PAiP-2025 conference ” Particle Astrophysics in Poland”

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Rektorska 4, Warsaw University of Technology

Book of Abstracts

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Recent progress in understanding of the physics of radio pulsars

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Recent progress in understanding the physics of radio pulsars

Radio pulsars, discovered 57 years ago, remain one of the profound puzzles of the modern astrophysics, as we still lack self-consistent quantitative models of emission processes in pulsar magnetospheres. However, the advent of powerful computers and significant improvements in numerical techniques for modeling relativistic plasma resulted in the creation of reliable numerical models of pulsar magnetospheres, what gave us hope to solve the problem of pulsar emission mechanism(s) in the foreseeable future. In this talk, I will review our current understanding of the physics of pulsar magnetospheres, highlight the most recent results of modeling physical processes in pulsar magnetospheres, and describe a few ways towards the solution of the pulsar emission mechanism(s) problem.

Reception and poster session / 76

Insight on the Hubble Tension: Evidence from Fast Radio Bursts

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Fast Radio Bursts (FRBs) are bright, millisecond-duration radio transients, a subset of which have been precisely localized to their host galaxies. Due to their high dispersion measures, FRBs offer unique insights into the ionized plasma along their sightlines, enabling their use as cosmological probes. One critical challenge in modern cosmology is the Hubble tension – a persistent discrepancy between early- and late-Universe determinations of the Hubble constant. In this study, we analyze a sample of 64 localized extragalactic FRBs observed by multiple telescopes, employing Bayesian techniques with distinct likelihood functions. Our findings demonstrate that FRBs can serve as effective tracers of the Hubble constant in the late-time Universe. Importantly, the derived values exhibit smaller uncertainties compared to prior studies, with 1σ error bars that no longer overlap with early-Universe estimates. These results reinforce the ongoing tension between early- and late-time measurements of the Hubble constant and highlight the potential of FRBs as cosmological tools.

Gravitational Waves / 77

Einstein Telescope

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I will describe the current status of the Einstein Telescope (ET) project and present the Polish participation. I will briefly discuss the highlights of the science case of ET. Finally I will summarize the future steps in the project.

PhD short talks / 79

Bubble wall velocity from hydrodynamics

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Terminal velocity reached by bubble walls in cosmological first-order phase transitions is an important parameter determining both primordial gravitational wave spectrum and the production of baryon asymmetry in models of electroweak baryogenesis. We developed a numerical code to study the real-time evolution of expanding bubbles and investigate how their walls reach stationary states. In this talk I discuss the recent results for local thermal equilibrium approximation for which we confirmed that pure hydrodynamic backreaction can lead to steady-state expansion and that bubble-wall velocity in such case agrees very well with the analytical estimates. However, this is not the generic outcome. Instead, it is much more common to observe runaways, as the early-stage dynamics right after the nucleation allow the bubble walls to achieve supersonic velocities before the heated fluid shell in front of the bubble is formed. In order to capture this effect, we generalized the analytical methods beyond the local thermal equilibrium and find a qualitative way to predict whether the runaway is physical, which has a crucial impact on cosmological observables.

Reception and poster session / 80

Bubble wall velocity from hydrodynamics

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methods beyond the local thermal equilibrium and find a qualitative way to predict whether the runaway is physical, which has a crucial impact on cosmological observables.

Reception and poster session / 81

Light-enhanced amplification structures for Dark Matter searches

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The development of radiation detectors has seen significant advancements over the past decades, particularly in those relying on electroluminescence. Optical time projection chambers (OTPCs) have become the preferred choice in the field of direct dark matter searches (more specifically in WIMP searches), having also been considered for neutrino experiments. Dark matter experiments examples include XENON, LZ, DarkSide, and CYGNO where directional information is expected to be explored. Moreover, these detectors have found applications in nuclear physics, such as in the study of $\beta\beta0\nu$ decay (NEXT) and 2p-decay and related processes (Warsaw-TPC).

Even though significant progress has been observed in the development of these detectors since the first works in the 1960s, the optimization of the light collection efficiency remains an important concern. Historically, these structures were mostly made up of meshes or conventional micro-pattern gas detectors (MPGDs) designed for avalanche mode and working mainly in quenched gases.

Given the expected scalability of most of the aforementioned detectors, light production and collection pose unique challenges. Dealing with alignment, and the use of meshes or wires spanning large areas presents practical limitations. In most cases, relying on scintillation originated in charge avalanches will affect not only the energy resolution but also impact the attainable spatial resolution. In addition, the use of lenses, while enabling the reduction of the number of optical sensors required to read large areas and improvement of the optical gain, may limit the spatial resolution attainable, introducing undesirable optical effects (e.g. aberrations). Nevertheless, it is important to consider techniques that can mitigate potential adverse effects associated with the current amplification structures and readout.

In this work, the challenges for improving the light collection as well as the minimization of the background in dual-phase TPCs resulting from spurious emission will be discussed. We will start with a brief overview of the evolution of electroluminescence studies, along with strategies to address some of the main challenges faced in the development of such detectors for Dark matter searches. Alternative structures, GEM-based, capable of providing higher optical gains without relying on avalanche multiplication, thus enhancing energy resolution and detector stability (while eliminating ion back-flow), will be presented.

Gravitational Waves / 82

The German Centre for Astrophysics and the Einstein Telescope

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The new German Centre for Astrophysics (DZA) to be founded in 2025 is a bold initiative to advance multi-messenger astrophysics including gravitational wave research. Central to the DZA's mission is the Einstein Telescope, a next-generation gravitational wave observatory that will transform our understanding of cosmic phenomena. Part of the DZA's work is the site investigation for the Einstein telescope in Lusatia, Germany. By integrating cutting-edge technology, data science and international collaboration, the DZA aims to address fundamental questions about the Universe while contributing to regional development in the central part of Europe on the German-Polish border. This talk will explore the scientific vision, technological innovations and strategic importance of the DZA and the Einstein Telescope in shaping the future of astrophysics.

Cosmic Rays / 83

The Pierre Auger Observatory: Current Status and Expectations from the Upgrade

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The Pierre Auger Observatory, with two decades of data, has significantly advanced our understanding of ultra-high-energy cosmic rays (UHECRs) with energies exceeding 10^18 eV. Key results of the Observatory include: precise measurement of the cosmic ray spectrum at the highest energies, observation of anisotropies in UHECR arrival directions, pointing to possible sources and mass composition of UHECRs. However, this progress has also revealed a complex astrophysical landscape and tensions with existing models of hadronic interactions. To further our knowledge, determining the primary composition of the cosmic rays is crucial. The so-called AugerPrime upgrade aims to achieve this by disentangling electromagnetic and muonic components of extensive air showers on an event-by-event basis. To this end, the surface array was improved by adding new scintillator and radio detectors to the existing water Cherenkov stations and also underground muon counters were installed in a dense region of the array. In addition, to improve performance, small PMTs increased the dynamic range of the water Cherenkov detectors, while upgraded station electronics improved signal timing and resolution. As the commissioning of the final components of AugerPrime reaches its conclusion and the enhanced array comes fully online, we discuss expectations for its performance and the first results of this now multi-hybrid detector.

PhD short talks / 84

Small Extensive Air Shower detector array - measurements and estimation

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CREDO collaboration studies cosmic-ray related phenomena on a large scale, searching for so called Cosmic-Ray Ensembles (CRE) or other unusual correlations and anomalies of non local nature. Such studies require data on Extensive Air Showers (EAS) and flux of secondary cosmic-ray particles that covers large areas. To perform such measurements, a large network of inexpensive detectors working continuously is necessary. This work presents a prototype of a station that can be used in such network. It comprises several small (5 cm × 5 cm × 1 cm) scintillator detectors connected in a flat coincidence circuit, which makes it a desktop-size device. Such station is designed to work for months or even years without the need for human intervention, as it can send collected data directly to the database through internet. Costs of construction of a complete device ranges from $1000 to \ $2000 depending on the number of detectors used. Results of measurements using the first prototype are compared with estin$ $ray studies.$

Neutrino Astrophysics / 85

White dwarf cooling through neutrinos and $L_\mu - L_\tau$

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Hot white dwarfs lose energy mainly in the form of neutrinos through plasmon decay from the inner part of the star. BSM physics can have visible contributions to the cooling of these compact objects. The aim of this study is to show how hot white dwarf cooling could be altered by a dark photon from the $L_\mu - L_\tau$ model and explore these effects from ultra-light to heavy intermediators. This leads to very interesting constraints to this BSM model.

Gamma-ray Astronomy / 86

Cherenkov Telescope Array Observatory - status and prospects

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The Cherenkov Telescope Array Observatory is the next-generation project for very high-energy gamma-ray astronomy. The project has recently achieved ERIC status. I will briefly review the current status of the project, recent progress, and future plans.

PhD short talks / 87

Binary White Dwarfs as Gravitational Wave Sources

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Gravitational Waves have proven to be an excellent tool for understanding populations of binaries. For the upcoming LISA detector, Binary White Dwarfs are one of the most promising sources. In this work, we focus on modelling the Gravitational Wave background from White Dwarf Binaries in the LISA sensitivity range and building a model of their population in the Milky Way.

The COMPAS binary synthesis program is used for population synthesis of the White Dwarf Binaries. Various evolution prescriptions and initial model parameters are used to study diverse population of White Dwarf Binaries. We investigate the dependence of the background spectrum on the assumptions on binary analysis. We discuss the possibility of constraints on binary evolution that LISA gravitational wave observations may yield.

Cosmology & Fundamental Physics / 88

A dark matter solution to the □0 and □8 tensions, and the integrated Sachs-Wolfe void anomaly

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The significant tensions in constraints on the Hubble constant ($_0$) and clustering amplitude ($_8$) between early- and late-universe observations challenge key assumptions of the LCDM cosmological model. One of these assumptions is the presence of cold dark matter, a yet-to-be-detected non-relativistic particle with minimal interaction with the Standard Model that dominates the mass budget of the universe.

We propose a phenomenological model where dark matter's pressure-to-energy ratio, or equation of state, w, evolves over time, enabling it to influence both the universe's expansion rate $_0$ and structure formation $_8$. The model reduces the $_0$ tension from ~5□ to ~3□ and the □8 tension from ~3□ to ~1□.

Moreover, this model explains the anomalously large Integrated Sachs-Wolfe (ISW) effect observed in cosmic voids, a key puzzle in large-scale structure analyses. Observations suggest an unexpectedly strong ISW signal from voids, which our model enhances by a factor of ~2. This provides a testable prediction and supports the idea that dark matter properties influence both small- and large-scale cosmology.
These results extend to unified or interacting dark matter-energy models, with void ISW signals offering a promising avenue for resolving cosmological tensions.

Reception and poster session / 89

Cosmic Web Environmental Effects on Subhalo Abundance and Internal Density Profiles

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The cosmic web is the largest geometric structure in our universe, consisting of an intricate network of voids, walls, filaments, and dense nodes. ΛCDM predicts that dark matter halos, which trace this multiscale structure, form hierarchically and host smaller substructures known as subhalos. Understanding how the abundance and internal kinematics of subhalos vary across different cosmic web environments is crucial for the unbiased interpretation of observations related to small scales and satellite galaxies. Additionally, cosmological observations and N-body simulations suggest that dark matter halos may be sites of particle annihilation, potentially producing detectable Standard Model particles. In this talk, I will present our study using a high-resolution N-body simulation to investigate how subhalo abundance and internal properties depend on their cosmic web environment, with implications for dark matter searches and small-scale structure formation.

Reception and poster session / 90

Estimating the Hubble constant from the mock GW data of Einstein Telescope

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The Hubble constant is a crucial cosmological parameter that is a measure of the rate of change of the cosmic scale factor per unit cosmic scale factor i.e. a_dot / a. There is a considerable discrepancy between the measurements of the Hubble constant from standard candle observations and those from cosmic microwave background (CMB) observations. Data from gravitational wave (GW) events can provide an independent constraint on the Hubble constant. Higher the number of events, the stronger is the constraint. A tight constraint is expected to be achieved in the era of the third generation detectors such as the Einstein Telescope (ET). Without relying on any electromagnetic observation, one can either use the double black hole (BH) merger or the double neutron star (NS) merger detections to break the mass-redshift degeneracy. We present a method of estimating the Hubble parameter using ET mock data for NS-NS events and discuss the challenges. We assume flat cosmology in our analysis.

Dark Matter / 91

Development towards Light Dark Matter Searches and Medical Applications

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Dark matter candidates with masses below 10 GeV/c² hold promise, and a new detector, DarkSide-LowMass, is proposed based on the DarkSide-50 detector and progress towards the DarkSide-20k. DarkSide-LowMass is optimized for low-threshold electron-counting measurements, and sensitivity to light dark matter is explored for various potential energy thresholds and background rates. I will

present the developments towards low mass dark matter searches with a new detector as well as sensitivity with DarkSide-20k, which is under construction.
I also discuss the activity for the medical application, a Positron Emission Tomography (PET) scanner, which uses the same technologies as dark matter searches.

PhD short talks / 92

Consolidating secluded sectors with the Higgs-Portals

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Secluded sectors containing self-interacting Dark Matter offer a compelling framework for explaining dark matter production through interactions confined within the dark sector. Introducing a feeble coupling between the dark and visible sectors via a Higgs portal not only opens up new avenues for detection and enriches thermal production dynamics, but also provides a potential explanation for the initial dark matter population via the freeze-in mechanism. In this talk, I will summarize the freeze-in production of dark matter in scenarios involving self-interactions. I will emphasize how variations in dark sector interactions can either tighten or relax cosmological constraints, leading to distinct signatures in long-lived particle searches and indirect detection experiments.

Multiwavelength Surveys & CMB / 93

Polish participation in the Vera Rubin Observatory: perspectives for Particle Astrophysics

Author: Agnieszka Pollo[1]

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I will summarize the status of the Polish participation in the Vera Rubin Observatory and its overlap with other key observatories and instruments. I will highlight the scientific perspectives of the Rubin Observatory and its impact on Particle Astrophysics in Poland, illustrated by some recent scientific results from our team.

PhD short talks / 94

Probing Graviton Mass Through Strong Lensed Gravitational Waves with Next-Generation Detectors

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Gravitational-wave (GW) astronomy is an established field that is rapidly expanding with increasing detections from merging compact binary systems. The next generation of GW detectors promises a tenfold increase in sensitivity, leading to a thousandfold increase in the observable volume of the Universe and a corresponding rise in detection rates. This growing dataset provides a unique opportunity to investigate fundamental aspects of physics, including probing the properties of gravitons through the study of strongly lensed gravitational waves.

In this work, we explore constraints on the mass of the graviton by analyzing strongly lensed GW signals from typical binary black hole mergers, using different gravitational lens models. Specifically, we use the point mass model for black holes and the singular isothermal sphere (SIS) model for galaxies to determine limits on the graviton mass. Additionally, we simulate the detector response for both next-generation ground-based GW detectors (e.g., Einstein Telescope) and space-based detectors (e.g., LISA) to further assess the capabilities of future observations. We evaluate the potential of future GW observations to provide meaningful constraints on the graviton mass, offering new insights into the nature of gravity at cosmic scales. Our study highlights the importance of gravitational lensing in extending the reach of GW astronomy to address fundamental questions in physics.

Neutrino Astrophysics / 95

Deep learning for neutrino interactions with nuclei

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The success of next-generation neutrino oscillation experiments, such as DUNE and Hyper-Kamiokande, relies heavily on our ability to predict neutrino-nuclei cross sections accurately. In my talk, I will demonstrate how deep learning techniques can enhance the models for neutrino and electron-nuclei scattering cross sections.

PhD short talks / 96

Black holes and gravitational waves from slow phase transitions

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Slow first-order phase transitions generate large inhomogeneities that can lead to the formation of primordial black holes (PBHs). We show that the gravitational wave (GW) spectrum then consists of a primary component sourced by bubble collisions and a secondary one induced by large perturbations. The latter gives the dominant peak if $\beta/H_0 < 12$, impacting, in particular, the interpretation of the recent PTA data. The GW signal associated with a particular PBH population is stronger than in typical scenarios because of a negative non-Gaussianity of the perturbations and it has a distinguishable shape with two peaks.

Reception and poster session / 97

Black holes and gravitational waves from slow phase transitions

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Slow first-order phase transitions generate large inhomogeneities that can lead to the formation of primordial black holes (PBHs). We show that the gravitational wave (GW) spectrum then consists of a primary component sourced by bubble collisions and a secondary one induced by large perturbations. The latter gives the dominant peak if $\beta/H_0 < 12$, impacting, in particular, the interpretation of the recent PTA data. The GW signal associated with a particular PBH population is stronger than in typical scenarios because of a negative non-Gaussianity of the perturbations and it has a distinguishable shape with two peaks.

Gravitational Waves / 98

Probing hadron-quark phase transition in twin stars using f-modes

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Although it is conjectured that a phase transition from hadronic to deconfined quark matter is possible in the ultrahigh density environment in Neutron Stars, the nature of such a transition is still unknown. Depending on whether there is a sharp or slow phase transition, one may expect a third family of stable compact stars or "twin stars"to appear, with the same mass but different radii compared to Neutron stars. The possibility of identifying twin stars using astrophysical observations has been a subject of interest, which has gained further momentum with the recent detection of gravitational waves from binary neutron stars. In this work, we investigate for the first time the prospect of probing the nature of hadron-quark phase transition with future detection of gravitational waves from unstable fundamental f-mode oscillations in Neutron Stars. By employing a recently developed model that parametrizes the nature of the hadron-quark phase transition via "pasta phases", we calculate f-mode characteristics within a full general relativistic formalism. We then recover the stellar properties from the detected mode parameters using Universal Relations in gravitation wave asteroseismology. Our investigations suggest that the detection of gravitational waves emanating from the f-modes with the third-generation gravitational wave detectors offers a promising scenario for confirming the existence of the twin stars. We also estimate the various uncertainties associated with the determination of the mode parameters and conclude that these uncertainties make the situation more challenging to identify the nature of the hadron-quark phase transition.

Neutrino Astrophysics / 99

The Giant Radio Array for Neutrino Detection - experimental status and plans

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The Giant Radio Array for Neutrino Detection (GRAND) is a next-generation observatory aiming to discover the sources of ultra-high-energy cosmic rays (UHECRs) through the detection of radio signals emitted during the interaction of the UHE particles with the atmosphere. This goal would be achieved by deploying 200,000 radio antennas over 200,000 km2 distributed worldwide, gathering enough UHE neutrino, cosmic ray and gamma-ray events to pinpoint UHECRs origin. The use of a sparse array of antennas would allow achieving statistics far beyond what is accessible to the current experiments at an affordable cost. Today, two GRAND prototype arrays, GRANDProto300 in China and GRAND@Auger in Argentina, constitute testbeds for the fully autonomous system of triggering on the radio signals and reconstructing parameters of very inclined air showers from radio data only. Both arrays have their first antennas deployed and are gathering data, with the search for first UHECRs ongoing. We will show simulations, detection methods, and the first results obtained with the currently operating detectors.

Cosmic Rays / 100

A strong dependence of the radio emission of air showers on X_{max} and primary composition

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It is well-known that the composition of the cosmic ray primary particle changes the characteristics of the air shower it induces, most notably the average atmospheric depth of the shower maximum (X_{max}). Showers induced by heavy primaries, such as Fe, develop faster and thus higher in the atmosphere than those induced by their lighter counterparts, like protons. This changes the observables of the shower, such as its radio emission detected at ground level. Traditionally, X_{max} is used as a surrogate for composition: X_{max} reconstructions are used to infer the average composition of a given cosmic ray flux.

In this work we describe a historically overlooked strong X_{max} dependence of the measured electric field amplitudes at ground level, even accounting for intrinsic differences in the electromagnetic (EM) energy of the showers due to different primary compositions, which would also affect these amplitudes. This strong composition dependence can be used, in a novel way, to directly infer the cosmic ray primary composition not only as an average for a flux, but also on an event-by-event basis, bypassing any X_{max} reconstructions and using comparisons to simulations or machine learning (ML) methods instead.

This X_{max} dependence can be understood in terms of two competing scalings of the measured electric field: One that goes with $(1/\rho)^J$, where ρ is the air density at X_{max} and J is a zenith dependent non-linearity factor. This density scaling decreases the geomagnetic emission of deeper, higher X_{max} showers. The other scaling goes with $(1/R)$, where R is the distance from X_{max} to the core of the shower at the ground, and instead increases the measured electric field of deeper showers. At lower zenith angles, the $(1/R)$ scaling is stronger and leads to larger measured electric fields in the case of the deeper showers induced by lighter primary compositions. The picture at higher zenith angles, i.e., at lower densities, is more nuanced and is highly affected by the geomagnetic field. In this region, the deflections due to the Lorentz force are much larger and increase the perpendicular momenta of $e^{\pm}$ in the shower, which would tend to increase the radio emission. However, these larger deflections also increase the time delays between the particle tracks in the shower, decreasing the coherence of the radio emission. This loss of coherence is highly dependent on the strength of the geomagnetic field and can slow down, or even reverse the increase of the radio emission with decreasing air density. This coherence loss is represented by the non-linearity factor J, which

governs if lighter primary compositions will induce higher or lower fields than heavy primaries at these higher zenith angles. Understanding the characteristics of these very inclined showers is crucial for future experiments, such as GRAND.

Neutrino Astrophysics / 101

KM3NeT: UHE neutrinos & more

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The network of two next-generation underwater Cherenkov neutrino telescopes: ARCA and ORCA is being successively deployed in the Mediterranean Sea by the KM3NeT Collaboration. The focus of ARCA is neutrino astronomy, while ORCA is mainly dedicated to neutrino oscillation studies. Both detectors are already operational in their intermediate states and collect valuable results, including the measurements of the atmospheric muons produced by cosmic ray interactions. This talk will discuss the recent exciting physics results of KM3NeT and give an overview of the Polish activity within the experiment.

Cosmology & Fundamental Physics / 102

Conversions in multi-component dark sectors: a phase space level analysis

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We study the thermal freeze-out of two-component dark matter (DM). The freeze-out in a multicomponent dark sector can be more complex and richer than the canonical single-component WIMP DM. This is owing to the relevance of processes of conversions, co-annihilations, co-scatterings, decays and self-scatterings in addition to those of annihilations and elastic scatterings, which can affect the momentum distributions of the dark sector particles and thereby the DM relic abundance. Models with suppressed elastic scatterings are known to have DM freeze-out outside of kinetic equilibrium so that a precise calculation of relic abundance needs to take into account the effect of non-thermal phase space distributions. The pseudoscalar mediated (Coy) DM model is an example of such a model. We develop a numerical tool to calculate the DM abundance in such models with a multi-component dark sector, from a solution of the full momenutum-dependent Boltzmann equations and use it to study a pseudoscalar mediated two-component DM model.

Cosmology & Fundamental Physics / 103

Neutrino mass and discrete dark matter

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The origin and nature of neutrino mass remain one of the most intriguing puzzles in particle physics. To account for the small but nonzero neutrino masses, we propose a hybrid mass-generation mechanism that integrates the canonical seesaw mechanism with radiative neutrino mass generation. This framework is formulated within a non-Abelian discrete flavor symmetry, whose spontaneous breaking not only explains the observed neutrino masses and mixing but also ensures the stability of dark matter. We explore the implications of this setup for neutrino and dark matter phenomenology, considering both Dirac and Majorana neutrinos within the context of this "discrete dark matter" mechanism.

PhD short talks / 104

Constraining Jet Dynamics of PKS 2155-304 Through Time-Dependent SED Analysis

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Blazars are a unique subclass of active galactic nuclei (AGN) characterised by their relativistic jets oriented towards Earth. This study focuses on the blazar PKS 2155-304, a high synchrotron-peaked BL Lac object located at a redshift of z=0.116. We utilised multiwavelength observations, ranging from optical to gamma-ray, primarily from the Fermi Large Area Telescope (LAT) and the Swift Observatory. The objective was to study the spectral energy distributions (SEDs) at various flux states, specifically selecting periods of varying gamma-ray and/or X-ray flux, including quiescent, flaring, and intermediate states. The SEDs were modelled using a one-zone leptonic framework with a broken power-law electron distribution within the JetSeT framework, an open-source tool for simulating radiative processes in relativistic jets. This tool was employed to fit the numerical model to the observed data. Upon completion of the epoch modelling, we obtained distributions for several important parameters, including the jet magnetic field, particle injection, and maximum energy of the relativistic particles. This analysis aims to uncover the underlying physical processes driving the observed variability in PKS 2155-304, contributing to our understanding of blazar behaviour and their emission mechanisms.

Reception and poster session / 105

Deciphering Blazar X-ray Variability: Insights from NICER Spectral Analysis

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Blazars, a subclass of active galactic nuclei, exhibit highly variable
non-thermal emission originating from relativistic jets aligned with the line

of sight to Earth. This variability offers key insights into the physical processes driving these systems. In this study, we analyzed the X-ray spectra of a sample of X-ray-bright blazars observed with NICER, fitting three spectral models: a single power law, a broken power law, and a log-parabola. Our results indicate that a single power law sufficiently describes the majority of the X-ray spectra. However, in certain cases, a broken power law or log-parabola model better represents the data, suggesting spectral variability linked to complex jet dynamics. These findings align with the standard blazar model, which attributes such variability to shocks propagating through relativistic jets, providing new insights into the emission mechanisms at play in these extreme environments.

Cosmology & Fundamental Physics / 106

Infall through the Black Hole Horizon, Outflows from Naked Singularities

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We performed the first simulations of accretion onto the compact objects in the Reissner-Nordström (RN) space-time. The results could not be more different for the two cases. For a black hole, just as in the familiar Kerr case, matter overflowing the cusp plunges into the black hole horizon. For the naked singularity, the accreting matter forms an inner structure of toroidal topology and leaves the system via powerful outflows. The results obtained in general relativity are representative of those for spherically symmetric naked singularities and black holes in a number of modified gravity theories.

Reception and poster session / 108

Numerical studies of relativistic jets from black holes

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Relativistic jets are powerful collimated outflows from accreting compact objects, especially spinning black holes. Jets, as well as their associated mechanisms of energy dissipation and particle acceleration, can be investigated by global or local numerical simulations using methods like general-relativistic magneto-hydro-dynamics (GRMHD), particle-in-cell (PIC), etc. This presentation shall highlight selected results from 3 projects related to relativistic jets.

1. GRMHD investigation on the initiation of magnetic flux eruptions in magnetically saturated accretion flows (”MAD”) onto Kerr black holes (with Mateusz Kapusta & Agnieszka Janiuk; 2024, A&A, 692, A37).
2. PIC simulations of relativistic reconnection plasmoids, focused on energy density enhancement due to magnetic tension (A&A, submitted).
3. Analysis of extreme-resolution GRMHD simulation of relativistic jets (with Mateusz Kapusta, Bart Ripperda & Alexander Philippov).

Multiwavelength Surveys & CMB / 109

ACME - new European research project for research infrastructures

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The Astrophysics Centre for Multimessenger studies in Europe is a new Horizon Europe-funded project for the years 2024-2028. It gathers 40 world-class collaborating institutions from 14 countries and brings together the astroparticle and astronomy communities for long-term collaboration.

ACME is a pathfinder to broaden and improve access to the research infrastructures services and data, assess and evaluate new models for better coordination and provision of at-scale services, provide harmonized trans-national and virtual access, develop centres of expertise, improve science data products management, improve interoperable systems for rapid identification of astrophysical candidate events and alert distribution to optimize follow-up observations, provide training for a new and broader generation of scientists and engineers, open the astrophysics and astroparticle physics data sets to other disciplines and increase citizen engagement. ACME will also organize several dedicated workshops for scientists and students to provide training in the use and combination of multi-messenger data. NCBJ is coordinating access to time-domain archives and follow-up of multimessenger targets.

Cosmic Rays / 110

Intriguing correlation between earthquakes and cosmic radiation

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There is a statistically solid (on a six sigma level) correlation between the global seismic activity and changes in the intensity of cosmic radiation recorded at the surface of our planet, dubbed the cosmo-seismic effect (https://press.ifj.edu.pl/en/news/2023/06/14/). The relationship which has recently been found in public data by the Cosmic Ray Extremely Distributed Observatory (CREDO) Collaboration is physically intriguing: the available astrophysical and geophysical paradigms do not point to a plausible conventional scenario which would explain the phenomenon without an external steering factor capable of affecting both cosmic radiation, and seismicity. In the talk I'll describe the key characteristics of the cosmo-seismic correlation, and highlight the main threads of the analysis oriented on possible physical interpretations. Since the phenomenon remains unexplained despite intense efforts, I'll take the opportunity to consult the audience, counting particularly on your critical thinking skills (maybe there is a trivial explanation we fail to see), and open-mindedness (if the paradigms fail maybe we should think beyond). Who knows where this unexpected scientific adventure may lead.

Particle Acceleration / 111

Particle acceleration in strongly magnetised mildly relativistic shocks

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Jets in active galactic nuclei (AGN) are known for their intense X-ray and gamma-ray emission, originating from non-thermal particles. These sources are also linked to high-energy neutrino events and are considered potential sites of ultra-high-energy cosmic ray production. Accelerated particles can be generated in shock waves formed in collisionless AGN plasmas. We report on our recent studies of oblique mildly relativistic strongly magnetised shock waves in electron-ion plasma by utilising large-scale Particle-In-Cell (PIC) simulations. We show that oblique magnetized mildly relativistic shocks can efficiently accelerate both ions and electrons to very high energies. We discuss the mechanisms of ion and electron energisation in different regimes of the shock obliquity.

Reception and poster session / 112

An upgraded way to identify sources of ultra-high-energy photons from astrophysical flares

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Identifying sources of ultra-high-energy (UHE) particles is one of the key tasks to understand our non-thermal universe in the extreme energy scales. Flares from some astrophysical objects are one of the prominent candidates for producing such UHE particles. The search for sources of UHE neutral particles is easier than for those of UHE charged particles, as the neutrals are not affected by magnetic fields and thus may be detected as groups of clustered events, correlated temporally and directionally. We present the stacking method, which is an upgrade to the standard unbinned likelihood method by including a time-clustering algorithm, to search for space-time clustering of UHE photons through studies of extensive air showers on Earth. We also include an additional factor to discriminate between the signal (photon-initiated events) and the background (hadron-initiated

events), termed as photon tag, based on the probability distribution functions of these events. We demonstrate the effectiveness of the stacking method supplemented with the photon tag in correctly identifying the number of flares and their durations within the given data. We also highlight the robustness of this method in determining a flare as it requires only a few events for its process. This upgraded method can further help in our search for cosmic ray sources by either identifying them or improving the detection limits of the UHE photon fluxes.

Cosmic Rays / 113

Muon content of air-showers - methods of studying the problem and recent results

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Observations of extensive air showers are used to probe hadronic interactions at energies much higher than in any experiments at man-made accelerators. One important observable, that can provide some constraints on the interaction models, is the muon content of air showers. This observable is also crucial in determination of the composition of the primary cosmic rays - it is expected that the muon content of air showers should increase with increasing mass of the primary particle. Recent results obtained by the Pierre Auger Observatory and other experiments show that the observed muon content is significantly larger than predicted by air shower simulations, that are performed using current hadronic interaction models. This discrepancy between results of observations and simulations is known as the muon-deficit problem. In this presentation different approaches to study the problem will be shown. The top-down method is used for comparing observed and simulated air showers, which enables calculating the rescaling factors for the muonic component of the signal; this method also allows us to calculate the beta exponent of the Heitler-Matthews model, which describes the relation between the number of air-shower muons and the primary mass and energy. New studies of the problem, that also allow changes of the depth of the shower maximum, show that the muon deficit might be smaller than previous estimates. The most recent updates of the hadronic interaction model, EPOS LHC-R, seem to lead to larger numbers of muons in air showers - this would further decrease the discrepancy. In the next years the AugerPrime upgrade, especially with new surface scintillators and underground detectors, will provide high-quality measurements enabling precise determination of the muon component of air showers.

Gamma-ray Astronomy / 114

SST-1M stereoscopic system: overview and preliminary results

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The SST-1M telescopes are prototypes of small-size single-mirror Cherenkov telescopes, developed collaboratively by Czech, Polish, and Swiss institutions. Their design is based on the Davies-Cotton concept, featuring a 4-meter mirror and an innovative SiPM-based camera. With a 9.42 m^2 segmented mirror, a 5.6 m focal length, and a wide 9-degree field of view, the SST-1Ms are optimized for detecting gamma rays in the TeV to multi-TeV energy range.

The two prototypes have been commissioned at the Ondřejov Observatory in the Czech Republic, where their performance is being evaluated in both monoscopic and stereoscopic observation modes.

Observations of galactic and extragalactic gamma-ray sources, such as Crab and Markarian 421, have already led to positive detections.

This presentation will provide an overview of the SST-1M project, including its design, development, and current status. Preliminary results from the observation campaigns will also be shown.

Gamma-ray Astronomy / 115

Latest Results from the High Energy Stereoscopic System (H.E.S.S.)

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The High Energy Stereoscopic System (H.E.S.S.), a ground-based gamma-ray observatory, has been instrumental in advancing our understanding of high-energy astrophysical phenomena. This presentation will highlight the most recent scientific results obtained using H.E.S.S., focusing on its contributions to the study of cosmic particle accelerators. I will discuss key discoveries, including spectral and spatial analyses of gamma-ray sources together with multi-wavelength and multi-messenger data.

In addition, the presentation will provide an overview of the observatory's plans for operations and research activities beyond 2025. This will include the legacy program, potential new science targets, and the observatory's continued role in multi-wavelength and multi-messenger astrophysics. These findings and future plans underscore H.E.S.S.'s significant role in particle astrophysics and its ongoing contributions to advancing our understanding of the high-energy universe.

PhD short talks / 116

Reconstruction of the deep air shower using Top-Down Reconstruction algorithm

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An extensive air shower with a particularly large depth of maximum development, Xmax, (~1200 g/cm^2) was observed at the Pierre Auger Observatory. With the help of the Top-Down Reconstruction chain, we aim at further studying this air shower. The Top-Down chain is a Monte Carlo simulation scheme which focuses on reconstructing the observed air shower while accounting for the well-known discrepancy in the number of muons between the observed and simulated showers. We have modified this reconstruction chain to analyse the unique event taking proton as the primary particle. The Top-Down simulation best matching the observed shower is presented as results. It implies that proton origin of the deep event cannot be excluded.

Reception and poster session / 117

SIMULATION OF BACKGROUND SIGNALS OF ATMOSPHERIC MUONS FOR P-ONE

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Neutrino Astronomy is proceeding with the development of new neutrino telescopes. The opaqueness of the Universe to the photons at high energies makes the neutrino an excellent probe to study most of the energetic objects of the cosmos. With this aim, the Pacific Ocean Neutrino Telescope (P-ONE) is planned to be deployed at the Cascadian Basin in the Pacific Ocean, off the coast of Vancouver Island, Canada. The site utilizes the Ocean Networks Canada (ONC) infrastructure for power and data transfer. P-ONE will be complementing the other existing neutrino observatories to provide a full sky coverage. P-ONE is also suitable for its sensitivity towards the galactic plane region.

The dominant background to such telescopes is the atmospheric muons. Reducing background signals is critical due to the low neutrino signal rates. Simulations using CORSIKA and MUPAGE have been conducted to model muon energy spectra, multiplicity, and arrival directions. MUPAGE's efficiency facilitated the estimation of the expected muon flux at the detector site, aiding in background rejection and enhancing astrophysical neutrino detection.

Gamma-ray Astronomy / 119

HAWC ten year anniversary

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I will present the most important results of the HAWC Observatory obtained over the last ten year with a focus on the newest discoveries.

Multiwavelength Surveys & CMB / 120

Halo asymmetry and galaxy clustering

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Studies of galaxy clustering show that the relationship between luminous structures and the underlying dark matter distribution is not straightforward. It depends on various, often interrelated, elements, such as the properties of the galaxies or the properties of the environment which in these galaxies reside.

Crucial for these dark-luminous matter relations studies are estimates of the masses of the dark matter halos. However, in studies of galaxy clustering within the framework of the Halo Occupation Distribution (HOD), it is usually assumed that the dark matter halo is spherically symmetric. At the same time, both modern N-body simulations and observational data suggest that most dark matter halos are in fact either oblate or prolate. To account for this, we propose a new, modified HOD model that takes into account halo asymmetries and improves estimates of dark matter halo masses. Using simulations, we show that this model accurately retrieves the halo asymmetry along with other halo parameters. It can therefore be successfully applied in new works.

Using our model, we find that the shape of the dark matter halos depends on the halo masses and is therefore correlated with the stellar mass of the galaxies. Moreover, based on the observational

results, we find 3 - 5% differences between the halo masses estimated using the HOD model, which assumes spherical symmetry, and our model.

PhD short talks / 121

Impact of galactic foregrounds in delensing and tensor-to-scalar ratio constrain

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In the era of high precision Cosmic Microwave Background (CMB) measurements, polarisation based internal lensing reconstruction methods will have the highest signal-to-noise ratio. Diffused contamination from polarised galactic emission is a main concern for such experiments that aims to do reconstruction of lensing potential at small scales. We investigate the impact of galactic foregrounds in lensing reconstruction for CMB-S4 like experiment. We implement non-parametric foreground cleaning method using multi-frequency observations of CMB to reduce bias in lensing reconstruction. We provide a complete pipeline for CMB-S4 like experiment to perform delensing and to put constrain tensor-to-scalar ratio. We implement our algorithm on different foreground models with varying complexity. Non-Gaussian small scale foregrounds can affect the tensor-to-scalar ratio constrains. Finally, We provide forecasts on sensitivities that can be achieved with CMB-S4 like specifications.

Gravitational Waves / 122

Prospects of testing dark matter with gravitational lensing and gravitational waves.

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Gravitational lensing and gravitational waves - new opportunities to test dark matter

Abstract.
We entered the era when the opening of gravitational wave (GW) window on the universe combined with ongoing (ZTF) and forthcoming (LSST) big real time surveys creates a braekthrough in multi-messenger astrophysics. Most of the astrophysical messengers travel along null geodesics and may undergo strong gravitational lensing (SGL). SGL theory has now become a mature field with manifold applications already explored. In my talk I will discuss how such multi-messenger/multi-wavelength data, especially regarding SGL systems, could be used to constrain certain properties of dark matter like its viscosity or the nature of dark matter, e.g. fuzzy dark matter halos.

Multiwavelength Surveys & CMB / 123

Astrophisical tracers of the late Universe expansion

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The expansion of the Universe at relatively small distances (up to redshifts about 9) can be measured with individual astrophysical sources. I will shortly list those types sources and the used techniques to determine the distance for each individual source. I will present the results of our group based on measurement of the time delays in quasars, and I will discuss the issue of the extinction in the context of comparing radius-luminosity relation distances with distances based on UV-X-ray relation in the same sample of quasars. I will shortly summarize the future prospects in the context of Vera Rubin Observatory and planned LSST.

Particle Acceleration / 124

Reinterpretation of the Fermi acceleration of cosmic rays in terms of the ballistic surfing acceleration in supernova shocks

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The applicability of first-order Fermi acceleration in explaining the cosmic ray spectrum has been reexamined using recent results on shock acceleration mechanisms from the Multiscale Magnetospheric mission in Earth's bow shock. It is demonstrated that the Fermi mechanism is a crude approximation of the ballistic surfing acceleration (BSA) mechanism. While both mechanisms yield similar expressions for the energy gain of a particle after encountering a shock once, leading to similar power-law distributions of the cosmic ray energy spectrum, the Fermi mechanism is found to be inconsistent with fundamental equations of electrodynamics.
It is shown that the spectral index of cosmic rays is determined by the average magnetic field compression rather than the density compression, as in the Fermi model. It is shown that the knee observed in the spectrum at an energy of 5×10^{15} eV could correspond to ions with a gyroradius comparable to the size of shocks in supernova remnants. The BSA mechanism can accurately reproduce the observed spectral index $s = -2.5$ below the knee energy, as well as a steeper spectrum, $s = -3$, above the knee. The acceleration time up to the knee, as implied by BSA, is on the order of 300 years.
First-order Fermi acceleration does not represent a physically valid mechanism and should be replaced by ballistic surfing acceleration in applications or models related to quasi-perpendicular shocks in space. It is noted that BSA, which operates outside of shocks, was previously misattributed to shock drift acceleration (SDA), which operates within shocks.
K. Stasiewicz, https://dx.doi.org/10.48550/arXiv.2407.15767

Dark Matter / 125

Dark Matter and the Cosmic Web variance

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The study and hunt for Dark Matter relies heavily on a proper modelling of the so-called astrophysical (or cosmological) factors. Local density of the prospective DM candidate in the solar vicinity

or in the Galactic neighborhood, as well as the distribution of shapes, masses and abundance of the gravitational collapse DM haloes are quantities that are predictions of the the standard cosmological model. These need to be estimated adequately in order to obtain precise and unbiased estimations for DM observables. This is relevant and important for both direct (i.e. Earth-based laboratory) as well as indirect (i.e. astrophysical) DM searches. In my talk I will present new results stemming from advanced morphological analysis of the large-scale structure in cosmological simulations. These morphological aspects raveled a surprisingly strong impact of the so-called Cosmic Web environment (usually segmented into nodes, filaments, walls and voids) on various DM haloes and subhaloes properties. Our analysis reveals new results indicating that the commonly adopted assumption of DM halo self-similarity mighty be holding approximately. Mapping the Cosmic Web effects on DM observables can yield differences from 10 to even 100% from the previously adopted baseline.I will offer some preliminary and tentative discussion on the potential impact of our new findings for the DM search.

Particle Acceleration / **126**

Relativistic reconnection as source of high-energy particles

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Astrophysical magnetic fields may store significant amounts of energy. The process of magnetic reconnection can release this energy fairly rapidly and transfer it directly to particles. In the relativistic regime, when magnetic energy density dominates the rest-mass plasma density, most of participating particles can achieve relativistic energies. Relativistic reconnection is a complex process involving large separation of scales, very strong electric fields, dynamic interactions of magnetic flux tubes. Rapid progress in understanding relativistic reconnection is being made by means of numerical simulations (with kinetic or fluid plasmas), and even in laboratory experiments. Relativistic reconnection is also an important ingredient in the landscape of relativistic magnetized turbulence.

Gravitational Waves / **127**

Searching for exceptional gravitational-wave sources in the LIGO-Virgo-KAGRA data

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The emerging field of Gravitational Wave Astronomy has already demonstrated its potential to explore the Dynamic Universe. We are just at the beginning of exploring the Universe with gravitational waves. While LIGO-Virgo-KAGRA regularly observes gravitational waves from compact binaries, we do not know what we may discover next. We may observe new source populations, multi-messenger events, sources with special properties, etc. Such exceptional astrophysical sources will likely play a key role in this endeavor of exploring the Universe. In my presentation, I will discuss searches for gravitational waves and focus on the model-independent searches that have already shown that they are suitable for making discoveries. I will also announce an incoming LIGO-Virgo-KAGRA workshop in Warsaw that I am organizing.

Reception and poster session / 128

Study of gamma/hadron discriminant variables in application to high-energy cosmic-ray air showers

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Identification of the primary cosmic rays on an event-by-event basis stands as one of the main goals for any cosmic-ray observatory. Several cosmic-ray air-shower experiments use photon tags for gamma/hadron primary particle discrimination. These photon tag variables, for example Ptail or Sb, are easily built from the total signals measured in an array of detectors and are correlated with the total number of muons in the air shower. This work shows a study of the Ptail discriminant variable and its comparison with the Sb variable for simulated showers with energy about 10^17 eV. The simulations were performed for the detectors of the Infill array of the Pierre Auger Observatory (433m-spaced detectors). For application to the Pierre Auger Observatory the time-based analysis was introduced for the Ptail discriminant, the detector traces (the signal time distributions) were used in the analysis instead of just the total signal. As the variables discussed are based on signals and traces, which can be directly measured in real data, they can be used as the discriminant variables in the real cosmic ray experiments.

Multiwavelength Surveys & CMB / 129

Exploring the Clustering and Diversity of Low Surface Brightness Galaxies in Dark Energy Survey Data

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Low surface brightness galaxies (LSBs) are estimated to account for 30% to 60% of the total number density of galaxies. In this work, we analyze a dataset of LSBs identified by Thuruthipilly et al. in the Dark Energy Survey (DES) Data Release 1. The aim is to organize these galaxies into categories more detailed than the traditional blue and red classifications.

To achieve this, we apply embedding methods such as T-SNE and UMAP to visualize the distribution of galaxies in a two-dimensional parameter space derived from morphology fitting results. This approach enables us to systematically organize the galaxies and observe the broad range of properties present in the dataset. Our analysis reveals distinct subgroups of LSBs, with notable correlations between their embedding positions and the presence of galactic nuclei.

Moreover, we identify a subgroup of LSBs that stands out from the broader population due to unique characteristics. By implementing a more detailed morphology fitting process compared to previous studies, we recover additional LSBs that were previously excluded, enriching the overall sample.

PhD short talks / 130

GRMHD Simulations of Accretion Disk Winds: Implications for Kilonova Emission and r-Process Element Formation

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Neutron star mergers, known to be the progenitors of short gamma-ray bursts, may also produce luminous transients called kilonova. These transients are powered by the radioactive decay of heavy elements synthesised in neutron-rich ejecta. Kilonova emission arises from two major sources: the dynamical ejecta expelled during the merger and the winds from the accretion disk. The accretion onto the rotating black hole is a source of power for the GRB jets, while the disk winds may act as collimation mechanism.

We model the kilonova process in the accretion disk winds using general relativistic magnetohydrodynamic (GRMHD) simulations. Our tool is the HARM-EOS code, developed recently by the CTP PAS astrophysics group. The code incorporates a tabulated, composition-dependent, 3-parameter equation of state. By varying the black hole, disk and wind properties in the initial configuration, we explore how they affect the dynamics of the ejecta. We probe their composition and quantify the relative abundances of heavy and light elements produced via rapid neutron capture (r-process). We run a nuclear reaction network, and using these results, we discuss the properties of the resulting kilonova emission, providing insight into its observational signatures.

Gravitational Waves / 131

Formation of Gravitational Wave Sources Originating From Globular Clusters

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Over the past decade, gravitational wave observations have confirmed more than 80 binary black hole mergers, providing unprecedented insights into the demographics of stellar-mass black holes. These discoveries raise fundamental questions about the astrophysical origins and formation pathways of these enigmatic systems. In this talk, I will delve into the dynamical processes driving the formation of binary black holes within the dense stellar environments of globular clusters. The production of merging black holes in such clusters is influenced by several uncertain factors, including the retention of black holes after natal kicks and the effects of cluster initial conditions on their long-term evolution. I will discuss these uncertainties and their implications for the properties and merger rates of binary black holes. Furthermore, I will highlight the role of three- and four-body dynamical interactions in facilitating black hole mergers and examine the potential for post-merger black holes to remain within clusters, leading to repeated mergers and the formation of intermediate-mass black holes.

Reception and poster session / 132

Constraints on the properties of νMSM dark matter using the satellite galaxies of the Milky Way

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Low-mass galaxies provide a powerful tool with which to investigate departures from the standard cosmological paradigm in models that suppress the abundance of small dark matter structures. One of the simplest metrics that can be used to compare different models is the abundance of satellite galaxies in the Milky Way. Viable dark matter models must produce enough substructure to host the observed number of Galactic satellites. Here, we scrutinize the predictions of the neutrino Minimal Standard Model (νMSM), a well-motivated extension of the Standard Model of particle physics in which the production of sterile neutrino dark matter is resonantly enhanced by a lepton asymmetry in the primordial plasma. This process enables the model to evade current constraints associated with non-resonantly produced dark matter. Independently of assumptions about galaxy formation physics we rule out, with at least 95 per cent confidence, all parameterizations of the νMSM with sterile neutrino rest mass, $M_{\rm s} \leq 1.4\,{\rm keV}$. Incorporating physically motivated prescriptions of baryonic processes and modelling the effects of reionization strengthen our constraints, and we exclude all νMSM parameterizations with $M_{\rm s} \leq 4\,{\rm keV}$. Unlike other literature, our fiducial constraints do not rule out the putative 3.55 keV X-ray line, if it is indeed produced by the decay of a sterile neutrino; however, some of the most favoured parameter space is excluded. If the Milky Way satellite count is higher than we assume, or if the Milky Way halo is less massive than $M_{200}^{\rm MW} = 8 \times 10^{11}\,M_\odot$, we rule out the νMSM as the origin of the 3.55 keV excess. We find that other works have obtained overly stringent constraints partly because of an error in publicly available codes to compute dark matter momentum distributions.

Cosmology & Fundamental Physics / 133

Hearing the Universe Humm with Pulsar timing array: Gravitational Waves and Primordial Black Holes from beyond SM

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We will discuss interpretation of the nHz stochastic gravitational wave background (SGWB) seen by NANOGrav and other Pulsar Timing Array (PTA) Collaborations in the context of supermassive black hole (SMBH) binaries. The frequency spectrum of this stochastic background is predicted more precisely than its amplitude. We will discuss how Dark Matter friction can suppress the spectrum around nHz frequencies, where it is measured, allowing robust and significant bounds on the Dark Matter density, which, in turn, controls indirect detection signals from galactic centers.
Next we will discuss alternative cosmological interpretations including cosmic strings, phase transitions, domain walls, primordial fluctuations and axion-like physics. We will discuss how well these different hypotheses fit the NANOGrav data, both in isolation and in combination with SMBH binaries, and address the questions: which interpretations fit the data best, and which are disfavoured.
We also discuss experimental signatures that can help discriminate between different sources of the PTA GW signals with complementary probes using CMB experiments and searches for light particles in DUNE, IceCUBE-Gen2, neutrinoless double beta decay, and forward physics facilities at the LHC like FASER nu, etc. and with Primordial Black Hole formation and its constraints.

Cosmology & Fundamental Physics / 134

Gravitational waves from more attractive dark binaries

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The detection of gravitational waves (GWs) has led to a deeper understanding of binaries of ordinary astrophysical objects, including neutron stars and black holes. We point out that binary systems may also exist in a dark sector with astrophysical-mass macroscopic dark matter. These "dark binaries" , when coupled to an additional attractive long-range dark force, may generate a stochastic gravitational wave background (SGWB) with a characteristic spectrum different from ordinary binaries. We find that the SGWB from planet-mass dark binaries is detectable by space- and ground-based GW observatories. The contribution to the SGWB today is smaller from binaries that merge before recombination than after, avoiding constraints on extra radiation degrees of freedom while potentially leaving a detectable GW signal at high frequencies up to tens of GHz.

Gravitational Waves / 135

Long-term measurements of infrasounds at Sos Enattos mine, one of the candidate sites for the Einstein Telescope

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Over two years ago, we installed an array of microphones to monitor infrasound activity at Sos Enattos mine, located in northeastern Sardinia, one of the candidate sites for the Einstein Telescope, future 3rd generation gravitational waves detector. The setup includes two microphones at a surface station and six additional microphones placed within underground cavities at varying depths. This configuration allows for comprehensive monitoring of infrasound signals across different environments within the site. During this long-term period, we continuously recorded synchronized signals from all microphones, capturing both short-term and long-term variations in the infrasound environment. We will present the initial results on the temporal variability of infrasound signals, the correlation between sensors located underground and on the surface, and the influence of external factors, such as weather conditions, on the recorded data.

PhD short talks / 136

Partially-contained samples in the Super-Kamiokande atmospheric neutrino oscillation analyses

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Atmospheric neutrino events observed at the Super-Kamiokande detector are divided into classes based on their topology. In the case of partially-contained events, neutrino interacts within the inner part of the detector, but some of the charged particles produced in this interaction leave the inner region and enter into the outer part of the detector, as opposed to the fully-contained events, for which no such particle escape is observed. This simple difference in topology implies that partially-contained events have bigger energy than the fully-contained ones, and consequently they are produced in different neutrino interactions and are sensitive to different neutrino oscillation parameters. For this reason, partially-contained events are an important part of any atmospheric neutrino analysis. In this talk, I will present the results of a preliminary study aimed at improving the resolution of reconstructed energy of partially-contained events, by identifying particles that leave the outer part of the detector. Since the neutrino oscillation probability explicitly depends on neutrino energy, improved resolution should entail better sensitivity to oscillation parameters in the future atmospheric neutrino analyses.

PhD short talks / 138

Joint Neutrino Oscillation Analysis of Atmospheric and Beam Data in the Super-Kamiokande Detector

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In my talk, I will present the motivation that stands for the joint oscillation analysis using both: atmospheric neutrino data collected by the Super-Kamiokande detector and T2K beam neutrino data. T2K is a long-baseline neutrino experiment designed to study neutrino oscillations, particularly the appearance of electron neutrinos in a muon neutrino beam and the disappearance of muon neutrinos, providing crucial insights into neutrino mixing parameters and the potential CP violation in the lepton sector. The analysis incorporates a broad range of neutrino interactions to provide a comprehensive assessment of neutrino oscillation parameters. The results would give refined constraints on oscillation parameters and pave the way for advanced analyses in next-generation detectors.

PhD short talks / 139

Forecast for the future detection of gravitational waves coming from supercooled phase transition

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Detecting gravitational waves (GW) has given us new possibilities to probe the Universe. In this talk, I will focus on the prospects of GW detection coming from cosmological supercooled phase transition (PT) with the future generation of detectors, i.e. LISA/ET. Observation of such an event will give us information about the physics of the early Universe.
In the standard model (SM), there is no cosmological PT, that could produce GW. But many extensions of SM predict that PT might have happened. So determining the correct model might be a non-trivial task after such a detection.

In this talk specifically, I will focus on the possibilities of reconstruction of the thermodynamic parameters and scalar field decay rate, which in particular might help to determine the correct model of the supercooled PT.

PhD short talks / 140

Quenching routes and dust attenuation in distant quiescent galaxies observed with JWST

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Unveiling the routes galaxies take to quiescence is one of the most open challenges in galaxy evolution. While the most of the studies focused on characterizing quiescent galaxies (QG) across cosmic time through their stellar properties using optical/near-infrared (NIR) data, the mid-infrared regime was only recently examined thanks to the advent of JWST. The need to understand the MIR emission in QGs has been emphasized due to recent discoveries of a peculiar population of quiescent, but dust-rich galaxies at high-redshifts ($z < 3$).

In this talk, I will present the preliminary results of a first study that investigated the quenching routes and the physical properties of MIRI-bright, dust-attenuated QGs in the distant universe. We selected a sample of quenched galaxies from the CEERS survey with NIRCam and MIRI detection and studied the influence of the star formation histories on their estimated dust-related parameters.

Cosmic Rays / 141

Status of the JEM-EUSO Collaboration: Ground, Balloon, and Space-Based Observations of UHECRs and Related Phenomena

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The JEM-EUSO (Joint Exploratory Missions for Extreme Universe Space Observatory) collaboration is an international initiative studying ultra-high-energy cosmic rays (UHECRs) and related phenomena. These particles, with energies exceeding 10^{20} eV, provide insights into extreme astrophysical processes but remain challenging to detect due to their low flux.

At the heart of JEM-EUSO's technology is an ultra-fast, highly sensitive UV camera capable of detecting extensive air showers (EAS) in the atmosphere with exceptional spatial and temporal resolution. This innovative approach enables detailed studies of fluorescence and Cherenkov light from cosmic ray interactions.

The collaboration employs a multi-platform strategy. Ground-based experiments like EUSO-TA have calibrated detection systems and validated models. Balloon-borne missions, such as EUSO-Balloon and EUSO-SPB1/SPB2, have demonstrated large-scale observations from the stratosphere and tested advanced technologies. Space-based missions, particularly Mini-EUSO on the ISS, have provided valuable data on UV backgrounds, transient luminous events, and meteoroids. While Mini-EUSO's small aperture limits its ability to detect UHECRs, it demonstrates the potential for future space-based detection.

Future efforts include the POEMMA space mission, designed for stereoscopic observations of UHECRs and multi-messenger phenomena, and the PBR (POEMMA Ballon with Radio) experiment, integrating radio detection and scheduled to fly in 2027. Associated experiments also explore meteoroids, nuclearites, and strange quark matter, broadening the scientific scope.

This presentation will summarize the progress of the JEM-EUSO collaboration, highlighting achievements across all platforms, future plans, and the significant contribution of the Polish team to scientific results.

PhD short talks / 142

Prospects of TDEs investigation as potential candidates of high energy neutrinos

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High energy neutrinos are unique particles with tiny masses, interacting via weak and gravitational forces. Their astrophysical origins, detection techniques, and determining their production mechanisms are challenging. Tidally disrupted events (TDE) are potential candidates for very-high- and ultra-high-energy neutrinos. The p-p and p-gamma are two interactions, which can produce such high-energy neutrinos, and metal-rich star accretion in TDEs provides ideal conditions for such processes to take place.

The KM3NeT (Cubic Kilometre Neutrino Telescope), located in the Mediterranean, hosts the next-generation neutrino telescopes, ARCA near Sicily and ORCA near Toulon, with an excellent angular resolution at the level of $0.10°$ and state-of-the-art hydrophones. The KM3NeT addresses the fundamental questions in astro-particle physics, including the neutrino mass hierarchy, and the origin of ultra-high energy cosmic rays. The presented study aims to reconstruct ultra-high-energy neutrinos via their acoustic signals, generated during their interactions with nuclei in salt water and producing particle cascades that deposit energy in the medium. Additionally, TDEs will be studied as potential sources of high-energy neutrinos.

Multiwavelength Surveys & CMB / 143

Tomographic cross-correlation of the CMB gravitational lensing and galaxy clustering - effect of photometric redshift errors

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The effect of gravitational lensing of the cosmic microwave background (CMB) provides a unique opportunity to obtain a picture of the gravitational potential of the large-scale structure of the Universe at very high redshifts. Tomographic cross-correlation of the gravitational potential with other tracers of the large-scale structure at known redshifts allows tracing the evolution of the structure and testing cosmological models. However, the analysis of upcoming data will require a very good understanding of any systematic errors that may bias cross-correlation measurements. In this talk we will present studies of systematic errors arising from redshift bin mismatch of galaxies with photometric redshift uncertainties. We show their impact on the cross-correlation measurement and cosmological parameter estimates for future data sets. We also present an efficient method for mitigation of the errors.

PhD short talks / 144

Probing radiation pressure instabilities in neutron star X-ray binaries using GLADIS

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Accretion disks around compact objects, such as black holes (BHs) or neutron stars (NSs), exhibit various types of spectral variability. These include long-term variabilities driven by thermoviscous instabilities in the accretion disks of low-mass X-ray binaries (LMXBs) and short-term variabilities, which are often attributed to thermal instabilities caused by radiation pressure from the central compact object. Transient neutron star X-ray binary sources, such as Swift J1858.6-0814, have demonstrated short-term variabilities. Our objective is to investigate these short-term variabilities in X-ray sources using the GLADIS code.
The Global Accretion Disk Instability Simulation (GLADIS) code, originally developed by the CTP Astro group for BH X-ray binaries and later adapted for Active Galactic Nuclei (AGN) sources, serves as an excellent tool for studying the time evolution of accretion disks through global 1D + 1D simulations. We extend this code to study NS X-ray sources, specifically incorporating the effects of the NS boundary layer and its irradiation.
In this presentation, I will provide a summary of my experience with the GLADIS code and discuss the results of our efforts to integrate the NS boundary layer into the simulations.

Particle Acceleration / 145

Recent Results on Particle Acceleration at Non-relativistic Shocks

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Shock waves in cosmic plasma are generally considered as most appropriate candidates for the role of particle accelerators, being the possible sources of relativistic electrons responsible for the nonthermal electromagnetic radiation (radio, X-rays, gamma) as well as cosmic rays (CR). They can be found in numerous astrophysical objects widely varying in scales, from Earth's bow shock and solar flares, through supernova remnant (SNR) shocks, up to Mpc-scale merger shocks in galaxy clusters. The details of particle acceleration at astrophysical shocks are not fully understood yet, and they still remain the subject of investigations. A dominant acceleration mechanism assumed to operate at non-relativistic shock waves is diffusive shock acceleration (DSA), also known as first-order Fermi process. However, the unresolved question still remains in DSA theory, known as "injection problem": it works only for particles with a Larmor radius larger than thickness of the shock transition. Some pre-acceleration is thus required, in particular for electrons because of their smaller mass. The possible mechanisms of initial particle energization strongly depend on physical conditions, which can vary in a very wide range for the different types of shocks.
According to the recent investigations, particle pre-acceleration necessary for injection to DSA can be realized either through the plasma instabilities (e.g. Buneman instability) or other acceleration mechanisms, such as shock surfing acceleration (SSA) or shock drift acceleration (SDA). The latter can work even for very slow shocks with Mach numbers $M << 10$ (e.g. merger shocks). In particular, in our recent studies with numerical kinetic simulations, we demonstrate that multi-wavelength magnetic turbulence increases the efficiency of the electron pre-acceleration at SDA. The acceleration process at such conditions is is stochastic SDA (SSDA), when particles are confined in the shock transition region by pitch-angle scattering off magnetic turbulence. The SSDA process has been found to be a plausible mechanism for the electron injection to DSA. This is consistent with observations of X-ray and radio emission that indicate the efficient electron acceleration at this kind of shocks.

Neutrino Astrophysics / 146

Pacific Ocean Neutrino Experiment: overview and recent developments

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The Pacific Ocean Neutrino Experiment (P-ONE) is an initiative to construct a multi-cubic-kilometre neutrino telescope in the depths of the Northeast Pacific Ocean.
P-ONE aims to complement the existing neutrino observatories and probe high-energy astrophysical neutrinos, providing insights into the southern celestial hemisphere, including the Galactic Plane. Capitalising on the established deep-sea infrastructure of Ocean Networks Canada, P-ONE has already conducted two successful pathfinder missions to assess environmental conditions, such as water optical properties, and background bioluminescence. Building on these efforts, the P-ONE collaboration has been working towards the realisation of the first detector line, emphasising modularity and scalability while addressing the challenges of the deep-sea environment. Planned for deployment in 2025, this detector line represents a significant step in P-ONE's roadmap. This talk will provide an overview of the development, as well as P-ONE's scientific objectives and vision.

Reception and poster session / 147

Overview of the data acquisition system architecture for the DarkSide-20k experiment

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The nature of dark matter remains unknown and its origin is currently one of the most important questions in physics. In particular direct searches for WIMP dark matter particle interactions with ordinary matter are carried out with large detectors located in underground laboratories to suppress the background of cosmic rays. One of the currently most promising detection technologies is based on the use of a large mass of liquid argon or xenon as a target in the detector.

In this talk I will briefly introduce the DarkSide-20k detector, now under construction in the Gran Sasso National Laboratory (LNGS) in Italy, the biggest underground physics facility. It is designed to directly detect dark matter by observing weakly interacting massive particles (WIMPs) scattering off the nuclei in 20 tonnes of underground-sourced liquid argon in the dual-phase time projection chamber (TPC).

The light generated during the interactions in the liquid argon is detected by custom silicon photomultipliers (SiPMs) assemblies of size 20 cm by 20 cm. The units installed in the veto detectors are equipped with application specific integrated circuits (ASICs) coupled to SiPMs allowing linear signal response up to 100 photons and signal to noise ratio of 5 for a single photon, while those for the TPC employ a discrete element front-end with similar performances.

The data acquisition system (DAQ) for the DarkSide-20k experiment is designed to acquire signals from the 2720 channels of these photosensors in a triggerless mode. The data rate from the TPC alone is expected to be at the level of 2.5 GB/s and will be acquired by 36 newly available commercial VX2745 CAEN 16 bit, 125 MS/s, high channel density (64 ch.) waveform digitizers. The Veto detector is readout by an additional 12 modules. The data is first transferred to 24 Frontend Processor machines for filtering and reduction. Finally the data stream is received by another set of Time Slice Processor computers where the whole detector data is assembled in fixed length time series, analysed and stored for offline use. These operations will be supervised by a Maximum Integration Data Acquisition System (MIDAS) developed in the Paul Scherrer Institute in Switzerland and TRIUMF laboratory in Canada.

Reception and poster session / 148

Storage ring searches for ALPs – experimental proof of principle

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Axions, originally introduced to address the strong CP problem in quantum chromodynamics, if sufficiently abundant, are a compelling candidate for dark matter. Axions or axion-like particles (ALPs), as components of the cold dark matter in our Galaxy, can be treated as a classical field. These ALPs are theorised to couple to the spin of nucleons and nuclei either directly, via the axion wind effect, or indirectly by inducing an oscillating electric dipole moment (EDM) in nucleons. This coupling mechanism provides a novel approach to search for ALPs using a storage ring, circulating with a beam of in-plane polarized hadrons, as an antenna. When the spin-precession frequency of the beam matches the ALP field frequency, a resonance occurs, leading to a build-up of the polarisation out of the ring plane, which is a signal for ALPs. Since the ALP mass and corresponding frequency are unknown, the resonance search is conducted by varying the beam momentum, which directly relates to the spin-precession frequency.

The JEDI collaboration performed a proof-of-principle experiment to validate this approach at the Cooler Synchrotron (COSY) in Juelich, targeting an ALP mass range of $0.495 - 0.502\,\mathrm{neV}/c^2$. While no ALP signal was observed, the experiment established a 90% confidence upper limit on the oscillating EDM at $6.4 \times 10^{-23}\,e \cdot \mathrm{cm}$. Additionally, the experimental method was successfully tested by introducing a simulated ALP signal in the ring using a radio-frequency Wien filter. In this talk, I will detail the experiment and discuss the result.

Neutrino Astrophysics / 149

Recent results from the joint oscillation analyses and diffuse supernova neutrino background searches at Super-Kamiokande

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In the first part of this talk recent results from the joint oscillation analyses using T2K beam neutrinos and atmospheric neutrinos will be discussed, together with the oscillation parameters which are derived from this study.
In the second part of the presentation the studies on the Diffuse Supernova Neutrino Background (DSNB) at the Super-Kamiokande will be covered.

PhD short talks / 151

Constructing an Attenuation Proxy Based on state-of-the-art cosmological simulation SIMBA.

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The LSST survey, with its first observations anticipated in May 2025, presents not only extraordinary opportunities but also significant challenges. A particularly compelling question is whether it will be possible to estimate or at least constrain the physical properties of dust, despite the survey's focus solely on the optical range. Dust plays a crucial role in the processes governing galaxy evolution, making this investigation particularly important. Leveraging the latest research and data from the state-of-the-art cosmological simulation SIMBA—which is among the few simulations to comprehensively account for both dust and gas in galaxies, I aim to find an answer to this question.

Dark Matter / 152

Status and Recent Results from the DEAP-3600 Experiment

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The nature of dark matter is still unknown and its origin in our universe remains one of the most important questions in physics. Particularly, in direct searches one looks for WIMP dark matter particle interactions with ordinary matter in underground laboratories which suppress the background of cosmic rays. One of the most promising detection technologies involves the use of a large mass of liquid argon as a target.
In this talk, I will present the design and operational status of the liquid argon single-phase DEAP-3600 Experiment (at Snolab, Canada). Further on, I will talk about recent results, including an overview of the direct measurement of the Ar-39 Half-life, and a new upcoming WIMP search analysis.

Gravitational Waves / 153

LIGO-Virgo-KAGRA gravitational-wave sources and observational results

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The talk will summarise main observational results obtained by the current network of gravitational wave detectors, including the ongoing O4 run which started May 2023. First part of O4 - O4a - ended January 2024, providing 81 new high-confidence gravitational wave candidates. I will also discuss challenges and outlook related to searches for transient signals emitted by tight binaries composed of compact objects, other transient signals, as well as long-duration (persistent) signals, and their diverse astrophysics.

PhD short talks / 154

Eccentric Inspiral-Merger-Ringdown Models for Binary Black Holes with Gauge-invariant Eccentricity

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Residual eccentricity in gravitational waveforms can be a unique tool to identify binary systems formed in dynamical environments. In general relativity, eccentricity is not defined uniquely. Different waveform models rely on gauge-dependent definitions of eccentricity, which leads to incompatibility between them. We remove this ambiguity by employing a gauge-invariant eccentricity definition in our modelling approaches. We present an eccentric Inspiral-Merger-Ringdown (IMR) model for binary black holes, calibrated against a set of target IMR waveforms. The model is also validated against an independent waveform family resulting overlaps better than ~ 96.5% within the calibrated range of binary parameters.

Dark Matter / 155

LEGEND experiment and other terrestrial searches in the context of cosmological constraints on the neutrinoless double beta decay

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The Large Enriched Germanium Experiment for Neutrinoless Double Beta Decay (LEGEND) has been designed to answer one of the highest priority questions in fundamental physics: is the neutrino a Majorana or Dirac particle, is the lepton number conserved, and what is the neutrino mass?

The first phase of the project, the LEGEND-200 detector, is currently running at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. Up to 200 kg of bare high purity germanium (HPGe) detectors isotopically enriched up to 90% in Ge-76 are deployed in liquid argon (LAr). The LAr serves as a cooling medium for the detectors, as well as a passive and active shield. The LAr instrumentation is composed of wavelength shifting (WLS) fibers connected to silicon photomultipliers detecting scintillation light of argon.In the GERDA experiment, the LAr veto was a very powerful tool for background rejection and minimization. By combining the lowest background levels with the best energy resolution in the field, LEGEND-200 will perform a quasi-background-free search for 0νββ decay. After collecting about 1 ton-year of data, it can make a discovery of neutrinoless double beta decay with just a handful of counts for a Ge-76 half-life of about 10^(27) years.

In the talk, the present status of LEGEND-200 will be discussed, as well as the prospects for construction of the full-scale detector based on 1000 kg of Ge-76. LEGEND-1000 is designed to probe the neutrinoless double beta decay with a discovery sensitivity for the Ge-76 half-life of about 10^(28) years, corresponding to an effective Majorana mass upper limit in the range of 9-21 meV to cover the inverted-ordering neutrino mass scale with 10 years of live time.

The LEGEND program will be discussed in the context of the current cosmological constraints.

PhD short talks / 156

Cleaning tests of the ESR foil

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The DarkSide experiment has been designed to search for direct interactions of the cold dark matter particles. Due to the expected very low signal, different techniques have been implemented to minimize the background. Currently the DarkSide-20k (DS-20k) detector is under construction in the underground laboratory at Gran Sasso (LNGS) in Italy.
One of the material which is going to be used in the DS-20k detector is the ESR foil. It is light highly reflecting and covered with the wavelength shifter (TPB) foil which will be used to maximaize the light detection in the TPC. Due to its large surface applied (some hundred square meters) and close proximity to the active volume its surface must be extremely radiopure, mainly with respect to Pb-210. The long-lived Pb-210 (T1/2 = 22 yr) decays through Bi-210 to Po-210. The last is an alpha emitter, which in the (alpha, n) reactions may produce neutrons. Interaction of neutrons are indistinguishable from those caused by the dark matter particles. Due to the low energy of gammas emitted in the Pb-210 decays (46.5 keV), low Pb-210 activities are usually established by a series of Po-210 measurements. The DS-20k requirements for the Pb-210 surface specific activity for the ESR foil is: C = 0.04 mBq/m2. The value measured by the XIA UltraLo-1800 alpha spectrometer is comparable with the spectrometer's background, ≤ 0.4 mBq/m2. Due to this fact, a cleaning technique which reduces the Pb-210 activity by a factor of 10 is needed. The ESR samples were contaminated with Pb-210 in a strong Rn source and then different cleaning methods were tested: cleaning by chemical solutions (i.e. isopropanol, HCl, citric acid) and plasma cleanings (atmospheric, vacuum). Cleaning by using chemical solutions and the atmoshperic plasma technique occured to be ineffective. Obtained Pb-210 reduction factors for the atmospheric plasma cleaning were 1.2 ± 0.2 and 0.9 ± 0.1. Pb-210 reduction factors obtained for the ESR samples treated by the vacuum plasma cleaning (two runs) are 4.8 ± 0.7 and 6.2 ± 0.8. More details about the method and analysis will be outlined in the short talk foreseen for PhD students. Detailed description will be given on the poster.

Reception and poster session / 157

Cleaning tests of the ESR foil

Authors: Grzegorz Zuzel[1]; Milena Czubak[1]; Oscar Azzolini[2]

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The DarkSide experiment has been designed to search for direct interactions of the cold dark matter particles. Due to the expected very low signal, different techniques have been implemented to minimize the background. Currently the DarkSide-20k (DS-20k) detector is under construction in the underground laboratory at Gran Sasso (LNGS) in Italy.
One of the material which is going to be used in the DS-20k detector is the ESR foil. It is light highly reflecting and covered with the wavelength shifter (TPB) foil which will be used to maximaize the light detection in the TPC. Due to its large surface applied (some hundred square meters) and close proximity to the active volume its surface must be extremely radiopure, mainly with respect to Pb-210. The long-lived Pb-210 (T1/2 = 22 yr) decays through Bi-210 to Po-210. The last is an alpha emitter, which in the (alpha, n) reactions may produce neutrons. Interaction of neutrons are indistinguishable from those caused by the dark matter particles. Due to the low energy of gammas emitted in the Pb-210 decays (46.5 keV), low Pb-210 activities are usually established by a series of Po-210 measurements. The DS-20k requirements for the Pb-210 surface specific activity for the ESR foil is: C = 0.04 mBq/m2. The value measured by the XIA UltraLo-1800 alpha spectrometer is comparable with the spectrometer's background, ≤ 0.4 mBq/m2. Due to this fact, a cleaning technique which reduces the Pb-210 activity by a factor of 10 is needed. The ESR samples were contaminated with Pb-210 in a strong Rn source and then different cleaning methods were tested: cleaning by chemical solutions (i.e. isopropanol, HCl, citric acid) and plasma cleanings (atmospheric, vacuum). Cleaning by using chemical solutions and the atmoshperic plasma technique occured to be ineffective. Obtained Pb-210 reduction factors for the atmospheric plasma cleaning were 1.2 ± 0.2 and 0.9 ± 0.1. Pb-210 reduction factors obtained for the ESR samples treated by the vacuum plasma cleaning

(two runs) are 4.8 ± 0.7 and 6.2 ± 0.8. More details about the method and analysis will be outlined in the short talk foreseen for PhD students. Detailed description will be given on the poster.

Cosmic Rays / 158

Solar modulation of galactic cosmic rays-recent updates

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The cosmic rays stream reaching Earth is of extragalactic origin, some come from the center of our Galaxy, while the source of cosmic rays of the lowest energies is Sun. A common way to register galactic cosmic ray (GCR) and its variability are measurements made by a global network of ground neutron monitors (NMs), operating continuously since 1951. They measure secondary cosmic rays: the nucleonic component of the atmospheric cascade initiated by primary cosmic rays. NMs show fluctuations in the original cosmic ray intensity. These variations occur as a result of a solar changeability and reflect the level of solar activity. The basic periodicity observed by neutron monitors is the 11-year cycle, which is a reflection of the Schwebe cycle, characterized by consecutive periods of amplified solar activity of about 11 years. There is a high anti-correlation between the number of sunspots that perfectly illustrate the level of solar activity and the GCR changeability. The next cycle is the 22-year Hale cycle, related to the reversal of the Sun's magnetic field polarity. There are observed also shorter periodicities: connected to solar rotation, as well as transients appearing in solar behavior. There will be discussed recent updates of long-, mid- and short-term modulation of GCR, based on the neutron monitors observations, as well as mathematical modeling of GCR transport.

Reception and poster session / 159

Dusty torus covering factor in AGNs: evolution, selection and calibration

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What dominates the quasars Spectral Energy Distribution at IR is dusty torus emission. It is described as the thermal reprocessor of the internal X-ray/UV accretion disc continuum.
Thus, internally, its emission strength should correlate with the strength of illuminating radiation and the amount of captured energy (due to covering factor). In the type 1 AGN, where the torus does not cross the line of sight, we also observe an apparent correlation between IR emission and opt-UV. To investigate its accuracy, we compare it with the proper SED fitting, where apparent photometry is addressed with a mixture of models.
This way we investigate the influence of contaminations from extinction, polar dust, starlight, and cold dust.
I will cover the data quality issues, contaminant correlations, and prospects of calibration for simple photometric observables to infer the proper torus properties.
Finally, I will cover the possibility of using the quasars opt-IR relation in cosmology.

Reception and poster session / 160

DarkSide-20k veto photon-detector units: construction and characterization

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DarkSide-20k, a direct dark matter search experiment, is located at the Gran Sasso National Laboratory (LNGS), Italy. It is designed to achieve groundbreaking 200-tonne-year exposure, nearly free from instrumental backgrounds. The core of the detector is a dual-phase Time Projection Chamber (TPC) containing 50 tonnes (20 tonnes fiducial) of underground liquid argon (UAr) with low levels of cosmogenic 39Ar isotope. The TPC is equipped with large area cryogenic Silicon Photomultiplier array detectors at top and bottom planes covering ~21m2, to acquire the faint signals emitted by the WIMP interaction with the detector. The neutron veto used to tag and veto neutron events is also equipped with SiPM detectors, positioned along the walls of the TPC on the outer side. SiPMs are arranged compactly to reduce the material used for the Printed Circuit Board (PCB), cables, and connectors forming the Veto PhotoDetection Units (vPDUs). Each vPDU consists of SiPMs, front-end electronics, and a motherboard, which distributes voltage and control signals and electrical signal transmission. Additionally, all SiPM materials have been carefully screened for radioactivity to minimize background interference.

This contribution will focus on the production of the vPDUs, emphasizing the rigorous Quality Assurance and Quality Control (QA/QC) procedures, and the final characterization of the first completed prototypes. Extensive testing in liquid nitrogen baths has been conducted on the vPDUs, including at a dedicated facility at Astrocent in Warsaw, aiming to assign a "quality passport" to ensure optimal performance and reliability within the DarkSide-20k experiment."

PhD short talks / 162

Phase transition and gravitational waves in maximally symmetric composite Higgs model

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In my talk, I will discuss transitions in a maximally symmetric composite Higgs model with next-to-minimal coset, where a pseudoscalar singlet emerges alongside the Higgs doublet. I will focus on the scenario involving an explicit source of CP violation in the strong sector, which induces a $\mathbb{Z}_2$ asymmetric scalar potential, and consequently leads to nonzero vacuum expectation value for the singlet. The presence of explicit CP violation leads to strong first-order phase transition from a false vacuum to the electroweak vacuum where the pseudoscalar singlet has a non-zero vacuum expectation value. As a result of such phase transitions, the production of potentially observable gravitational waves at future detectors will offer a complementary avenue to probe the composite Higgs models, distinct from collider experiments.

Dark Matter / 164

(sub-)GeV dark matter - asymmetric dark matter

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Asymmetric dark matter (ADM) explains the present DM abundance by asymmetry between DM particles and anti-particles, like visible matter or standard model (SM) baryons.
ADM is particularly interesting when the visible and dark asymmetries have a common origin, since their abundances are different only by a factor of ~5.
When the asymmetries are equilibrated in the early Universe and thus comparable, DM mass should be in the GeV range.
In this talk, we illustrate how an ADM scenario works, by taking dark baryon DM as a concrete example, since it has several attractive features.
To alleviate cosmological problems, we also introduce a massive dark photon that couples to SM particles.
The very dark photon leads to various experimental and astrophysical signatures.
We give an overview of the signatures in DM direct and indirect detection experiments, and fixed-target and long-lived particle searches.

Gamma-ray Astronomy / 165

Large-Sized Telescopes: progress in construction and first scientific results

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Abstract: The Large-Sized Telescopes (LSTs) with mirror diameters of 23 m are the largest type of telescopes to be used in the future Cherenkov Telescope Array Observatory. Four of such telescopes are planned in the Northern (La Palma, Spain) and two in the Southern (Paranal, Chile) sites. The first telescope, LST-1, has been inaugurated in October 2018 in Observatorio Roque de los Muchachos, La Palma, Canary Islands, Spain and since then is taking commissioning and early science data. Three more telescopes are currently under construction in the same site. I will report on the progress of the project and on the first scientific results obtained with LST-1.

Neutrino Astrophysics / 166

The Hyper-Kamiokande experiment

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Hyper-Kamiokande is the next generation water Cherenkov neutrino detector,
which construction started in 2020 in Japan, and the experiment is expected to start data taking in 2027. Its fiducial volume, 8 times bigger than Super-Kamiokande, instrumented with new photosensors, combined with the upgraded to 1.3 MW J-PARC neutrino beam produced 295 km away and upgraded a near detector suite, will enable the determination of the CP violation in the leptonic sector, and precise measure atmospheric neutrino oscillations. Improved studies of astrophysical neutrinos (supernova burst neutrinos, supernova relic neutrinos, and solar neutrinos) and the search for proton decays in various final-state decays will also be possible. In this talk, I will present an overview

of the physics program, the status of construction, and Polish involvementin the Hyper-Kamioknade project.

Cosmology & Fundamental Physics / 167

Signatures of astrophobic QCD axion

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to be added

Dark Matter / 168

The DarkSide search for dark matter

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Dark Matter / 169

Introduction to dark matter candidates

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to be added

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Is There Missing Physics From the Standard Model of Cosmology?

Author: Wendy Freedman[1]

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Town meeting –community discussion

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Reception and poster session / 175

Reconstruction of the deep air shower using Top-Down Reconstruction algorithm

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An extensive air shower with a particularly large depth of maximum development, Xmax, (~1200) was observed at the Pierre Auger Observatory. With the help of the Top-Down Reconstruction chain, we aim at further studying this air shower. The Top-Down chain is a Monte Carlo simulation scheme which focuses on reconstructing the observed air shower while accounting for the well-known discrepancy in the number of muons between the observed and simulated showers. We have modified this reconstruction chain to analyse the unique event taking proton as the primary particle. The Top-Down simulation best matching the observed shower is presented as results. It implies that proton origin of the deep event cannot be excluded.

Reception and poster session / 176

Eccentric Inspiral-Merger-Ringdown Models for Binary Black Holes with Gauge-invariant Eccentricity

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Residual eccentricity in gravitational waveforms can be a unique tool to identify binary systems formed in dynamical environments. In general relativity, eccentricity is not defined uniquely. Different waveform models rely on gauge-dependent definitions of eccentricity, which leads to incompatibility between them. We remove this ambiguity by employing a gauge-invariant eccentricity definition in our modelling approaches. We present an eccentric Inspiral-Merger-Ringdown (IMR) model for binary black holes, calibrated against a set of target IMR waveforms. The model is also validated against an independent waveform family resulting overlaps better than ~ 96.5% within the calibrated range of binary parameters.

Reception and poster session / 177

Binary White Dwarfs as Gravitational Wave Sources

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Gravitational Waves have proven to be an excellent tool for understanding populations of binaries. For the upcoming LISA detector, Binary White Dwarfs are one of the most promising sources. In this work, we focus on modelling the Gravitational Wave background from White Dwarf Binaries in the LISA sensitivity range and building a model of their population in the Milky Way.

The COMPAS binary synthesis program is used for population synthesis of the White Dwarf Binaries. Various evolution prescriptions and initial model parameters are used to study diverse population of White Dwarf Binaries. We investigate the dependence of the background spectrum on the assumptions on binary analysis. We discuss the possibility of constraints on binary evolution that LISA gravitational wave observations may yield.

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Announcements and dinner logistics

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