A method for calibrating the beam width for a measurement setup was developed. The effects of beam widths on the optical phase sensitivity are simulated by an ABCD-transfer-matrix-method. We modified the experimental setup to measure the sensitivity with the matching beam width from the simulation.

Result
The beam width has an effect on the sensitivity of planoconcave optical sensors. Depending on the radius of curvature and the reflectivity of the mirrors of the optical detectors, the highest phase sensitivity exists at a certain beam width. The phase sensitivity could thus be increased by fifty percent.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-06` / **134**

Meshing Around: Unstructured Spherical Centroidal Voronoi Tessellation Mesh Grids For Better High-Resolution Numerical Weather Prediction

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Since their advent in the 1950s, Numerical Weather Prediction (NWP) models have used structured lat-lon mesh grids for forecasting, which subdivide the 2D (horizontal) global surface into square grid cells of equal size. This has historically resulted in issues such as unnecessarily high resolution at the poles (the 'pole problem'), and flow distortions at nest boundaries with the use of regional nested models that involve abrupt mesh transitions between coarse and fine domains.

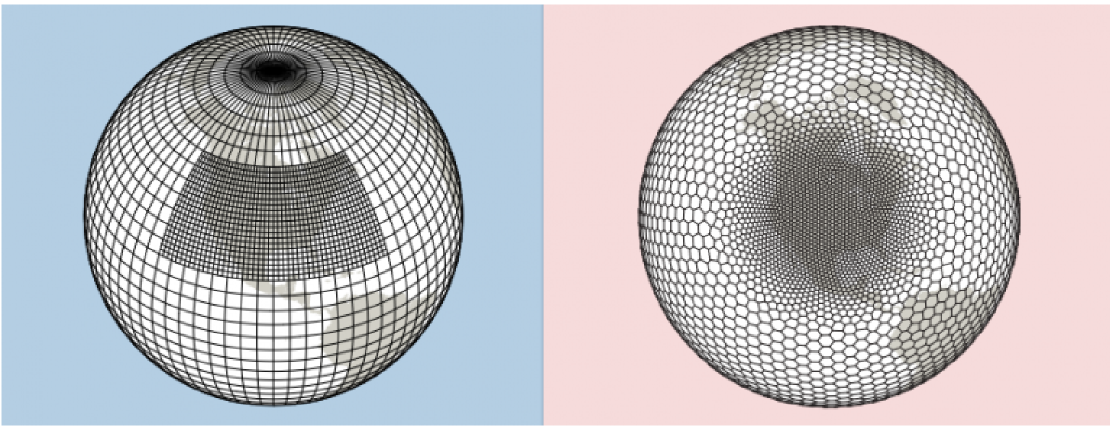

Figure 1: Conventional WRF nested-grid model vs MPAS variable-resolution global mesh

In recent years, there has been an interest in the use of unstructured Spherical Centroidal Voronoi Tessellation (SCVT) mesh grids for NWP forecasting. With 5-, 6- and 7-sided polygons of variable cell size and geometry, these mesh grids are a type of staggered Arakawa C-grid, with the primal grid being a centroidal Voronoi tessellation and the dual grid being a Delaunay triangulation. By solving for normal velocities on cell edges and conserved quantities at the centroids, these grids scale advantageously on massive parallel computing systems and potentially allow for higher forecast skill due to their superior isotropy.

I detail how these grids are generated using Lloyd's algorithm under a user-defined density function, creating variable-resolution meshes that seamlessly transition between coarse and fine regions to eliminate the problems faced by conventional lat-lon grids. This can be particularly useful in the regional context where small cities and countries such as Singapore require extremely high resolutions of 100-300m over their urban areas, but deal with high Lateral Boundary Condition (LBC) error rates when using parasitic nested lat-lon grids. I also explore the generation of highly-refined SCVT meshes with the JIGSAW-GEO software, and their use with the MPAS-Atmosphere model to perform high-resolution NWP over Singapore and regional NWP over the Southeast-Asia region.

Poster Sessions (Quantum Technology) - Board: `QT-P-01` / **133**

Domain location on circular spin arrays

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Quantum state discrimination is a fundamental problem in quantum information theory, with a multitude of configurations, though exact solutions are scarce. One notable case involves a circular array with two possible known states, where optimal discrimination is achieved via square root measurement. However, a general method for arbitrary unknown states lacks a closed-form solution. This work aims to address this gap by developing an optimal algorithm for the average success probability over all two possible unknown states. The problem translates to discriminating possible rotations of the change point in the circular array, resulting in a circulant Gram matrix. Consequently, we demonstrate that the optimal discrimination method can also be achieved through square root measurement.

Poster Sessions (Biophysics) - Board: `Bph-P-02` / **9**

Molecularly Informed Mesoscopic Modeling of Biological Lipid Membranes: A Phase-Field Based Multiscale Approach

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Aggregates of lipids in living systems can range over several magnitudes in their size. The first choice of and most trustable modelling certainly is molecular dynamics, where a system is fully populated by molecules made from individual, interacting particles, providing by their trajectories aggregate behavior and means for detailed study. For the resource-constrained lipid scientist though, the computational cost of these simulations limits the dimensions of the investigated systems to the microscopic scale -even if coarse-graining is employed. For this reason we follow the suggestion by Ito et al. to approximate amphiphilic lipid molecules in an aqueous environment by a copolymer-homopolymer mixture, more precisely by the respective Ohta-Kawasaki model. The simplification still captures key aggregate properties by means of coupled phase-fields over the full range of length scales. To this end, we parametrize the phenomenologically assumed phase-field model for the prototypical DPPC lipid in water, using information derived from according molecular data and a combination of gradient-free methods, classification and interpolation. By this simplistic approach, we are able to approximate the steady state predicted patterns anticipated for this type of lipid in contact with water, and thus enable comparatively economic studies of the plethora of lipid aggregates.

Poster Sessions (Condensed Matter and Solid State Physics) - Board: `CMSSP-P-06` / **20**

Microstructure and thermal properties of modified polyethylenes

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Polyethylene is by far the most widely used and produced plastic in the world, mainly for packaging. However, polyethylene poses environmental problems as it does not degrade in the natural environment. Therefore, in view of the current and future environmental crisis, it is necessary to introduce certain alternatives.

The aim of the present work is to investigate different modified polyethylenes, which are degradable by incorporated ketone groups, for their thermal characteristics and structural properties. It also aims to determine whether these samples are suitable for future research work.

To answer this question, differential scanning calorimetry (DSC) measurements and X-ray measurements were carried out. The samples selected are a high-density polyethylene (HDPE) as reference and three modified polyethylenes with different CO contents.

The evaluation shows that the thermal properties regarding melting and crystallization point are very similar to the standard HDPE. Furthermore, the melting enthalpy indicates a lower crystallinity. Further investigations using X-ray scattering revealed that the crystalline layer thickness decreases depending on the CO content. The amorphous layer thickness becomes larger with increasing CO content.

Current research is being carried out in the field of NMR (Nuclear Magnetic Resonance), but also on the detailed evaluation of the small-angle X-ray scattering data with regard to isothermal long-term measurements in relation to crystal mobile and crystal fixed polymers and the distribution of the ketone groups in the chain during the crystallization process.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-02` / **95**

Classification and Prediction of extreme events in complex time series - Application to electricity price data

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Reliable infrastructure networks like the electricity grid are crucial for modern society.

The demand and supply of electricity need to be always balanced to ensure grid stability.
Various markets have formed to achieve power grid and electricity price stability These different markets enable trading over different time spans and ensure that supply and demand are always met.
Furthermore, parallel markets are connected to achieve this goal, as is the case for different day-ahead markets in Europe via the EUPHEMIA algorithm.
This results in a complex system of interacting parties such as electricity producers and consumers, external factors like regulations and weather conditions, and more.

An increasing amount of openly accessible data regarding the electricity net, power system, and external factors makes research in many different areas like grid frequency research, electricity network robustness, market analysis, and much more possible.

In my bachelor thesis, I took a look at freely available electricity price data from the ENTSOE transparency platform and various fuel price data.
I then identified extreme price events such as very high (> 50€/MWh) and negative prices.
Building on that I showed that a common linear model with dependence on the residual load can not explain said outliers.
Two logistic regression models were used due to their inherent interpretability to classify the outliers.
To classify these sparse events I used different training approaches such as over- and undersampling to compensate for the disbalance in data points (0.5% of the data points were negative, 1.9% over 50€/MWh). The aim of the thesis was mainly to get used to machine learning techniques and data preparation rather than to use big black box neural network machinery.

Despite its simplicity, the model showed expected as well as surprising phenomena that I will explain further in my poster.

Poster Sessions (High Energy Physics) - Board: `HEP-P-02` / **170**

Conformal parametrization of the pion vector form factor

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This study introduces the parametrization of the pion vector form factor utilizing conformal transformations as an alternative to dispersion theory. After offering a foundational understanding of dispersive bounds, the parmetrization is adjusted such that the form
factor exhibits the desired behavior for asymptotic values and the threshold. The final outcome is assessed by comparing the theoretical
prediction to the Omnès function.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `AAC-P-07` / **37**

Investigating the Formation of Heavy Elements in Neutron Star Collisions and Rapid Neutron Capture Process

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The collision of neutron stars and the subsequent rapid neutron capture process serve as the origin of kilonovea radiation, playing a fundamental role in the production of elements heavier than iron in the cosmos. In this paper, we aim to model the kilonovea light curve and the mechanisms of heavy element formation within it. Finally, through comparing observational data with the semi-analytical Arnett model and simulations obtained from the Metzger model, we delve into the details of the models and the exploring parameters governing the temporal evolution of kilonovea light curves.

Poster Sessions (Nuclear Physics) - Board: `NP-P-03` / **18**

The Plasma Window for Enhanced Particle Beam Transmission from Vacuum to Atmosphere

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Neutrons play a dominant role in the stellar nucleosynthesis of heavy elements. We review a scheme for the experimental determinations of neutron-induced reaction cross sections using a high-intensity neutron source based on the 18O(p,n)18F reaction with an 18O-water target at SARAF's upcoming Phase II. The quasi-Maxwellian neutron spectrum with effective thermal energy kT ≈ 5 keV, characteristic of the target (p,n) yield at proton energy Ep ≈ 2.6 MeV close to its neutron threshold, is well suited for laboratory measurements of MACS of neutron-capture reactions, based on activation of targets of astrophysical interest along the s-process path. 18O-water's vapour pressure requires a separation in between the accelerator vacuum and the target chamber. The high-intensity proton beam (in the mA range) of SARAF is incompatible with a solid window in the beam's path. Our suggested solution is the use of a Plasma Window, which is a device that utilizes ionized gas as an interface between vacuum and atmosphere, and is useful for a plethora of applications in science, engineering and medicine. The high power dissipation (few kW) at the target is expected to result in one of the most intense sources of neutrons available at stellar-like energies. Preliminary results concerning proton beam energy loss and heat deposition profiles for target characteristics and design, a new fullscale 3D CAD model of the Plasma Window (as well as its operation principles) and the planned experimental scheme at SARAF, are reviewed. Moreover, work includes a feasibility study for the use of a plasma window for the Gamma Factory, a proposed high energy (up to 400 MeV) photon source at CERN.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-04` / **153**

Mechanical Properties of Mexico

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In this study we calculated the center of mass and the geometric center of México's territory profile based on maps that represent the country's terrain using color codes in the maps, allowing for a clear visualization of México's topography. We wrote the code in Python to perform the calculations and obtained the country's topographic data and land border profile from public databases.
The center of mass was determined by calculating the weighted position of all "mass"points in the national territory, considering local altitude over sea level as the mass distribution variable. On the other hand, the geometric center was calculated as the point equidistant to all edges of the country in its geometric form.

This work was undertaken with the aim of providing informative insights in science, serving both as a resource for public dissemination and as a means to delve into multidisciplinary research. Focusing on projects such as the use of neural networks in physics research, quantum computing, and economic predictions using mathematical and physical methods. Beyond its primary focus on physics, this study spans across computing, geography, and data science, allowing for a deeper understanding of how mass is distributed in a given area. The understanding of the center of mass is crucial across multiple disciplines, offering practical applications for scientific analyses and simulations in diverse fields such as computer science and physics.

Poster Sessions (Astrophysics, Astronomy, Cosmology) / 205

2024 Polymele Occultation and Convex Form Model of Asteroid 298 Baptistina

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The study of asteroids is essential for the understanding of the universe's past, present and future. Studying the remains of our Solar System's formation can guide us to understand the evolution, distribution and composition of matter around other stars, which is useful for Astronomy, Astrophysics, and even Astrobiology. There are different ways in which we can study asteroids. The first one that will be treated is the observation of occultations, specifically about the experience of participating in the 2024 Polymele Occultation Observation Campaign with NASA's LUCY Mission, which centered on Polymele, an asteroid with its own natural satellite. The second one is photometry, it is possible to create 3D models for asteroids given their light curves, these have been made for less than 1% of the known asteroids, particularly, the experience of creating one for Baptistina will also be treated in this work.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-08` / **161**

Parameterisation and Performance Limits of Indoor Photovoltaic Modules

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With the upcoming demand for "Internet of Things" (IoT) devices, intensive research has been conducted on sustainable power solutions for these devices. IoT devices utilize sensors embedded in everyday objects, such as light switches, doors, and vehicles, to collect and communicate data over the internet. One promising method to power these devices is indoor photovoltaics (PVs). Next-generation indoor PVs leverage recent advancements in PV technologies, incorporating flexible, inexpensive, and sustainable materials such as molecular semiconductors. Under low light conditions, a single PV cell may not generate sufficient voltage to efficiently power an IoT device; thus, multiple PV cells are typically connected to form a mini-module. This study aims to calculate the optimal number of cells required for indoor PV modules to maximize overall IoT system efficiency under various lighting scenarios. Initially, the thermodynamic limit of a single ideal PV cell was simulated under typical indoor lighting conditions. Following this, the performance of an ideal 5 cm × 5 cm module was evaluated using finite element modelling (FEM). Voltage-dependent efficiency data from typical energy harvesting chips were employed to predict the overall energy harvesting efficiency of this module. Subsequently, leveraging data on state-of-the-art indoor PV technologies, various models were developed to calculate and compare the overall energy harvesting efficiency across several systems. The analysis revealed that the optimal number of cells for the modelled systems ranged from approximately 4 to 6 cells. However, this finding is highly dependent on the illuminance conditions under which the module is deployed, as system efficiency is significantly influenced by the voltage at the maximum power point.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-10` / **169**

Python Physics Power

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Python has emerged as a powerful tool in the field of physics, revolutionizing both research and education. My poster will highlight several key applications of Python that make it indispensable for physicists today. Firstly, Python excels in numerical simulations, including Molecular Dynamics (MD), Computational Fluid Dynamics (CFD), and Monte Carlo Simulations, allowing scientists to model complex physical systems with ease. Its robust data analysis and visualization capabilities enable efficient handling of large datasets, graphing, plotting, and even machine learning and AI applications, which are increasingly important in modern physics research. Additionally, Python's symbolic computation abilities facilitate analytical calculations that were once cumbersome and time-consuming. Quantum computing, a cutting-edge field, benefits from Python's ability to simulate quantum systems, while astronomers and astrophysicists use Python for data reduction, analysis, and the simulation of astrophysical phenomena. Python also plays a crucial role in experimental control and automation, providing tools for instrument control and data acquisition systems. Furthermore, Python's versatility extends to education and outreach, where interactive learning tools and gamification of learning make physics more accessible and engaging. Through this poster, I aim to combine compelling visuals, interactive elements, and clear explanations to showcase Python's versatility and efficiency in physics, fostering innovation and enhancing our understanding of the universe.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `ACC-P-09` / **271**

The KM3NeT project

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KM3NeT is a research infrastructure housing the next generation of Cherenkov neutrino telescopes. It consists of two detectors with similar technology currently under construction in the Mediterranean Sea: ARCA (off-shore Sicily, Italy) and ORCA (off-shore Toulon, France) dedicated to Astroparticle and Oscillation Research with Cosmics in the Abyss, respectively. ARCA will instrument 1 Gton of seawater, with the primary goal of detecting high energy cosmic neutrinos from distant astrophysical sources with energies between tens of GeV and PeV., while ORCA has a smaller volume with a few megatonnes of seawater. ORCA will detect atmospheric neutrinos in the 1 - 100 GeV energy range, studying neutrino properties. In this poster I present the KM3NeT project, current status and expected performances on measurements of the neutrino oscillation parameters, the mass ordering, the diffuse neutrino flux and the search for supernovae.

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Poster Sessions (Condensed Matter and Solid State Physics) - Board: `CMSSP-P-04` / **10**

Light-driven interlayer propagation of collective-mode excitations in layered superconductors

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Superconductors exhibit a nonlinear interaction with an applied light, which can resonantly excite the collective amplitude (Higgs) mode. Here we study light-induced dynamics of layered superconductors, where each layer is coupled to adjacent layers via the Josephson coupling and the first few layers near the surface are driven by an in-plane-polarized light. We study the system under the assumption that the interlayer Coulomb interactions are sufficiently screened out and that the phase-difference mode becomes available in the low-energy regime. We find that interlayer transport is induced via excitations of the collective amplitude and phase-difference modes, even when the applied electric field is parallel to the planes. We provide analytic calculations as well as numerical simulations of the real-time dynamics, and investigate the influence on the light-induced interlayer Josephson current and intralayer third-harmonic generation.

Poster Sessions (Condensed Matter and Solid State Physics) - Board: `CMSSP-P-02` / **118**

Investigating Nanoscale Joule Heating in Lithium Niobate Memristors

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Domain walls in ferroelectric materials are an exciting new type of graphene-like 2D functional interface with properties that can differ significantly from the surrounding bulk. Like graphene, they can display various transport regimes, such as semiconducting, metallic, and even superconducting, behaviour. Domain walls are a part of the ferroelectric microstructure (they are interfaces that separate polar domain variants) that can be created, erased or moved by applied voltages, and in this sense are reconfigurable. A decade of research has focused on exploiting this reconfigurable

electrical property variation seen within domain walls with an aim to create voltage configurable nanoelectronic devices. Lab-level transistor 1 and memristor devices 2 have been reported, where device functionality is derived entirely from the number of electrically conducting domain walls connecting device electrodes, thereby enabling a tuneable device resistance for multi-state memory applications. However, much less is known about the fundamental electrothermal properties of domain walls and their influence on device operation, despite similar studies in resistive switching memories where self-heating and local temperature are key to operation [3]. We have been using Scanning Thermal Microscopy (SThM), supported by finite-element modelling, to investigate the self-heating properties of domain walls in electroded thin-film ferroelectric LiNbO3 devices. Electrically conducting domain walls were introduced into the material by an electrical poling procedure. The devices were cross-sectioned using a Focused Ion Beam procedure such that the domain wall microstructure in the 500nm thick ferroelectric layer could be visualised directly using Piezoresponse Force Microscopy. Finite-element modelling of the self-heating of the domain walls is being used to inform the ongoing SThM investigations of biased cross-sectioned devices.

1 X Chai et.al, Nat. Commun. 11, 2811 (2020).
2 J. P. V. McConville et.al, Adv. Funct. Mater. 30, 2000109 (2020).
[3] W. S. Deshmukh et al. Sci. Adv. 8, eabk1514 (2022).

Poster Sessions (High Energy Physics) - Board: `HEP-P-06` / **68**

Properties of doubly heavy spin 1/2 baryons

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We determine the masses and residues of the ground and excited spin 1/2 baryons consist of two heavy b or
c quark utilizing the QCD sum rule formalism. In the calculations, we consider the nonperturbative operators up to ten mass dimensions in order to increase the accuracy compared to the previous calculations. We report the obtained results for both the symmetric and antisymmetric currents defining the doubly heavy baryons of the ground state (1S), first orbitally excited state (1P), and first radially excited state (2S). We compare our results with the predictions of other nonperturbative approaches as well as existing experimental data which is available only for the ground state of Ξcc channel. These predictions can help the experimental groups in their searches for all members of the doubly heavy baryons in their ground and exited states.

Poster Sessions (High Energy Physics) - Board: `HEP-P-04` / **75**

Electromagnetic interactions between charged spectators and participants in heavy-ion collisions

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As a result of the collision between heavy ions moving with relativistic or ultra-relativistic velocities, the quark-gluon plasma is produced along with remnants (spectators) which are responsible for generating the electromagnetic field. After the collision, some particles are created in the quark-gluon plasma or a space around by virtual photons interactions. Using the Monte-Carlo method, a study was conducted regarding the influence of the electromagnetic field on charged leptons. The main focus concerned the flow parameters - directed and elliptic flow - indicators of anisotropy in particle distributions concerning the reaction plane.

The research concentrated on the emission of pions, muons and kaons from quark-gluon plasma caused by Pb+Pb collisions at an energy equal to 17.3 GeV, with impact parameter b=14 fm (peripheral collisions) and the comparison of results for positively and negatively charged particles. To make the analysis more comprehensive, the events were also studied for different energies (17.3 GeV, 50 GeV and 200 GeV), impact parameters (14 fm, 7 fm) and emission time (0.01 fm/c, 0.5 fm/c, 1.0 fm/c). The outcome of the theoretical study using Monte-Carlo simulation could be verified experimentally.

Poster Sessions (Optics and Lasers) - Board: `OL-P-01` / **8**

Emergence of Synchronisation in a Driven-Dissipative Hot Rydberg Vapour

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Continuously driven non-linear systems show interesting behaviour such as bistability and self-oscillations, and have recently come into the focus of theoretical and experimental research again. The system's nonlinearity fundamentally changes the response to constant driving such that it can even facilitate time-periodic, self-oscillating states. An interesting question regards the interplay of many self-oscillating entities with coupled dynamics due to an interaction between the individual oscillators. A collective response of the ensemble has been observed for certain coupling regimes and is known as synchronisation. This transition towards a synchronised state has been used to describe the rhythmic flashing of fireflies and the chirp pattern of snowy tree crickets. Even the applause of an audience can transition from random clapping to a collective rhythmic pattern, which can be explained within the framework of synchronisation.
To experimentally study the synchronisation transition for many oscillators one needs a coupling between a large number of constituents while also maintaining tunability of the system parameters. So far, these demands on the system have proven challenging to meet experimentally. Recently, we have observed the emergence of synchronisation in a driven-dissipative hot Rydberg vapour 1. Synchronisation occurs in a strongly-driven three-level ladder scheme in Rb where we couple the intermediate $^5P_{3/2}$ state to a Rydberg state. The synchronised state manifests as oscillations of the transmission of the probe beam through the atomic vapour. Wide tunability of the system parameters as well as fast oscillation frequencies on the order of 10 kHz allow for an exploration of the synchonisation transition over a large parameter space and with many constituent coupled oscillators.

1 K. Wadenpfuhl and C. S. Adams, Emergence of Synchronization in a Driven-Dissipative Hot Rydberg Vapor, PRL 131, 143002 (2023)

Poster Sessions (Interdisciplinary/Other) - Board: `ID-P-05` / **82**

Test of homemade Solid-Phase Microextraction Fiber

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Recently, a lot of research has been carried out on non-telecommunications applications of optical fibers. They are used as components of optoelectronic devices, optical components of integrated circuits, or laser technology. Exploitation of the light guiding properties of optical fiber can be used to prepare Solid-Phase Microextraction (SPME) fiber by making a coating of its parts with a layer of polymeric material. The paper will show the use of the optical fiber processing technique and the photopolymerization method to obtain polymer layers on tapered standard optical fibers. As the basis of the homemade SPME, fiber is a manufactured tapered optical fiber at one end. The process of optical fiber tapering involves stretching the fiber over a flame from a moving torch, in which a mixture of propane-butane-oxygen gases is burned. The experimental setup of the optical fiber tapering process is shown in Figure 1. The tapered fiber is cut into two equal parts. The fiber end prepared in this way is coated with a photopolymerizing mixture - the main component is the monomer TCDMA (tricyclo (5.2.1.0) decanedimethanol diacrylate). The fiber is exposed in the environment of the analyte under study, and adsorption of the analyte occurs on the sorbent. The fiber is then transferred to a chromatograph, where the analytes are desorbed and identified. We would like to study the description of properties of the manufactured fibers on selected simulated volatile chemical warfare agents. The experiment shows how to make homemade SPME fibers, their adsorption and desorption properties, and checks their performance. The results of the experiment will be compared with commercial SPME fibers.

Poster Sessions (Interdisciplinary/Other) - Board: `ID-P-01` / **27**

ICPS 2025

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The next edition of your favorite event, ICPS 2025, will be held in beautiful Serbia! From August 3 to August 10, 2025, you will be our guest in lovely Novi Sad. We will guide you through our event's program, the opportunities it will provide for you, any answer any of your questions or doubts.

The International Conference of Physics Students (ICPS) is an annual conference bringing together hundreds of students from the whole world, joined by their interest in physics. It has a rich program, with balanced scientific, cultural and social activities for lucky students to come there.

Poster Sessions (Condensed Matter and Solid State Physics) - Board: `CMSSP-P-03` / **14**

Mechanical Properties of GaN Nanowires

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Gallium Nitride (GaN) nanowires have gained significant attention in recent years due to their remarkable mechanical properties and their potential applications in various fields. These nanowires, with diameters ranging from tens to hundreds of nanometers and lengths extending from a few nanometers to several micrometres, offer unique advantages in nanogenerators and optoelectronic devices.

One notable property of GaN nanowires is their piezoelectric behaviour. As piezoelectric materials, they can generate electric charges when subjected to mechanical deformation. What sets GaN nanowires apart is their ability to undergo large deformations, leading to the creation of substantial electric charges. This characteristic makes them promising candidates for piezoelectric nanogenerators, where mechanical energy can be converted into electrical energy.

In the context of nanogenerators, GaN nanowires have demonstrated exceptional performance. These nanowires exhibit a piezoelectric constant of several picometers per volt (pm/V), enabling them to generate voltages of up to 1.2V when subjected to mechanical stress or strain. Such voltage outputs hold tremendous potential for powering small-scale electronic devices and sensors.

Furthermore, our work focuses on studying GaN nanowires using Sagnac interferometry. Sagnac interferometry is a highly sensitive technique that allows for the precise measurement of physical quantities, such as the mechanical deformation or vibrations of nanowires. By employing this technique, we aim to explore and understand the mechanical properties of GaN nanowires in greater detail.

In summary, GaN nanowires present exciting opportunities in the realm of nanogenerators and optoelectronic devices. Their piezoelectric characteristics, coupled with their ability to undergo substantial deformations, enable the generation of significant electric charges. In our research, we utilize Sagnac interferometry as a tool to investigate the mechanical properties of GaN nanowires, ultimately advancing our understanding of these materials and their potential applications in various technological domains.

Poster Sessions (Quantum Technology) - Board: `QT-P-02` / **143**

Integrating Triboelectric Nanogenerators with TiO2-based UV Photodetectors for Self-Powered Sensor Systems

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UV photodetector has diverse applications ranging from advanced communications to leak detection. UV photodetectors play a crucial role in harnessing the power of UV light for various functions. The demand for more compact, precise, portable, and energy-efficient photodetectors has prompted the exploration of nanotechnology and nanofabrication techniques.

This study focuses on developing a TiO2-based photodetector known for its ability to absorb UV light due to its 3.2 eV bandgap. By monitoring changes in resistance based on UV light intensity, the photodetector's functionality was enhanced by integrating it with a triboelectric nanogenerator (TENG). The TENG, activated through tapping actions between Kapton and FTO materials, provided the necessary power for the photodetector.

Through rigorous testing, this research showcases the potential and reliability of the TiO2 photodetector when coupled with TENG technology. The self-powering capabilities exhibited in this study position the integrated system as a promising energy source for sensor applications, offering a new frontier in sustainable and autonomous sensing technologies.

Poster Sessions (High Energy Physics) - Board: `HEP-P-01` / **65**

Magnetic Resonance Spectroscopy in the CASPEr Dark Matter Experiment

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An overview of our experimental program to detect axions and axion-like particles (ALPs) as possible candidates for Dark Matter (DM) using Nuclear Magnetic Resonance (NMR) techniques within the cosmic axion spin precession experiment (CASPEr) is presented 1. Axions are hypothetical particles that could also solve the strong CP violation problem. due to the high number density required for axions to be a significant portion of DM, their aggregate behavior can be described as classical waves: it would oscillate at the Compton frequency. Axions also interact with the Standard Model (SM) particles. Nuclei interacting with the background axion DM acquire time-varying CP-odd nuclear moments, such as an Electric Dipole Moment (EDM). In analogy with NMR, these moments cause spin precession in a sample induced by coupling between the axion field and the axial nuclear current in the presence of an electric field. Precision magnetometry can be used to look for such a precession. The signals from these particles will be very weak, so all possibilities for signal enhancement need to be considered and for that, the chosen nuclei are 129-Xe that are hyperpolarized using the spin-exchange optical pumping (SEOP) technique. The hyperpolarized xenon is then to be placed in an external magnetic field that will be swept from ultra-low field up to 14.1 T looking for the resonance with the axion field, while the xenon nuclei undergo precession due to the gradient interaction. The first-generation experiments explore many decades of axion parameter space beyond the current astrophysical and laboratory bounds. It is anticipated that future versions of the experiment could ultimately cover the entire range of masses up to μeV, complementary to cavity searches.

1 Derek Jackson-Kimball, et al. "Overview of the Cosmic Axion Spin-Precession Experiment (CASPEr)" , Microwave Cavities and Detectors for Axion Research, 105–21, Springer Proceedings in Physics, 2020.

Poster Sessions (High Energy Physics) - Board: `HEP-P-05` / **190**

The God Particle - Higgs Boson at the LHC

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The content focuses on the discovery of the Higgs Boson at the Large Hadron Collider (LHC) at CERN. It covers the challenges of detecting the Higgs Boson due to its mass, the purpose and operation of the LHC in creating high-energy collisions, the role of detectors like ATLAS and CMS in detecting the particle, the announcement of its discovery on July 4, 2012, and the subsequent confirmation in March the following year.

Poster Sessions (Quantum Technology) - Board: `QT-P-04` / **48**

Quantum Error Correction criteria for Hybrid Quantum Systems

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Quantum Error Correction (QEC) is crucial for any practical implementation of Quantum Information protocols. It mitigates decoherence, compensates for imperfections in quantum operations, and is fundamental for scaling quantum algorithms. QEC enables reliable quantum computation on a

larger scale. Our research focuses on establishing criteria to construct a logical basis for a Hybrid Quantum System (HQS) comprising solid-state spins and oscillators. Appropriate stabilizers, error operations, and recovery operations will be designed and analyzed. The hybrid logical encoding obtained here will be used to find robust qubit states that are resilient errors within the hybrid degrees of freedom. Further logical operations among these qubits will also be constructed and analyzed for experimental parameters.

Poster Sessions (Nuclear Physics) - Board: `NP-P-02` / **77**

Precision measurement of the position of cathode wires in a system of proportional high-pressure chambers in an experiment to measure the charge radius of a proton in elastic electron-proton scattering.

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This work is devoted to a review of the project on precision measurement of the charge radius of the proton PRES and its experimental setup, in particular the proportional chamber system. A project has been proposed at the St. Petersburg Institute of Nuclear Physics, the purpose of which is to precisely change the charge radius of a proton in electron-proton elastic collisions. A key feature of the experimental technique is the simultaneous registration of both the scattered electron and the recoil proton. One of the important components of this experiment - a system of multi-wire proportional high-pressure chambers designed to register the track of a scattered electron. To ensure accurate restoration of the coordinates of the electronic track, a comprehensive system for measuring the position of the cathode wires of the camera is being developed.

Poster Sessions (Optics and Lasers) - Board: `OL-P-02` / **179**

High energy pulsed mode-locked normal dispersion thulium-doped all-fiber laser

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In recent years, thulium-doped fibre (TDF) laser systems operating around the 1.9-micrometre region, so-called "eye-safe", have remarkably performed in various applications, such as medical treatments, remote sensing, scientific research, industrial material processing, etc. Most of these applications are achieved by mode-locked TDF lasers working in the anomalous dispersion that limits the single pulse energy because of its inferior ability to accommodate nonlinear phase compared with normal dispersion operations. Some commercial ultra-high numerical apertures (UHNA) single-mode optical fibres can also compensate for the TDF laser cavity dispersion. However, UHNA fibres have smaller core diameters than SMF to obtain the higher NA, which is unsuitable for high-power laser operation. Besides, the optical gain is still generated in the anomalous dispersion TDF fibres; net normal dispersion operations cannot avoid solitons' pulse breaking.

Here, we fabricated a large-mode-area W-type normal dispersion TDF (NDTDF) that offers normal dispersion at a wavelength above 1650nm to deliver high pulse energy. The presented all-fibre mode-locked TDF laser operated in the net normal dispersion and all-normal-dispersion regimes in the LP02 mode based on an in-house mode selective coupler (MSC). The homemade MSC using a long-period grating (LPG)realized highly efficient mode conversion from LP01 to high-order modes (LP11, LP21, LP02) in the drawn NDTDF.

Poster Sessions (Nuclear Physics) - Board: `NP-P-04` / **121**

Star in a jar - Farnsworth-Hirsch Fusor

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We are a group of students from Gdańsk University of Technology and want to bring thermonuclear fusion to our University by creating our own fusor. In this poster we want to share our progress on the project.

A fusor is a device designed to heat ions using an electric field to the temperature required for achieving thermonuclear fusion. This is achieved by inducing potential difference between two metal cages inside of a vacuum, which in turn causes the ions to receive lots of kinetic energy. If a gas with right molecular composition is provided then it can be used as fuel. Unfortunately it is not able to produce energy, because it requires much more power than it is capable of providing.

This poster details our construction process, challenges we have encountered, successful demonstration of electrostatic confinement mechanism by building a device capable of ionizing the gas that was left in a vacuum chamber and our future plans. Right now we are focusing on redesigning the whole setup so it will be able to provide a higher vacuum, because the vacuum we achieved is not high enough to allow fusion. Later on we want to focus on upgrading the inner cage and the system responsible for inducing the potential difference between the cages.

Poster Sessions (Optics and Lasers) - Board: `OL-P-04` / **180**

The effect of surface fluorine doping on the structure of a thin layer of SnO2 used as an electron transfer layer in optoelectronic devices

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In this research, SnO2 material was used to make a thin layer of electron carrier for use in optoelectronic devices. Optical properties such as the percentage of transmission and band gap energy and desired morphological properties such as thickness were measured and investigated. On the other hand, the quality of the surface coating and its relationship with the contact angle were investigated by electrochemical characterization. Then, the effect of ammonium fluoride solution on the mentioned properties was re-examined. The observed changes were in accordance with the prerequisites of the electron transport layer in optoelectronic devices.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-01` / **105**

A Review of Machine Learning Techniques for Modeling Turbulence in Fluids

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Turbulence in fluids represents one of the most complex and challenging phenomena in fluid mechanics. Accurately modeling turbulence is crucial for various engineering and scientific applications, such as aerodynamics, meteorology, and environmental engineering. Traditional numerical methods, including Direct Numerical Simulations (DNS) and Large Eddy Simulations (LES), demand substantial computational resources and have limitations in scale and applicability.

This poster aims to review the current machine learning (ML) and artificial intelligence (AI) techniques used for modeling turbulence. Beginning by outlining the fundamental nature of turbulence and the inherent difficulties in its modeling, including its chaotic behavior, high Reynolds number flows, and the wide range of spatial and temporal scales involved. Understanding these challenges highlights the importance of developing more efficient and accurate modeling methods.

Furthermore, there is an exploration of various ML and AI approaches that have been proposed to tackle these challenges. Techniques such as deep learning (DL), neural networks (NN), and unsupervised learning algorithms are used to predict turbulent structures and their dynamics. These methods offer significant advantages in processing large datasets from experiments and simulations, leading to the development of more precise and efficient models.

This review aims to present the benefits and limitations of these approaches compared to traditional methods, emphasizing the potential of ML and AI to revolutionize turbulence modeling. Integrating these techniques with conventional numerical methods can result in hybrid models that better predict and control turbulent flows. This advancement holds promise for enhanced performance in various practical applications, paving the way for future research and development.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-07` / **162**

Modelling of Diffusion: Simple Anomalous Diffusion

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In 1827, Scottish botanist *Robert Brown* noticed that particles in a liquid move chaotically in different directions. In the beginning of the 20th century, Albert Einstein showed that for long times mean squared displacement (MSD) of Brownian particles is proportional to time. This kind of diffusion is called *normal diffusion.* On the other hand, anomalous diffusion, characterized by a deviation from Brownian motion, is a phenomenon observed in various complex systems. Unlike normal diffusion, where mean squared displacement (MSD) is linearly proportional to time: $\langle x^2 \rangle \propto t$, anomalous diffusion exibits nonlinear relationship, discribed by: $\langle x^2 \rangle \propto t^\alpha$, where :
if $\alpha < 1$ we have ***Subdiffusion***, when particles spread more slowly than Brownian Particles.

if $\alpha > 1$ we have ***Superdiffusion***, when particles spread faster than in normal diffusion.
This poster will provide a brief introduction into anomalous diffusion and the results of modelling using Monte-Carlo method will be shown. Initial conditions influencing anomalous diffusion will be discussed and diffusion coefficients will be shown. Diffusion has significance in various physical, biological and financial stochastic processes. Due to its importance, understanding these models will enhance our comprehension of complex systems and it will also pave the way for further researches.

Keywords: Anomalous Diffusion, Modelling, Monte-Carlo Method, Stochastic Processes.

Poster Sessions (Earth Sciences) - Board: `ES-P-02` / **89**

Atmospheric Boundary Layer

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The poster will present the Atmospheric boundary layer and the atmospheric phenomena that occur there . Also I will present the experimental detection methods that are used to detect the ABL .Besides , the poster will show the algorithm I used in my own research to detect the ABL using data from a shipborne campaign .

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `AAC-P-02` / **150**

Investigation of the influence of an updated model for the extragalactic background light on the multi-messenger signatures of Blazar 3C279 with CRPropa

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In order to come closer to understanding extragalactic sources of cosmic rays and their intrinsic mechanisms, the analysis of various multi-messenger signals has proven to be extremely promising in recent decades. Typically, numerical simulations are undertaken to investigate the validity of various astrophysical scenarios. Predictions considering photonuclear interactions depend significantly on the modeling of extragalactic photon fields. Therefore, in the present work an updated model of the extragalactic background light was implemented in the open-source code CRPropa 3.2 to investigate its effects on γ-ray signals from blazar 3C279. In particular, the new model showed a higher prediction of produced photons by inverse Compton scattering when simulating electromagnetic cascades, while the opacity of the universe for gamma radiation was lower than in previous models.

Poster Sessions (Biophysics) - Board: `Bph-P-03` / **36**

Instabilities in ferrofluids modulated by external magnetic field

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This study systematically examines the physical parameters influencing the macroscopic pattern formation in a ferrofluid under a magnetic field. Our experiments focus on spike height variations and Rosensweig instabilities within the context of magnetorheological effects. The home-built apparatus consists of a permanent neodymium magnet attached in a set up developed using the principle of hydraulics. It is observed that despite the apparent randomness, the Rosensweig instabilities display deterministic patterns. Varying viscosities of the same ferrofluid, achieved through carrier fluid evaporation, reveal a consistent trend, specifically, a decrease in response field and an increase in spike height. This work provides the capability of predicting the ferrofluid spikes formation under a given field strength. Further, the formed patterns demonstrate the three-dimensional distribution of magnetic field lines, enhancing our understanding of spatial dynamics of the ferrofluid system.

Poster Sessions (Earth Sciences) - Board: `ES-P-04` / **165**

Sensitivity of the resolved atmospheric gravity waves on the model configuration

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My research explores the impact of Rossby waves (RWs) and gravity waves (GWs) on atmospheric dynamics, crucial for understanding weather and climate processes. Using the Weather Research and Forecasting (WRF) model, specifically version 4.3 with enhanced stratospheric simulations, and ERA5 data for initial conditions, the study focuses on high-resolution simulations over the Philippines during a typhoon from October 24 to 27, 2020.

Key analyses include vertical wind speed variations before and after the typhoon, spatial distribution of total precipitation, and zonal wind component patterns. The results show significant increases in vertical motions post-typhoon, highlighting the typhoon's influence on atmospheric dynamics. This research demonstrates the importance of advanced modeling and data assimilation in resolving GW effects.

Overall, this study enhances understanding of how typhoons generate GWs and their impact on atmospheric processes, improving weather prediction models and insights into atmospheric wave phenomena.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `AAC-P-06` / **137**

Network parameters of flaring and non-flaring active regions in the solar magnetogram

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In this research, we studied the characteristics of the graph network of a solar flaring active region (FAR) and a solar non-flaring active region (non-FAR). Our method in this research includes data pre-processing, extracting patches and their flux using the Yet Another Feature Tracking Algorithm (YAFTA), making a visibility graph (VG), calculating network parameters, and obtaining time series of network parameters for both FAR and non-FAR. In this regard, we used the data recorded by the Solar Dynamic Observatory (SDO)/Helioseismic and Magnetic Imager (HMI) at a wavelength of 6173 Å with a resolution of 0.50 ± 0.01 arcseconds. The data set related to FAR 12734 was taken at 03/08/2019 for a time period of 1 to 6 UT. This set contains 400 consecutive images with a time lag of 45 seconds and dimensions of 290 x 290 pixels. The set of non-FAR 12395 containing 480 consecutive images with the same time and spatial resolution of the FAR data set was recorded on 08/08/2015 for a time period of 18 to 24 UT. The dimensions of the data set are 610 x 610 pixels. Applying VG to the time series of the mean flux of patches in regions of interest, the network parameters show that the average degree of nodes in the FAR is higher than the non-FAR. The average energy graph for the flux of the patches in the FAR is larger than in the non-FAR. In the FAR, the average eigencentrality for the series of mean flux of the patches is negative, while for the non-FAR, this value is obtained to be positive. The degree-distributions of nodes in both FAR and non-FAR follow the power-law functions with exponents of -1.54 and -2.01 for FAR and non-FAR, respectively.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `AAC-P-10` / **149**

The Impact of the Temporal Luminosity Evolution on the Signal of Ultra-High-Energy Cosmic Rays

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While the origin of cosmic rays at the highest energies remains unclear to date, nearby radio galaxies are considered as potential candidates. Limiting the sources of ultra-high-energy cosmic rays (UHECR) to such a small number, their finite lifetime would have a significant impact on the resulting energy spectrum and mass composition at Earth. This is due to the so-called magnetic horizon effect that yields hard spectra of the individual CR nuclei. In this work, we illustrate this effect and examine its influence by an analysis of different potential source luminosity evolutions. The results demonstrate a good agreement with the experimental data, if the sources have shown an increased luminosity in the past according to either a normal or log-normal evolution.

Poster Sessions (Interdisciplinary/Other) - Board: `ID-P-03` / **176**

Possible effect of GCR in long-term atmospheric emissions

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Long term change in atmospheric red line emission intensity is described by Wolf number, Galactic Cosmic Rays (GCR) and other luminous flux parameters. We have shown that, GCR contributes and affects the precision of estimating different parameters affecting the process. We have estimated the role of GCR and observed a possible mechanism to describe its influence on higher levels of atmosphere.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `AAC-P-08` / **120**

Silent messengers of the universe - a dive into neutrino astrophysics

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The subatomic particles born in abundance in stars and supernovae, known as neutrinos are characterized by their weak interactions with matter. Due to that, they are able to travel vast distances from their source without being absorbed or deflected. This results in neutrinos having great potential in the development of technology specializing in probing the universe. As such, this poster presents an overview of the role neutrinos play in the growing field of astrophysics. Key points included will cover the technological advancements in neutrino observatories (such as Super-Kamiokande or IceCube) as well as explore the discoveries accomplished through them.

Due to cutting-edge neutrino detection technologies, researchers were able to not only shine a new light on the understanding of dark matter or the origins of cosmic rays but also fundamental properties of neutrinos themselves. As of right now, the field of neutrino astrophysics is rapidly evolving, offering promising opportunities for future studies. With the growth of our understanding of neutrinos, the ability to unveil mysteries of the universe follows.

Poster Sessions (Astrophysics, Astronomy, Cosmology) - Board: `AAC-P-04` / **160**

Modelling of diffusion: observations in Fermi acceleration

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Fermi acceleration refers to a type of motion in which charged particles are constantly reflected, most often through magnetic mirrors. Such a motion takes its name from a famous scientist, Enrico Fermi. Accelerated Fermi motion is the main mechanism for how we would describe the accelerated motion of cosmic rays. These aspects where mainly discussed by **A.J. Lichtenberg** and **M. A. Lieberman** in book: "Regular and Stochastic Motion". Main topic was examining diffusion, helping us understand these astrophysical objects.
However, this aspect is not fully examined. Our knowledge is limited because we cannot observe cosmic rays with enough precision, because of that aspect of diffusion remains uncertain.
This research will be using computational methods, like **MATLAB**, helping us understand this process better.
While researching this topic, there has been spotted anomalous diffusion, also some interesting observations concerning cosmic rays and it shows how initial parameters could change our whole perception of a process.

Significanse of this research is studying the behaviour of cosmic rays, which could be explaining a lot of gaps in science.

Keywords: Diffusion, Cosmic rays, accelerated Fermi motion.

Poster Sessions (High Energy Physics) - Board: `HEP-P-03` / **12**

Spontaneous Symmetry Breaking and Goldstone Theorem

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We discuss the concept of spontaneous symmetry breaking and illustrate it with a general example. We consider Wigner-Weyl and Nambu-Goldstone realisations of symmetry in the quantum theory. Next, we state Goldstone's theorem and sketch its proof. We discuss why quantum chromodynamics is not realised in the Wigner-Weyl mode. We also consider different order parameters of spontaneous chiral symmetry breaking.

Poster Sessions (Biophysics) - Board: `Bph-P-01` / **119**

EFFECTS OF NON-THERMAL PLASMA TREATMENT ON SEED GERMINATION AND SEEDLING DEVELOPMENT OF CUCUMBER (Cucumis Sativus) AND CORIANDER(Coriandrum sativum)

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The electron density, energy consumption per cycle, and power dissipation of plasma generated by a dielectric barrier discharge (DBD) at atmospheric pressure and room temperature were measured across a range of applied voltages. The impact of non-thermal plasma (NTP) on the germination of coriander (Coriandrum sativum) and cucumber (Cucumis sativus) seeds was thoroughly investigated, alongside assessments of seedling relative length and weight, plant diameter, and leaf count. An extensive electrical characterization of the plasma produced by DBD was conducted with varying voltages. The optimal voltage for seed treatment was determined to be 15.65 kV (200 divisions) among nine different applied voltages. Argon gas at a flow rate of 5 liters per minute was used to generate the DBD plasma. Coriander and cucumber seeds were exposed to the plasma for 3, 5, and 7 minutes, and 1, 3, 5, and 7 minutes, respectively. Key parameters such as water absorption capacity, mass loss, germination percentage, and vigor index were evaluated. Plasma treatment markedly enhanced germination-related metrics for both coriander and cucumber seeds. This included improvements in germination percentage, fresh and dry weight, vigor index, and various seedling growth characteristics such as length, width, and weight. Consequently, a significant increase in the yield of both coriander and cucumber was observed.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-03` / **152**

Mechanical Properties of Mexico

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In this study we calculated the center of mass and the geometric center of México's territory profile based on maps that represent the country's terrain using color codes in the maps, allowing for a clear visualization of México's topography. We wrote the code in Python programming language to perform the calculations and obtained the country's topographic data and land border profile from public databases.
The center of mass was determined by calculating the weighted position of all "mass"points in the national territory, considering local altitude over sea level as the mass distribution variable. On the other hand, the geometric center was calculated as the point equidistant to all edges of the country in its geometric form.

This work was undertaken with the aim of providing informative insights in science, serving both as a resource for public dissemination and as a means to delve into multidisciplinary research. Focusing on projects such as the use of neural networks in physics research, quantum computing, and economic predictions using mathematical and physical methods. Beyond its primary focus on physics, this study spans across computing, geography, and data science, allowing for a deeper understanding of how mass is distributed in a given area. The understanding of the center of mass is crucial across multiple disciplines, offering practical applications for scientific analyses and simulations in diverse fields such as computer science and physics.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-05` / **164**

Modelling of Diffusion: Langevin equation

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Langevin equation can be related to Brownian motion and diffusion to the concept of friction. Describing the dynamics of particles influenced by random forces *(the behavior of particles undergoing random motions due to thermal fluctuations)*, it allows for the prediction and analysis of diffusion phenomena under various conditions. An equation of motion such as this, which includes a time-dependent random force, is known as **stochastic**.
I will be using analytical methods to show equation derived based on the relationship between the reaction rate and the number of reactions occurring in a time interval, also computational methods **[MATLAB]** to help us visualize problem, which also makes the process less complex and time-consuming.

Keywords: Langevin equation, Diffusion, Modelling in Matlab.

Poster Sessions (Computational Methods for Physics Applications) - Board: `CMPA-P-09` / **60**

Optimization of beam emission spectroscopy modelling with extreme learning machines

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Beam emission spectroscopy (BES) is an active plasma diagnostic employed for plasma density measurements. BES synthetic diagnostics are computationally expensive and comprehensive modelling suites designed to provide a better understanding of the diagnostic's perception of underlying plasma phenomena. RENATE-OD is an advanced BES synthetic diagnostic relying on a rate-equation solver to derive the beam emission for given input plasma profiles.
Due to the resource intensiveness of the calculation, the capabilities of RENATE-OD are severely limited in three-dimensional modelling, where hundreds of thousands of calculations can be needed.
In this work we examined a subset of neural networks called Extreme Learning Machines (ELMs) for the problem described above. We generated a robust artificial dataset consisting of pairs of realistic plasma density profiles (containing a wide range of plasma fluctuations) and temperature profiles. The corresponding linear emission density profiles were calculated with RENATE-OD. This dataset was used to train and evaluate the ELM models.
We aimed to harness the advantages of both worlds, the precision of the classical numerical calculations done by RENATE-OD and the efficiency and scalability of machine learning models. We created a model that can significantly speed up 3D modelling by predicting the solutions of the underlying linear differential equation system. Obtaining the predictions this way was found to be faster by roughly three orders of magnitude.
We also coupled our artificial dataset with existing turbulence models and added plasma turbulence to the inputs of our models to test their robustness and applicability to realistic scenarios, while using the results to further validate our work with the existing plasma physics models.

Poster Sessions (Condensed Matter and Solid State Physics) - Board: `CMSSP-P-05` / **166**

Theoretical approaches for predicting core-level binding energies

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To understand reaction mechanisms in heterogenous catalysis, X-ray Photoelectron Spectroscopy (XPS) is a widely used characterization technique as it allows the identification of involved species based on core-level binding energies. This approach exploits the fact that electron core-level binding energies are highly sensitive to the local chemical environment, resulting in shifts upon changes in the adsorption geometry or conversion to a different chemical species. However, relating the observed core-level binding energy shifts to corresponding adsorption geometries is not straightforward, establishing the need for theoretical predictions for reliable interpretation.
The proposed poster reviews three methods for calculating core-level binding energies using density functional theory (DFT), namely the initial state, final state and Slater-Janak approach. The assumptions and expected performance of each method are compared, with special attention to additional information that can be obtained from such a comparison, for example on the relaxation energy contribution to the predicted core-level binding energies. In addition to providing accurate predictions, the potential of theoretical calculations for identifying the main factors contributing to core-level binding energy shifts is discussed. This eventually allows to establish simple principles for rationalizing shifts observed in experiments.

Poster Sessions (Condensed Matter and Solid State Physics) - Board: `CMSSP-P-01` / **140**

Copper namoparticles in aluminum matrix at elevated temperatures

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Aluminum aqueous batteries offer several promising properties: low cost, safe operation, eco-friendliness, and high theoretical capacity. Their main challenges, which are linked to the formation of the oxide layer and side hydrogen reactions, can be reduced by using the Al - Al2Cu lamellar geometry of electrodes. The preparation of heterogeneous nanostructural electrodes from layered Al films and Cu nanoparticles may offer a convenient way to explore emphasized textthe effect of different geometries. In this project, we focused on nanostructures consisting of layers of Al and Al with Cu nanoparticles of different thicknesses annealed ex-situ and in-situ in the transmission electron microscope. We aimed to determine the suitability of these types of nanostructures for future research.

Poster Sessions (High Energy Physics) - Board: `HEP-P-07` / **62**

Towards a new parametrization for tensor- and axial-vector-meson transition form factors

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High-precision quantities such as the anomalous magnetic moment of the muon a_μ have gained increasing interest in the high-energy-physics community. In this context, the Muon g-2 experiment at Fermilab will have an unprecedented precision that requires a commensurate theoretical estimate. The corresponding error is fully driven by hadronic uncertainties, including uncertainties of the hadronic vacuum polarization and hadronic light-by-light contribution. In order to improve on the latter, a more extensive study of the resonance contributions (in the GeV range) is necessary. Specifically for the transition form factors of the the axial-vector- and tensor-meson resonances, the underlying mechanisms are not very well understood. We create a dynamical model for the transition form factors, making use of the Bardeen-Tung-Tarrach procedure in order to ensure gauge invariance, implement symmetry constraints, and control kinematic singularities. The form factors are then modelled by a sum of triangle Feynman diagrams with phenomenological input for the vertices.

Guest Speakers / **196**

The Atomic Nucleus as a Quantum Laboratory

Author: Ulf-G. Meißner[None]

Student Lectures (Computational Methods for Physics Applications) / **71**

Bootstrapping Quantum Mechanics

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Bootstrapping is a numerical method initially used in the Conformal field theory (in this context, also known as the conformal bootstrap). We applied this method to Quantum mechanics to determine the energy levels of two simple quantum mechanical systems: the harmonic oscillator and the double-well. In the case of the double-well, we also focused on the energy splitting of the ground and the first excited states.

Student Lectures (Interdisciplinary/Other) / 1

Knowledge is Meant to be Communicated: Importance of Public Science Communication

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The last few years saw a meteoric rise in scientific content in social media. Many scientists and science enthusiasts have participated in this huge renascence. What started from YouTube a decade back has now transitioned into Instagram, X, TikTok, and more. However, science still seems behind, especially in underrepresented communities - like the one I am coming from. Misinformation, disinformation, pseudoscience, and others still represent a strong threat. In this talk, the state of science communication will be discussed, with a focus on my own experience. The goal of this talk is to offer a point of view coming from a unique background and to take other perspectives on this matter too.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 79

Mini-Neptunes: super Earths or water worlds?

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Exoplanets are planets outside the solar system. Mini-Neptunes (planets with a radius ranging from 1.8 to 4 the radius of the Earth) are one of their most populated clusters, even though they do not exist in our Solar System. This makes them become a key to planetary formation understanding, representing a fascinating and quickly growing area of exoplanetary science and astrobiology.

The radius of mini-Neptunes can be obtained using the transit method by measuring the changes in the flux received from a star when a planet transits; this is, its orbital movement makes it pass between its host star and an observer.

The mass of transiting sub-Neptunes is determined using the radial velocity method, based on the Doppler shift of the light received from a star that moves because of the gravitational interaction with a planet that orbits it.

The combination of these two methods leads to the determination of densities of sub-Neptunes. Some authors 1 state that different densities of these planets lead to different compositions: super-Earths, rocky planets with extended H/He atmospheres or water worlds, planets with a high (up to 50% or more) water composition.

However, others 2 find degeneracies and contradictions by considering different evolutionary models, concluding that density is not enough to characterize mini-Neptunes and there is more information needed, for instance, by studying their atmospheres.

Future developments are expected to revolutionize exoplanetary science and break these degeneracies to understand how mini-Neptunes are and their formation mechanisms.

1 Luque, R., Pallé, E. (2022). "Density, not radius, separates rocky and water-rich small planets orbiting M dwarf stars". Science 377, 1211-1214. DOI: 10.1126/science.abl7164.

2 Rogers, J. G., Schlichting, H. E., Owen, J. E. (2023). "Conclusive Evidence for a Population of Water Worlds around M Dwarfs Remains Elusive". The Astrophysical Journal Letters 947(1), L19. DOI: 10.3847/2041-8213/acc86f.

Student Lectures (Interdisciplinary/Other) / 28

ICPS 2025

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The next edition of your favorite event, ICPS 2025, will be held in beautiful Serbia! From August 3 to August 10, 2025, you will be our guest in lovely Novi Sad. We will guide you through our event's program, the opportunities it will provide for you, any answer any of your questions or doubts.

The International Conference of Physics Students (ICPS) is an annual conference bringing together hundreds of students from the whole world, joined by their interest in physics. It has a rich program, with balanced scientific, cultural and social activities for lucky students to come there.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 80

The energy and power of radiation emitted by primordial black holes.

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The present study aims to estimate the energy and power of particles emitted by primordial black holes, which have a mass ten times smaller than the Sun.
At the first stage of the research, the maximum Lorentz factor of the electron was estimated, in particular, several mechanisms that could limit the acceleration of particles were considered, and only the mechanism that gave the lowest value was studied. It was found that such a mechanism is the particle's landing on the magnetic field line, which limits the Lorentz factor to the order of 10^5.
The energy of the emitted photon was further discussed, in calculating which maximum Lorentz was used. Also, with the help of the Goldrich-Julian density, the number of particles inside of light cylinder was counted and multiplied by the radiated power of one to obtain the total radiated power.
Finally, it is accepted that the energy of photons reaches 1 Tev, and electrons reaches 10^(-1) Tev, and the radiation power is 10^7 ergs⁄sec.

Student Lectures (Computational Methods for Physics Applications) / 159

Parameterisation and Performance Limits of Indoor Photovoltaic Modules

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With the upcoming demand for "Internet of Things" (IoT) devices, intensive research has been conducted on sustainable power solutions for these devices. IoT devices utilize sensors embedded in everyday objects, such as light switches, doors, and vehicles, to collect and communicate data over the internet. One promising method to power these devices is indoor photovoltaics (PVs). Next-generation indoor PVs leverage recent advancements in PV technologies, incorporating flexible, inexpensive, and sustainable materials such as molecular semiconductors. Under low light conditions, a single PV cell may not generate sufficient voltage to efficiently power an IoT device; thus, multiple PV cells are typically connected to form a mini-module. This study aims to calculate the optimal number of cells required for indoor PV modules to maximize overall IoT system efficiency under various lighting scenarios. Initially, the thermodynamic limit of a single ideal PV cell was simulated under typical indoor lighting conditions. Following this, the performance of an ideal 5 cm × 5 cm module was evaluated using finite element modelling (FEM). Voltage-dependent efficiency data from typical energy harvesting chips were employed to predict the overall energy harvesting efficiency of this module. Subsequently, leveraging data on state-of-the-art indoor PV technologies, various models were developed to calculate and compare the overall energy harvesting efficiency across several systems. The analysis revealed that the optimal number of cells for the modelled systems ranged from approximately 4 to 6 cells. However, this finding is highly dependent on the illuminance conditions under which the module is deployed, as system efficiency is significantly influenced by the voltage at the maximum power point.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 91

MHD INSTABILITIES IN SHEAR FLOWS OF ANISOTROPIC COSMIC PLASMAS. I. FIRE HOSE MODES

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The stability of an anisotropic collisionless plasma layer to small disturbances within the framework of magnetohydrodynamics (MHD) is explored. We base our analysis on moment equations derived from the Vlasov kinetic equation, accounting for heat flow along spatially shearing flows. To determine the complex spectral parameter governing the instability growth rate, we solve the boundary value problem using the WKB approximation, assuming a smooth hyperbolic velocity profile. The resulting general integral dispersion equation describes various body and interface instabilities in the presence of heat flow along the magnetic field—a phenomenon well-studied in infinite stationary anisotropic plasma.

Our findings reveal that reducing the layer width significantly enhances the mirror instability while strongly suppressing the oblique fire-hose instability. Specifically, we focus on the aperiodic oblique fire-hose instability within a confined layer and observe that the spatial gradient in flow velocity plays a crucial role. As the layer width narrows and the velocity gradient increases, the body hose modes transform into surface Kelvin-Helmholtz (KH) modes at the discontinuity surface between the two flow regions.

Keywords: Solar wind, anisotropic plasma instability, MHD shearing flows

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Mudflow Analysis using Generalized Rheological Equation and Cellular Automation on Lattice map

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In this work we study mud-flow system based on the generalized rheological equation. In the simplified case of 1D inclined landscape we will try to tackle the problem and derive the corresponding analytic solution for pressure distribution, then we will consider 2D flow around cylindrical columns. Finally using the results obtained we will attempt to refine the set of rules required for cellular automation on the lattice system to deterministically solve and analyze the evolution of landslides at hazardous areas in Georgia.

Student Lectures (Interdisciplinary/Other) / 17

The Plasma Window for Enhanced Particle Beam Transmission from Vacuum to Atmosphere

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Neutrons play a dominant role in the stellar nucleosynthesis of heavy elements. We review a scheme for the experimental determinations of neutron-induced reaction cross sections using a high-intensity neutron source based on the 18O(p,n)18F reaction with an 18O-water target at SARAF's upcoming Phase II. The quasi-Maxwellian neutron spectrum with effective thermal energy $kT \approx 5$ keV, characteristic of the target (p,n) yield at proton energy $Ep \approx 2.6$ MeV close to its neutron threshold, is well suited for laboratory measurements of MACS of neutron-capture reactions, based on activation of targets of astrophysical interest along the s-process path. 18O-water's vapour pressure requires a separation in between the accelerator vacuum and the target chamber. The high-intensity proton beam (in the mA range) of SARAF is incompatible with a solid window in the beam's path. Our suggested solution is the use of a Plasma Window, which is a device that utilizes ionized gas as an interface between vacuum and atmosphere, and is useful for a plethora of applications in science, engineering and medicine. The high power dissipation (few kW) at the target is expected to result in one of the most intense sources of neutrons available at stellar-like energies. Preliminary results concerning proton beam energy loss and heat deposition profiles for target characteristics and design, a new fullscale 3D CAD model of the Plasma Window (as well as its operation principles) and the planned experimental scheme at SARAF, are reviewed. Moreover, work includes a feasibility study for the use of a plasma window for the Gamma Factory, a proposed high energy (up to 400 MeV) photon source at CERN.

Student Lectures (Computational Methods for Physics Applications) / 203

Implications of the memory effect on stochastic resonance

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Stochastic resonance (SR) is a phenomenon in which a signal that is normally too weak to be detected by a sensor can be amplified by adding white noise that contains a wide range of frequencies. Frequencies in the white noise that match the frequencies of the original signal resonate with each other, amplifying the original signal while leaving the rest of the white noise unamplified. This increases the signal-to-noise ratio, making the original signal more visible. Stochastic resonance is often used in nonlinear, bistable systems. Our report discusses this very method, which we use to obtain energy. The model presented, namely the double potential well, describes the effect of noise on the system. Energy recovery is demonstrated through numerical experiments and modeling.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 99

Enhancing Fermi-LAT Source Detection Through a Novel Denoising Technique

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Background noise elimination is a pivotal concern in data analysis and signal detection. Here, we introduce a novel denoising technique tailored specifically for gamma-ray data collected by the Fermi-LAT telescope. Our study highlights the transformative impact of integrating this method before applying clustering algorithms such as DBSCAN and MST. This integration significantly enhances the accuracy and efficiency of detecting gamma-ray sources. Through the examination of both simulated and authentic 15-year Fermi-LAT data, we emphasize the method's ability to unveil previously unnoticed sources and improve the characterization of established ones.

Student Lectures (Interdisciplinary/Other) / 35

Dissociative electron attachment to carbonates

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Dissociative electron attachment (DEA) is a resonant process by which a low-energy electron attaches to a molecule, causing electronic excitation into a temporary negative-ion state, and inducing fragmentation into neutral and anionic species. Low energy electrons are present from ionizing radiation in the atmosphere and in many industrial products such as Lithium Ion Batteries (LIBs)1. Therefore, our aim is to investigate DEA to a diverse group of compounds, e.g., carbonates. Diethyl carbonate (DEC) is an organic linear symmetric carbonate with extensive industrial applications. It is most commonly used in LIB anodes and as a fuel additive. DEC has high polarity, low toxicity, biodegradability, and is associated with high oxygen content and decreased particulate emissions as a fuel additive2. Because of its symmetric structure, DEC is used globally in the production of polycarbonates. DEC is an excellent solvent, widely utilized in pharmaceutical products, fertilizers, pesticides, and dyes. However, DEC is also listed as a volatile organic compound and potential photopollutant[3]. Because of its varied use in industry, a DEA study of DEC can establish the safety of DEC and larger polycarbonate systems. Furthermore, the degradation of DEC and various other carbonates is a chief cause of LIB degradation; our study hopes to illuminate carbonate decay pathways present in LIBs. Our analysis also expands the database on electron-induced dissociation of organic carbonates. Our preliminary studies involved an apparatus with a quadrupole mass spectrometer to

study DEA to gas-phase DEC[4]. Our analyses of ion yields found 4 anionic fragments from DEC: O-, CH2CHO-, HCOO-, and C2H5CO3-. The three multi-atomic anions exhibit charge delocalization activated by dissociation of the carbonate group. Using the B3LYP functional and the aug-cc-pVTZ basis set, we provide a density functional theory analysis of the fragments to determine plausible fragmentation channels associated with each ion peak.

Student Lectures (Interdisciplinary/Other) / 54

The influence of solar radiation and atmospheric circulation on temperature anomalies in Warsaw

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The aim of the presented study is to analyze the influence of solar radiation and atmospheric circulation on the occurrence of temperature anomalies in Warsaw.

The research will focus on understanding how these variables affect temperatures in Poland and examining the variability of anomalies as a result of global warming. The study is based on measurement data collected by the Radiation Transfer Laboratory over the past 20 years. Appropriate statistical analysis methods will be used to investigate the correlations between the intensity of solar radiation, atmospheric circulation, and temperature deviations from the average, with the obtained results undergoing reanalysis.

The results of the study, providing current data and analyses, can be utilized in further research and contribute to a better understanding of the local effects of global warming. Investigating these relationships can also help in developing practical applications related to predicting temperature anomalies and planning adaptations to climate change.

Student Lectures (Computational Methods for Physics Applications) / 188

Non-equilibrium dynamics of Lennard-Jones systems

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Our research analyses 2-dimensional and 3-dimensional atomistic numerical systems utilizing a Lennard-Jones potential to investigate non-equilibrium dynamics exhibited at low-temperature supercooled states. The widely regarded theory of dynamic facilitation in supercooled liquids posits the existence of dynamic heterogeneities observable as so-called regions of high and low mobility. Our research attempts to quantify the effects of such heterogeneities on the measurable quantities such as the orientational structure parameter and Kurtosis of the velocity distribution. Namely, we are interested in studying the impact of thermostats on the non-equilibrium states of the system. We utilize a wide range of common and custom-created thermostats to observe how the temporal or spatial definitions of temperature influence the possible emergence of non-equilibrium effects such as supercooling and glass transition.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 104

The effects of Solar Activity cycles on the asteroseismic parameters from 25 years of observations with GOLF and VIRGO on the ESA SOHO space telescope

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The Solar and Heliospheric Observatory (SOHO) provides us with unprecedented short-cadence spectroscopic and photospheric data of the Sun-as-a-star for 27 years. Here the data from the GOLF and VIRGO/SPM instruments are used. This dataset completely covers the previous solar cycles (23 and 24) and contains the onset of the current solar cycle. The measurement of the solar activity cycle with instruments that integrate over the whole solar surface is important because then we can compare the results with asteroseismic studies of other solar-like stars on the main sequence, provided by the rich data of the space telescopes such as NASA Kepler, TESS or the forthcoming European PLATO mission.

In this talk I want to present the results of my master's thesis, where the influence on the asteroseismic parameters during the solar activity cycle was studied. We investigate the reported correlation of the shift of the radial and low-degree non-radial oscillation modes with the activity of the Sun. The level of solar activity is estimated from the SOHO time series data. Additionally, we obtain proxies for solar activity from the SILSO international sunspot number and the 10.7 cm radio flux. We extend the analysis until 2023 and provide first insights into the behavior of solar-oscillation modes in the ongoing solar cycle 25.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 106

The impact of Self-Interacting Dark Matter in dwarf galaxies

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The ΛCDM model is the most widely accepted model of cosmological structure formation and evolution. It includes a form of Cold Dark Matter (CDM), which is non-quantum, non-relativistic and collisionless. It settles into extended and dense self-gravitating haloes as a result of cosmic structure formation. CDM haloes act as a stabilizing agent for galaxies, while the late-time accelerating expansion of the Universe is sourced by a cosmological constant Λ. Due to the disagreement between ΛCDM-based simulations and observations on galactic and sub-galactic scales and the fact that traditional dark matter candidates remain undetected, the theoretical space for alternatives has been widening, making the particle nature of dark matter a fundamental question in Physics.
In the Self-Interacting Dark Matter (SIDM) model, strong self-interactions modify the inner dynamics of dark matter haloes and could potentially solve outstanding inconsistencies between CDM and observations of dwarf galaxies. We focus on the final stage of the SIDM halo evolution - the "gravothermal collapse" phase. We show that in a certain region of the parameter space of SIDM models, dwarf-size SIDM haloes have a bimodal distribution, with some having central density cores and others being centrally cuspy; the latter being those that have collapsed and contain an intermediate-mass black hole. This offers a promising solution to the so-called "diversity problem" in Milky-Way satellites. We extend the analysis of the core-collapse phase in SIDM haloes towards including the impact on the baryonic component within. In particular, we discuss how the use of adiabatic invariants

can be exploited to predict the response of stellar orbits to the collapsing SIDM core. Furthermore, we study the impact of gravothermal collapse on the formation and evolution of dwarf-size galaxies with idealised/controlled simulations using the AREPO code.

Student Lectures (Interdisciplinary/Other) / 69

RAF - Analog Space Mission - The first analog space base on mining heaps

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For ten days, a post-mining heap from the coal mine in Bytom was transformed into an analog space base. This place became a hub of scientific activity as young researchers from the Scientific Club of Geophysics at the University of Warsaw embarked on an innovative project to simulate Martian conditions. The mission, named RAF-Analog Space Mission, aimed to replicate space conditions, test behaviors and principles applicable in outer space, and conduct essential scientific research.

The mission team comprised three students: Natalia Godlewska, an astronomy student and co-leader of the project; Norbert Nieścior, a physics student; and Piotr Lorek, a student of biotechnology and medical chemistry. These "astronauts" spent ten days living and working in a specially designed analog space base on the heap. The mission's primary objective was to conduct various scientific studies, including geophysical, geological, psychological, and astrobiological research.

The central phase of the project involved setting up a mobile base composed of a camper (serving as the living quarters) and a delivery van (serving as the scientific laboratory), connected by an airlock. This setup, located on approximately 30 square meters, provided a controlled environment simulating Martian conditions. The participants followed strict protocols, leaving the base only in space suits to maintain the illusion of being on Mars.

Analog space bases are terrestrial simulations of space conditions—in this case, Martian conditions. Analog astronauts strive to live and operate under space-like rules and constraints. The base allowed the team to experience and adapt to the challenges of life on Mars.

Tutorials / 117

TRIZ- Theory of inventive problem solving

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Our tutorial aims to give the students an insight into TRIZ- theory of inventive problem solving, and demonstrate its methods and practical applications. This theory, developed in the Soviet Union, covers all the principles that inventors can use in their work and allows them to find effective solutions to problems in any field of work.
The first part of our tutorial is dedicated to methods of fantasizing that allow to tune the brain to creative and critical thinking. The second part introduces the main terms and concepts of the Theory. The final part of the presentation discusses some principles of the theory of inventive problem solving using specific examples, and the audience can immediately apply the skills of invention they have acquired in practice.
As a result, the listeners of this tutorial will learn to consider any problem as inventive, come up with multiple ways to solve it, and identify the most effective (least resource-intensive) solutions.

Tutorials / **24**

Introduction to COMSOL - Modelling Nanostructures

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This tutorial provides an introductory yet focused overview of mechanically modelling nanostructures using COMSOL Multiphysics. The session will cover basic features of COMSOL, emphasising the mechanical simulation of nanostructures. Participants will learn to navigate the user interface, create geometries, choose materials, apply meshes, and calculate properties of nanoscale structures such as a Si nanobeam and a SiN nanostring. By the end of the tutorial, participants will be equipped to apply COMSOL in their studies and research. The tutorial will also advance their understanding of nanoscale mechanical systems.

The tentative outline of the tutorial is:
1) Setting up COMSOL
2) Simulating a Si nanobeam:
* Selecting the right kind of simulation *(Eigenfrequency)*
* Building the geometry
* Selecting the material
* Defining the boundary conditions *(both ends of the beam are fixed)*
* Building the mesh
* Running the simulation & computing eigenfrequencies
* Comparing the simulated eigenfrequencies with analytical results
3) Simulating a SiN string under strain:
* Selecting the right kind of simulation *(Stationary)*
* Building the geometry
* Selecting the material
* Defining the boundary conditions *(both ends of the beam are fixed, a side of the beam bears load)*
* Building the mesh
* Running the simulation & computing the displacement
* Changing the colour scale
* Building a 1D plot of the displacement
* Adding initial stress of SiN to the simulation
* Rerunning the simulation
* Building a 2D plot of the stress
* Calculating the average stress in one direction
4) Simulating a more complex nanostructure *(if there is time left)*

Tutorials / **114**

Introduction to latex

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The writing of articles, essays, and term papers are something that every physics student have to face at some point and more than once. In this case, it is crucial to focus on the essence of the work, as scientific research itself is time-consuming and you do not want to spend even more time on formatting and paperwork. This is exactly where we can help students with our latex tutorial. Since you are programming your future scientific work in latex, you can forget about formatting and make your life easier. However, latex has a very high entry threshold and not everyone will be able to figure it out on their own and feel all of its charms. Our tutorial will cover the following topics:
1. Creating a cover page for your work.
2. Creating a table of contents for the document.
3. Creating paragraphs of plain text with different formatting.
4. Writing formulas.
5. Creating tables.
6. Inserting images and creating simple images.

Tutorials / 273

School Day Workshop and TC India initiatives

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The "School Day Initiatives of TC India" workshop aims to raise awareness and encourage participation in the IAPS School Day. This event inspires school students with interactive physics sessions, hands-on experiments, and engaging demonstrations.
The workshop will highlight TC India's successful activities, such as physics demonstrations, astronomy sessions, and games. Participants will learn about the event's objectives, benefits, and impact, and receive practical guidance on organizing their own School Day events.
By sharing success stories and providing resources, the workshop seeks to empower more committees and individuals to enhance physics education and inspire future scientists through IAPS School Day.
This would be a interactive session means students can ask their doubts in between the session instead of just listening. We will also share some tips from our past experience on the logistics and planning, organization of such events.

Guest Speakers / 193

Quantum Algorithms for Particle Physics

Author: Lena Funcke[None]

Guest Speakers / 197

Emergent Laws of Physics and Biological Simplicity

Author: Ilya Nemenman[None]

Student Lectures (Quantum Technology) / 100

Liouville equation on quantum computer

Authors: Thibault Fredon[1]; Julien Zylberman[2]; Fabrice Debbasch[2]; Nuno Loureiro[1]

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Solving systems of nonlinear differential equation, such as found in plasma physics, is a current challenge in fault-tolerant quantum computing. To this aim, a method to solve the classical Liouville equation on quantum computers is developed using the Koopman-Von Neumann transform.The quantum algorithm evolves an initial wavefunction in discrete space and time whose probability density evolves according to Liouville equation. The quantum circuit associated to the algorithm mainly requires the Quantum Fourier Transform and diagonal unitaries which are efficiently implementable with Walsh series. The resource requirement is analyzed. To exemplify the method, two Liouville systems are studied using the algorithm: a 1D Harmonic Oscillator to exemplify the method, and the Lokta-Volterra system to explore the algorithm's performance on a non linear system.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 113

relatively accelerated motion of a particle, on a spiral

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The main purpose of this research is to describe the motion of a relatively accelerated particle, which is moving on a spiral. First, we write an equation of a spiral in polar coordinates and then we write the appropriate metric for the particle. With this information we write the lagrangian and try to find how velocity is dependent on time, and from that, if possible, find how the radius vector is dependent on time. Our goal is to transfer particles centrifugal energy into z axis directed motion energy. Then we apply this theoretical motion to the real situation near the black holes.

Student Lectures (Biophysics) / 7

New opportunity to look insight the viral world using optical methods

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Nowadays, due to the recent Covid-19 pandemic, rapid detection and identification of pathogenic microorganisms causing diseases become the urgent problem for scientists and clinicians. We consider some optical methods, and their application to study absorption and scattering properties of viral particles in purpose of virus identification.
Currently, polymerization chain reaction (PCR) method is used for detection of various types of viruses. Despite its widespread successful use, as practice shows, PCR method has disadvantages. This work presents the possibility of detecting viral bioparticles and studying their physical and biological properties using various spectroscopic methods such as Raman, UV and IR spectroscopy. Knowledge of spectral signatures of particles is the most important in sensing and identification systems. Another tool to estimate the spectra of viral particles is based on simulation method. We discus the possibility to determine the spectral properties of viral particles using mathematical models, solving electrodynamics boundary problems. This approach considers the virus as a particle of different geometrical and physical parameters: Inner and outer diameters, dielectric permittivity of the coat (protein capsid) and core (DNA/RNA), shape, triangulation number, polarizability, etc. Research revealed that absorption and scattering spectra of viral particles mainly depend on the characteristics of the viral particle itself, surrounded medium, viral concentration in that. Modeled spectra will be presented for target virus MS2, which is used as a simulant for viruses, e.g. smallpox or Ebola. MS2 virus is an icosahedral, positive-sense single-stranded RNA virus. Spherical geometry of viral particle makes possible to apply May's theory and method elaborated by our team. Simulation method is used to determine the wavelength dependence of the electromagnetic field scattered on the viral particle emerged in different medium.
Work is supported by Shota Rustaveli National Science Foundation of Georgia(SRNSFG)[FR-23-4069]

Student Lectures (Biophysics) / 112

Embracing Machine Learning for Inverse Problems Based on Spectroscopy

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The quest to interpret spectra (UV, VIS, Raman, etc.) is a well-known problem for physicists from fields such as experimental, complex systems, or phonics, where with each sample a spectrum can be measured to check its quality and properties, that quest can be seen with each newly studied material or compound 1. Recent advancements in theoretical frameworks, such as genetic algorithms, and series-based[1] Machine Learning 2, have provided tantalizing glimpses into the basic understanding of such spectroscopy and the nature of some nuances not yet well understood [3].

This presentation will introduce and explore a basic understanding of Machine Learning and inverse problems based on spectroscopy (absorption, scattering, and reflection). We will also delve into the implications of recent developments in Machine Learning-based inverse problems solved in selected spectroscopy techniques.

[1] It is often that when working with a series of data, that data is entangled with time, and thus it is commonly known as "time-series" data, and machine learning models developed upon it are known as time-series machine learning models. The spectrum might vary in a base for obtaining data and that is why the name "series-based" was used to minimize confusion, but techniques that might be used to analyze it with machine learning approaches are indeed known under the name "time-series".

References
1 Tanudji, Jeffrey et al. (2023). Surface Facet Effect on the Adsorption of Iodine and Astatine on Gold Surface. e-Journal of Surface Science and Nanotechnology. 22.

2 Mayer, Alexandre et al. "Genetic-algorithm-aided ultra-broadband perfect absorbers using plasmonic metamaterials."Optics express 30 2 (2021): 1167-1181.
[3] Shizhao Lu, and Arthi Jayaraman. "Machine learning for analyses and automation of structural characterization of polymer materials".Progress in Polymer Science 153 (2024): 101828.

Student Lectures (Quantum Technology) / 138

Integrating Triboelectric Nanogenerators with TiO2-based UV Photodetectors for Self-Powered Sensor Systems

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UV photodetector has diverse applications ranging from advanced communications to leak detection. UV photodetectors play a crucial role in harnessing the power of UV light for various functions. The demand for more compact, precise, portable, and energy-efficient photodetectors has prompted the exploration of nanotechnology and nanofabrication techniques.

This study focuses on developing a TiO2-based photodetector known for its ability to absorb UV light due to its 3.2 eV bandgap. By monitoring changes in resistance based on UV light intensity, the photodetector's functionality was enhanced by integrating it with a triboelectric nanogenerator (TENG). The TENG, activated through tapping actions between Kapton and FTO materials, provided the necessary power for the photodetector.

Through rigorous testing, this research showcases the potential and reliability of the TiO2 photodetector when coupled with TENG technology. The self-powering capabilities exhibited in this study position the integrated system as a promising energy source for sensor applications, offering a new frontier in sustainable and autonomous sensing technologies.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 124

Complex dynamics of ion acoustic and cyclotron waves

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Acoustics of kinematically complex shear flows is already well studied, using the non-modal approach method in the context of described kinematic complexity. Linear coupling of ion acoustic and cyclotron waves in plasma flows is also considered to be well studied, they are studied in simple, parallel flow. The main goal of our research is to try and study the coupling of this two waves, however in kinematically complex flows using the non- modal approach method.

Student Lectures (Biophysics) / 136

EEG/MEG source analysis of the visual evoked response

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The non-invasive localisation of active brain regions is not only an important task in basic brain research, but also clinically, for example in the preoperative diagnosis of epilepsy. This is made possible by electroencephalography and magnetoencephalography (EEG/MEG), which measures the electromagnetic field outside the head, from which the underlying current density distribution in the brain can be calculated. This represents a complex inverse problem. Using evoked stimulus responses, source reconstruction methods can be evaluated on real but controlled data sets. The visual evoked response is suitable for estimating active zones in the brain due to the direct topological relation between stimulus and activated cortex volume.
My bachelor's thesis deals with the question of whether different areas in the visual cortex can be reconstructed for different visual angles used for the stimulation. The stimuli are three different visual angles with a flickering dartboard-like pattern in the lower right quadrant. In theory, it is described in such a way that stimuli in the lower right quadrant of the visual field lead to neuronal activity in the upper left of the calcarine sulcus in the primary visual cortex. Thereby, central stimuli (closer to the fixation cross) are located more lateral closer to the skull, whereas peripheral stimuli are located deeper in the brain. A data set of 1000 pattern reversals (on average 2 per second) are recorded per stimulus during simultaneous EEG and MEG measurements. The measurements are conducted on 8 subjects. The data is analysed using the CURRY8 software. The results and further details will be presented in the talk.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 127

Extra Tidal Region of Globular Cluster - 5466

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In this study, we conducted a comprehensive analysis of the extra-tidal part of the globular cluster NGC 5466. This cluster was chosen for its unique characteristics, including a blue horizontal branch and a large, centrally concentrated distribution of blue stragglers. Our goal was to gain a deeper understanding of the structure and composition of this region of the cluster. To achieve this, we first obtained data of NGC 5466 from Gaia ERD3. Then we procced to separate the intra- and extra-tidal stars data from the whole data set. Once we had separated the extra-tidal stars, we applied several filters to identify which are the potential stars of the cluster. These filters included proper motion, which we did using membership probability, and isochrone fitting using the CMD plot of the Cluster stars. By applying these filters, we were able to identify stars that are potentially part of the cluster. Our results provide new insights into the structure and composition of NGC 5466's extra-tidal part. We found that the filters we applied were effective in selecting stars that are likely to be part of the cluster. This has important implications for future studies of globular clusters and their extra-tidal regions, as it provides a robust methodology for identifying cluster members.
Overall, by combining advanced data analysis techniques with careful selection criteria, we were able to gain new insights into this fascinating globular cluster.

Student Lectures (Quantum Technology) / 175

Fabrication and Characterization of Graphene Quantum Dots: Investigation of Dopant Effects on Optical and Structural Properties

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In this research, graphene quantum dots (GQDs) are made by a simple, fast, cost-effective method using the thermal decomposition of citric acid. By adding different impurities to GQDs and contaminating it with different structures, an attempt is made to increase the luminescence intensity, and also by modifying the surface of these points by polyethylene glycol using the hydrothermal method, an attempt is made to improve their performance. XRD, TEM, HRTEM, FESEM, MAPPING, EDX, PL and UV-Vis analyzes are used to characterize the manufactured nanoparticles and also the feasibility of these materials is investigated from the optoelectronic and electrochemical point of view.

Student Lectures (Quantum Technology) / 181

Precision Gravity Gradient Sensing Using Magnon Systems

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Quantum technology is a rapidly advancing field in physics, with significant implications for various applications. In this talk, I will delve into quantum sensing, with a specific emphasis on gravity gradient sensing. Our ongoing research focuses on utilizing magnon systems, particularly involving a YIG (yttrium-iron-garnet) sphere, for detecting the Earth's gravity gradient. By coupling the magnon system to the electromagnetic field within a microwave cavity, we aim to achieve high-precision measurements. This innovative approach has the potential for wide-ranging industrial applications, such as the detection of oil, gas, and metal deposits. Furthermore, the integration of magnonic systems and spin-electromagnetic field coupling within microwave cavities holds promising potential for advancements in quantum computation and quantum information processing.

Student Lectures (Biophysics) / 185

On the possibility of existence of living organisms on pulsar exoplanets

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The classical model of harvesting energy for autotroph organisms is based on the ability to produce through photosynthesis with solar-origin photons. However, subsurface regions lack the latter energy source and this presents new challenges for the evolution of life. In order to survive in such extreme environments, alternative mechanisms have been proposed.

Bacterium Candidatus Desulforudis audaxviator, which was discovered in a South African mine, is a living form that can harvest energy from radiolysis induced by particles emitted from radioactive Uranium from the surrounding rock. Via Monte Carlo simulations, we have results that Galactic Cosmic Rays, especially muons, can be used as a steady source of energy, which itself could be the reason for slow metabolizing life developing on extraterrestrial life on exoplanets.

Implications of these mechanisms for finding life in the Solar System and elsewhere in the Universe are discussed. In this paper, we are trying to adjust the proposed mechanism to the pulsar and white dwarf's exoplanets. We estimated hospitability on each exoplanet and calculated radiation, temperature, and gravitation. Evaluate the hypothesis and demonstrate the evolution probability of the rocky and gas giant's exoplanets.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 128

Unveiling Hidden Gamma-Ray Sources: Discoveries with SEMIFIC III on Fermi-LAT Data

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For the past fifteen years, the Fermi telescope has diligently captured data on high-energy gamma rays, providing invaluable insights into the universe's most energetic phenomena. In our quest to enhance data analysis, we developed SEMIFIC III, an algorithm tailored for denoising all-sky (The extragalactic sky at absolute Galactic latitudes above 20◦ has been investigated) Fermi data with energies exceeding 3 GeV. Through this sophisticated noise reduction technique, we successfully unveiled previously obscured faint gamma-ray sources. By harnessing the power of clustering algorithms, we meticulously pinpointed these elusive sources. This innovative dual-step approach has led to the discovery of previously unrecognized gamma-ray sources.

Student Lectures (Biophysics) / 189

Exploring biological tissue through optical spectroscopy: Modelling and Experiment

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As part of our research, we investigated light scattering in biological tissues. We used both experimental research and computer modeling methods to address this issue. The aim of the research is to utilize spectroscopic methods to determine the general composition of biological tissue, specifically human skin. Experimental research was conducted in the medical field, focusing on the skin's reflectance spectrum and the ankle-brachial index.
Research has shown that spectroscopic methods in the visible range of optical spectroscopy yield good results for detecting angiologic diseases. Additionally, experimental results obtained by our group are in good agreement with simulations, particularly Monte Carlo modeling of light transport in tissue. Through this method, we calculated reflectance at dozens of wavelengths in the visible range, thus acquiring a reflectance spectrum that matched our experimental results. Simulation allows us to easily model certain abnormalities without involving patients.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 154

The Impact of Data Temporal Density on the Probability of Detecting Nearby Planets in Gravitational Microlensing Events

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Gravitational microlensing is a powerful astrophysical method for detecting celestial objects that are not directly observable. This phenomenon, predicted by Einstein's general theory of relativity, occurs when a massive object (lens) bends the light from a more distant object (source), resulting in a magnified image.

Microlensing is particularly effective for studying distant stars and detecting exoplanets, including low-mass, cold planets. It allows us to observe events where the light from a distant star is temporarily amplified by a massive intervening object.

In this project, we investigate how the temporal density of observational data impacts the probability of detecting nearby planets during microlensing events. Using data simulations, we analyze how reducing telescope exposure times affects the likelihood of planet detection. Optimizing these exposure times is crucial for improving the efficiency of detecting microlensing events and studying faint, distant objects like exoplanets.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 156

PBH overproduction bounds on LISA PT target sources

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Brief presentation of my Master's Dissertation:
Based on recent development on the description of primordial black hole (PBH) formation out of strong first order phase transition (PT), I discuss how this could limit the parameter space of interest for future gravitational wave detectors such as LISA.

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The revolution of quantum technologies: from quantum computing to cryptography

Author: Giuliano CHIRIACÒ[None]

Guest Speakers / 195

Symmetries and Phenomenology of Strings

Author: Anamaria Font[None]

Student Lectures (Interdisciplinary/Other) / 78

Non-linear longitudinal waves in Ferrite rod

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Magnetostriction is one of the most important properties of ferromagnetic materials, as it couples magnetic and mechanical effects, therefore, mechanical stress is induced under the influence of a magnetic field. In our case, for instance, we put Ferrite rod in the alternating magnetic field that is produced by regular coil and observe its behavior changing frequency of the magnetic field. As the rod undergoes periodical mechanical deformation, longitudinal waves are induced, and consequently, sound is produced by the rod. The main purpose of the investigation is to study these waves.
In the first part of the study, we demonstrate the phenomena, where the experiment shows that different wave modes of the natural order external magnetic field frequency propagate through the rod. Thus, in our theoretical model, which is based on the forced wave equation and the non-linearity of the magnetization of the ferrite rod material, we must consider all boundary conditions properly, in order to qualitatively describe its behavior dependence on the frequency of the alternating magnetic field. Additionally, we will compare the theoretical results to the experimental ones, where we used a microphone to record the sound of the ferrite rod and then performed Fourier analysis. This analysis will allow us to determine the actual relative deformation of the rod as a function of time.
In the last part of the study, we will demonstrate an additional experiment involving a jumping bead on the top end of the rod under several initial conditions. If the amplitude and frequency of the oscillation of the top end are sufficiently high, the bead may lose contact with the surface of the ferrite rod. Moreover, after several collisions, the jumping height may increase. Therefore, this simple experiment can help us estimate the power and efficiency of the ferrite rod.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 158

acoustics of relativistic Hagen-Poiseuille flow

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Hagen-Poiseullie flow is a very widespread type of flow in nature. However, in astronomy and astrophysics.we often encounter with relativistic Hagen - Poiseullie flows. The task is to study this flow and its acoustic effects in the relativistic limits and compare it to the nonrelativistic flows.

Student Lectures (High Energy Physics) / 155

From Quarks to Cosmos : A Journey Through Particle Physics

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I will delve into the fascinating world of particle physics, exploring the fundamental particles and forces that constitute our universe. I will begin with an introduction to the Standard Model, detailing the classification and properties of elementary particles such as quarks, leptons, and gauge bosons. The role of the Higgs Boson and its significance will be highlighted. Following this, I will talk about the four fundamental forces, focusing on their unique characteristics and the particles that mediate them. The talk will also cover the advanced experimental techniques used in particle physics, including particle accelerators and detectors, and review significant recent discoveries like the Higgs Boson. I will discuss the challenges faced in current research and the future directions that promise to expand our understanding beyond the Standard Model. The presentation will conclude with a reflection on the broader implications of particle physics.

Student Lectures (Interdisciplinary/Other) / 83

Relativistic Fluid Dynamics: A Study on Taylor Flow

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Relativistic Taylor flow (Taylor-Couette flow) involves the study of fluid dynamics between two coaxial, rotating cylinders, where relativistic effects become significant due to high rotational speeds. In classical physics, Taylor flow describes the motion of a viscous fluid contained between two rotating cylinders. This classical setup is fundamental in understanding fluid stability and transition to turbulence. The primary parameters governing classical Taylor flow are the angular velocities of the cylinders, the gap between them, and the fluid's viscosity.
In the context of Relativistic Taylor flow, we extend the classical Navier-Stokes equations to incorporate relativistic effects, necessary when the rotational speeds approach a significant fraction of the speed of light. Our study examines several configurations: one with a static inner cylinder and rotating outer cylinder, another with a rotating inner cylinder and static outer cylinder, and a scenario where one cylinder is positioned infinitely far away. Through numerical simulations and theoretical analysis, we explore the stability, vortex structures, and angular momentum transport in these configurations.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 163

Coupling and mutual transformation of acoustic and gravitational modes in kinematically complex flows.

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The purpose of the research is to study kinematically complex flows in which the bond of acoustic and gravitational modes and their mutual transformation takes place. Gravitational waves appear along with acoustic waves in a stratified fluid, which complicates the characterization of fluid motion. We described the background flow through a shear matrix of velocity gradients in order to study the coupling of gravity and acoustic wave modes and their mutual transformation. We constructed a perturbation function, using which we removed the temporal part in the full derivative of the wavenumber vector. As a result, we obtained interesting constant quantities and derived equations for the components of the wave number vector and their derivatives. On the basis of which, we derived the second-order differential equation for the wave number vector in a general form. Since we have a coupled system, the analytical solution of this equation becomes difficult. Therefore, our goal is to find specific flows, special cases, for which the differential equation can be solved analytically. At the same time, we try to numerically solve the second-order differential equation for the wave number vector. It is also our goal to graphically display the bond moments of these two wave modes, which can be achieved by choosing specific boundary conditions. In this research both two- and three-dimensional flows will be considered. Also, our perturbated flow is compressible. On the basis of this theory, we would like to talk about its application in astrophysics, for example, astrophysical currents and the rotation of stars. **enter code here**

Student Lectures (High Energy Physics) / 72

Study of b-quark production in ultra-peripheral heavy-ion collisions at the LHC

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Ultra-peripheral collisions (UPC) involve collisions at impact parameters large enough, such that there are no hadronic interactions - ions interact only electromagnetically, either via photonuclear or two-photon interactions. UPCs of heavy ions at the LHC are the energy frontier for electromagnetic interactions. They provide a unique opportunity to study various physics phenomena from a precision test of quantum electrodynamics and quantum chromodynamics, to the search for new physics beyond the standard model. In the presented study, we briefly introduce the electrodynamics of the underlying photon-photon process, relying on equivalent photon approximation, followed by an overview of b-jet tagging algorithms. Their performance is evaluated using b-tagging efficiency and light jet rejection, first for low-level taggers based on jet topology (IP3D, SV1) and up to the state of art deep neural networks (DL1r). Jets are reconstructed from ATLAS detector response to energy depositions in its tracker and calorimeter. To arrive at the true particle-level energy, we analyze the jet energy scale and its corrections for a better understanding of the systematic uncertainty of our sample data.

Student Lectures (Interdisciplinary/Other) / 93

An application of XRF spectroscopy to heritage science - the case study of ancient roman building materials from Lebanon

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The talk will explore the application of X-ray fluorescence analysis to the investigation of archaeological samples of plaster and mortar from the ancient roman villages of Chhim and Jiyeh, Lebanon. The topic of statistical analysis of results (based on PCA and hierarchical analysis) and their interpretation will be discussed, i.e., how to translate differences in the chemical composition of plaster and mortar samples into dating architectural monuments, determining the origin of building materials, and shedding light on how ancient builders approached their work.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 168

Maximal possible energies of electrons accelerated by the magnetic field of a rotating black hole

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Aims: To evaluate the maximal possible energies of electrons accelerated by the magnetic field of a rotating black hole. We investigate how the range of maximal possible energies and its main constraining factor depend on the mass of the black hole.
Methods: To model the acceleration of the electron on the magnetic field line we use bead-on-the-wire approximation and for the constraining mechanisms, we examine inverse Compton scattering, curvature radiation and bead-on-the-wire approximation breakdown. *Results:* For Stellar-mass black

holes ($1 - 10^2 M_{\odot}$) high Lorentz factor electrons have Lorentz factors in range of $10^6 - 10^{8.5}$ with main constraining factors of curvature radiation and co-rotation and low Lorentz factor electrons have Lorentz factors in range of $10^2 - 10^5$, constrained by IC –Thomson regime. For Intermediate Mass Black Holes ($10^2 - 10^5 M_{\odot}$) high Lorentz factor electrons have Lorentz factors in range of $10^{7.5} - 10^{11.5}$ with main constraining factors of curvature radiation and co-rotation and low Lorentz factor electrons have Lorentz factors in range of $1 - 10^5$, constrained by IC –Thomson regime. For Super Massive Black holes ($10^5 - 10^9 M_{\odot}$) high Lorentz factor electrons have Lorentz factors in range of $10^{10} - 10^{15}$ with main constraining factors of curvature radiation and co-rotation.

Student Lectures (High Energy Physics) / 177

Geometric Formulation of Quantum Mechanics: Greening Quantum Gravity's Arid Spaces

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Reconceptualizing quantum mechanics through the lens of symplectic manifolds, this research introduces a transformative geometric formulation that challenges and extends the traditional framework. At the core of this approach is the innovative use of differential geometry and symplectic topology, which are indispensable for our comprehensive quantum mechanical model.
Addressing pioneering work of geometric formulation of quantum mechanics by Ashtekar, the research transcends the conventional limitations such as those of the Killing vector notion. Following the establishment of a novel equivalence between Schrödinger's equation and Hamilton's equation using symplectic geometry, the transformation of the conventional Hilbert space into a Kähler manifold is a cornerstone of this research.
The study, conducted at the IPM Institute for Research in Fundamental Sciences, successfully resolves critical issues within the existing formalism, showcasing the new methodology's superior capabilities. Drawing inspiration from Ashtekar's foundational work, the research equips physicists with a novel toolset for tackling complex problems in quantum gravity and further in quantum cosmology. The implications of this research are profound, offering a novel perspective on the universe and demonstrating the power of symplectic manifolds as mathematical physical prospects to provide groundbreaking insights into the nature of quantum reality.

Student Lectures (Interdisciplinary/Other) / 116

On the construction of harmonic functions with rational degrees of homogeneity in Euclidean space

Authors: Anastasia Beresneva[1]; Daniil Borisov[1]; Ekaterina Posokhova[1]; Evgeny Runev[1]

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Harmonic functions and harmonic forms are one of the most important objects of mathematical and theoretical physics. For example, they are widely used in field theory, determining the strength and induction of some electrostatic and magnetostatic fields. As a rule, harmonic functions are defined on multidimensional Euclidean and pseudo-Euclidean spaces. Due to the additional symmetries of the model, the specified objects must satisfy various conditions, such as homogeneity conditions.

This paper presents a method of constructing new homogeneous harmonic functions in the case of rational homogeneity index of the original function. No additional restrictions are imposed on the homogeneity index of both the original function and the new function constructed from it. As an example, we consider the case of constructing harmonic functions in two-dimensional Euclidean space.

Differential operators of the first and second orders with coefficients in the form of linear and quadratic forms are used to study the properties of such functions. The problem is reduced to the analysis of solvability conditions of linear partial differential equations of the first and second orders. Obtained method of constructing new homogeneous harmonic functions was based on the theory of analytic functions of a complex variable. The paper presents an example of construction of a harmonic function by the above method.

Student Lectures (High Energy Physics) / 187

Functional Representation of the S-Matrix in Liouville Theory

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Liouville theory, a prominent example of exactly solvable models in two-dimensional conformal field theory (CFT), is essential for understanding quantum field theories and statistical mechanics in lower dimensions. It also plays a crucial role in non-critical string theory for formulating quantum gravity.
This work focuses on Liouville theory in a 1+1 dimensional cylindrical geometry, aiming to derive a closed-form solution for the S-matrix, which governs transitions between asymptotic in- and out-fields. It is parameterised by the eigenvalues of the coherent states. Recurrence relation is derived and solved to recover a well known expression for the reflection amplitude as well as the first level transition. An analytic representation for the S-Matrix is obtained in the form of Dotsenko-Fateev-type integrals, with preliminary results corroborating existing studies.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 174

Gamma ray bursts and their central engine of these bursts and some discussion on their accretion disks

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At great distances from our galaxy, the Milky Way, highly energetic bursts were detected over short periods. Extensive research has been conducted based on these bursts, making this a highly complex and detailed topic call Gamma ray bursts (GRBs).
These gamma-ray bursts are theorized to have a central engine responsible for emitting a final jet and an accretion disk around a supermassive black hole as the central engine of these gamma-ray bursts. Accretion refers to the process of material falling inward toward the inner regions, ultimately collapsing onto the black hole.
There are numerous processes for this accretion disk, which are very complex, and various parameters can be examined concerning these accretion disks.
I will discuss gamma-ray bursts, the types of sources that create them, and the resulting central engine. Finally, I will delve into the accretion disk around the black hole as the central engine of these bursts, examining a specific parameter related to mass accumulation on these disks.
Additionally, in an accretion disk, material accumulates, and depending on the viscous force resulting from the turbulence in the disk, mass accumulation varies at different radii. Different layers

of varying mass and density exist in different regions of the gaseous accretion disk, leading to an inhomogeneous distribution of mass. I will discuss this mass accumulation.
This inhomogeneous mass distribution is the reason for having a final jet with a shock-like structure.

Student Lectures (High Energy Physics) / 191

Diagonalization of four-fermionic interaction Hamiltonian on a sphere with magnetic monopole

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In the thesis(/presentation) we have discussed many-electron system on Lowest Landau Level(LLL) on a sphere with magnetic monopole and derived four-fermionic interaction Hamiltonian using spherical coordinates. With fixed magnetic charge value we have created Fock states and showed that if Hamiltonian is written using some useful operators, it can be diagonalized. In order to achieve this goal, we have done analytical calculations using MAPLE.

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Obtaining various magnetic fields with a two-dimensional system of currents

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The importance of magnetic fields in modern physics is great, and mankind has known for a long time how a moving charge creates a magnetic field. That is, if we know the coordinates and velocities of charges moving in space or the current density at every point in space, then we can determine what the magnetic field induction is and where it is directed at any point.
The difficulty of analytically solving this problem depends on the system of currents that creates the magnetic field we are looking for, but the way to solve the problem is quite straightforward, and using Bio-Savart's law, even with a numerical method and therefore with a small error associated with it, we can always determine the magnitude and direction of the magnetic field induction at some point.
Here I will try to solve a special case of the inverse problem. The inverse problem involves not finding the magnetic field, but finding the system of currents: magnitudes, directions and locations, to obtain the desired magnetic field. I think the task in this regard has quite a practical content: "Tell us what kind of magnetic field you need and we will find the appropriate arrangement of currents."
Unfortunately, we are not able to solve the problem at such a level that we can get the desired vector B (x,y,z) at any (x,y,z) point of the space.
To make the task analytically solvable, we must narrow the search spectrum, thus, as the title tells us, we will consider such a system of currents, which is placed in one plane. We will try to determine what kind of fields we can get and, if possible, analytically find the "backward path", that is, if possible, on the contrary, show the currents by means of a magnetic field.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 182

The Dynamics of Gravity Waves and Aperiodic Modes in Kinematically Complex Flows

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The aim of the research is to study the behavior of internal gravity waves and their effects on incompressible flows. Internal gravity waves occur in stratified fluids, which cause the particles to oscillate between the layers with different densities. Gravity waves are an explanation to many natural phenomena, including different atmospheric events.

Our method for the study included perturbing the flow, eliminating the temporal component from the full derivative of the wave number vector and using the adiabatic approach, linearizing the terms. To derive our main equations, we calculated the shear matrix of velocity gradients. Through calculations, we found the connection between the wave number vector components and the velocity vector components, from which we created a variable. This variable allowed us to write our main second order differential equation, which was simplified into an equation without the first order differential term using a specific method and some constant quantities. Solving it analytically posed a challenge and one of the goals of the study is finding ways to do so. A numerical approach can be utilized in order to find a solution for said equations. We aim to apply our findings not only to Earth-related occurrences, but to astrophysical events, as well, such as the differential rotation of many celestial objects.

Student Lectures (Interdisciplinary/Other) / 207

2+1D Non-Hermitian chiral Majorana surface states in topological superconductor

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Our goal is to find symmetries for surface majorana modes of 3D topological superconductors. In Topological superconductors there are some surface states that can only exist on the surface of the three dimensional topological bulk. To investigate surface states that are 2+1D chiral non-Hermitian Majorana fermions with complex energy dispersion we extend the case of 1+1D hermitian massless Majorana fermions with real energy dispersion. We will show that the conformal symmetries that naturally arise in the 1+1D case can also be extended to 2+1D.

Student Lectures (High Energy Physics) / 274

PLANCKS: From preliminaries to the competition

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I have participated in two PLANCKS preliminaries and one international final, since then I have been honoured to have organised twice as many PLANCKS events as I participated in. As a member of the UK and Ireland's PLANCKS Advisory Board, my role is to provide guidance to each year's OC and take the lead in organising the exam paper.

In this talk, the audience can choose what area of the international theoretical physics I will cover in the session. The three choices are:

Running a PLANCKS preliminary
Developing the PLANCKS programme
Writing the PLANCKS exam paper.

Student Lectures (Astrophysics, Astronomy, Cosmology) / 183

On the Asymptotic Persistence of Langmuir Modes in Kinematically Complex Plasma Flows

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The visible matter in the universe predominantly consists of plasma. Plasma flows are inherently dynamic and often characterized by non-uniform velocity patterns. This differential motion results in a velocity gradient, which gives rise to shear. Shear flows are omnipresent in many astrophysical scenarios such as planetary atmospheres, the solar heliosphere, the accretion and protogalactic disks, etc.
The study focuses on the dynamics of Langmuir modes, waves and shear Langmuir vortices, in kinematically complex astrophysical shear flows. Due to non-self-adjoint behaviour of the equation linked with shear flow dynamics, an alternative nonmodal approach is adopted. For the two-dimensional background flow model, an explicit second-order ordinary differential equation governing the Langmuir dynamics in flows with kinematic complexity is derived. The subsequent analysis of this equation reveals the shear-induced phenomena characterized by asymptotic persistence. This includes exponential growth and vortical solutions interacting with waves, with a distinct " echoing"pattern. Besides these solutions, the existence of parametrically unstable wave solutions is also expected. The analysis also extends to the more general three-dimensional flow model. The preliminary results obtained for this case are presented in the thesis.
The results obtained within the study is particularly significant in space weather and solar physics, where shear flows and shear-induced phenomena drive various dynamical processes such as the generation of MHD waves, mode coupling and solar wind acceleration.

Workshops / 201

Tennis Ball Towers: startling structures made of frictious spheres

Author: Andria Rogava[None]