National Conference on AI & ML Driven Recent Advances in Condensed Matter and High Energy Physics

Report of Contributions

Contribution ID: **1** Type: **not specified**

Non-extensivity impacts on Hadronic Drag and Diffusion coefficients

In this work, we analyze the drag and diffusion coefficients of hadrons propagating in a thermal hadronic medium using the Fokker–Planck equation formulated within the Tsallis non-extensive statistical framework. The Tsallis non-extensive parameter q quantifies the deviation from equilibrium (q >1) and provides for a more realistic description of the medium, not perfectly thermalized. The hadronic bath, consisting of various mesonic and baryonic species, is controlled by different mass cutoffs which constitutes the spectral composition of the medium. Our analysis shows that both the drag coefficient F and the momentum diffusion coefficients Γ increases exponentially with temperature and a systematic increase with increasing q and mass cutoffs. The spatial diffusion coefficient D_x exhibits a decreasing trend with temperature T, non extensive parameter q and mass cutoffs which highlights the significant influence of non-equilibrium effects and hadronic composition of hadronic medium on the transport behaviour of propagating hadrons.

Condensed Matter Physics

NA

High Energy Physics

Phenomenology

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Co-author: Dr TIWARI, Swatantra Kumar

Presenter: SINGH, Aditya Kumar

Contribution ID: **2** Type: **not specified**

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Condensed Matter Physics

NA

High Energy Physics

Phenomenology

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Contribution ID: **3** Type: **not specified**

Potential Application of Emulsion Technology in Healthcare

There is a lot of promise for developing radiopharmaceutical carrier systems using emulsion technology. Radiopharmaceuticals, which aid in the diagnosis and treatment of several illnesses, including cancer, are crucial to nuclear medicine. A variety of widely accepted safe materials may be used to make particles with various compositions, sizes, forms, and surface properties, enabling their utility to be customized for particular purposes. The structure of emulsion formulation consists of an external phase and an internal phase. Oil in water or water in oil (i.e., O/W or W/O) emulsion and water in oil in water or oil in water in oil (i.e., W/O/W or O/W/O) triple emulsion are two forms of emulsions that may be differentiated based on the phases' structure and characteristics. Emulsion preparation methods are also suitable for use in medical applications since they are frequently simple, inexpensive, dependable, and scalable. The article highlights various potential applications of emulsion technology in the healthcare sector.

Condensed Matter Physics

High Energy Physics

High Energy Physics

High Energy Physics

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Contribution ID: **4** Type: **not specified**

Charm quark energy loss and D meson nuclear modification factor in PbPb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

First we calculate the transverse momentum (p_{T}) spectra of D meson in proton-proton (pp) collision at $\sqrt{s}$ = 5.02 TeV and compare with the CMS measurements of D meson. The calculation describes the measured data very well. We use a hydrodynamic picture for Quark-Gluon Plasma (QGP) evolution during which p_{T} spectra of charm quark is modified due to collision and radiative energy loss. We use Peigne and Peshier formalism to calculate the collisional energy loss and Reaction operator formalism (DGLV) and Generalized dead cone approach to calculate the radiative energy loss. We performed the calculation of D meson nuclear modification factor R_{AA} in PbPb collision at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV for the kinematic region covered by CMS experiments. The radiative energy loss from generalized dead cone approach alone is sufficient to produce D meson R_{AA}. The radiative energy loss from DGLV formalism plus collisional energy loss gives good description of D meson R_{AA}.

Condensed Matter Physics

NA

High Energy Physics

Phenomenology

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Contribution ID: **5** Type: **not specified**

Mirrors That Hear the Universe: The Coating Technology Behind LIGO's Gravitational Wave Detection

In Einstein's general theory of relativity, gravitational waves were initially predicted in 1916. According to him these cataclysmic events produce brief perturbations in spacetime curvature that propagate outward as GW ripples. These waves convey energy in the form of gravitational radiation and move at the speed of light. The Laser Interferometer Gravitational-Wave Observatory (LIGO) uses kilometer-scale Michelson interferometers to measure length changes smaller than one-thousandth of a proton's diameter, which is necessary to detect these incredibly faint signals. The interferometer's mirrors, whose performance is largely dictated by their optical coating technology, are at the centre of this extraordinary sensitivity. This study focused how multi-layer dielectric mirror coatings with ultra-high reflectivity allow LIGO to attain the extraordinary precision needed for gravitational wave detection. We go into the materials used, the strict specifications on optical loss, surface roughness, and mechanical dissipation, and the physical concepts of thin-film interference used to develop these coatings. Nowadays, gravitational wave detectors function as modified Michelson interferometers, with thermal noise from the highly reflective mirror coatings placing a crucial limit on the sensitivity of both present and future devices.

Condensed Matter Physics

High Energy Physics

High Energy Physics

High Energy Physics

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Presenter: SHARMA, maneesha (GLA University Mathura)

Contribution ID: **6** Type: **not specified**

Robust Low-z Hubble Constant Determination Using Machine Learning Assisted Outlier Detection of Type Ia Supernovae from the NED-D Dataset

Abstract
Context: Accurate determination of the Hubble constant (H0) using low-redshift Type Ia super novae (SNIa) is critical for precision cosmology. Outliers in distance measurements act like noise in high-precision experimental data, potentially biasing results, similar to errors in beam-based imaging systems.
Purpose: We develop a reproducible pipeline for low-z H0 estimation, explicitly motivated by applications requiring high-precision, noise-resilient measurements in imaging-intensive experimental setups. The goal is to minimize the impact of anomalous SNIa while ensuring reliable results.
Methods: The NED-D SNIa dataset is analyzed using Isolation Forests to detect and remove outliers with inconsistent distances or velocities. Weighted H0 is calculated from the cleaned sample, and bootstrap resampling is employed to quantify uncertainties. An interactive exploration of outliers is provided, highlighting SNIa that strongly influence H0.
Findings: The cleaned sample yields H0 ≈ 66–68 km/s/Mpc with uncertainties around 1 km/s/Mpc. Outlier removal significantly reduces bias and variance. The ranked outlier table identifies influential supernovae, analogous to pinpointing critical deviations in experimental imaging systems.
Significance: Machine learning-assisted outlier detection combined with reproducible uncertainty quantification provides a robust framework for high-precision cosmological measurements. This approach mirrors strategies in beam diagnostics and imaging experiments, where reliable anomaly detection and uncertainty control are crucial for accurate interpretation.
Keywords: Hubble constant; Low-redshift supernovae; Isolation Forest; Bootstrap uncertainty; Weighted H0; Robust measurement; Imaging diagnostics.

Condensed Matter Physics

The study of the Hubble expansion provides critical constraints on the vacuum energy density, which is analogous to the study of topological phases and symmetry breaking in condensed matter systems. Additionally, the implementation of robust outlier detection mirrors the "noise-resilient" protocols required to extract coherent signals from disordered materials and many-body systems

High Energy Physics

The determination of the Hubble constant (H_0) is fundamental to constraining the Dark Energy Equation of State and potential physics beyond the Standard Model, directly impacting High Energy Physics (HEP) models of the early universe. Furthermore, the use of Machine Learning for outlier rejection and uncertainty quantification mirrors the rigorous data-processing pipelines essential for interpreting high-energy particle collisions and beam diagnostics

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Contribution ID: **7** Type: **not specified**

Discovery Reach of Neutrinoless Double-Beta Decay

Neutrinoless double-beta decay ($0\nu\beta\beta$) is a lepton-number-violating nuclear process that, if observed, would provide direct evidence for Majorana neutrinos and insight into the absolute neutrino mass scale. The next generation of $0\nu\beta\beta$ experiments, employing a broad range of candidate isotopes, are designed to fully probe the inverted mass hierarchy and to extend sensitivity into the normal hierarchy. Recent cosmological indications favoring the normal hierarchy further motivate this effort, although probing this region remains challenging under the current theoretical uncertainties associated with nuclear matrix elements. Recognizing the critical impact of theoretical inputs on the design and interpretation of experimental searches, this work systematically incorporates uncertainties in nuclear matrix elements, the axial-vector coupling, and phase-space factors, particularly emphasizing nuclear matrix elements, spanning recent ab-initio and phenomenological nuclear-structure calculations, to evaluate the projected sensitivity of forthcoming $0\nu\beta\beta$ experiments.

Condensed Matter Physics

Not Applicable

High Energy Physics

Yes

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Contribution ID: **8** Type: **not specified**

Galaxy 2D to 3D Depth Visualization –Cosmic Eye (NGC 2566) using MiDaS and Accuracy Evaluation using SSIM

Abstract
Context: Accurate 3D reconstruction from 2D images is vital for both astronomical studies and imaging-intensive experimental systems, where structural identification under limited resolution and noise is crucial.
Purpose: This work evaluates the MiDaS DPT-Large model on synthetic galaxy images with ground-truth depth maps, motivated by applications requiring precise structural detection for monitoring and alignment in experimental setups.
Methods: Synthetic datasets simulating galaxies with bulges and rings were generated. Depth maps predicted by MiDaS were compared to ground truth using SSIM, and Canny edge detection was applied to assess structural correspondence.
Findings: Direct SSIM averaged 0.4508, while edge-based SSIM reached 0.9253, showing strong preservation of morphological boundaries. Batch testing over ten images yielded SSIM from 0.3370 to 0.5337. 3D visualizations highlighted accurate recovery of global structures, though fine ring details remain challenging.
Significance: Monocular depth estimation demonstrates potential for structural analysis and real-time monitoring in imaging-intensive experimental systems, including beam diagnostic and alignment applications.
Keywords: Galaxy 3D reconstruction; monocular depth estimation; MiDaS; SSIM; synthetic galaxy images; imaging diagnostics
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Condensed Matter Physics

The depth reconstruction and SSIM-based evaluation draw strong parallels with condensed matter physics, where image-based inference and structural similarity metrics are used to study phase transitions and lattice defects. The approach reflects how emergent 3D structures can be inferred from limited 2D observations, a core challenge in modeling complex condensed systems.

High Energy Physics

This work contributes to high-energy physics by demonstrating how AI-based depth inference techniques, originally developed for particle and collider data analysis, can be adapted for three-dimensional structural reconstruction in astrophysical systems. The methodology supports improved modeling of matter distribution and energy dynamics in galaxies, which is central to understanding high-energy processes governing cosmic evolution.

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Contribution ID: **9**   Type: **not specified**

Advantage of Nuclear Emulsion Detector in Rare Event Searches

A type of photographic emulsion known as "nuclear emulsion" reveals the passage of charged particles during chemical development and leaves behind visual traces of silver grains. In addition to its remarkable spatial resolution, capacity to serve as both a tracking and target device, and excellent signal-to-noise ratio for particular kinds of reactions, nuclear emulsion detectors (NED) provide distinct benefits in rare event searches. The NED applications for directional dark matter searches, exotic particle detection, and high-precision particle trajectory imaging to probe nuclear interactions will be the main focus of this work.

Condensed Matter Physics

High Energy Physics

High Energy Physics

High Energy Physics

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Presenter: Dr KUMARI, Babita (GLA University Mathura)

Contribution ID: **10** Type: **Oral**

Use of Nuclear Emulsion Detector in Different Field

In this paper we have discuss about the nuclear emulsion detector and its
uses in current research. And know about what is the use of nuclear emulsion detector in different field like Neutrino search, Dark matter search and Medical field and also discuss about that how nuclear emulsion detector in work in medical field, Dark matter and Neutrino search and why this detector use in these field we have discuss about in this paper.

Condensed Matter Physics

High Energy Physics

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Track Classification: High Energy Physics

Contribution ID: **11** Type: **not specified**

Study the Target Effect in Pseudorapidity Distribution of Shower Particles at Relativistic Energy

In relativistic heavy-ion collisions, pseudorapidity is an important kinematic characteristic because it directly reveals the angular emission pattern, longitudinal dynamics, and multiparticle creation mechanisms of secondary particles. Because pseudorapidity simply depends on the emission angle and roughly resembles rapidity at relativistic energies, it is important in nuclear emulsion studies when momentum information is not immediately available. Thus, pseudorapidity distributions' shape, width, and target dependency function as sensitive probes of the space-time evolution of the participant region created during the collision. The pseudorapidity distributions of shower particles released in krypton–emulsion interactions with an incidence energy of 1 A GeV are thoroughly examined in this publication. In order to investigate target-mass effects, the analysis compares interactions with heavy (AgBr) and light (CNO) target nuclei incorporated in the emulsion. The observation shows that Gaussian functions properly clarify the pseudorapidity distributions, suggesting that particle emission is collective in nature. A pronounced enhancement in particle density is observed for AgBr targets relative to CNO targets, highlighting the significant influence of target size on particle production.

Condensed Matter Physics

High Energy Physics

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Contribution ID: **12** Type: **not specified**

Investigating the variability of self-affine multiplicity for the events generated at relativistic energy for 84Kr-AgBr reactions

The two-dimensional factorial moment approach and the idea of the Hurst exponent (H) are used to study self-affine multiplicity fluctuation. It is suggested that the anisotropy of phase space causes the regional differences in multiplicity at relativistic energy multiparticle creation to be self-affine rather than self-similar. The best power law behaviors are shown at H=0.7 for compound particles released in 84Kr-AgBr reactions at 1 A GeV. Additionally, covered are the multifractality and non-thermal phase change that take place in the production of the compound particles in 84Kr-AgBr interaction. There is no indication of a non-thermal phase change in the synthesis of compound particles.

Condensed Matter Physics

High Energy Physics

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Contribution ID: **13** Type: **Poster**

Self-Affine Surface Evolution and Monofractal Analysis of Ag Ion–Irradiated ZnO Thin Films

Zinc oxide (ZnO) thin films with a thickness of 120 nm were deposited on Si substrates maintained at 300 ℃ using the electron beam evaporation technique. The deposited films were subsequently irradiated with 100 MeV Ag ions at various fluences of 1×10^{10}, 5×10^{10}, 1×10^{11}, 3×10^{11}, 7×10^{11}, 1×10^{12}, 1×10^{13}, and 3×10^{13} ions/cm^2. High-energy heavy ion irradiation resulted in the formation of self-affine nanostructures on the ZnO thin film surfaces. Atomic force microscopy (AFM) was employed to obtain topographical images of both pristine and ion-irradiated films. Classical surface roughness parameters, including arithmetic mean roughness (Sa), root mean square roughness (Sq), skewness (Ssk), kurtosis (Sku), peak height (Sp), and valley depth (Sv), were evaluated for each surface. Shannon entropy was used to quantify the topographical uniformity of the rough surfaces. Minkowski functionals were applied for the quantitative analysis of geometrical and topological surface features. Furthermore, surface complexity and growth behavior in both lateral and vertical directions were analyzed using monofractal parameters. Monofractal surfaces are characterized by homogeneous scaling properties, exhibiting uniform scaling behavior described by a single singularity exponent.

Condensed Matter Physics

High Energy Physics

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Contribution ID: **14** Type: **Oral**

Identifying background sources and their impacts at sub-keV energy region for rare event searches with Ge detectors

The TEXONO Collaboration has established a detection system with an ultra-low energy high purity germanium detector at Kuo-Sheng Nuclear Power Plant to monitor neutrino–nucleus coherent scattering and to seek for dark matter. Understanding background origins and their impact to the energy spectrum is crucial in this experiment because of the weak nature and

modest recoil energy of these uncommon events. During detector maintenance in non-operational conditions above ground, high-energy neutron-induced interactions inside the

Germanium crystal yield tritium (3H). The varied Ge isotopes and neutron kinetic energy produced by TENDL2015 determine the generation cross-section of 3H and 68Ge, respectively. Fast cosmic-ray neutrons can form isotopes in Ge that can cause background in dark matter studies. When solar activity is at its lowest, the cosmic ray-induced neutron flux is at its highest, and vice-versa. The observed differential flux of neutrons caused by cosmic rays as a function of neutron energy at the KSNL experimental site and their effects on sub-keV energy domains will be the main focus of this study.

Condensed Matter Physics

High Energy Physics

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Track Classification: High Energy Physics

Contribution ID: **15** Type: **not specified**

Listening to the Universe: Gravitational Waves as a New Probe of Fundamental Physics

Since the first successful detection in 2015, the area of gravitational wave research has advanced quickly, bringing in a new age in astronomy. We focus over the benefits and drawbacks of existing ground-based observatories like LIGO and, Virgo as well as the critical role of future third-generation detectors like the Einstein Telescope and space-based missions like LISA. Improvements in cryogenic technology, increased frequency coverage, and integration with multi-messenger astronomy are highlighted as important areas of study. GW astronomy has become a key component of contemporary observational astrophysics thanks to ground-based interferometers like Virgo, KAGRA, and LIGO, which made groundbreaking discoveries. The low-frequency sensitivity and horizon reach of the current generation of detectors are nevertheless constrained by a number of fundamental and technical noise sources, such as quantum shot noise, thermal Brownian motion in optical coatings, seismic disturbances, and suspension-related thermal fluctuations. Next-generation observatories like LIGO-India, the Einstein Telescope (ET), and the Cosmic Explorer (CE) are being built with revolutionary technological advancements to overcome these obstacles. This study explains the state of gravitational wave detection today and considers potential future paths that could deepen our comprehension of the cosmos.

Condensed Matter Physics

High Energy Physics

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Track Classification: High Energy Physics

Contribution ID: **16** Type: **Poster**

Distinguishing Surface from Bulk Events in Point-Contact Germanium Detectors for Neutrino and Dark Matter Detection

The TEXONO collaboration conducted neutrino-nucleus scattering studies and light dark matter investigations using germanium detectors with sub-keV sensitivity. By raising the detector mass from 500g to 1500g, the TEXONO collaboration has gradually progressed the usage of PCGe detectors over time, greatly improving sensitivity to low energy events pertinent to neutrino and dark matter studies. In addition to this scaling in detector mass,

significant efforts have been made to address the ongoing difficulty of differentiating surface-originated background signals from genuine bulk interactions, especially in the low-energy

area where the rise-time starts to intersect. In order to identify signals at levels equivalent to electronic noise, subsequent research concentrated on improving energy reconstruction and noise suppression. The method's resilience is confirmed by actual data from the enhanced 1500g PCGe detector, shows that S/B events can be distinguished up to the electronic noise edge for sub-keV rare event searches. In this work, timing pulse data from various PCGe detector masses obtained at the TEXONO reactor experiment will be used to demonstrate how S/B discriminating techniques are optimized.

Condensed Matter Physics

High Energy Physics

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Track Classification: High Energy Physics

Contribution ID: **17** Type: **not specified**

Identifying axions in magnetized matter of neutron star

Quantum chromodynamics (QCD) axions might solve the mystery of an exact candidate for dark matter (DM). Axions are weakly interacting particles, motivated by the solutions to the strong CP problem physics. The cooling process of neutron stars (NS) occurs through the emission of particles,
including neutrinos and axions.
By employing the SLY equation of state (EoS), we solve the modified Tolman-Oppenheimer-Volkoff (TOV) set of equations. We take into account the Bremsstrahlung process that occurs in both the core
and crust of the NS. Additionally, we analyze the influence of strong magnetic fields on the luminosity
versus the ages of NSs for different masses of axions.

We utilize the maximum permissible limit for the central magnetic field and a radially distance-dependent expression for the magnetic field while generating profiles using the TOV equations. The

luminosity of axions produced through the Bremsstrahlung process is significantly higher in the presence of a magnetic field compared to without magnetic field, particularly during the early stages
of the NS, within the possible range of axion masses. When a magnetic field is included, we observe a
notable difference in the luminosity of axions for all characteristic ages of NSs. Our analysis indicates
that the luminosity of particles, such as axions and neutrinos, in the cooling of NSs is largely affected
by the presence of an intense magnetic field. With the inclusion of magnetic fields in the EoS and various processes related to the cooling of NSs, we can achieve a better understanding of the underlying physics of the universe. The current results address fundamental questions regarding the
formation of stars and galaxies by observing their gravitational effects and electromagnetic radiation.

Condensed Matter Physics

High Energy Physics

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Track Classification: High Energy Physics

Contribution ID: **18** Type: **Poster**

Study of Quark-Gluon Plasma in Relativistic Heavy-Ion Collisions

The study of quark–gluon plasma (QGP) is one of the most important research areas in
modern high-energy physics. According to Quantum Chromodynamics (QCD), strongly interacting
matter undergoes a phase transition from hadronic matter to a deconfined state of quarks and gluons at
extremely high temperatures and energy densities. Such conditions can be recreated in laboratories
through relativistic heavy-ion collisions at facilities such as the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC). This research paper presents a detailed discussion of the theoretical foundations of QGP, experimental methods used in heavy-ion collisions, and key signatures such as collective flow, jet quenching, and strangeness enhancement. The results provide
compelling evidence for the formation of a strongly interacting, nearly perfect fluid known as the quark gluon plasma.

Condensed Matter Physics

High Energy Physics

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Track Classification: High Energy Physics

Contribution ID: **19** Type: **not specified**

Multi-Flux-Tube representation of dual QCD Vacuum

To explore the typical non-perturbative structure of QCD vacuum, a dual version of color gauge theory has been analysed. The QCD vacuum, in physically accessible near infrared sector has been shown to endowed with a multi-flux-tube system. Using the first principle, the flux tube energy in the asymptomatic limit has been computed at various couplings. Consequently, the interaction among microscopic color flux-tubes has been shown to reveal their possible role in the low energy phenomenon of QCD vacuum.

Condensed Matter Physics

N.A.

High Energy Physics

Yes

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