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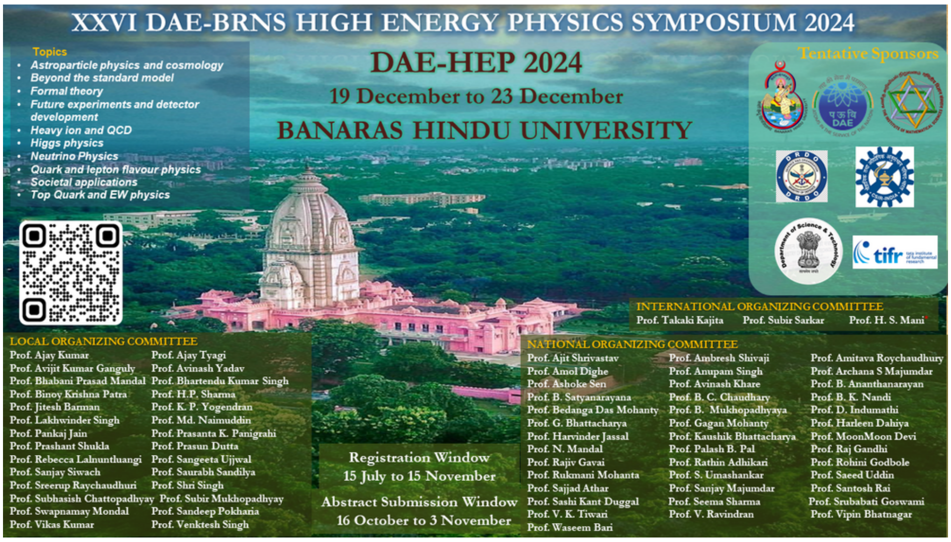

Book of Abstracts

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Forecasting the Discovery Reach of Next-Generation Neutrinoless Double Beta Decay Experiments

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Worldwide, there is significant ongoing research dedicated to the experimental search for neutrinoless double beta decay ($0\nu\beta\beta$). The reason lies in the fact that the most sensitive experimental avenue to determine if neutrinos are Majorana particles is through the search for $0\nu\beta\beta$, which further offers insights into the absolute mass scale of neutrinos and the mechanism behind mass generation. The forthcoming $0\nu\beta\beta$ experiments target the detection of signals within the inverted mass ordering and advancing their sensitivity into the normal ordering regimes. Prior to the execution of experiments, we undertake a quantitative assessment of the projected experimental sensitivity, focusing primarily on the discovery potentials. We analyze the sensitivity of the counting method using full Poisson statistics [1] and compare the results with those obtained from its continuous approximation. Sensitivity can be further improved by incorporating additional measurable signatures, such as energy, which is accounted for in a maximum likelihood analysis [2]. Our research highlights a practical approach for assessing the potential sensitivity of future $0\nu\beta\beta$-projects based on their anticipated backgrounds before their execution.

References

[1] M. K. Singh et al. In: Phys. Rev. D 101 (1 2020), p. 013006.
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Field of contribution:

Phenomenology

4

Coherent Neutrino-Nucleus Elastic Scattering at the Kuo-Sheng Reactor: Probing Standard Model and New Physics with the TEXONO Experiment

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Predicted soon after the discovery of the Z boson, coherent neutrino-nucleus elastic scattering (CνA_{el}) is a Standard Model (SM) process in elementary particle physics. The observation of CνA_{el}

is pivotal in advacing our understanding of the SM and exploring potential physics beyond it [1, 2]. The goal of the TEXONO experiment is to observe CνA_{el} of reactor electron antineutrinos interacting with Germanium nuclei in the fully coherent regime. The TEXONO experiment, to study SM and beyond SM aspects of CνA_{el}, employs state-of-the-art point-contact high-purity Germanium detectors with a threshold of $\mathcal{O}$(100 eV) at the Kuo-Sheng nuclear power plant [3]. This presentation will outline our research activities and highlight the most recent advances in exploring SM and BSM physics with CνA_{el}.

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[3] A.K. Soma et al. In: Nucl. Instrum. Methods Phys. Res. A. 836 (2016), pp. 67–82.

Field of contribution:

Experiment

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Search for Higgs Pair Production at LHC and Improvements for Run 3

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Significant progress was made with LHC Run-2 data in probing the Higgs boson (H) self-interaction via searches for HH pair production. The strength of the H self-interaction is unmeasured so far, and its value has implications ranging for the long-term stability of the universe to the presence of new physics. With the large datasets now being collected at the LHC, we have entered a new era in which HH measurement will be one of key priorities of the High Luminosity LHC. In this talk, I will first summarize the progress made by the ATLAS and CMS collaborations with Run-2 data, then focus on crucial efforts made using Artificial Intelligence by the CMS Collaboration to greatly improve the HH measurement sensitivity with Run-3 data. This includes the implementation of novel trigger strategies, more accurate jet flavor identification, and improvements in jet energy regression estimates. These innovations will pave the way for an accelerated sensitivity of the Higgs self-interaction strength in Run-3 and beyond.

Field of contribution:

Experiment

6

The Hypertriton Puzzle in Relativistic Heavy-Ion Collisions

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The yields of hadrons and light nuclei in relativistic collisions of heavy-nuclei at a center of mass energy of 2.6 TeV can be described remarkably well by a thermal distribution of an ideal gas of hadrons and light nuclei interacting only via the decay of resonances. Given the particularly small binding energy of hypertritons relative to the temperature describing the yields (about 156 MeV), one might naturally expect hypertrions to dissociate in medium, making the agreement of hypertriton yields with thermal predictions highly puzzling. The puzzle is compounded by the fact that small binding energy is associated with the large size of the hypertriton. This size is on a similar scale to the overall size of the fireball and much larger than the length scale over which temperatures in the fireball vary over phenomenologically relevant amounts. In this talk, I will quantify the tension this effect causes and show that it is sufficiently large to render the thermal model inconsistent: its natural assumptions are in conflict with its outputs. The possibility that hypertritons are formed at freeze out as compact objects, quark droplets, that subsequently evolve into hypertritons is considered as a way to resolve the puzzle. It is noted that beyond making the assumption that compact quark droplets form, additional detailed dynamical assumptions which have not been justified are needed to make the thermal model work. The issue of why, despite these issues, the hypertriton is well described by a simple statistical description at freeze out is unresolved. Resolving the hypertriton puzzle is important as it may clarify whether the phenomenological success of the simple thermal model for yields accurately reflects the simple picture of the underlying physics on which it is based.

Field of contribution:

Theory

7

Flavour in the Dark: Investigating Dark Matter with Low-Mass Spin-0 Mediator

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This work explores a simplified dark matter (DM) model featuring a spin-0 mediator with masses below 10 GeV. The parameter space is systematically divided into various mediator mass regions, and model constraints are derived using a diverse array of observables. These include flavour-changing charged and neutral current processes, rare and semileptonic decays of pseudoscalar mesons, electroweak precision observables (EWPOs), and data from fixed-target experiments. The model's potential to account for recent Belle-II data concerning invisible B-meson decays is also studied. Our investigation includes a detailed analysis of DM properties and incorporates constraints from Big Bang nucleosynthesis. We establish robust parameter bounds through both individual and simultaneous analyses, underscoring their implications for DM phenomenology. Furthermore, we illustrate mapped constraints on analogous interaction parameters in UV-complete models. This study contributes to a comprehensive exploration of constraints and theoretical implications associated with low-mass spin-0 mediators with fermionic DM models.

Field of contribution:

Phenomenology

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Analyzing Constraints on Simplified Dark Matter Models via Flavour and Electroweak Measurements

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This study focuses on a combined analysis of various available inputs to constrain the parameter spaces of a simplified dark matter (SDM) model featuring a spin-0 mediator and fermionic dark matter (DM). The spin-0 mediator interacts with standard model (SM) fermions, SM gauge bosons, and DM. We constrain the parameter spaces of different relevant couplings, DM mass, and the mediator mass, using the data from flavour-changing charged and neutral current processes, CKM matrices, W and Z-pole observables, DM relic density, and direct and indirect detection bounds. We have calculated bounds on the couplings from both separate and simultaneous analyses of the mentioned processes. We identify correlated parameter spaces for all the relevant parameters, which include the couplings and the masses. For the DM and mediator masses, we have scanned the region between 100 GeV and 1000 GeV. Using our results, we have obtained bounds on the couplings of possible higher dimensional operators from which we can formulate our SDM.

Field of contribution:

Phenomenology

9

Transport coefficients of Hadronic matter near T_C and Spontaneous Chiral Symmetry Breaking Effect

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In this work we make an attempt to understand the dynamics of bulk viscosity near QCD phase transition. In particular we try to establish a relationship between singular behavior of bulk viscosity near critical region with some underlying symmetry of the system under consideration. We find that it is possible to relate singular behavior of bulk viscosity with the process of spontaneous chiral symmetry breaking of the system.

In this model We consider a strongly interacting fermionic matter, that is in a state with broken chiral symmetry and the system is placed slightly out of equilibrium. Invoking quasi-particle description for strongly interacting fermions, with dynamic quasi-particle excitations, we evaluate the thermodynamic properties of this matter in the relativistic mean-field (RMF) approximation.

Taking into consideration the Boltzmann transport equations in relaxation time approximation, we evaluate the transport properties of this medium. It is found that due to the coupling of fermionic quasi-particle excitations and σ modes (whose strength is governed by the expectation value of Chiral Condensate) ζ/s can get singular near transition region, both along O(4) transition line and in the Z(2) universality class.

Our results remain applicable in the limit of vanishing expectation value of Chiral Condensate that is in the limit T ~ T_C, where σ-field strength is given by its vacuum expectation value.

It therefore seems appropriate to do away with the adhoc assumption of Hagedorn states, that were found to produce similar singular behavior of bulk viscosity near transition region in case of Hadron Resonance Gas models.

Field of contribution:

Theory

10

Study of X(3872)-> J/psi gamma and search for X(3872)->psi(2S) gamma using the Belle and the Belle II Experiments

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The resonance state $X(3872)$, also known as $\chi_{c1}(3872)$ was discovered by the Belle collaboration in 2003 in the decay $B^+ \to X(3872)K^+$ where $X(3872) \to J/\psi\pi^+\pi^-$. A lot of theoretical as well as experimental studies have been carried out on this state, but its nature is still not well known. Currently, X(3872) is a strong contender for tetraquark, $\bar{D^0}D^{*0}$ molecule, $\chi_{c1}(2P)$ state, admixture of $c\bar{c}$ and $\bar{D^0}D^{*0}$ molecule state. Radiative decays of X(3872) can provide insights into the structure of the state. Recently LHCb has measured $R_{\psi\gamma}$ which is the ratio of B.F. of $X(3872) \to \psi(2S)\gamma$ to $X(3872) \to J/\psi\gamma$ and supported Belle measurement over BaBar. However, there is still some conflict between LHCb and BESIII results. Belle and Belle II combined study can help in solving this conflict. We plan to present a preliminary Monte Carlo (MC) study of signal and background for these decay modes.

Field of contribution:

11

A method to measure the angular distribution of atmospheric cosmic muons at the Earth

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The angular distribution of atmospheric cosmic-muons is studied using PYTHIA8 simulations and the simulation results were contrasted with the experimental data. In this work, the standalone PYTHIA8 code is augmented by adding oxygen molecules in a relative abundance of 78:22 (Nitrogen:Oxygen) to resemble a more realistic atmosphere [1]. The integrated vertical intensity $(I_\mu(\theta))$ of cosmic-muons varies with $cos^n\theta$ where θ is the zenith angle and n is the exponent term. The experimental data were measured at two surface laboratories [SINP (Kolkata) & UCIL (Jadugoda)]. The PYTHIA8 simulation results are compared with these experimental data and also with the published data where the different n values show the effect of different altitudes from the sea-level. The simulated vertical flux intensity $(I_\mu(\theta))$ as a function of the zenith angle (θ) of cosmic-muons shows a good level of agreement with the spectral shape of our experimental data as well as with that from literature. The integrated vertical muon flux $(I_\mu(\theta))$ and the exponent term (n) are extracted fitting all the experimental data for each case. The vertical flux intensity of cosmic muons has been characterized as a function of momentum (p) and energy (E). Moreover, PYTHIA8 simulation study is done for the charge asymmetry of the number of positive and negative cosmic muons and for the relative difference of the counts of cosmic muons and muon neutrinos also. This study highlights the challenge of PYTHIA8 simulation in the astrophysics arena in the context of extensive air showers (EAS) improving its predictive power by incorporating a more realistic atmospheric model.

References:

1. B. H. Wani, T. Sinha, G. Banerjee and W. Bari, *International Journal of Modern Physics A* **0**, 2450093 (0), https://doi.org/10.1142/S0217751X24500933, doi:10.1142/S0217751X24500933.

Field of contribution:

12

Observation of enhanced long-range elliptic anisotropies inside high-multiplicity jets in pp collisions at $\sqrt{s}$ = 13 TeV in CMS

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It was originally thought that small collision systems such as electron-positron, electron-proton, and proton-proton(pp) collisions would produce final states that were too small and dilute for secondary partonic rescatterings to drive the system toward thermal equilibrium. Collective hydrodynamic behavior was not expected to play an important role in these final states, notwithstanding some early studies. Surprisingly, strong longrange collective correlations, similar to those observed in AA collisions, were discovered in the azimuthal distributions of charged particles in the laboratory reference frame of pp collisions having a large final state multiplicity in the entire event. This raised the question of whether a tiny QGP droplet is created in such conditions. The first search for long range near-side correlations and QCD collective effects in jets produced in 13 TeV pp collisions using the CMS experiment are presented. The measurement is performed using charged particles from individual jets, after their kinematic variables have been calculated in a coordinate basis having the z-axis coinciding with the jet direction. Two-particle correlations are studied as a function of the number of charged particles in the jet. The first three Fourier harmonics of long-range azimuthal correlations are extracted and compared with those calculated using Monte Carlo (MC) event generators which model the jet fragmentation process.

Field of contribution:

Experiment

13

Quasi-normal mode of dyonic hairy black hole and its interplay with phase transitions

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We explore the dynamics of the massless scalar field in the context of hairy black holes within the Einstein-Maxwell-scalar gravity system. Utilizing both the series solution and shooting methods, we numerically compute the corresponding quasinormal modes (QNMs) across various black hole parameters. Notably, the values obtained from these two methods exhibit robust agreement. The consistently negative imaginary part of the QNM underscores the stability of the massless scalar field in the backdrop of the black hole. Our investigation reveals that both the decay and oscillatory modes of the scalar field perturbation exhibit a linear increase with the horizon radius, particularly notable for large black holes. We conduct a comprehensive analysis of QNMs across diverse black hole parameters, encompassing the electric charge, magnetic charge, horizon radius, and the hairy parameter. Moreover, we extend our scrutiny to the QNM behavior near the small/large black hole phase transition. Intriguingly, we discern distinct characteristics in the nature of QNMs between the large and small black hole phases, indicating the potential of QNMs as a probing tool for black hole phase transitions.

Field of contribution:

14

Testing of Counter Mother Boards for the Cosmic Muon Veto Detector

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The readout system for the Cosmic Muon Veto Detector (CMVD) includes Counter Mother Boards (CMBs) that interface with Silicon Photomultipliers (SiPMs) located at both ends of each di-counter unit and readout electronics. The di-counter is composed of two adjacent extruded plastic scintillator (EPS) strips. The CMBs are a critical component of the readout system, playing a key role in both data acquisition and SiPM calibration.
Each CMB is also responsible for supplying precise bias voltage to four SiPMs. The CMB also has an onboard TPH sensor, to monitor conditions such as temperature and humidity, which are crucial for maintaining stable operation of the SiPM's. The board also includes LEDs and an LED driver circuit specifically for calibrating the SiPMs, allowing for periodic checks and adjustments to ensure consistent performance over time.
A dedicated test setup was designed to evaluate the performance of each CMB before the installation. This testing process involves a series of diagnostics to verify the functionality of all critical components, including the bias voltage circuits, signal integrity, and LED calibration system by measuring the signals of a few characterised SiPM through each of these CMB boards.
This paper details the thorough characterization process for the CMBs, presenting an overview of the testing methodology, the results of the evaluations, and the steps taken to resolve recurring issues. By identifying and addressing potential faults in circuitry, the overall reliability of the CMVD can be significantly enhanced, ensuring it meets the required veto efficiency of 99.99%.

Field of contribution:

Experiment

15

Simulation studies of cosmic muon veto detector around RPC-stack

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The INO-ICAL collaboration has developed multiple prototype detectors utilizing Resistive Plate Chambers (RPCs) as sensitive detectors at TIFR, Mumbai, and IICHEP, Madurai. The Cosmic Muon Veto Detector (CMVD) aims to explore the feasibility of constructing a large-scale neutrino experiment at shallow depths. A primary objective of the CMVD is to achieve a veto efficiency exceeding 99.99%, while maintaining a false-positive rate below 10^{-5}.

To accomplish this, a small-scale veto wall has been constructed using several extruded plastic scintillators (EPS) measuring approximately $450\,\text{cm} \times 5\,\text{cm} \times 1\,\text{cm}$. The veto wall is positioned atop a $1\,\text{m} \times 1\,\text{m}$ RPC stack and comprises up to four staggered layers of scintillators. The staggering of each layer ensures that no dead space exists between adjacent units. Scintillation light is collected using two Kuraray Y-11 wavelength-shifting (WLS) fibers, with Silicon Photomultipliers (SiPMs) employed for signal readout.

The performance of each EPS and the SiPMs has already been validated through dedicated test setups. Monte Carlo simulations have been developed, incorporating all known detector parameters, including SiPM noise, observed spectra, and the time resolution associated with cosmic muons along the entire length of the EPS. The efficiency of the veto wall is estimated using reconstructed muon tracks in the RPC stack, ensuring sufficient measurement points and high-quality fits. This paper will present a detailed description of the veto algorithm and the expected efficiency of the veto system, highlighting its potential for future shallow-depth neutrino experiments.

Field of contribution:

Experiment

16

Charge dependent cosmic muon flux at Madurai, India

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The INO-ICAL collaboration has developed a prototype detector called mini-ICAL at IICHEP, Madurai, India ($9^\circ\ 56'\,\text{N}, 78^\circ\ 00'\,\text{E}$) to evaluate detector performance and address the engineering challenges associated with constructing a large-scale INO-ICAL detector. The mini-ICAL consists of 11 layers of iron plates, each measuring $4\,\text{m} \times 4\,\text{m} \times 5.6\,\text{cm}$, with $45\,\text{mm}$ gaps between each layer to accommodate the Resistive Plate Chambers (RPCs) with dimension $2\,\text{m} \times 2\,\text{m}$ as tracking devices. Located on the surface, the detector collects cosmic muon events generated by air showers resulting from the interaction of primary cosmic rays with the upper atmosphere. The iron is magnetized to a maximum field of $1.5\,\text{T}$ by applying a current of $900\,\text{A}$ through 36 copper coils, enabling the identification of muon particle types as μ^+ or μ^-. A Kalman filter-based track fitting algorithm is employed to reconstruct the charge and 4-vector of charged particles within the RPC stack.

The simulation utilizes the CORSIKA event generator and Geant4 toolkits for detector geometry and muon interactions, along with considerations for detector noise and inefficiency, etc. The Monte Carlo simulation is then used in the unfolding technique to derive the muon spectrum at the Earth's surface from the observed data. This talk presents the analysis results as a function of momentum and azimuthal angle, ranging from $\sim 1\,\text{GeV/c}$ to $3\,\text{GeV/c}$ across different zenith angle ranges up to 50°. The data is also compared with predictions from various hadronic models within the CORSIKA event generator.

Field of contribution:

Experiment

17

Chaos, nonconformality and holography

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The behavior of a chaotic system and its effect on existing quantum correlation has been holographically studied in the presence of nonconformality. Keeping in mind the gauge/gravity duality framework, the nonconformality in the dual field theory has been introduced by considering a Liouville type dilaton potential for the gravitational theory. The resulting black brane solution is associated with a parameter η which represents the deviation from conformality. The parameters of chaos, namely, the Lyapunov exponent and butterfly velocity are computed by following the well-known shock wave analysis. The obtained results reveal that the presence of nonconformality leads to suppression of the chaotic nature of a system. Further, for a particular value of the nonconformal parameter η, the system achieves Lyapunov stability resulting from the vanishing of both the Lyapunov exponent as well as butterfly velocity. Interestingly, this particular value of η matches with the previously given upper bound of η known as Gubser bound in the literature. The effects of chaos and nonconformality on the existing correlation of a thermofield doublet state have been quantified by holographically computing the thermomutual information in both the presence and absence of the shock wave. Furthermore, the entanglement velocity is also computed, and the effect of nonconformality on it has been observed. Finally, the obtained results for the Lyapunov exponent and the butterfly velocity have also been computed from the pole-skipping analysis. The results from the two approaches agree with each other.

Field of contribution:

Theory

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Noise of gravitons and the uncertainty principle

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The effect of the noise induced by gravitons in
the case of a freely falling particle from the viewpoint of an
external observer has been recently investigated. The quantum gravity modified Newton's law of free fall was obtained.
We extend this work by calculating the variance in the
velocity and eventually the momentum of the freely falling
massive particle. From this simple calculation, we observe
that the product of the standard deviation in the position with
that of the standard deviation in momentum picks up a higher
order correction which is proportional to the square of the

standard deviation in momentum. We also find out that in
the Planck limit (both Planck length and Planck mass), this
uncertainty product gives the well-known form of the generalized uncertainty principle. A similar uncertainty product is obtained when the graviton is in a squeezed state. The analysis is then extended for the gravitons being in a thermal state. Here we obtain a temperature dependent uncertainty product. If one replaces this temperature with the Planck temperature and the mass of the particle by the Planck mass, the
usual generalized uncertainty product appears once again.

Field of contribution:

Theory

19

Probing the quantum nature gravity using a Bose-Einstein condensate

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The effect of noise induced by gravitons has been investigated using a Bose-Einstein condensate. The general complex scalar field theory with a quadratic self-interaction term has been considered in the presence of a gravitational wave. We then vary the action and make use of the principle of least action, and obtain two equations of motion corresponding to the gravitational perturbation and the time-dependent part of the pseudo-Goldstone boson. Coming to an operatorial representation and quantizing the phase space variables via appropriately introduced canonical commutation relations between the canonically conjugate variables corresponding to the graviton and bosonic part of the total system, one obtains a proper quantum gravity setup. We observe that the solution of the time-dependent part of the pseudo-Goldstone boson has infusions from the noise induced by gravitons and the corresponding differential equation of motion is Langevin-like. Using this result, we obtain the quantum gravity modified Fisher information which has been termed as the quantum gravitational Fisher information (QGFI). The inverse square root of the stochastic average of the QGFI gives the minimum uncertainty in the measurement of the gravitational wave amplitude. The minimum uncertainty does not go to infinity as the measurement time approaches zero in a quantum gravity setup rather it has a measurable finite value for gravitons with high squeezing. In order to sum over all possible momentum modes, we next consider a noise term with a suitable Gaussian weight factor which decays over time. We then obtain the lower bound on the final expectation value of the square of the variance in the amplitude parameter. Because of the noise induced by the graviton, there is a minimum value of the measurement time below which it is impossible to detect any gravitational wave using a Bose-Einstein condensate. Finally, we consider interaction between the phonon modes of the Bose-Einstein condensate which results in a decoherence. We observe that the decoherence effect becomes significant for gravitons with minimal squeezing.

Field of contribution:

Phenomenology

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Emission of Neutrinos in Neutron Stars: Exploring the Effects of Modified Gravity and Magnetic Fields through TOV Equations

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The existence of dark matter has long been extensively studied in the past few decades. In this study, we investigate the emission of neutrinos and photons from neutron stars (NSs) by employing the modified theory of gravity and the corresponding Tolmann-Oppenheimer-Volkoff (TOV) system of equations. The extreme matter densities and magnetic fields inside a NS provide a unique laboratory for studying fundamental physics, including the interplay between gravity and quantum field effects. The impact of a strong magnetic field has also been incorporated into the corresponding TOV equations. We here attempt to see how neutrinos and photons emissions from these strange compact objects are impacted by employing the modified TOV equations due to modified theories of gravity, like $f(R,T)$ gravity or scalar-tensor theories, and strong magnetic fields. Our analysis focusses on how these modifications influence NS's structure, cooling processes, and emission processes, particularly through neutrino and photon emission rates. We also explore the implications of such modifications on the observational signatures that current and future astrophysical instruments could detect. This research contributes to the broader effort of linking predictions of the theoretical models with the observational data to refine our understanding of physics of the neutron stars and the fundamental forces governing the universe.

Field of contribution:

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Mechanical design of a Threshold Cherenkov Detector

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Abstract:
A cylindrical threshold Cherenkov detector has been designed and fabricated at the TIFR to determine the shape of the differential cosmic muon flux spectrum at the low energy ranges, which is the dominant component at the earth's surface. This Cherenkov detector is sensitive to muons with an energy threshold from around 1.2 to 6.5 GeV for the pressure of filled nitrogen at -0.5 to 15 bar respectively. It is proposed to measure the integral muon intensity at these thresholds and fit the data based on a diffusion model of muon production by pions in the Earth's atmosphere which describes the integral energy distribution as a power law with exponent ~ −2.7. Through this, we will be able to infer the feasibility of using a threshold Cherenkov detector to accurately measure the shape of the cosmic ray muon energy distribution.
The detector is made using a seamless Stainless Steel tube of size 200 NB (schedule 10) × 1800 mm length filled with Nitrogen gas. The inner surface of the tube will be lined with a metallized Mylar sheet for enhancing the reflectivity of UV light. The bottom of the reflector is in conical form to concentrate the UV light to a 50 mm dia cross section of the PMT face. There is a quartz window at the bottom to mount UV PMT. A custom design scintillator assembly has been made wherein two scintillators are mounted at 90 degrees and connected to one PMT. Two layers of this scintillator assembly are mounted at the top and diagonally at the bottom end of the tube. They form the trigger assembly. The mechanical design details will be described in the talk.

Field of contribution:

Experiment

22

A combined explanation of $b \to s\ell\ell$ anomalies and $B \to \pi K$ puzzle within SMEFT

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Two categories of four-fermion SMEFT operators are semileptonic (two quarks and two leptons) and hadronic (four quarks). At tree level, an operator of a given category contributes only to processes of the same category. However, when the SMEFT Hamiltonian is evolved down from the new-physics scale to low energies using the renormalization-group equations (RGEs), due to operator mixing this same SMEFT operator can generate operators of the other category at one loop. Thus, to search for a SMEFT explanation of a low-energy anomaly, or combination of anomalies, one must: (i) identify the candidate semileptonic and hadronic SMEFT operators, (ii) run them down to low energy with the RGEs, (iii) generate the required low-energy operators with the correct Wilson coefficients, and (iv) check that all other constraints are satisfied. In this paper, we illustrate this method by finding all SMEFT operators that, by themselves, provide a combined explanation of the (semileptonic) $b \to s\ell\ell$ anomalies and the (hadronic) $B \to \pi K$ puzzle.

Field of contribution:

Phenomenology

23

Prospects of QCD & Lund Jet Plane Studies at FCC-ee

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This analysis describes prospects of the sensitivity of the strong coupling constant ⊠s at the FCC-ee using studies based on 3-jet/2-jet cross-section ratio (R3/2) and the Lund Jet Plane (LJP) representation. Preliminary results demonstrate the dependence of R3/2 on ⊠s, providing key insights into the re-interpretation of these measurements through QCD studies. For LJP studies, preliminary representations of primary and secondary LJPs are presented, utilizing jet clustering and declustering algorithms for the e+e- collision environment. Additionally, the other potentials of the LJP tool at FCC-ee are emphasized.

Field of contribution:

Experiment

24

Jet Energy Scale Uncertainty Using Single Particle Response Measurements

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The study presents a generic approach that deals with jet constituents to derive the jet energy scale (JES) uncertainty. It uses single-particle E/p response measurements obtained from 13 TeV Run 2 LHC data from proton-proton collisions. The E/p method offers a higher precision level than the traditional pT-balance method, but it is in good agreement with it. Both methods are combined to derive the JES. The final output of this combination results in a significant improvement in JES uncertainty across a wide range of jet pT values. The study unveils key insights and advancements in the precise determination of jet energy scales.

Field of contribution:

Experiment

25

The Next to Minimal Two Higgs Doublet Model, Entropy Production and Stochastic Gravitational Waves

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This study undertakes a reconsideration of the potential for a first-order electroweak phase transition, focusing on the next-to-minimal two Higgs doublet model (N2HDM). Our exploration spans diverse parameter spaces associated with the phase transition, with a particular emphasis on examining the generation of stochastic Gravitational Waves (GW) resulting from this transition. The obtained results are meticulously compared against data from prominent gravitational wave observatories, and the possibility of their detection in the future GW observations have been established. In passing by we analyse the strength of the phase transition through the production of entropy during the electroweak phase transition.

Field of contribution:

Phenomenology

26

Performance of CMS silicon tracker

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Positioned at the innermost regions of the CMS detector, the silicon tracking system aims to measure charged particle trajectories with high precision. The tracking system is instrumented with both silicon pixel and strip detectors. The strip detector has been operational since the start of LHC Run 1 operations, whereas a new pixel detector was installed in 2017. The innermost layer of the pixel detector was again replaced at the start of Run 3. Since the beginning of LHC Run 3 operations, both the detectors have been operating efficiently, collecting collision data at 13.6 TeV. In this talk, the performance of the detectors will be shown, highlighting the key features which lead to good performance. Along with that, the alignment techniques which correct for precise trajectory reconstruction, and the ways it mitigates radiation damage, will also be discussed.

Field of contribution:

Experiment

27

Pole-skipping and chaos in D3-D7 brane systems

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In this work, we analyse the pole-skipping phenomena of finite temperature Yang-Mills theory with quark flavors which is dual to D3-D7 brane systems in bulk. We also consider the external electric field in the boundary field theory which is dual to the world volume electric field on the D7 brane. We work in the probe limit where the D7 branes do not back-react to the D3 brane background. In this scenario, we decode the characteristic parameters of the chaos namely, Lyapunov exponent λ_L and butterfly velocity v_b from the pole-skipping points by performing the near effective horizon analysis of the linearised Einstein equations. Unlike pure Yang-Mills, once charged quarks with a background electric field are added into the system, the characteristic parameters of the chaos show non-trivial dependence on the quark mass and external electric field. We have observed that λ_L and v_b decreases with increasing electric field. We further perform the pole-skipping analysis for the gauge invariant sound, shear, and tensor modes of the perturbation in the bulk and discuss their physical importance in the holographic context.

Field of contribution:

Theory

28

An equivalence of three butterflies in Lifshitz background

Authors: Adrita Chakraborty[1]; Banashree Baishya[None]; Nibedita Padhi[2]

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In this work, we investigate two salient chaotic features, namely Lyapunov exponent and butterfly velocity, in the context of an asymptotically Lifshitz black hole background with an arbitrary critical exponent. These features are computed using three methods: entanglement wedge method, out-of-time-ordered correlator computation and pole-skipping. We present a comparative study of the aforementioned features where all of these methods yield exactly similar results for the butterfly velocity and Lyapunov exponent. This establishes an equivalence between all three methods for probing chaos in the chosen gravity background. Furthermore, we evaluate the chaos at the classical level by computing the eikonal phase and Lyapunov exponent from the bulk gravity. These quantities emerge as nontrivial functions of the anisotropy index. By examining the classical eikonal phase, we uncover different scattering scenarios in the near-horizon and near-boundary regimes. We also discuss potential limitations regarding the choice of the turning point of the null geodesic in our approach.

Field of contribution:

Theory

29

Design, fabrication and characterization of a bias supply circuit for SiPMs

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Co-authors: Gobinda Majumder [2]; Mandar Saraf [3]; Ravindra Raghunath Shinde [4]; Satyanarayana Bheesette

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To study the feasibility of a shallow-depth neutrino detector, a Cosmic Muon Veto Detector (CMVD) is being built around the RPC detector stack at TIFR, Mumbai. The CMVD will use extruded plastic scintillators for muon detection and wavelength-shifting fibers coupled with silicon photomultipliers (SiPMs) for signal readout. These SiPMs require a very accurate, precise, and stable power supply for stable gain characteristics. We developed a bias voltage supply circuit that is capable of supplying $18 - 68V$ in $50mV$ steps and up to about $4mA$ current. It features digital voltage adjustment and stabilization, as well as current monitoring capabilities using external controllers such as microcontrollers or FPGAs. In addition to providing better flexibility, the external controller enables possibilities like temperature compensation. Designed to power multiple SiPMs, this circuit can be easily integrated with the front-end electronics of SiPMs.

Field of contribution:

30

A Compact Test and Trigger Scintillator with SiPM Readout and Custom Electronics

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Since a long time ago, members of the High Energy Physics community have been using plastic scintillator paddles, coupled to a photomultiplier tube (PMT) as the detector for making a cosmic ray telescope to generate a cosmic ray muon trigger. One big drawback of such paddles has been the use of bulky photomultiplier tubes, which sometimes pose a great challenge in making a particular geometry. Not only are the PMTs bulky, but they also are quite expensive, require a high bias voltage as well as current, moreover, they cannot be used in the presence of even a tiny magnetic field.

Keeping this in mind, we designed and built a compact plastic scintillator paddle using SiPM for readout instead of a PMT. Extruded Plastic Scintillator (EPS) strips, manufactured in the Fermilab EPS factory were used. These strips have a top groove along the length for keeping the fibre. A Fibre Guide Bar (FGB) was designed to terminate the fibre at a pre-defined location exactly in front of an SiPM. The SiPM sits in a well in a specially designed SiPM Mounting Block (SMB) and a Counter Mother Board (CMB) is used as an interface between the SiPM and the front-end amplifier placed at a convenient location. The mechanical parts were manufactured in the TIFR central workshop. The paddles were assembled with Wavelength Shifting (WLS) fibres and SiPMs. A dozen paddles were prepared. After testing the paddles, it was found that all of them had a muon detection efficiency better than 99%.

For operating these paddles, front-end electronics was designed comprising of a 4-channel amplifier-discriminator card, a custom made SiPM bias generator, display and controller for the bias, and a low voltage power supply to operate these devices in the module. External NIM modules were used to form a cosmic muon trigger. This paper will discuss construction and characterisation of the scintillator paddles and the standalone electronics designed for them.

Field of contribution:

Experiment

31

Design and development of DRS4 and FPGA based DAQ board for the Cosmic Muon Veto Detector

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A cosmic muon veto detector is being built around the RPC detector which is operational at TIFR, Mumbai. It will study the feasibility of building a shallow depth neutrino detector. It's being built using extruded plastic scintillator (EPS) strips. Muon interactions in the EPS are detected by SiPMs mounted at the end of 2 wavelength shifting fibres which are inserted in the EPS strips.

The muon detection efficiency of the CMVD is required to be more than 99.99%. Faithful detection of muons requires SiPM charge measurement. SiPM signals are converted to voltage pulses by trans-impedance amplifiers. A DRS4 based readout system is being designed to sample the signals at a rate of 1 GSa/s. The samples are digitised on receiving a mini-ICAL trigger, and zero suppressed data are transmitted to the back-end data server. The data acquisition is controlled by an AMD Spartan-7 FPGA. A soft-core processor (microblaze) is instantiated inside the FPGA to carry out the DAQ process control. An FPGA based DAQ board consisting of 5 DRS4 ASICs and a network interface is being designed. This paper will discuss the prototype design of the SiPM readout board using the DRS4 ASIC and the Spartan-7 FPGA.

Field of contribution:

Experiment

32

Design and Fabrication of a Charge Injection System for the CMS HGCAL Front-End Electronics QC

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The CMS Collaboration is preparing to replace its current endcap calorimeters for the HL-LHC era with a high-granularity calorimeter (HGCAL), featuring a previously unrealized transverse and longitudinal segmentation, for both the electromagnetic and hadronic compartments, with 5D information (space-time-energy) read out. The proposed design uses silicon sensors for the electromagnetic section and high-irradiation regions of the hadronic section, while in the low-irradiation regions of the hadronic section, plastic scintillator tiles equipped with on-tile silicon photomultipliers (SiPMs) are used. The full HGCAL will have approximately 6 million silicon sensor channels, in around 30,000 detector modules. Each of these modules will be readout by a front-end board (hexaboard) using among other components a dedicated readout chip called the HGCROC. Either 3 or 6 HGCROCs, for 198 channel or 444 channel data readout respectively, are housed on each hexaboard depending on whether it is for the outer region of the HGCAL or the inner region of the HGCAL in the high radiation environment.

The HGCROC chips are available in a BGA-376 package. Before the Hexaboards can be approved for use in the HGCAL, it is very essential to know whether all the pins (balls) of the HGCROCs are properly soldered to the pads on the Hexaboard and make a good electrical contact to the board. It is also essential to make this decision very quickly because of the very large number of boards that will be required. A charge injection (CI) system is being designed and built in order to qualify the hexaboards at the factory level. The CI system will incorporate capacitive signal injection into the hexaboards so that no electrical/mechanical contact need be made to the board so that it remains in pristine state before silicon sensor can be wire-bonded to it. The CI system incorporates a programmable switch matrix so that the test signal can be injected into any desired combination of inputs of the hexaboard at a time. The hexaboard inputs are injected with charge and the corresponding data is readout by a hexa-controller and analysed to evaluate the electrical connection between the hexaboard and the HGCROC chips. This paper will discuss the design and performance of the CI system for the quality control of assembled hexaboards of the CMS HGCAL.

Field of contribution:

Experiment

33

Observational Methodologies for the Probable Detection of Cosmic Strings

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Cosmic Strings are hypothetical energy densities arising from topological defects in the early universe. Despite various theoretical studies over the years, there has yet to be significant evidence of its existence. Cosmic Strings produce gravitational waves and cause gravitational lensing making these two methodologies the most studied upon. Theories have also suggested the decay of cosmic strings into particles making them another possible source of detection. Recent studies have focused on the interaction of cosmic strings with spinning black holes and have proposed that their spin reduces when attached to cosmic strings. This when considered in the case of an X-ray Binary system, directly affects the orbital period and a change in the accretion disk and hence are great methodologies for their detection.

Field of contribution:

Theory

34

The role of mutual information in the Page curve

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In this work, we give two proposals regarding the status of connectivity of entanglement wedges and the associated saturation of mutual information. The first proposal has been given for the scenario before the Page time depicting the fact that at a particular value of the observer's time $t_b = t_R$ (where $t_R \ll \beta$), the mutual information $I(R_+ : R_-)$ vanishes representing the disconnected phase of the radiation entanglement wedge. We argue that this time is the Hartman-Maldacena time at which the fine-grained entropy of radiation goes as $S(R) \sim \log(\beta)$, where β is the inverse of Hawking temperature of the black hole. On the other hand, the second proposal probes the crucial role played by the mutual information of black hole subsystems in obtaining the correct Page curve of radiation.

Field of contribution:

Theory

35

Single and entangled atomic systems in thermal bath and the Fulling-Davies-Unruh effect

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In this work, we revisit the Fulling-Davies-Unruh effect in the framework of two-level atomic systems, both single and entangled, which remain static within a thermal bath. We analyze the interaction between these atomic systems and a massless scalar field, considering both free space and a cavity environment. By computing atomic transition rates and comparing them with the findings of our previous work [*Phys. Rev. D 108 (2023) 085018*], we demonstrate that in free space, an equivalence exists between the upward and downward transition rates of a uniformly accelerated atom, as observed by an inertial observer, and those of a static atom immersed in a thermal bath, provided that the temperature of the thermal bath coincides with the Unruh temperature. However, this equivalence in the level of transition rates is disrupted when the atom is placed inside a cavity. For two-atom systems, when the initial state is in a general pure entangled form, we observe that the equivalence between the accelerated and static thermal bath scenarios holds only under specific limiting conditions in free space and is entirely broken in a cavity setup. Nonetheless, the ratio of the upward to downward transition rates in the thermal bath agrees precisely with those in the accelerated systems, both in free space and within the cavity.

Field of contribution:

Theory

36

Upgrade of the Front-End Electronics of the C217 RPC Detector Stack at TIFR

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Abstract: A 12 layered 1 m × 1 m Cosmic Muon tracker, based on gaseous detector, Resistive Plate Chamber (RPC) [1] has been operational since 2007 in C217, TIFR. This detector has an in-house developed Data Acquisition (DAQ) [2] chain. Hybrid Micro-Circuits (HMC) based pre-amplifiers, Emitter Coupled Logic (ECL) based analog front end and Complex Programmable Logic Device (CPLD) based Digital front end have been configured to collect data using a VME backend.
During the long-term operation of the detector, we have observed sudden electronic noise pick-up in the stack and instability of the front-end amplifiers. Many measures were implemented to reduce the noise. Though they helped, but a permanent solution was needed to improve the data quality with new age technology. One way is to design and mount amplifier cum discriminator boards as close as possible to the detector and transmit the differential logic signals to the digital front-end. Upgradation was also needed to improve the power consumptions of the electronics.
Compact 8-in-1 NINO-ultrafast low power amplifier cum discriminator boards [3] have been specially developed as front-end which gives discriminated LVDS output. To incorporate the NINO

boards in existing DAQ chain, we have developed new adapter boards in place of the Analog Front-end. A scheme of modified DAQ system and integration and RPC performance in terms of efficiency and noise rate will be discussed.

References:
1. Development of glass resistive plate chambers for INO experiment, N.K.Mondal, et. al, NIM A, Volume 602, May 2009, Pages 744-748.
2. Electronics and data acquisition system for the ICAL prototype detector of India-based neutrino observatory, S. Dasgupta, et. al, NIM A, Volume 701, February 2013, Pages 153-163.
3. Development of Fast, Low Power 8-Channel Amplifier-Discriminator Board for the RPCs, P.K. Kaur, et. al, XXII DAE High Energy Physics Symposium. Springer Proceedings in Physics, vol 203. Springer, Cham. https://doi.org/10.1007/978-3-319-73171-1_134

Field of contribution:

Experiment

37

Inflationary Gravitational Wave Spectral Shapes as test for Low-Scale Leptogenesis

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We study thermal and non-thermal resonant leptogenesis in a general setting where a heavy scalar ϕ decays to right-handed neutrinos (RHNs) whose further out-of-equilibrium decay generates the required lepton asymmetry. Domination of the energy budget of the Universe by the ϕ or the RHNs alters the evolution history of the primordial gravitational waves (PGW) of inflationary origin, which re-enter the horizon after inflation, modifying the spectral shape. The decays of ϕ and RHNs release entropy into the early Universe while nearly degenerate RHNs facilitate low and intermediate-scale leptogenesis. We show that depending on the coupling y_R of ϕ to radiation species, RHNs can achieve thermal abundance before decaying, which gives rise to thermal leptogenesis. A characteristic damping of the GW spectrum resulting in knee-like features would provide evidence for low-scale thermal and non-thermal leptogenesis. We explore the parameter space for the lightest right-handed neutrino mass $M_1 \in [10^2, 10^{14}]$ GeV and washout parameter K that depends on the light-heavy neutrino Yukawa couplings λ,
in the weak ($K < 1$) and strong ($K > 1$) washout regimes. The resulting novel features compatible with observed baryon asymmetry are detectable by future experiments like LISA and ET. By estimating signal-to-noise ratio (SNR) for upcoming GW experiments, we investigate the effect of the scalar mass M_ϕ and reheating temperature T_ϕ, which depends on the $\phi - N$ Yukawa couplings y_N.

Field of contribution:

Phenomenology

38

Probing flavor violation and baryogenesis via primordial gravitational waves

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We show that observations of primordial gravitational waves of inflationary origin can shed light into the scale of flavor violation in a flavon model which also explains the mass hierarchy of fermions. The energy density stored in oscillations of the flavon field around the minimum of its potential redshifts as matter and is expected to dominate over radiation in the early universe. At the same time, the evolution of primordial gravitational waves acts as bookkeeping to understand the expansion history of the universe. Importantly, the gravitational wave spectrum is different if there is an early flavon dominated era compared to radiation domination expected from a standard cosmological model and this spectrum gets damped by the entropy released in flavon decays, determined by the mass of the flavon field m_S and new scale of flavor violation $\Lambda_{\rm FV}$. We derive analytical expressions of the frequency above which the spectrum is damped, as-well-as the amount of damping, in terms of m_S and $\Lambda_{\rm FV}$. We show that the damping of the gravitational wave spectrum would be detectable at BBO, DECIGO, U-DECIGO, $\mu-$ARES, LISA, CE and ET detectors for $\Lambda_{\rm FV} = 10^{5-10}$ GeV and $m_S = \mathcal{O}(\rm TeV)$. Furthermore, the flavon decays can source the baryon asymmetry of the universe. We identify the $m_S - \Lambda_{\rm FV}$ parameter space where the observed baryon asymmetry $\eta \sim 10^{-10}$ is produced and can be tested by gravitational wave detectors like LISA and ET. We also discuss our results in the context of the recently measured stochastic gravitational background signals by NANOGrav.

Field of contribution:

Phenomenology

39

Suitability of DRS4 for readout of SiPMs in the Cosmic Muon Veto Detector

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The Cosmic Muon Veto Detector (CMVD) at TIFR, Mumbai, will be made of extruded plastic scintillators and SiPMs and require an efficiency of 99.99% or better and a false count rate of 10^{-5} or lower. To achieve this goal, a suitable high-speed, low-noise electronic DAQ system is required. The SiPM signal will be used for charge measurement for the detection of muons, whereas the trigger will come from the RPC detectors. However, the original analog signal from the SiPMs will be lost by the time the DAQ system triggers the acquisition process due to trigger generation delay and latency, and charge measurement will not be possible. Hence, a suitable temporary storage system is required to hold the signal long enough for the trigger to be generated and the data acquisition process to start. We have found that the DRS4 chip, developed by PSI, Switzerland, is a good candidate for this analog signal storage application, which can operate up to $5\,GSa/s$ with $1\,V_{p-p}$ input span and has 1024 cells to sample and hold the analog signal. Since a typical SiPM pulse has a rise time of $8-10\,ns$, a pulse width of about $100-150\,ns$, and an amplitude of $20-200\,mV$: a sampling time of $1\,ns$ is good enough for this application, and hence the DRS4 can be operated at a speed of $1\,GSa/s$. However, a proper offset correction mechanism is required, where individual offset for every cell has to be determined and must be subtracted from the signal. When paired with a suitable ADC and fast processing electronics, and after proper offset correction, it is possible to achieve the full dynamic range required to cover the full spectrum of muon pulses (∼30\,pC) at the required least count of 0.1\,pC for the calibration of SiPM.

Field of contribution:

40

Microcontroller-based custom DAQ system for characterisation of scintillator paddles

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We present a custom DAQ system for a test setup that characterizes some unknown scintillator paddles. In this setup, 3 scintillator paddles with known properties are used to characterize a fourth scintillator paddle. Each scintillator is read using an SiPM, where the 3 SiPMs corresponding to the known scintillators are powered from the same bias source, while the SiPM for the scintillator under test is biased independently. The signals from the SiPMs are amplified and discriminated to produce logic signals. These logic signals are fed through three- and four-fold coincidence logic, and the output is fed to an STM32 series microcontroller. The internal hardware counters are used to count the pulses within a certain time window. In case of a malfunction of one trigger scintillator, this board is also able to bypass that to measure the efficiency of the test scintillator. The time window is adjustable from the user interface. The set time window and counts are displayed on a small display attached to the microcontroller. Here choosing a microcontroller over an FPGA leads to some advantages like reduced complexity, lower cost, and faster development time, leveraging on the built-in hardware of the microcontroller such as the 32-bit CPU, hardware interrupt facilities, hardware counters, I/O interface controllers, etc.

Field of contribution:

41

Quality Control setups description of GEM detector for CMS experiment

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Abstract: The CMS experiment at CERN is foreseen to receive a substantial upgrade during Long Shutdown-3 (LS3) to handle the large number of pileup events in the High-Luminosity LHC. The objective is to increase the integrated luminosity by a factor of 10 beyond the LHC's design value. The CMS just commissioned the Gaseous Electron Multiplier (GEM) detector, namely GE1/1, at the endcap during LS2. GEM detectors represent a new addition to the muon system in CMS, in order to complement the existing systems in the endcap, part of CMS most affected by large radiation doses and high event rates. The GEM chambers will provide additional redundancy and measurement points, allowing a better muon track identification and also wider coverage in the very forward region. For Phase-2 upgrades, CMS has outlined plans for further endcap upgrades, such as GE2/1 and ME0, as part of the LS3 upgrade. For GE2/1 detectors, the part of the detector assembly is expected to take place at different production sites including Panjab University, India. Besides assembly, also all QCs will be performed before sending them to CERN for installation. This contribution will describe these Quality control tests (QC1 to QC5), their setups and corresponding results of the triple GEM detector testing.

Summary: Gas Electron Multiplier(GEM) Detector was introduced by F. Sauli in 1997, which is a composite grid consisting of two conducting layers separated by a thin insulator (i.e. Kapton/Apical) etched with a regular matrix of open channels. GEM is the type of Micropattern gaseous detectors (MPGD) which is used to detect and characterize ionizing radiation such as charged particles or photons.The unique aspect of these detectors is the use of micro-patterned structures within the gas volume to facilitate the precise localization of ionization events within the detector. The CMS GEM detectors are made of three layers, each of which is a 50 μm thick copper-clad polyimide foil. These chambers are filled with an Ar/CO2 gas mixture, where incident muons trigger primary ionization, subsequently leading to an electron avalanche that generates an amplified signal for detection. To ensure proper and robust operation of the chambers within their performance specifications once installed in CMS, a detailed Quality Control (QC) procedure is employed in all the production sites, which are equipped with the same laboratory infrastructure and instrumentation. This protocol aims to carefully assess the detector performance at each step.
Quality control (QC) and quality assurance (QA) are key factors to ensure the delivery of fully efficient detectors yielding their best performance when installed in CMS. The final chamber quality and performance depend on the production quality and on the accuracy of the chamber assembly operation, tracking, and documentation. Quality control (QC) testing for gas electron multiplier (GEM) detectors involves a series of checks to verify their functionality and reliability before deployment and QC5 is the one of the checks. First QC1; the detector undergoes a visual inspection to ensure there are no physical defects or damages. Next in QC3; gas leak test is performed to calculate the GEM detector's gas leak rate or to check gas tightness. And then QC2 to QC4 , electrical tests are performed to check the integrity of the high-voltage connections and the uniformity of the applied electric field. Performance tests QC5; are conducted by exposing the detector to a known radiation source, assessing parameters such as gain, spatial resolution, and efficiency. Additionally, uniformity tests are used to evaluate the detector's response across its entire active area, ensuring consistent performance. In this contribution, I motivate and discuss the quality control procedures that were developed to standardize the performance of the detectors.

Field of contribution:

Experiment

42

Neutron Stars with BHF Modified Density-Dependent Nucleon Masses and Weakly Interacting Dark Matter

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The phenomenology community has extensively investigated the extreme conditions of matter within fermionic dark matter (FDM) admixed neutron stars using various effective field theories. A popular model in this context is hereby referred to as the σ − ω − ρ + FDM model, which incorporates fermionic dark matter interacting with baryonic matter through new scalar and vector mediators. However, previous studies have overlooked the impact of medium effects on the effective masses of nucleons. In this work, we address this oversight by taking into account a density-dependent effective mass for nucleons derived from the Brueckner-Hartree-Fock many-body approach. We systematically examine how this modification influences the equations of state of neutron star matter and, subsequently, the macroscopic properties of neutron stars, including their rotational characteristics. Our results demonstrate that incorporating the effective mass correction leads to improved agreement with recent experimental observations. Additionally, we derive constraints on the model parameters and provide predictions regarding the masses of neutron stars and the distributions of dark matter within the cores of neutron stars.

Field of contribution:

Phenomenology

43

J/Ψ and ρ^0 vector meson production in light of an analytical solution to BK evolution equation

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In the perturbative regime of quantum chromodynamics (QCD), exclusive diffractive processes, like exclusive vector meson production, are great ways to look into the structure of hadrons. The HERA accelerator facility explored the exclusive process involving light and heavy vector mesons, $ep \to eV(V = J/\Psi, \rho, \phi)$. This work focuses on the theoretical prediction of exclusive J/ψ and ρ^0 vector meson generation. We employ an analytical solution of the Balitsky-Kovchegov (BK) equation to get the differential and total cross-sections of J/Ψ and ρ^0 vector mesons using the color dipole description of deep inelastic scattering (DIS). We also show how Q^2 affects the ratio of longitudinal to transverse cross-section for J/Ψ and ρ^0. Two favored vector meson wave function models—Boosted Gaussian (BG) and Gaus-Light Cone (Gaus-LC)—that show a slight sensitivity to the specified vector meson wave functions are included in our analysis. Our theoretical predictions are in good agreement with known experimental data for vector meson production. For the theoretical prediction of exclusive vector mesons within a certain range of Q^2, the analytical solution of the BK equation turns out to be reliable.

Field of contribution:

Phenomenology

44

Photon emission from a finite baryonic Quark-Gluon Plasma

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The photon emission from a finite Baryonic Quark-Gluon Plasma is evaluated through the Annihilation and Compton processes using the Boltzmann distribution function. The evaluation is done with the consideration of a finite baryonic parameter in the quark mass and the coupling constant. By the consideration of this parameter in the system the production rate of photon is enhanced from the earlier theoretical calculations through this distribution function. It indicates that the improvement obtained in the emission rate shows the formation of Quark-Gluon Plasma in such a baryonic matter.

Field of contribution:

Phenomenology

45

Investigating the hadronic phase dynamics via resonance studies with ALICE at LHC Energies

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Hadronic resonances, with lifetimes comparable to the duration of the hadronic phase, can be used as effective probes for studying its evolution in heavy-ion collisions. Exploring the dynamics of the hadronic phase reveals the roles of rescattering and regeneration in resonance production. In particular, rescattering reduces the resonance yields and may alter their transverse momentum, while regeneration can lead to their enhancement. By analyzing the ratios of resonance yields to those of long-lived particles across various charged-particle multiplicities, valuable insights into hadronic interactions and system evolution are obtained. Additionally, comparing results from smaller collision systems, such as pp and p–Pb, with larger systems like Xe–Xe and Pb–Pb collisions highlights potential collective phenomena and variations in the lifetime of the hadronic phase.

This contribution presents ALICE results from Run 2 and Run 3 on mesonic and baryonic resonances across various collision systems at LHC energies. Focus on the $\mathrm{K}^{*0}(892)$, $\Lambda(1520)$, $\Sigma^{\pm}(1385)$, $\Xi^{0}(1530)$, and $\phi(1020)$ resonances will be given, in particular on their transverse momentum (p_{T}) distributions, their p_{T}-integrated yields, and the ratios of p_{T}-integrated resonance yields to those of long-lived particles. Furthermore, the experimental results will be compared with theoretical predictions to understand the particle dynamics in the hadronic phase.

Field of contribution:

Experiment

46

Dynamic Mass of Hadrons in Three Flavour Nambu-Jona Lasinio Model

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It is beyond any doubt that quantum chromodynamics (QCD) is the theory of strong interactions. While its perturbative aspects have been studied, its non-perturbative aspects are not so well explored. This non perturbative domain is called QCD vacuum and is studied by effective field models. One such model to study QCD Vacuum regime is NJL model. Using NJL model we will obtain QCD vacuum hadron masses and see how masses are impacted with increasing temperature both at vanishing baryon chemical potential ($\mu = 0$) and non vanishing baryon chemical potential ($\mu \neq 0$).

Field of contribution:

Phenomenology

47

Search for Vector-Like Quarks (T‘→t(Wb) H(WW*)→ t(lνb)H(4q)) in pp Collisions at a center-of-mass energy of 13 TeV with the CMS Experiment.

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A decade after the discovery of the Higgs boson by the ATLAS and CMS experiments at the LHC, along with the subsequent observation of ttH events and studies of Higgs decays into pairs of W/Z bosons and τ leptons, the search for physics beyond the Standard Model (BSM) continues to present significant challenges. Vector-like quarks (VLQs) are hypothetical spin-1/2 particles of a fourth generation, possessing both left- and right-handed components that transform identically under the $SU(3)_C \times SU(2)_L \times U(1)_Y$ symmetry group. These particles are central to various BSM models, which propose solutions to the hierarchy problem and Higgs mass stabilization while remaining consistent with Higgs cross-section measurements. This presentation will provide an overview of the current status of the search for VLQ particles, specifically (T′) decaying into a top quark ($t \to Wb \to l\nu b$) and a Higgs boson($H \to WW^* \to 4q$) at the CMS experiment. Additionally, we will explore the use of jet substructure techniques for identifying Higgs decays, with a focus on a novel Higgs$\to 4q$ tagger based on Deep Neural Network.

Field of contribution:

Experiment

48

SMEFT analysis of charged lepton flavor violating B-meson decays

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Charged lepton flavor violation (cLFV) processes, potentially important for various Beyond the Standard Model Physics scenarios are analyzed in the Standard Model Effective Field Theory (SMEFT) framework. We consider the most relevant 2 quark-2 lepton $(2q2\ell)$ operators for the leptonic and semi-leptonic LFV B-decay (LFVBD) processes $B_s \to \mu^+ e^-, B^+ \to K^+\mu^+e^-, B^0 \to K^{*0}\mu^+e^-$, and $B_s \to \phi\mu^- e^+$. We analyse the interplay among the Wilson coefficients responsible for these LFVBDs and other cLFV processes like $CR(\to e), \ell_i \to \ell_j\gamma, \ell_i \to \ell_j\ell_k\ell_m$ and $Z \to \ell_i\ell_j$, to find the maximal possible LFV effects in B-meson decays. We probe the scale of new physics in relation to the constraints imposed by both classes of the LFV decays while considering both the present bounds and future expectations. In
view of proposed experiments at LHCb-II and Belle II to study charged LFV processes, we have also provided the upper limits on the indirect constraints on such LFVBDs. For the processes where B meson is decaying to $^{\pm}$ and $e^{\mp}$, we show that new physics can be constrained by an enhancement of 2-4 orders of magnitude on the current sensitivities of the BRs of $B^+ \to K^{++}e^-, B^0 \to K^{*0}\mu^+e^-$ and $B_s \to \phi\mu^{\pm}e^{\mp}$.

Field of contribution:

Phenomenology

49

Tensionless Strings: Closed and Open

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We study null open strings and establish, for the first time, that the worldsheet residual gauge symmetry algebra is the Boundary Carrollian Conformal Algebra (BCCA). We present the construction of open null strings and demonstrate that, under Dirichlet boundary conditions, Boundary Carrollian Conformal Algebra emerges as the algebra of constraints. Additionally, we show that the BCCA can be obtained by contracting a single copy of the Virasoro algebra, confirming that null open strings arise as the tensionless limit of tensile open strings. This discovery initiates a broader study of Carrollian Conformal Field Theory (CCFT) with boundaries, opening a range of new research possibilities, given the growing importance of Carrollian symmetries.

Field of contribution:

Theory

50

Gravitational wave constraints on burdened primordial black holes

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We investigate the implications of memory burden on the gravitational wave (GW) spectrum arising from the Hawking evaporation of light primordial black holes (PBHs). By considering both rotating (Kerr) and non-rotating (Schwarzschild) PBHs, we demonstrate that the overproduction of primordial GWs from burdened PBHs could impose stringent constraints on the parameters governing backreaction effects. These constraints, derived from ΔNeff measurements by Planck and prospective experiments such as CMB-S4 and CMB-HD, offer novel insights into the impact of memory burden on PBH dynamics.

Field of contribution:

Phenomenology

51

Improved Exclusion Limits for Leptoquarks by incorporating additional production channels and associated BSM searches at the HL-LHC

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Leptoquarks (LQs) offer a promising framework for exploring physics beyond the Standard Model (BSM). These particles, inspired by higher gauge theories like Pati-Salam and Grand Unified Theories, are currently being probed at the LHC, primarily through pair production (PP). Our study improves the LHC exclusion limits by including additional production modes like single productions, t-channel LQ exchange, and its interference with the Standard Model background, sometimes providing more substantial constraints than PP alone. We also account for model-independent production through mixed QCD-QED processes, which can significantly shift the exclusion limits based on the electric charge of the LQs. Furthermore, since LQs often arise alongside other BSM particles, such as vector-like fermions and right-handed neutrinos, we investigate the potential for strong production of these particles along with LQs at the HL-LHC, offering new perspectives on collider search strategies.

Field of contribution:

Phenomenology

52

Displaced vertex signatures in Leptophobic U(1) Extension of the Standard Model

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The Standard Model (SM) of particle physics, while highly successful, leaves several key phenomena unexplained, motivating the search for physics beyond the SM (BSM). One promising extension is the Leptophobic U(1) model, which avoids collider search constraints and introduces right-handed neutrinos (RHNs). These RHNs can participate in neutrino mass generation via seesaw mechanisms, leading to mixing between heavy RHNs and light SM neutrinos. This mixing allows RHNs to decay into Standard Model (SM) particles. For RHNs with masses around a few GeV, small mixing can result in displaced decays, producing long-lived particles (LLPs) with significantly displaced vertices. In this talk, I will present our analysis of the Leptophobic U(1) model and its implications for LLP searches at current experiments like CMS and LHCb, as well as future detectors optimized for displaced vertex searches, including MATHUSLA, CODEXb, and FASER.

Field of contribution:

Phenomenology

53

Next-to-next-to-leading order QCD corrections to semi-inclusive DIS

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Polarized semi-inclusive deep-inelastic scattering (SIDIS) is a key process in the quest for a resolution of the proton spin puzzle. We present the complete results for the polarized SIDIS process at next-to-next-to-leading order (NNLO) in perturbative quantum chromodynamics. Our analytical results include all partonic channels for the scattering of polarized leptons off hadrons and a spin-averaged hadron identified in the final state. A numerical analysis of the NNLO corrections illustrates their significance and the reduced residual scale dependence in the kinematic range probed by the future Electron-Ion-Collider EIC

Field of contribution:

Phenomenology

54

Prospects of thermal protection advancements in large-scale cryostats for rare event search experiments

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Experimentalists worldwide are dedicating tremendous efforts to the design of cryostats aimed at minimizing the dominant radiation-induced heat load on the cryogenic liquid housed within. These advancements are crucial for maintaining the safe, stable, and reliable operation of detectors, particularly in large-scale experiments aimed at investigating rare physics phenomena with increasing sensitivity at ton-scale capacities [1]. In these experiments, ensuring a stable cryogenic liquid temperature is crucial for minimizing both thermal noise and liquid evaporation. This can be achieved by mitigating the ambient heat transfer from the hot outer wall to the cold inner wall of the cryostat [2, 3]. Current work investigated the effects of no insulation, single-layer insulation, and multilayer insulation on reducing environmental heat load at the cryostat's cold wall boundary, with particular emphasis on the efficacy of single-layer insulation against radiative heat transfer. The GERDA cryostat was utilized as a practical case study to illustrate these effects. Positioning an ultra-low emissivity intermediate layer near the cryostat's cold wall can achieve a remarkable reduction in heat load, estimated between 40-60 %, thereby decreasing the cryogenic liquid's evaporation rate significantly. This presentation will provide an overview of our research endeavors and emphasize the latest developments in cryogenics, particularly focusing on their implications for rare event search experiments.

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Field of contribution:

Experiment

55

Sub-MeV dark matter detection with 2D materials

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Light dark matter search has emerged as the latest frontier in the direct detection experiments. Small kinetic energy of sub-MeV mass dark matter requires novel target materials and techniques for detection. 2D materials like bilayer graphene with small energy gap could be useful in this regard. Its voltage-tunable sub-eV band gap makes it a promising candidate for a sub-MeV dark matter search experiment. In this talk, I will describe how to calculate dark matter scattering rate with electrons in bilayer graphene and show its sensitivity projection in future experiments. I will also show the relatively large daily modulation in the scattering rate that stems from the rotation of the earth about its axis and the anisotropic response of bilayer graphene. This signal modulation will help reject the background events in such an experiment.

Field of contribution:

Theory

56

Collective dynamics of polarized spin-half fermions in relativistic heavy-ion collisions

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In this talk, I will present our development of a new framework for relativistic perfect-fluid hydrodynamics that includes spin degrees of freedom, building on recent theoretical advancements aimed at explaining spin polarization in heavy-ion collisions. While standard relativistic hydrodynamics has successfully described the properties of the strongly-interacting matter produced in these collisions, understanding the differential measurements of spin polarization remains a challenge. Current models have partially explained experimental data by coupling spin polarization with the vorticity of the medium. However, these models suggest that spin should be treated as an independent degree of freedom, whose dynamics are not solely tied to flow circulation. Assuming spin as a macroscopic property, we propose that its dynamics should follow hydrodynamic laws in equilibrium. Our framework is derived from quantum kinetic theory for Dirac fermions and models the dynamics of matter in relativistic heavy-ion collisions. Assuming small polarization effects, we derive conservation laws for the net-baryon current, the energy-momentum tensor, and the spin tensor based on de Groot–van Leeuwen–van Weert definitions. We explore the properties of the spin polarization tensor, analyze the propagation properties of its components, and derive the spin-wave velocity for arbitrary statistics. Our findings indicate that only transverse spin components propagate, similar to electromagnetic waves. Furthermore, we investigate the spacetime evolution of spin polarization in systems with certain symmetries and calculate the mean spin polarization per particle, comparing our results with experimental data. Our results show qualitative agreement with experimental observations and other models for some observables. Additionally, we examine the impact of external electric fields on spin polarization dynamics within a Bjorken-expanding background.

Field of contribution:

Theory

57

Stochastic relativistic advection diffusion equation from the Metropolis algorithm

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We study an approach to simulating the stochastic relativistic advection-diffusion equation based on the Metropolis algorithm. We show that the dissipative dynamics of the boosted fluctuating fluid can be simulated by making random transfers of charge between fluid cells, interspersed with ideal hydrodynamic time steps. The random charge transfers are accepted or rejected in a Metropolis step using the entropy as a statistical weight. This procedure reproduces the expected stress of dissipative relativistic hydrodynamics in a specific (and noncovariant) hydrodynamic frame known as the density frame. Numerical results, both with and without noise, are presented and compared to relativistic kinetics and analytical expectations. An all order resummation of the density frame gradient expansion reproduces the covariant dynamics in a specific model. In contrast to all other numerical approaches to relativistic dissipative fluids, the dissipative fluid formalism presented here is strictly first order in gradients and has no nonhydrodynamic modes. The physical naturalness and simplicity of the Metropolis algorithm, together with its convergence properties, make it a promising tool for simulating stochastic relativistic fluids in heavy ion collisions and for critical phenomena in the relativistic domain.

Field of contribution:

Theory

58

Abelian gauge and two potential theory of gravito-dyons

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The manifestly covariant, dual symmetric and gauge invariant two potential theory of generalized electromagnetic fields of gravito-dyons has been developed consistently from U(1)×U(1) gauge symmetry. Corresponding field equations and equation of motion are derived from Lagrangian formulation adopted for U(1)×U(1) gauge symmetry for the justification of two four potentials of gravito-dyons.

Field of contribution:

Theory

59

Gravitational collapse of matter in the presence of quintessence and phantom-like scalar fields

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In this work, we propose a model of the gravitational collapse of dark matter in the presence of a minimally and nonminimally coupled scalar field, which is used to model quintessence and phantom-like dark energy. We focus on algebraic coupling, where the interaction Lagrangian is independent of the derivatives of the scalar field. Our treatment is based on the principles of general relativity and follows the dynamics up to virialization. We consider a spherical patch that starts to collapse gravitationally, similar to the top-hat collapse scenario. It is seen that although the dark matter

sector collapses the dark energy sector does keep a profile that is almost similar to the dark energy profile for the background expanding the Friedmann-Lemaitre Robertson-Walker (FLRW) universe for suitable model parameters. Our investigation reveals that increasing the coupling strength leads to dark energy clustering with dark matter on certain cosmological scales, where the influence of dark energy becomes significant. This phenomenon arises from the specific nature of the nonminimal coupling considered in this model. Furthermore, to properly formulate the problem within a general relativistic framework, abandoning the idea of a closed FLRW isolated collapsing patch is necessary. General relativity requires that the collapsing spherical patch be matched with an external generalized Vaidya spacetime, which governs the flux of matter and radiation between the interior collapsing region and the exterior. It is shown that nearly all collapses are accompanied by some flux of matter and radiation in the generalized Vaidya spacetime. Interestingly, some spherical regions of the Universe are found to avoid collapse altogether, instead expanding indefinitely and forming void-like structures. Whether a particular spherical region collapses or expands depends on the initial conditions and the specific model parameters.

Field of contribution:

Theory

60

Determining unitarity triangle angle ϕ_3 with $B^\pm \to D^*(D\gamma/\pi^0)h^\pm$ decays at Belle and Belle II

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The precise measurement of the Cabibbo-Kobayashi-Maskawa unitarity triangle angle ϕ_3 plays a crucial role in testing the consistency of the standard model (SM) description of CP violation. The determination of ϕ_3 with $B^- \to D^{(*)}K^-$ decays is theoretically robust, free from loop-level contributions, making it an ideal benchmark for comparison with beyond-the-SM-sensitive measurements. In this talk, we present a measurement of ϕ_3 using a model-independent Dalitz plot analysis of the decay $B^\pm \to D^*(D\gamma/\pi^0)h^\pm$, with $D \to K_s^0\pi^+\pi^-$. The decays of D to $D\gamma$ and $D\pi^0$ are reconstructed both—exclusively, where the neutral pion or photon is explicitly identified—and partially, where the neutral pion or photon is not included. The combined Belle and Belle II data set is used.

Field of contribution:

Experiment

61

Probing Alternative Left-Right Symmetric Model in the leptonic sector.

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In this work[1], we examine the constraints coming from the leptonic sector on the parameter space of the alternative left-right model. These left-right scenarios emerge from the breaking of a grand unified theory based on the E_6 symmetry group and introduces new exotic quarks and light bosons in its particle spectrum. For the current exploration, we focused on both flavour-conserving observables, the muon anomalous magnetic moment, and flavour-violating processes, $\mu \to e\gamma$ decay and $\mu - e$ conversion in Al, Ti and Au nuclei. We performed the multi-dimensional scans of the model parameter space and showed that the contributions to the anomalous magnetic moment remain below the experimental measured value at 2σ. However, the current and future experimental sensitivities to flavour-violating muon processes are expected to put lower bounds on the mass of the peculiar $SU(2)_R$ gauge boson of the model. This provides complementary constraints relative to existing limits, which are indirect and derived from collider bounds on the mass of the associated neutral gauge boson Z'.

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Field of contribution:

Phenomenology

62

Study the Angular Distribution of atmospheric Muons

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Co-authors: Mandar Saraf [2]; Ravindra Raghunath Shinde [3]; Shilpi Jain [1]; Gobinda Majumder [1]

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A cosmic ray telescope has been designed to analyze the angular distribution of cosmic ray muons. The cosmic ray telescope configuration involves four scintillators, grouped in pairs with each pair separated by a distance. The size of each scintillator detector is 4cm×4cm and the distance between each pair can vary from 10cm to 500cm. Scintillator detectors coupled with SiPMs as the primary device for detecting muons. The variation of muon flux with the zenith angle of cosmic rays follows the function form, $f(\theta) \propto \cos^n \theta$, where n depends on the latitude and longitude. The measurements at 8 different orientations give the value of the exponent, n = 2.0703. The initial aim of the project is to experimentally validate this correlation. But, this is a portable setup and can be set up in any EHEP school or science exhibition to show the variation of muon spectra as a function of zenith angle. This talk will give the details of the experimental setup including electronics and the estimation of n with its error.

Field of contribution:

Experiment

63

Study the prepulses and afterpulses of Photomultiplier Tube

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The timing resolution of the photomultiplier tubes(PMTs) signals is measured with an accuracy of a few nanoseconds and depends on the PMT size, dynode configuration, applied HV, etc. In large-scale experiments, precise timing is crucial. However, prepulses and afterpulses can degrade the overall time response and trigger conditions of the experiment. We have studied the rate of prepulses and after pulses for PMTS (electron tubes, 9266QB) using an LED source. The UV PMT is used for the first time in our lab and wanted to study the noise rate of those and compare it with earlier PMT in the lab. The talk will present the rate, arrival time, pulse height of those PMTs at different applied voltages on the PMT circuit.

Field of contribution:

Experiment

64

A parameter-free analysis of the QCD chiral phase transition and its universal critical behavior.

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One of the outstanding questions in studies of the QCD phase diagram
is to determine the order of the QCD phase transition and, in case it
turns out to be second order, determine the underlying universality class
that controls its universal critical behavior in the vicinity of chiral phase transition temperature T_c
. Previous works estimate this T_c
by extrapolating pseudo-critical temperatures obtained at non-zero values
of the light quark masses from maxima in the chiral susceptibilities
or the inflection point of the relevant, suitably renormalized, order
parameter i.e. the 2-flavor light-quark chiral condensate M_l.
In order to extrapolate the thus obtained pseudo-critical temperatures to
the chiral limit one however, generally makes use of information and
properties of the associated universality class in the form of critical
exponents and scaling functions.
In this work we aim to study as a function of T, the behavior of an improved,
renormalized 2-flavor light chiral condensate M which is obtained as
$M = M_l - H\chi_l$, with the light quark chiral susceptibility χ_l
and the light-to-strange quark mass ratio $H = m_l/m_s$. Aside from having
no additive and multiplicative divergences as well as no $\mathcal{O}(H)$ regular terms,
the thus defined order parameter has the advantage that its behavior at
small values of the quark masses is related to a universal scaling function.
This allows to extract information on the underlying universality class.
We construct the ratio of M for two different values m_l (or H). Within the
scaling region around T_c , we observe a unique intersection point for this

ratio for different values of smaller-than-physical m_l. This common point of intersection provides a determination of T_c and the critical exponent δ without the need of referring to a particular universality class.
This approach followed here will allow to constrain the influence of the axial anomaly on universal critical behavior in (2+1)-flavor QCD and will also help to further constrain the quark mass region in which a first order phase transition in 3-flavor QCD may arise. This will require careful extrapolations to the continuum limit. At present in this new work, we attempt to demonstrate the suitability of this approach in the framework of (2+1)-flavor QCD on lattices with fixed temporal extent $N_t = 8$.

Field of contribution:

Theory

65

Exclusive rare semileptonic decays of B and B_c mesons

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We investigate the exclusive rare semileptonic decays: $B(B_c) \to K(D_{(s)})l\bar{l}/\Sigma\nu_l\bar{\nu}_l$ $(l = \mu, \tau)$ in the framework of relativistic independent quark (RIQ) model based on an average flavor independent confining potential in equally mixed scalar-vector harmonic form. The invariant weak form factors, parametrising the matrix elements between participating meson states are calculated in the parent meson rest frame. The momentum transfer dependence of the form factors is reliably determined in the accessible kinematical range: $q^2_{min} \leq 0 \leq q^2_{max}$. Our predicted branching fractions for $B \to K\mu^+\mu^-/\tau^+\tau^-(\Sigma\nu_l\bar{\nu}_l)$, $B_c \to D(D_s)\mu^+\mu^-$, $B_c \to D(D_s)\tau^+\tau^-$ and $B_c \to D(D_s)\Sigma\nu_l\bar{\nu}_l$, obtained in order of $10^{-7}(10^{-6})$, $10^{-9}(10^{-7})$, $10^{-9}(10^{-8})$ and $10^{-8}(10^{-7})$, respectively are in reasonable agreement with other Standard Model predictions and Lattice QCD results, and available experimental data. The averaged values of the lepton polarization asymmetries for decay modes are obtained. Upcoming future experiments could measure the unmeasured branching fractions.

Field of contribution:

Phenomenology

66

Search for the decay $B \to D^{(*)}\eta\pi$ at Belle and Belle II

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Co-authors: Karim TRABELSI [2]; Saurabh Sandilya [3]

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We present a search for the yet-unobserved $B \to D^{(*)}\eta\pi$ decay at Belle and Belle II. This search aims to provide insights into the semi-leptonic (SL) gap, which refers to the deficit in the sum of the branching fractions of known exclusive decays compared to the measured inclusive $b \to c\ell\nu$ branching fraction. Common models addressing this deficit suggest the existence of $B \to D^{(*)}\eta\ell\nu$ decays with a branching fraction of the order of 10^{-3}, which could imply a branching fraction of $B \to D^{(*)}\eta\pi$ of the order of 10^{-4} based on a naive prediction derived from the ratio of branching fractions of $B \to D^{(*)}\pi$ and $B \to D^{(*)}\ell\nu$. The study of $B \to D\eta\pi$ will also aid in understanding the two pole structure of $D_0^*(2400)$ meson through the coupled channel $D\eta$. Utilizing the ˜1.1 ab^{-1} of data collected at Belle and Belle II combined, we are initiating a preliminary search to investigate and potentially observe these decays for the first time. This search is also expected to significantly enhance our understanding of the B hadronic sector.

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Field of contribution:

Experiment

67

Time of Flight (ToF) detector in the EIC experiment

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The electron-Ion Collider is designed to scan internal structure of particles like neutron and protons. It is aimed to study some of the important questions in the particle physics for example how quark and gluon contributes to proton spin, mapping quarks and gluons distribution and movements within protons, etc. One of the key challenges at EIC is particle identification (PID), which requires excellent separation of kaon, pions and protons.
Time of Flight is one of the detector which along with Cherenkov detectors is designed to give excellent PID over wide range of momentum for the ePIC detector and also help in 4-D (x, y, z, t) reconstruction of the events. ToF detector has two integral sub detectors Barrel TOF (BTOF) and Forward TOF (FToF) with a timing resolution of 35 ps and 25 ps respectively. ToF is going to use AC-LGAD sensors for the both Barrel and Forward sub detectors which enables identification of charged particles for example pions and kaons in low momentum range at the 3σ level. There are challenges for example radiation hardness of sensors, achieving good timing resolution, cooling of detector during operation, etc. To understand various challenges that can come across while building and running the detector, currently simulations are being done using DD4HEP (GEANT4) and PYTHIA., which includes studying background, expected frequency of the events in detector, also challenges in design of detector along with the study of AC-LGAD sensors. Simulations are also being done to digitise the events information by converting energy deposition into ADC and TDC and incorporating noise in the detector simulations. In this presentation the current status of simulation and sensor study for the Time Of Flight detector will be presented. And also various aspect and challenges for ToF detector will be discussed.

Field of contribution:

Experiment

68

Higgs-Higgs bound state in 2HDM - A possibility or not?

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The possibility of a Higgs-Higgs bound state in the two Higgs doublet model is investigated . Specifically we look for the effect of dimension six operators, generated by new physics at a scale of a few TeV, on the self-couplings of the heavy CP even scalar field in the model. We construct an effective field theory formalism to examine the physics of the Higgs sector. The magnitudes of the attractive and repulsive coupling strengths are compared to estimate the possibility of the formation of the H – H bound state. Another way to check if a bound state is formed or not is from the formation and decay times of the bound state. The possibilities in various types of two Higgs doublet models have been discussed elaborately. The bound state energy has been evaluated and the allowed parameter space has been studied in the linear and non-linear realizations.

Field of contribution:

Phenomenology

69

Measurement of the tau g – 2 factor in the ultraperipheral Pb-Pb collisions recorded by the CMS experiment

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Measurements of the anomalous magnetic moment of leptons provide stringent tests of the Standard Model and hints of physics beyond the Standard Model. These measurements for electrons and muons are among the most precisely measured quantities in physics. However, due to the short lifetime of the tau lepton, its anomalous magnetic moment cannot be determined through precession measurements. We will show the latest measurement of the anomalous magnetic moment of the tau lepton based on a data sample of ultraperipheral Pb-Pb collisions with an integrated luminosity of up to 1.7nb^{-1}, depending on the decay channel, collected by the CMS experiment at a center-of-mass energy per nucleon pair of $\sqrt{s_{NN}}$ = 5.02 TeV. The dependence on Z^4 (Z = 82 for lead) enhances the cross-section for photo-production with respect to proton-proton and electron-positron collisions. This measurement is improved with respect to the previous CMS measurement via the addition of three tau-tau decay modes, a factor of four in luminosity, and the incorporation of both cross-section and kinematic distributions in the determination of g $-$ 2. The measured value of the $\gamma\gamma \rightarrow \tau\tau$ fiducial cross section is the most precise to date, while the g $-$ 2 measurement is one of the most precise in Pb-Pb and e-e collisions.

Field of contribution:

70

Ultraheavy multiscattering dark matter: DUNE, CYGNUS, kilotonne detectors, and tidal streams

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For scattering cross sections large enough to make the detector in direct searches optically thick to the incident dark matter, dedicated multi-scatter signatures are being sought. We provide some significant updates to the multi-scatter program. First, we refine earlier treatments of the dark matter flux through detectors, generalizing to arbitrary geometries and velocity distributions. Using this and considerations of energy deposition, we derive the reaches in cross section and mass of various proposed large volume-detectors. These include a kilotonne fiducial mass "module of opportunity" at DUNE, a kilotonne xenon detector suggested for neutrinoless double beta decay, the gaseous detector CYGNUS, and the dark matter detectors XLZD and Argo. We show that where the velocity vector can be reconstructed event-by-event, key properties of the local velocity distribution such as the mean speed can be marked, and tidal streams can be picked up if they make up about 10% of the local dark matter density.

Field of contribution:

71

Production and collective flow measurement of charm strange mesons in heavy ion collisions at 5.02 TeV with CMS experiment

Author: Nihar Ranjan Saha[1]

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The interaction of heavy quarks with the quark-gluon plasma (QGP) significantly influences their azimuthal distribution and transverse momentum (p_{T}) spectra. Consequently, azimuthal anisotropy coefficients (v_n) and nuclear modification factors (R_{AA}) of heavy flavor hadrons serve as essential observables for probing QGP properties. This talk presents the first measurements of the elliptic (v_2) and triangular (v_3) flow coefficients of $D_s^{\pm}$ mesons in lead-lead (PbPb) collisions at a center-of-mass energy of 5.02 TeV, recorded by the CMS experiment. These measurements are performed as a function of transverse momentum across various centrality classes, with significantly improved precision. The broad kinematic coverage and direct comparison with non-strange D mesons offer critical insights into different charm quark flow mechanisms. Moreover, the first-ever measurement of the v_3 coefficient for $D_s^{\pm}$ mesons enables the exploration of initial-state fluctuations. Additionally, spectra and nuclear modification factors (R_{AA}) for both prompt and non-prompt D^0 mesons in PbPb collisions will be presented, with comparisons to theoretical models.

Field of contribution:

Experiment

72

Two-loop form factors for Dark Matter production from colored Standard Model particles

Authors: Ambresh Shivaji[1]; Warsimakram Imamsab Katapur[None]

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A UV complete model where the Dark Matter (DM) particle interacts with gluons via a colored scalar mediator provides a viable phenomenological model that can be tested at hadron colliders. We consider two cases. First, a zero-jet process where the complete annihilation of Standard Model (SM) particles to DM particles takes place, which contributes to the relic density of DM. The second is a Mono-jet case where an SM particle is produced along with a DM pair. Mono-jet signatures are relevant for Collider searches due to the missing transverse momentum. The Leading order contributions to these processes are loop-induced, which suffer from large-scale uncertainties. NLO QCD corrections are needed to bring down the scale uncertainties. We compute two-loop amplitudes in QCD which contribute to these processes. By decomposing the amplitude in terms of Form factors and making use of the projector technique, scalar Feynman Integrals are obtained. Further, with the help of the IBP identities, an analytical expression for amplitude is obtained in terms of Master Integrals. The amplitude is made UV finite by Counterterm Renormalization. We will discuss the results of the zero-jet case and ongoing work in the mono-jet case.

Field of contribution:

Theory

73

Two-loop form factors for Dark Matter production from colored Standard Model particles

Authors: Ambresh Shivaji[1]; Warsimakram Imamsab Katapur[None]

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Field of contribution:

Theory

75

Studying the transport properties of a rotating QGP medium in the novel relaxation time approximation method

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In this work, the influence of rotation on the electrical conductivity, the thermal conductivity and the elliptic flow of the QGP medium has been explored. The noncentral heavy ion collisions could possess finite angular momentum with a finite range of angular velocity, which results into rotation of the produced medium. Like other extreme conditions, the rapid rotation could conspicuously alter various properties including the transport properties of the QGP medium. In calculating the aforesaid transport coefficients, we have used the novel relaxation time approximation for the collision integral in the relativistic Boltzmann transport equation within the kinetic theory framework in conjunction with the finite angular velocity. It is observed that the angular velocity increases the charge transport and the heat transport in the medium. Additionally, as compared to the relaxation time approximation, the novel relaxation time approximation estimates smaller values of the electrical conductivity and the thermal conductivity. These differences between the conductivities in the said approximations become more significant at high temperatures than at low temperatures. Further, the elliptic flow is found to be enhanced due to the emergence of rotation in the QGP medium. Furthermore, as compared to the relaxation time approximation, the values of the elliptic flow are higher in the novel relaxation time approximation for the nonrotating medium as well as for the rotating medium. This indicates an increase in the interactions among the produced particles in heavy ion collisions, resulting in faster thermalization of the medium. Thus, as the rotation intensifies, the medium moves closer to equilibrium.

Field of contribution:

Phenomenology

76

Probing electroweak phase transition in extended singlet scalar model with resonant HH production in bbZZ channel using parameterized machine learning

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Co-author: SUJAY SHIL [2]

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In this paper, a collider signature of a heavy Higgs boson at 14 TeV HL-LHC is studied, where the heavy Higgs boson decays into a pair of standard model (SM) Higgs boson, which further decays to $bbZZ$ state and subsequently to bb^{+-} final state. To study this, we consider singlet scalar extension of the SM and select the parameter space and mass of the heavy Higgs boson such that it prefers a strong first-order electroweak phase transition (EWPT). The study is done following the $bbZZ$ analysis of CMS Collaboration and further using parameterized machine learning for final discrimination which simplifies the training process along with an improved discrimination between signal and background over the range of benchmark points. Despite the lower branching fraction, this channel can be a potential probe of the EWPT with the data sets collected by the CMS and ATLAS experiments at the 14 TeV HL-LHC with $3\,\mathrm{ab}^{-1}$ of integrated luminosity and a production of resonant di-Higgs signal can be potentially discovered up to 490 GeV of resonance mass.

Field of contribution:

Phenomenology

77

Exploring all strange tetraaquark in diquark-antidiquark formalism.

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Over the past two decades, numerous resonant states containing multiple strange quarks have been experimentally observed, shedding new light on the structure of exotic hadrons. In this study, we calculate the mass spectra of strange tetraquarks across various color configurations using both semi-relativistic and non-relativistic frameworks, with relativistic mass corrections incorporated via a Cornell-like potential model. The semi-relativistic approach accounts for relativistic corrections to the kinetic energy, enhancing the accuracy of our predictions. Additionally, we investigate the decay properties of these tetraquarks by exploring multiple decay mechanisms, allowing us to assess both their mass and decay characteristics simultaneously. This dual approach is crucial for identifying promising candidates for future experimental verification. Our results include predictions for various strange tetraquark states, which are compared with other theoretical models and the two-meson decay threshold. These comparisons provide valuable insights into the stability and behavior of these states, offering a clearer understanding of strange tetraquark dynamics. Ultimately, this work contributes to the ongoing effort to explore the exotic hadron spectrum and refine our theoretical models in light of experimental findings.

Field of contribution:

Phenomenology

78

Novel insights into jet quenching and the search for boost invariance in forward rapidity in PbPb collisions with CMS

Author: Sayan Chatterjee[1]

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Jets traverse a longitudinally boosted, flowing quark-gluon plasma (QGP), causing their internal structure to undergo anisotropic modifications due to the superposition of vacuum-like showers and medium-induced gluon emissions. These interactions lead to softer particles drifting with the QGP flow away from the jet core, where high-p_{T} particles remain concentrated, resulting in an intra-jet asymmetry that encodes essential information about the properties of the QGP. Investigating this asymmetry, particularly at higher rapidities, offers a novel avenue to probe jet-medium dynamics. This study examines the near-side peak to explore jet modifications and to search for novel boost invariance phenomena in forward rapidity for the first time at the LHC in PbPb and pp collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV, utilizing data collected by the CMS detector with a pseudorapidity coverage of $|\eta| < 2.4$. The peak exhibits substantial broadening along the longitudinal ($\Delta\eta$) axis from peripheral to central PbPb collisions, particularly for low-pT particles, indicating energy loss by the progenitor parton. Comparisons with different theoretical models enhance our understanding of the observed medium effects. The first-time investigation of rapidity-dependent boost invariance reveals a significant asymmetry in associated particle yields, with a marked difference between $\Delta\eta > 0$ and $\Delta\eta < 0$. This asymmetry becomes increasingly pronounced at forward rapidity and intensifies from peripheral to central PbPb collisions, notably for high-p_{T} particles, suggesting that the jet structure is influenced by the QGP's longitudinal flow dynamics.

Field of contribution:

Experiment

79

Masses and Radii of Strongly Magnetized Oblate Spheroidal White Dwarfs

Author: Rajasmita Sahoo[1]

Co-authors: Pranjal Anant Tambe [2]; Somnath Mukhopadhyay [1]

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This study explores the mass-radius relationship of oblate spheroidal magnetized white dwarfs within the parameterized γ-metric formalism. A relativistic free Fermi gas of electrons embedded in strong Landau quantizing magnetic fields at absolute zero temperature is considered. Due to the anisotropy in the pressures parallel and perpendicular to the direction of the magnetic field, these magnetized white dwarfs become oblate spheroids. This deformation is accounted in the presence of a deformed Schwarzschild metric known as the γ-metric. Stable super-Chandrasekhar white dwarfs ($> 5M_{\odot}$) are obtained. We see that at constant central density, as the central magnetic field increases, the mass first increases and then decreases. The equatorial radius follows a reverse trend, that is, it first decreases and then increases. We also found that the maximum mass occurs at higher central electron number density as the central magnetic field increases. This shows that due to the pressure anisotropy induced by the strong magnetic field, the Equation of State (EoS) becomes softer and hence makes the star more compact.

Field of contribution:

Theory

80

Silicon-Tungsten Based Multilayer Electromagnetic Calorimeter Development for Societal Applications

Author: Ganesh Jagannath Tambave[1]

Co-authors: Bedangadas Mohanty [1]; Kirti Prakash Sharma [2]; Ranbir Singh [1]; Sawan Sawan [2]; Varchaswi Kashyap [1]

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Silicon (Si) detectors are commonly used in nuclear and particle physics experiments due to their capability to precisely measure the energy, position, and time of the particles produced during the experiment. There are different types of silicon detectors fabricated (Si pads, Si pixels, Si strips, MAPs type etc.) based on the need of its applications in nuclear, particle and medical physics. The silicon detectors are mainly used in particle tracking and vertex detectors. A sandwich structure of

a pad array coupled with high Z material such as tungsten, if arranged in layers, could be used as an electromagnetic calorimeter for measuring the energy and shower profile of high-energy electrons and gamma rays produced in collider experiments.
In this context, several n-type pad array detectors are fabricated on a 6-inch silicon wafer at Bharat Electronics Limited (BEL), Bangalore. Each array is of 8 cm x 9 cm, consisting of 72 pad cells each with an active area of 1 cm x 1 cm. The pad array is readout using a highly integrated readout chip named HGCROC. A dedicated PCB hosting HGCROC and a readout board capable of processing signals of 20 HGCROCs has been developed in India. During this presentation the design, fabrication, and performance test results of 15 layers of Si-W sandwiched calorimeter obtained using 1 GeV to 5 GeV pions and electrons will be reported.

Field of contribution:

Experiment

81

Exploring the effect of chiral torsion on neutrino oscillation in long baseline experiments

Author: Riya Barick[1]

Co-author: Amitabha Lahiri [1]

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In curved spacetime, neutrinos experience an extra contribution to their effective Hamiltonian coming from a torsion-induced four-fermion interaction that is diagonal in mass basis and also causes neutrino mixing while propagating through fermionic matter. This geometrical quartic interaction term appears as the modification to the neutrino mass and significantly influences both neutrino conversion and survival probabilities. Since this term varies linearly with matter density, long baseline (LBL) experiments would be a good choice to probe this effect. We put bounds on torsional coupling parameters and also see the impact of torsion on physics sensitivities (the precise determination of leptonic CP phase, mass ordering, octant of 2-3 mixing angle) in the DUNE experiment.

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[2] R. Barick, I. Ghose and A. Lahiri, LHEP 2023, 362 (2023) doi:10.31526/lhep.2023.362 [arXiv:2305.05903 [hep-ph]].
[3] R.Barick, A. Lahiri (In Preparation).

Field of contribution:

Phenomenology

82

Effective theory of light Dirac neutrino portal dark matter with observable ΔNeff

Author: Sujit Kumar Sahoo[1]

Co-authors: Debasish Borah [2]; Dibyendu Nanda [3]; Narendra Sahu [4]; SATYABRATA MAHAPATRA [5]

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Inspired by the null detection of dark matter from direct search experiments, we propose a ν_R-philic dark matter (DM) using an effective field theory (EFT) framework. Specifically, we focus on a dimension-6 operator $\overline{\chi}\chi\overline{\nu_R}\nu_R$, where ν_R represents the right-handed Dirac partner of standard model (SM) neutrinos. In the early Universe, the annihilation of DM to ν_R establishes the relic density. We also introduce another dimension-6 operator, $\overline{\nu_R}\nu_R\overline{f}f$, such that ν_R acts as a portal between the DM and standard model (SM) fermions to provide a signature of DM through direct detection. We estimate the $\Delta N_{\rm eff}$ considering the interactions of ν_R with SM thermal bath and constraint the effective scale from the latest data from PLANCK and DESI. To this end, We also explore UV-complete realizations, including the Left-Right Symmetric Model (LRSM) and U(1)B-L extensions of the SM. Our results offer updated perspectives on the interplay between Dirac neutrinos, dark matter, and cosmological observations, highlighting the implications of recent DESI findings for particle physics models beyond the Standard Model.

Field of contribution:

Phenomenology

83

Development of experimental setup and enhanced analytical methodologies to study cosmic γ-ray flux variations during total solar eclipses

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During the past quarter century, there have been many attempts to observe a possible inverted Gaussian-shaped decrease during total solar eclipses, coinciding lowest point with totality [1], but these attempts have ended with contradictory results. Here, we introduce an experimental setup optimized for cosmic γ-ray collection, minimizing terrestrial interference. Leveraging four large-volume NaI(Tl) scintillation detectors, we collected the γ-ray flux data during the total solar eclipse of 22 July 2009 from two geographically distinct locations: Indore and Siliguri [2]. The setups were elevated substantially above the ground to reduce terrestrial γ-rays, utilizing the detectors to measure flux before, during, and after the eclipse visible at the sites. However, varying levels of radon daughters in rain during the eclipse period complicated the spectral analysis. We developed a RooFit-based method combining exponential and Gaussian functions to generate unified energy spectra that effectively handles different time segments and rain impacts [3]. Subsequently, we have incorporated a novel approach to isolate the true background from the rain-affected terrestrial background that

reduced the rain-affected γ-ray flux data more than half in magnitude. With improvement in experimental set up, data modelling and fresh perspective for data analysis, the present study establishes a foundational approach crucial for future total solar eclipse experiments.

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Field of contribution:

Experiment

84

SIMP dark matter during reheating

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Strongly interacting massive particle (SIMP) has become one of the promising dark matter (DM) candidates due to its capability of addressing the small-scale anomaly, where the final DM abundance is set via the freeze-out of $3 \to 2$ or $4 \to 2$ annihilation process involving solely the dark sector particles. In this work, we explore the freeze-out of SIMP DM during the inflationary reheating epoch. During reheating, the radiation energy density evolves differently based on the shape of inflaton potential and spin of its decay products than the standard radiation-dominated picture; as a result, in this scenario, the freeze-out temperature varies distinctly with DM mass compared to the standard case. Large entropy injection due to inflaton decay demands a smaller cross-section to satisfy the observed relic than the standard radiation-dominated freeze-out case. The required cross-section, satisfying the relic density constraint and the maximum allowed thermally averaged cross-section by the unitarity of the S-matrix, set an upper limit on the DM mass. The upper bound on the mass of the dark matter for $3 \to 2$ ($4 \to 2$) is 1 GeV (7 MeV), assuming a radiation-dominated background. Interstingly, these limits get relaxed to 10^6 (10^4) GeV for $3 \to 2$ ($4 \to 2$) SIMP dark matter for quadratic inflaton potential. We find that a small amount of DM parameter space survives for reheating with quadratic inflaton potential after considering the lower bound of reheating temperature, put by the latest CMB observation depending on the inflationary models. In the case of the quartic inflaton potential, the allowed DM parameter space gets reduced compared to the quadratic case.

Field of contribution:

Phenomenology

85

Gravitational Neutrino Reheating : A minimal framework for reheating and leptogenesis

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Despite having important cosmological implications, the reheating phase is believed to play a crucial role in both cosmology and particle physics model building. Conventional reheating models primarily rely on arbitrary coupling between the inflaton and massless fields, which lacks robust predictions. In this article, we propose a novel reheating mechanism where the particle physics model, namely, the type-I seesaw model, is shown to play a major role in the entire reheating process, and the inflaton is assumed to be free from arbitrary coupling. This is the first reheating model of its kind that, besides being successful in resolving the well-known neutrino mass and baryon asymmetry problems, constrains a large class of inflation models, offers successful reheating, and predicts a distinct primordial gravitational-wave spectrum and nonvanishing lowest active neutrino mass. Our novel mechanism opens up a new avenue of integrating particle physics and cosmology in the context of reheating.

Field of contribution:

Phenomenology

86

Exploring Multiple Interactions in Photoproduction: From HERA to EIC energies

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The interactions in electron-proton collisions is dominated by the interaction of real photons emitted by the electrons with the protons. The presence of multiple parton interactions has been already established in such collisions at HERA energies and it plays a vital role in exploring dynamics of hadronic final state production in photon-proton interactions. The present work reports the significance of study of multiple parton interactions in such photoproduction processes involving hadronic final state at the Electron-Ion Collider energies as compared to the HERA energies.

Field of contribution:

Phenomenology

87

Study of the response of SLD to a major background for InDEx at JUSL

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The direct detection of dark matter relies on the rare interactions of dark matter particles with the ordinary matter. The world leading direct detection experiments are mostly sensitive in the 25–40 GeV/c2 WIMP mass and the null results from those experiments have pushed the interest to explore the low WIMP mass region specially below 10 GeV/c2. In this context, the Indian Dark matter search Experiment (InDEx) at Jaduguda Underground Science Laboratory (JUSL), employed C2H2F4 Superheated Liquid Detectors (SLDs) due to their sensitivity to nuclear recoils while remaining insensitive to minimum ionizing particles, such as gamma and beta radiation, at certain temperatures. However, operating the SLD at higher temperatures that corresponds to the lower threshold (gamma sensitive regime) one can probe the lower WIMP masses. Therefore, to explore the WIMP masses in gamma sensitive regime, the precise identification of threshold temperature of the SLD for gamma-ray induced bubble nucleation is necessary. This study investigates the temperature threshold at which the gamma-ray induced bubble nucleation occurs in C2H2F4 SLD. Superheated liquid is a metastable state of the liquid and the energy deposition by the charged particles, neutrons, gamma-rays etc. can cause nucleation which leads to the transition from metastable liquid state to the stable vapour state. The mini-explosion from metastable liquid state to stable vapour state gives an acoustic signal lasting about few milliseconds and can be recorded with condenser microphone or piezo-electric sensors. Experiment was performed with C2H2F4-SLD which was fabricated at SINP by suspending the superheated droplets into a visco-elastic gel matrix. Two sets of experiments were performed at each operating temperatures between 31℃ and 49℃, one for background and another in presence of 137Cs (5 mCi) gamma-ray source. For the detection of the acoustic signals, condenser microphone as a sensor was used in the experiment. Results show that the detector becomes sensitive to gamma-rays at 44.5℃ ± 1.4℃ which corresponds to 0.65 keV thresholds. It was observed that the gamma sensitivity of SLD depends on the droplet size. For smaller droplets (˜10μm) which are currently used in InDEx at JUSL, the detector becomes gamma-ray sensitive at relatively higher temperatures. This explains the higher threshold as observed in the present measurement compared to the previous studies with larger droplets. This observation is important for optimizing the detector's performance, particularly for exploration of the low mass WIMP. The preliminary sensitivity of InDEx near gamma-ray threshold will be presented along with the predicted sensitivity of InDEx for the future run with larger exposures.

Field of contribution:

Experiment

88

First look at the detection efficiences of Triple-GEM Detectors in pp Collision at CMS with 2023 data.

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The CMS muon system is being upgraded with the GE1/1 station of Gas Electron Multiplier (GEM) detectors to handle the increased muon flux in the very forward eta region. This work analyzes muon

detection efficiency with the GE1/1 station using p-p collision data with center of mass energy of 13.6 TeV. A dataset enriched with muons from Z-decay, with a total integrated luminosity of ˜ 6 fb−1, has been utilized. A standalone muon algorithm is used to reconstruct muons and to measure the detection efficiency of the GE1/1 station. Tracks are back-propagated to the GE1/1 detector modules to identify the most compatible GEM hits. The detector modules are operated between 680 - 690 μA of equivalent divider current, slightly below the current of ˜ 700 μA expected for the bias voltage working point.

Field of contribution:

89

Phenomenology of A_4 modular symmetry flavor model for Dirac neutrinos

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We propose a Dirac mass model within the framework of Type-I seesaw, utilizing A_4 modular symmetry. Modular symmetry is crucial, as the Yukawa couplings are structured as modular forms, specifically in terms of the Dedekind eta function $\eta(\tau)$. This symmetry ensures that the Yukawa couplings transform similarly to the other matter fields, eliminating the need for extra flavon fields. The spontaneous breaking of the A_4 modular symmetry is driven by the vacuum expectation value (vev) of the complex modulus τ. Our model yields predictions for neutrino oscillation parameters, including a preference for the normal mass hierarchy in the neutrino spectrum. Additionally, we demonstrate that the decay of the heavy Dirac fermions in the model can generate the observed baryon asymmetry of the Universe through Dirac leptogenesis.

Field of contribution:

Phenomenology

90

Spin-alignment of vector mesons in relativistic heavy-ion collisions

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In the present study, we explore the phenomenon of spin alignment of ϕ and K^{*0} vector mesons, as recently observed by the ALICE and STAR collaborations. While a range of sources could potentially contribute to this phenomenon, it is hypothesized that the primary influences are the vorticity and electromagnetic fields, which align with the qualitative description of global polarization data for Λ hyperons. Contrary to this, the quark combination model suggests that the impact of these fields on the spin alignment of ϕ and K^{*0} mesons should be less pronounced than that on Λ hyperons polarization. This prediction stands in contradiction to recent experimental findings. Notably, the large spin alignment of ϕ mesons is attributed to a strong vector meson force field, indicating that quarks become polarized when interacting with a dense medium via a strong force. This reasoning, however, is unable to explain the spin alignment of J/ψ observed in experiments, thus highlighting a gap in our understanding of vector meson spin alignment. In light of these observations, our work aims to shed light on the spin alignment mechanisms of vector mesons by examining two distinct hadronization processes: quark recombination and fragmentation, involving polarized quarks and antiquarks. We specifically investigate the influence of magnetic fields and medium momentum-space anisotropy on the spin-alignment observable, namely the 00^{th}-component of the spin-density matrix (ρ_{00}), for ϕ, K^{*0}, and ρ spin-1 mesons. Our findings reveal that ρ_{00} is inversely related to medium anisotropy and directly related to the strength of the magnetic field, providing a qualitative explanation for the experimental data observed. This study advances our understanding of spin dynamics in vector mesons and highlights the complex interplay between magnetic field, medium anisotropy, and hadronization processes in shaping such phenomena.

Field of contribution:

Theory

91

Station and outlooks of neutrino physics

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Neutrinos are very special particles that have led over and over to unexpected and vital discoveries, a number of which have been identified with Noble prizes. Neutrinos have been theoretically invented in 1930 by way of Pauli to maintain strength–momentum conservation and their first experimental detection in 1956 via a crew lead by way of Reines and Cowan on the Savannah River reactor was any other landmark. Later it changed into discovered that 3 versions (flavors) exist, which became once more a major discovery. subsequent, solar neutrinos confirmed oscillations on their manner to Earth, that's a quantum mechanical effect, something commonly best applicable on atomic scales. Neutrinos were determined to have very tiny masses, that's up to now the best solid evidence for particle physics beyond the standard model and has critical consequences for structures inside the Universe. there are various other topics in which it's miles already recognized that neutrinos play an important function, however there also are very good reasons and perhaps even indicators that greater sudden outcomes may also show up in the destiny.

Field of contribution:

Theory

92

QGP as the Most Vortical Fluid and its Effect on the Λ-Hyperon Polarization

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In scenarios like QGP being a vortical fluid, the partons are supposed to be polarized, and, as a result, hadrons produced at the chemical freezeout boundary are also thought to be polarized. Such a non-zero polarization of $\Lambda(\bar{\Lambda})$ hyperons has been observed in heavy-ion collisions at ALICE and STAR Collaborations. Recent studies suggest the transverse component of the vorticity field is responsible for the global spin polarization, while the longitudinal component of the vorticity field accounts for the local polarization. The local polarization of Λ-hyperons arises due to the anisotropic flows in the transverse plane, indicating a quadrupole pattern of the longitudinal vorticity along the beam direction. The present study focuses on the global and local polarization of Λ and $\bar{\Lambda}$ in Au+Au and Pb+Pb collisions at $\sqrt{s_{NN}}$ = 200 GeV and 5.02 TeV, respectively. We consider second-order viscous hydrodynamics with non-zero vorticity, which is coupled with the spin of the particles and gives rise to spin polarization in the system. Under the vortical QGP evolution framework, we explore the centrality and transverse momentum (p_{T}) dependent global and local polarization of Λ-hyperon. These findings advocate the existence of a thermal medium and offer a qualitative understanding of the medium evolution and spin polarization of hyperons in heavy-ion collisions.

Field of contribution:

Phenomenology

93

Implications of Trimaximal Mixing for Fermionic Dark Matter and Lepton Flavor Violation in Scotogenic Framework

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In this work, we study the (co-)annihilation dynamics and lepton flavor violation (LFV) in the context of fermionic dark matter within the Scotogenic model, assuming trimaximal mixing (TM_2) nature for neutrino mixing matrix. TM_2 mixing matrix is used to parameterize the complex Yukawa coupling matrix. Our objective is to identify the parameter space that simultaneously satisfies data from neutrino oscillations, the cold dark matter (CDM) relic density, and the upper bound on the branching ratio of the LFV process Br($\mu \to e\gamma$). To explore the (co-)annihilation dynamics, we consider three scenarios, finding that only two are viable. Furthermore, regardless of whether the neutrino mass hierarchy is normal (NH) or inverted (IH), a mass splitting of
$lesssim 15\%$ between the mass of CDM particle N_1 and the next heavier particle N_2, is necessary to satisfy the constraints. In the IH case, the predicted range for Br($\mu \to e\gamma$) falls within the sensitivity of the MEG II experiment. In both hierarchies, CP-violating and CP-conserving solutions are allowed. Furthermore, the cosmological upper bound on the sum of neutrino masses excludes a significant portion of the effective Majorana mass parameter space ($|m_{ee}|$). The predicted range of $|m_{ee}|$ lies within the detection precision of neutrinoless double beta decay ($0\nu\beta\beta$) experiments for the IH case.

Field of contribution:

Phenomenology

94

Exploring Berry phase from Lewis phase : Gravitational wave interacting with a quantum harmonic oscillator

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Here, we explored the Berry's geometric phases through the Lewis phases. Considering a gravitational wave carrying only plus polarization and interacting with an isotropic two dimensional quantum harmonic oscillator, we showed how the geometric phase which is completely dependent on the gravitational perturbation due to the incoming gravitational wave, can be revealed from the adiabatically approximated form of Lewis phase which essentially connects the eigenstate of Lewis invariant to the Hamiltonian eigenstate. We not only present an elegant method for finding the Berry phase but also clarify the underlying nature of Berry's geometric phase by obtaining explicit expressions for the non-trivial Berry phase in the case of a plane-polarized gravitational wave, with different choices for the harmonic oscillator frequency. Finally, we consider a gravitational wave, with cross polarization only, interacting with an isotropic two-dimensional harmonic oscillator. By rotating the coordinate system, we show that the cross polarization is effectively similar to plus polarization in this new basis. For this, we again obtain the Lewis phase and the total Berry phase of the system. Our study suggests that the non-trivial Berry phase in this setup could serve as an effective tool for detecting gravitational waves.

Field of contribution:

Theory

95

Entropy and Information measure of an Anharmonic oscillator

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we compare two methods for describing quantum system, using the example of an anharmonic oscillator: the Wigner distribution and the Husimi distribution. These help us to understand a system's information content, especially how it changes with different parameters, like anharmonicity (λ) and energy levels (n). For both distributions, we calculate various information measures such as mutual information, correlations and entropies such as Shannon and Rényi entropies . Our findings show that the Wigner distribution generally has lower entropy and is closer to the theoretical uncertainty limits, while the Husimi distribution leads to more information loss. The Wigner distribution also gives higher values for mutual information and correlations. This suggests that the Wigner distribution provides a more accurate picture of the system's information content, particularly for an anharmonic oscillator.

Field of contribution:

Theory

96

Measurement of BF and CP asymmetries of Bd to Ks0 pi0 at Belle & Belle 2

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The $B^0 \to K_S^0\pi^0$ decay is dominated by $b \to s$ loop amplitudes. Such flavor-changing-neutral current transitions are highly suppressed in the Standard Model and provide an indirect route to search for new physics. This channel is an important cog in the so-called "K\pi puzzle," where the amplitudes of the four $B \to K\pi$ decays—two neutral modes and two charged modes—are related to each other. The latest studies by Belle II have reduced some of the existing tension in these measurements.

We propose a more detailed study of this channel using the combined Belle + Belle II data, where the former study will be updated with a multivariate analysis (MVA) based approach for K_S^0 and π^0, providing significant room for improvement. For the Belle II data, we will also include the Run II data. This combined dataset is targeted for completion by 2026.

The excellent neutral-particle reconstruction capability of Belle II allows a unique measurement of CP violation asymmetry in this neutral B-meson decay channel, serving as an important consistency test of the Standard Model. We perform a measurement of the CP-violating parameters A and S, as well as the branching fraction (BF) in $B^0 \to K_S^0\pi^0$, using a sample of 772M (Belle) and 387M+ (Belle II) $B\bar{B}$ events recorded in e^+e^- collisions at a center-of-mass energy corresponding to the $\Upsilon(4S)$ resonance.

Field of contribution:

Experiment

97

Search for the rare decays of Higgs and Z boson to a J/Psi or Psi' meson and a photon in CMS at √s = 13 TeV

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Results from search for the rare decays of the standard model\,(SM) Higgs and Z boson to a J/Ψ or Ψ′ meson and a photon, with subsequent decay of the meson to a pair of muons will be presented in this contribution. The analysis is performed using data recorded by the CMS detector during full Run 2 from proton-proton collisions at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 123 fb^{-1}. No excess of events has been observed over the SM background. Upper limit at 95% confidence level are set on the branching fractions of these decay channels.

Field of contribution:

98

Comprehensive Phenomenology of the Dirac Scotogenic Model: Novel Low Mass Dark Matter

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The Dirac Scotogenic model provides an elegant mechanism for generating small Dirac neutrino masses at the one-loop level. A single abelian discrete $\mathcal{Z}_6$ symmetry simultaneously protects the "Diracness" of the neutrinos and the stability of the dark matter candidate. This symmetry originates as an unbroken subgroup of the so-called 445 $U(1)_{B-L}$ symmetry. Here we thoroughly explore the phenomenological implications of such a construction including analysis of electroweak vacuum stability, charged lepton flavor violation and the dark matter phenomenology. After taking all the constraints into account, we also show that the model allows for the possibility of novel low mass scalar as well as fermionic dark matter, a feature not shared by its canonical Majorana counterpart.

Field of contribution:

Phenomenology

99

Measurement of angular observables of the rare decay Bs0 →phi mu mu at 13 TeV by CMS Detector

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The angular analysis of the rare decay Bs0 → phi mu mu is performed in bins of squared dimuon invariant mass (q2), using an integrated luminosity of 137.5 fb-1 of data collected by the CMS detector at center-of-mass energy, √s = 13 TeV. The CP asymmetry (A6) and CP averaged (FL) angular observables are measured to be in agreement with the Standard Model prediction in the low q2 region 1.1-6.0 GeV2 /c4, using Run II pseudo-data sample. Results using data are blinded at present. Pseudo-data results are available.

Field of contribution:

100

GEM Detector Fabrication and Characterization Facility at Panjab University

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The Gas Electron Multiplier(GEM) detector is one of the most important Micro-Pattern Gaseous Detector (MPGD) first introduced in 1997 by F. Sauli at CERN. These detectors utilize the principle of gas ionization, where an incoming particle interacts with the gas,ionizing it and creating electron-ion pairs. The core of the GEM detector is the GEM foil, a thin insulating layer (usually made of kapton) sandwiched between two conductive layers,perforated with microscopic holes. GEM detectors are advanced gas-based detectors widely used in particle physics experiments for particle tracking, imaging, and particle identification. The fabrication and characterization facility of these GEM detectors is available in our Panjab University, Chandigarh. This paper present the overview of facilities along with selected Quality Control Tests (QCs) of these GEM detectors like QC1(Visual inspection of GEM foils), QC2(Leakage Current Test), QC3(Gas Leak Test), QC4(I-V Characteristic and Intrinsic Noise Rate Measurement).

Field of contribution:

Experiment

101

Performance of the charge injection board to test the connectivity of the HGCROC chip with the hexaboard

Authors: Gobinda Majumder[1]; Jasmine Chhikara[1]; Mandar Saraf[2]; Rajdeep Mohan Chatterjee[1]; Shilpi Jain[1]

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The CMS Collaboration is preparing to upgrade its current endcap calorimeters for the HL-LHC era by implementing a high-granularity calorimeter (HGCAL). This new design will feature unprecedented transverse and longitudinal segmentation in both the electromagnetic and hadronic compartments, enabling 5D information (space, time, energy) readout. Silicon sensors are utilized for the electromagnetic section and high-irradiation regions within the hadronic section, while plastic scintillator tiles with on-tile silicon photomultipliers (SiPMs) are used in the low-irradiation regions of the hadronic section. The full HGCAL will consist of approximately 6 million silicon sensor channels organized across 30,000 detector modules. Each module is read out by a front-end board, known as the hexaboard, which incorporates dedicated readout chips called HGCROCs.

To ensure proper assembly, each of the 78 channels of the HGCROCs must be correctly soldered onto the hexaboard. To facilitate quality control, a custom charge injection board was designed. This board can inject a desired amount of charge capacitively into each channel via the wire-bonding pads on the hexaboard. In this presentation, we will discuss the results from testing the charge injection board, which was developed as a quality control measure for assembled hexaboards in the HGCAL project.

Field of contribution:

Experiment

102

Time series representation of event data : A new approach to gamma-hadron separation in single imaging Cherenkov telescopes

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Imaging Atmospheric Cherenkov Telescopes (IACTs) have became essential tool for the detection of Very High Energy (VHE) gamma ray sources. IACT data contain overwhelming background of cosmic ray induced Cherenkov images. Conventional methods distinguish signal events from background using shape and orientation features extracted from spatial distribution of time-integrated intensity in camera plane. In recent studies, deep-learning models based on Convolutional Neural Networks (CNN) and Long Short Term Memory (LSTM) networks have been shown to out-perform the classical approach. All the current and future generation IACTs collect photo-sensor waveform data at high sampling rates. While traditional method use only the spatial information in an IACT image, deep learning methods represent IACT event in 2D pixel maps of intensity and waveform parameters. Though geometrical representation of events is well suited
for CNNs, insights hidden in time evolution of Cherenkov images across camera plane may not be easily captured. We propose a novel approach that leverages the temporal evolution of Cherenkov images in the camera plane. IACT event data is represented as a time series of centroids and total content of instantaneous Cherenkov images.
We train CNN and LSTM based classifiers using this representation as input and investigate the efficiency of trained classifiers. The performance of traditional gamma/hadron classification method in IACT is used as the benchmark, where shape and orientation features of an IACT image are utilised as input to Random Forest classification algorithm. We find that simple single-layer architectures of CNN/LSTM trained with sequence of instantaneous centroids and total content as input outperform Random Forest model trained on shape parameter. The study serves as a proof-of-concept for using time series representation of Cherenkov images in IACT data analysis.

Field of contribution:

103

Partition Functions and Phases of Quantum Field Theories in AdS Spaces

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The effective action, finding which to the leading order involves computation of one-loop determinants, happens to be the primary ingredient for studying the phases of a quantum field theory. In this talk, which is based on our papers [1] and [2], I will describe a method for computing one-loop partition functions for fermions and U(1) vectors on AdS$_{d+1}$ space for zero and finite temperature for arbitrary dimensions d that reproduces results known in the literature. The derivation is based on the method of images and uses the eigenfunctions of the Dirac and vector Laplacian operators respectively on Euclidean AdS. For finite temperature, partition functions are obtained by generalizing the eigenfunctions so that they obey the desired periodicities (anti-periodicities) for bosons (fermions) under the quotient group action, which defines the thermal AdS spaces. Employing these results, I will then discuss the phases of fermionic field theories in AdS spaces for $d = 1, 2, 3$ and scalar QED in $d = 2, 3$ as regions in the corresponding parameter spaces. Along the way, I will also highlight the deviations from the flat space results.

References:

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Field of contribution:

Theory

104

A comparative study of high multiplicity pp and heavy ion collision using q-Weibull distribution function

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One of the primary goals of ongoing and upcoming particle physics experiments is the study of QCD matter created under extreme condition of temperature and energy density called Quark Gluon Plasma (QGP). Earlier, it was believed that the QGP formation takes place only in heavy ion collision whereas the pp collision is being used as a baseline to study the QGP state is heavy ion collision. However, recent results from high multiplicity pp collision at LHC reported certain effects that are so far considered typical to heavy ion collision. ALICE experiment result on strangeness enhancement may signal the formation of QGP like state in high multiplicity pp collision. These results opens up a new avenue in high energy physics to search for the QGP state. With the availability of high multiplicity pp collision data at different multiplicities and energies, it will be interesting to analyze the variation of thermodynamical properties with multiplicity in pp collision and compare it with the data from heavy ion collision.

One of the thermodynamical property is the non extensive parameter q, which indicates how much a system deviate from thermal equilibrium. We will present a comparative study of parameter q extracted using the transverse momentum (p_T) spectra of charged hadrons produced in high multiplicity pp and heavy ion collision. We will discuss the results related to p_T range dependent variation of parameter q with multiplicity for different collision system and energies.

Field of contribution:

Phenomenology

105

Effect of Magnetic Fields on Urca Processes in Neutron Star Mergers

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Isospin-equilibrating weak processes, called "Urca"processes, are of fundamental importance in astrophysical environments like (proto-)neutron stars, neutron star mergers, and supernovae. In these environments, matter can reach high temperatures of tens of MeVs and be subject to large magnetic fields. We thus investigate Urca rates at different temperatures and field strengths by performing the full temperature and magnetic-field dependent rate integrals for different equations of state. We find that the magnetic fields play an important role at temperatures of a few MeV, especially close to or below the direct Urca threshold, which is softened by the magnetic field. At higher temperatures, the effect of the magnetic fields can be overshadowed by the thermal effects. We observe that the magnetic field more strongly influences the neutron decay rates than the electron capture rates, leading to a shift in chemical equilibrium.

Field of contribution:

Theory

106

Mass Spectra and decay properties of Ξ_bb baryon using hCQM

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In this study, we investigate the properties of the doubly heavy baryon Ξ_bb using the Hyper Central Constituent Quark Model (hCQM). Our calculations yield the masses of both ground and excited states of Ξ_bb, incorporating higher-order corrections, including second-order mass corrections within spin-dependent terms. This approach enables precise determination of spin splitting. We determine the spin-parity J^p for ground and excited states, shedding light on the quantum nature of Ξ_bb. Our predicted resonance masses are compared with other theoretical approaches, providing a comprehensive understanding of it's decay properties.

Field of contribution:

Phenomenology

107

Addressing dark matter in minimal extended seesaw framework

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Different models have been proposed to resolve the puzzling mystery of dark matter. We study a feasible dark matter candidate in the framework of minimal extended seesaw (MES) [1]. The model is augmented with Δ(96) symmetry that leads to TM_1 mixing pattern. A sterile state in intermediate mass range has been added to the standard model to realize the framework [2]. The structure of the mass matrices are obtained from Δ(96) symmetry[3]. We find that sterile neutrino mass in keV range can have significant contribution to the dark matter content of the Universe [4]. The viability of the proposed model is tested considering the allowed cosmological ranges of the relic abundance, decay rates as well as its mixing with the active neutrinos.

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Field of contribution:

Phenomenology

108

Low temperature study of QCD at finite chemical potential using Random Matrix Theory

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We study an SU(N) matrix model with a Gross-Witten-Wadia weight function and a low-temperature fermionic term at finite chemical potential. We provide exact results for several physical quantities in the large N limit in the confined phase, such as (density of eigenvalues), free energy, and winding Wilson loops. As expected, this model exhibits the sign problem.

Field of contribution:

Theory

109

Single level QCD at zero chemical potential using Random Matrix Theory

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We study an SU(N) matrix model with a bosonic weight function and a fermionic interaction term at zero chemical potential. This model represents QCD at a single energy level. We compute the phase transition and provide exact results for several physical quantities in the confined phase, such as free energy and winding Wilson loops.

Field of contribution:

Theory

110

Effects of initial state conditions on the azimuthal angular correlation of $\mathrm{D}^0 - \mathrm{D}^0$ in heavy ion collision

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The study of thermalization of heavy flavors (HF) in the Quark Gluon Plasma (QGP) is one of the major physics goals of the upcoming heavy-ion experiments. Heavy flavors are primarily produced by hard scatterings during the early stages of ultra-relativistic hadronic collisions. Their azimuthal angular correlation ($\Delta\varphi$) can be modified at different stages of collisions. Probing the initial state of these collisions is important to quantify the degree of HF thermalization.

This study investigates the impact of different pre-equilibrium models on the azimuthal angular correlations of $\mathrm{D}^0 - \mathrm{D}^0$ mesons in Pb—Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.5 TeV. Recent studies indicate that, despite the stage's duration being less than 1 fm/c, the pre-equilibrium glasma phase significantly influences heavy quark azimuthal angular correlation. The treatment of the initial stage of heavy ion collisions can influence the interactions of heavy flavors at this stage, thereby affecting the correlation between D mesons. The effects of different initial states are quantified by measuring the yield and width of the $\Delta\phi$ distribution. This study is crucial for drawing robust conclusions regarding heavy quark thermalization in the quark-gluon plasma (QGP).

Field of contribution:

Phenomenology

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Mass Spectra and Spin-Parity Analysis of Newly Observed $\Xi_b^{'}$ Baryons

Authors: Pooja Jakhad[None]; Ajay Kumar Rai[1]

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In 2021, the LHCb Collaboration observed three new Ξ_b baryonic states: $\Xi_b(6227)$, $\Xi_b(6327)$, and $\Xi_b(6333)$. The spin-parity of these states remains undetermined. This study examines the mass spectra of the $\Xi_b^{'}$ baryon. To achieve this aim, we utilize the framework of the relativistic flux tube model, incorporating a heavy bottom quark and a light diquark representation of baryons. We incorporate the spin-dependent interactions in the limit of heavy quark symmetry. The results obtained align well with the existing experimental masses. The findings indicate that the $\Xi_b(6227)$ is a viable candidate for the P-wave $\Xi_b^{'}$ baryon with J^P value $\frac{1}{2}^-$ or $\frac{3}{2}^-$. Additionally, the baryons $\Xi_b(6327)$ and $\Xi_b(6333)$ can be effectively understood as P-wave $\Xi_b^{'}$ baryons with J^P values $\frac{3}{2}^-$ and $\frac{5}{2}^-$, respectively. This study can contribute to constructing the highly excited states of the $\Xi_b^{'}$ baryonic family.

Field of contribution:

Phenomenology

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Implications of LMA and Dark-LMA Solutions for Inverse Neutrino Mass Matrix with One Zero Texture and Vanishing Trace

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In the presence of non-standard interaction (NSI), the solar neutrino problem has two solutions, one is for standard Large Mixing Angle (LMA) with solution $\sin^2{}_{12}$ = 0.3 and other is $\sin^2{}_{12}$ = 0.7. The latter is known as the Dark-Large Mixing Angle (D-LMA) solution. In this work, we have investigated the one zero texture and vanishing trace of inverse neutrino mass matrix in the context of LMA and D-LMA solution of the solar neutrino problem. In our work, we have six cases to study and we found that the textures which are allowed for LMA solution are also allowed for D-LMA solution. Further, we show the correlations between different parameters for 3⊠ ranges of neutrino oscillation data. The case $m_{11}^{-1} = 0$ is not allowed as it cannot reproduce the correct neutrino phenomenology. Similarly, the case with $m_{12}^{-1} = 0$ predicts inverted hierarchical neutrino masses and is consistent with only LMA phenomenology. More results will be presented in the full length paper.

Field of contribution:

Phenomenology

113

Study of tWZj signal and its backgrounds

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The discovery of the Higgs boson in particle physics has opened a new era for valuable research to understand nature better. In recent times, physicists have been trying to find new physics to enhance their knowledge of physics beyond the standard model. For this purpose, studying the effect of modification in Higgs coupling and top Yukawa coupling is essential because it may show physics signatures in kinematic variable distributions vividly.
In this study, we modified Higgs to top Yukawa coupling using Effective Field Theory (EFT) with a dimension six operator, which leaves imprints of modification at a low energy scale on Wilson Coefficients. We are studying the effect of off-shell Higgs coupling in the physics of longitudinal gauge bosons at 13 TeV energy using proton and b quark collision, simulated by the MadGraph event generator and then the detector response is modelled using Delphes. Events, in which 3 leptons from leptonic decay of W and Z bosons, boosted top quark accompanied by a forward jet coming from light quark, are used for this study. We call this final state tj⊠+3 leptons. This process has a topology similar to Vector Boson Scattering (VBS), with a forward jet that will be useful for discriminating signal from the background. There exist various background processes which can mimic our signal. Such background processes are $t\bar{t}Z$, WW, WZ, ZZ, single top production, QCD+jets production, etc. We discriminated signal from the background using the Deep Neural Network (DNN) algorithm of Machine Learning (ML). In tWZj production, kinematic distributions of mass of the diboson system and top quark are found sensitive to the top Yukawa coupling modifier Y_t. Results in terms of limit estimation for top Yukawa coupling Y_t are derived.

Field of contribution:

Phenomenology

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Observation on the effect of prolonged irradiation on GEM detector

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Gas Electron Multiplier (GEM) is a cutting edge detector technology that belongs to the group of Micro Pattern Gaseous detectors (MPGD). One of the key factors in selecting detectors for High Energy Physics (HEP) experiments is its long-term stable operation. One effective way to benchmark the stability of the chambers is to examine how well they perform under prolonged irradiation. A study has been carried out to investigate the stability in performance of a single mask triple GEM chamber prototype in terms of gain and energy resolution and count rate in the laboratory using a 5.9 keV ^{55}Fe X-ray source. The gain and energy resolution are corrected for the variation of ambient temperature/pressure ratio (T/p). The effect of the variation of bias current on the performance of the detector is also studied. The details of the experimental setup, methodology, and results will be presented.

Field of contribution:

Experiment

115

A search for light pseudoscalar from the decay of Standard Model Higgs boson in CMS using 137 fb^{-1} Run-2 data

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After the discovery of the 125 GeV Higgs boson (H) at CERN LHC, the next physics program is set on measuring its properties with precision as well as searching for new physics. In some of the Beyond Standard Models (BSM) such as next to minimal supersymmetric standard model (NMSSM), the Higgs sector is extended by adding an additional doublet, and also a singlet scalar. The extended Higgs sector in NMSSM predicts seven Higgs bosons, namely the two CP odd (A_1, A_2); 3 CP even (H_1, H_2, H_3) and two charged Higgs ($H^{\pm}$). Interestingly, for a certain region of parameter space, the masses of A_1, H_1 can be found to be less than 60 GeV. Looking for such lighter states of the mass range from a few GeV to $m_H/2$ at the LHC experiments is hence an interesting area in CMS and ATLAS collaboration. Recently, quite a few searches have been carried out to look for lighter states, in the SM-like Higgs boson decay H $\rightarrow$ AA, where "A" is considered to decay to $b\bar{b}, \tau\tau, \mu\mu, \gamma\gamma$.

\par In this presentation, we will summarize our search for the exotic decays of the 125 GeV Higgs boson to a pair of light pseudoscalars "A" in the H $\rightarrow$ AA $\rightarrow$ bb$\gamma\gamma$ decay channel, using 13 TeV proton-proton collision data recorded with the CMS detector in Run-2, corresponding to an integrated luminosity of 137 fb^{-1}. The search is performed with M_A from 20-60 GeV in the VH (V=W/Z boson) production mode of the Higgs boson. The expected limits at 95\% confidence level (CL) are placed on the signal strength in this particular decay channel.

Field of contribution:

Experiment

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Study of Texture Zero Neutrino Models with Vanishing Sub-trace and their Flavor Structures

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In this work, we carry out a systematic investigation of thirty six possible structures of neutrino mass matrix, M_ν having textures of one zero element and one vanishing sub-trace taking the latest 3σ neutrino data. Correlation plots of the ratio of solar to atmospheric mass splittings, R_ν and the Dirac CP phase δ for each texture are examined and found only fourteen textures phenomenologically viable with 3σ range. The restricted ranges of δ for allowed textures are used to predict theoretically the Majorana CP Phases (α and β) which are yet to be measured experimentally. With these results, we also calculate the Majorana mass term, $|m_{ee}|$ on which the neutrinoless double beta decay rate depends, and the Jarlskog invariant, J_{cp} for the strength of CP violation and also study the correlations between the CP phases and the mixing angle θ_{23}. Besides them, we also checked the experimental compatibilities for the parameters effective electron neutrino mass m_{ν_e}, total 'sum' of neutrino masses Σ_ν. The consistency of mass orderings of textures is checked with $\frac{m_3}{m_1}$ and phenomenological identification of textures having no octant degeneracy for θ_{23}. Finally,

the flavor symmetry realization of textures is done under the symmetry group $S_3 \times Z_4$ in Type II seesaw mechanism.

Field of contribution:

Phenomenology

117

A new class of traversable wormhole metrics

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In this work, we have formulated a new class of traversable wormhole metrics. Initially, we have considered a wormhole metric in which the temporal component is an exponential function of r but the spatial components of the metrics are fixed. Following that, we have again constructed a generalized wormhole metric in which the spatial component is an exponential function of r, but the temporal component is fixed. Finally, we have considered the generalized wormhole metric in which both the temporal and spatial components are generalized exponential functions of r. We have also studied some of their properties including throat radius, stability, and energy conditions, examined singularity, the metric in curvature coordinates, effective refractive index, innermost stable circular orbit(ISCO) and photon sphere, Regge-Wheeler potential and their quasinormal modes, gravitational entropy, and determined the curvature tensor. The radius of the throat is found to be consistent with the properties of wormholes and does not contain any types of singularities. Most interestingly, we find that their throat radius is the same for the same spatial component and the same range of values of m. In addition to these, they also violate the Null Energy Condition(NEC) near the throat. These newly constructed metrics form a new class of traversable wormholes.

Field of contribution:

Theory

118

Simulation studies of event-by-event fluctuations of mean transverse momentum ($\langle p_{\mathrm{T}} \rangle$) in pp collisions at $\sqrt{s}$= 13 TeV with PYTHIA8 and HERWIG7 models

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Measurements of event-by-event mean transverse momentum ($\langle p_{\mathrm{T}} \rangle$) fluctuations are reported in terms of the integral correlator $\langle \Delta p_{\mathrm{T}} \Delta p_{\mathrm{T}} \rangle$ and skewness of the event-wise $\langle p_{\mathrm{T}} \rangle$ distribution in

pp collisions at $\sqrt{s} = 13$ TeV with the Monte Carlo event generators PYTHIA8 and HERWIG7. The final-state charged particles with transverse momentum ($p_{\rm T}$) and pseudo-rapidity (η) range $0.15 \leq p_{\rm T} \leq 2.0$ GeV/c and $|\eta| \leq 0.8$ were considered for the investigations. The correlator $\langle \Delta p_{\rm T} \Delta p_{\rm T} \rangle$ is observed to follow distinct declining trends with the average charged particle multiplicity ($\langle N_{\rm ch} \rangle$) for the PYTHIA8 and HERWIG7 models. Furthermore, both models yield positive finite skewness in low-multiplicity events. The observables are additionally studied using the transverse spherocity estimator (S_0) to comprehend the relative contributions of hard scattering (jets) and soft multi-partonic interactions (MPI). The present comparative measurements using these models would provide a better understanding of the fluctuation dynamics and construct a crucial baseline to search for non-trivial fluctuations in heavy-ion collisions.

Field of contribution:

Phenomenology

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Prompt and non-prompt production of open and hidden charm hadrons at the Large Hadron Collider using machine learning

Authors: Gagan Mohanty[1]; Kangkan Goswami[2]; Neelkamal Mallick[2]; Raghunath Sahoo[3]; Suraj Prasad[2]

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The studies of heavy flavor (charm or bottom) hadrons in relativistic collisions provide an undisputed testing ground for the theory of strong interactions, quantum chromodynamics (QCD). As the majority of the heavy flavor particles are produced in the initial stages of the heavy-ion collisions, they experience the whole QCD medium evolution. The lightest open charm meson, D^0, and hidden charm vector meson, J/ψ, are particularly useful as they are abundantly produced as compared to other open and hidden charm hadrons, respectively. The D^0 and J/ψ mesons that are either directly formed during initial scattering or as the decay products of higher charm stages are referred to as the prompt production, which is essential to probe the QCD medium. On the other hand, the non-prompt D^0 and J/ψ mesons are usually formed as the decay products of beauty hadrons and can provide a key understanding of beauty hadrons.

In this contribution, we use machine learning (ML) models to segregate the prompt and non-prompt productions of D^0 and J/ψ mesons in proton-proton (pp) collisions at $\sqrt{s} = 13$ TeV using the track-level information of the particles like an experimental environment. We have used the PYTHIA8 event generator to simulate the events for the study, which provides a good qualitative description of experimental measurements. We have considered the $D^0 \rightarrow \pi^+ K^-$ and J/$\psi \rightarrow \mu^+ \mu^-$ decay channels for our study. To separate prompt from non-prompt sector of charmonia and open charm mesons, topological production of D^0 and J/ψ are considered. We have used XGBoost, CatBoost, and Random Forest models for D^0 related studies, whereas for J/ψ, we have used XGBoost and LighGBM models. For D^0, we have used invariant mass ($m_{\pi K}$), pseudoproper time (t_z), pseudoproper decay length (c_τ), and distance of closest approach ($\mathrm{DCA}_{\mathrm{D_0}}$) as the training inputs. For J/ψ meson, the input sample is chosen keeping ALICE Run 3 muon forward tracker upgrade in mind, which includes, invariant mass ($m_{\mu\mu}$), transverse momentum, pseudorapidity, and c_τ. The machine learning models provide up to 99\% accuracy to dissect the prompt and non-prompt production of both D^0 and J/ψ. Transverse momentum, rapidity and multiplicity differential comparisons between the true and predicted values are compared to evaluate the performance of the models. Experimental comparisons are also made wherever applicable. The ML methods used in the present study can replace the traditionally used fitting method with the added advantage of track label identification. The present

ML-based identification of prompt and non-prompt charm hadrons can be useful in experiments that require precise measurements.

Field of contribution:

Phenomenology

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A family of gauge fixing conditions for studying the divergence problem of the Siegel-Zwiebach action in the massless limit

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We know that the massive symmetric rank-two tensor is closely related to the linear theory of massive gravity, within the framework of open string theory. In the present work we develop a family of gauge fixing conditions to study the divergence problem of the Siegel-Zwiebach (SZ) propagator in the massless limit. The SZ Lagrangian describes a massive rank two tensor interacting with a vector and a scalar fields in the critical dimension of the bosonic string. In the Fierz-Pauli (FP) gauge condition, the SZ Lagrangin changes to a new Lagrangian, called FP Lagrangian, which was proposed to describe the massive symmetric spin two particle. In the massless case, the FP Lagrangian has been identified as the linearized Lagrangian of Einstein's gravity. But it has been found that the propagator of FP Lagrangian in the massless limit diverges, making it unsuitable for studying massive symmetric rank two particle in small-mass limit. The new family of gauge-fixing conditions worked out here is shown to be capable of addressing this issue, neatly connecting the FP and transverse-traceless (TT) gauge conditions. It has been found that the propagator is nonsingular in the massless limit of SZ Lagrangian in TT gauge which makes it appropriate for studying massive spin two particle.

Field of contribution:

Theory

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Magnetically Induced Quarkonium Melting in a Dynamical Einstein-Born-Infeld-Dilaton Framework

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We extend the potential reconstruction technique to establish a dynamical Einstein-Born-Infeld-dilaton model, which serves as a framework for investigating the melting of holographic quarkonium under an applied magnetic field. The model's non-linearity enables the magnetic field to interact directly with the quarkonium's internal structure, bypassing the need to introduce charged flavor degrees of freedom that back-react. By calculating the melting temperature from the spectral functions, we observe a transition from inverse magnetic catalysis to magnetic catalysis occurs as the magnetic field strength rises. Additionally, we examine the impact of anisotropy induced by the external field.

Field of contribution:

Theory

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Diffusion matrix related to charmed state and a new probe for QCD critical point

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We estimate the diffusion coefficient matrix for baryon number, strangeness, electric charge, and charm quantum numbers in an interacting hadron gas. For the first time, this study provides insights into the charm current and estimates the diffusion matrix coefficient for charmed states, treating them as part of a quasi-thermalized medium. We analyze the diffusion matrix coefficient as a function of temperature and center-of-mass energy, assuming van der Waals-like interactions among hadrons, which include both attractive and repulsive forces. The diffusion coefficients are determined using the relaxation time approximation to the Boltzmann transport equation, showing good agreement with existing model calculations in the hadronic regime. We observe that at low $\sqrt{s_{NN}}$, hadrons carrying conserved charges such as baryon number (B), electric charge (Q), and strangeness (S) diffuse more rapidly compared to charmed hadrons. As a result, charm fluctuations generated in the early stages of heavy-ion collisions remain significant until freeze-out. In experiments, the net proton number cumulants are typically used as a proxy for net baryon fluctuations. However, the greater diffusion of baryons could lead to a smearing of the critical point signal. Thus, we propose using net charm number fluctuations as a new probe to locate the QCD critical point.

Field of contribution:

Phenomenology

123

Bremsstrahlung Corrections To The Lepton-Proton Scattering In Effective Field Theory

Author: Bhoomika Das[1]

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Charge asymmetry is examined by comparing the electron/muon—proton scattering with positron/anti-muon—proton scattering. This method is a sophisticated tool for investigating the two-photon exchange phenomenon, which significantly contributes to the radiative corrections to the lepton—proton scattering. The emission of real photons (Bremsstrahlung process) also contributes to the observed charge asymmetry. We present a theoretical framework and numerical analysis of soft photon emission related to charge asymmetry in lepton and antilepton scattering with protons at MUSE kinematics (i.e. at the incident momentum of lepton $p_l = 115$ MeV, 153 MeV, and 210 MeV). We have taken into account the soft-photon bremsstrahlung process and evaluated the bremsstrahlung contribution (real photon emission i.e. $e^{\pm}/\mu^{\pm}(p_l) + p(P_p) \rightarrow e^{\pm}/\mu^{\pm}(p_l') + p(P_p') + \gamma(k)$) to the elastic lepton-proton scattering process using heavy baryon chiral perturbation theory, a low-energy effective field theory for QCD. The differential scattering cross-section, evaluated here, is calculated at $\frac{1}{M}$ accuracy, where M is the mass of the proton.

Field of contribution:

Theory

124

Induced electric field due to thermoelectric effects in an evolving quark-gluon plasma

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We have estimated the induced electric field in quark-gluon plasma (QGP) due to its thermoelectric effects. At present, the relativistic heavy-ion collisions are capable of creating QGP, a locally thermalized medium composed of quarks and gluons.
During the space-time evolution of the QGP medium, interesting thermoelectric phenomena occur due to the presence of electrically charged particles (quarks) in the QGP medium. These phenomena result in the generation of an electromagnetic (EM) field within the medium, even in central heavy-ion collisions. In peripheral collisions, the presence of a spectator current at the early stage generates a transient magnetic field and disrupts the isotropy of the induced electric field. For numerical estimation of the induced electric field, we used a quasiparticle-based model that incorporates the lattice quantum chromodynamics (lQCD) equation of state (EoS) for QGP. The cooling rates used in our calculations are derived from Gubser hydrodynamic flow, while the thermoelectric coefficients—such as Seebeck, magneto-Seebeck, and Nernst coefficients—are crucial for estimating the induced electric field. Furthermore, we explore the effects of an external time-varying magnetic field on the induced electric field and also consider the quantum effects of Landau quantization. Our findings reveal that the space-time profile of the induced electric field is zero at the center and increases away from the center. During the early stages of QGP evolution, the electric field can reach a maximum value of approximately $eE \approx 1\ m_{\pi}^2$, which gradually weakens over time.

Field of contribution:

Phenomenology

125

Anisotropic flow fluctuation in presence of α-clustered structure of ^{16}O nuclei in ^{16}O-^{16}O collisions at the LHC

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Azimuthal anisotropy quantified as anisotropic flow coefficients are important observables that can provide key information about the collectivity of the system formed during heavy-ion collisions. The anisotropic flow coefficients are sensitive to both the geometrical configuration of the collision overlap region and the transport properties of the medium. Recently, hints of collectivity in small collision systems like pp and p–Pb have been reported, which are traditionally used for baseline measurements to study the quark-gluon plasma (QGP) signatures and cold nuclear matter effects in heavy-ion collisions. This makes O–O and p–O collisions interesting, as they bridge the multiplicity gap between pp, p–Pb, and Pb–Pb collisions and can provide pivotal information about the observed QGP signatures in small systems. In addition, ^{16}O is a doubly magic nucleus and possesses α-cluster nuclear configuration, where one can imagine four α-particles arranging themselves at the corners of a randomly-rotated regular tetrahedron.

In this contribution, we shall present the effect of the presence of the α-cluster nuclear configuration of ^{16}O on elliptic flow (v_2), triangular flow (v_3) and elliptic flow fluctuations in O–O collisions at $\sqrt{s_{\rm NN}} = 7$ TeV using a hybrid CGC+hydro model based on IPGlasma+MUSIC+iSS+UrQMD framework. The results of α-cluster nuclear configuration of ^{16}O are also compared with the Woods-Saxon nuclear profile. The results show an enhanced value of v_2 and v_3 in the highest multiplicity regions for the α-cluster case as compared to the Woods-Saxon profile. Further, a strong increase in the value of v_3/v_2 is observed when going from the top 10-20\% to the top 0-10\% multiplicity class for the case with α-clusters. Additionally, we find that the elliptic flow fluctuations show opposite trends with a decrease in final state multiplicity for α-cluster and Woods-Saxon nuclear density profiles. We conclude that the observables related to fluctuations are more sensitive and suited to study the effects of the α-clustered geometry in O–O collisions.

Field of contribution:

Phenomenology

126

Next-Generation Silicon Detectors for High Luminosity LHC experiments

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This talk presents the upgrade of silicon-based tracking detectors in the CMS, ATLAS, LHCb, and ALICE experiments for the HL-LHC. The different design choices of the detectors to cope with the challenges posed by the HL-LHC environment are discussed.

Field of contribution:

Experiment

127

Isolating Hard Gluon Bremsstrahlung Contributions in High-Energy Collisions.

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In high-energy collisions, understanding the contribution of hard gluon Bremsstrahlung is crucial for accurate particle interaction modeling. This study investigates the mechanisms by which hard gluon emissions influence the overall event structure and multiplicity distributions. By employing advanced simulation techniques and event generators, we systematically isolate the effects of hard gluon Bremsstrahlung from other background contributions. This provides insights into the interplay between hard and soft processes in small collision systems, enhancing our understanding of perturbative and non-perturbative QCD effects. The findings are expected to have significant implications for future experimental analyses and theoretical frameworks in high-energy physics.

Field of contribution:

Phenomenology

128

Beauty production in pp collisions at √s = 13 TeV via non-prompt D mesons

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The study of hadron production containing charm or beauty quarks in proton-proton (pp) collisions provides essential insights into the predictions of perturbative quantum chromodynamics (pQCD). The ALICE detector allows for precise measurements of non-prompt D-meson production, which serves as an effective tool to explore the production of beauty quarks in pp collisions.

This analysis presents recent results on the transverse momentum \(p_{T} \)-differential production cross section for D mesons originating from beauty-hadron decays (referred to as non-prompt D mesons). These findings are compared with those for prompt D mesons produced directly in pp collisions at center-of-mass energies of \($\sqrt{s}$ = 5.02 \) TeV and \($\sqrt{s}$ = 13 \) TeV. Additionally, the \(p_{T} \)-differential production yield ratios, such as non-prompt \(D^+/D^0 \) and \($D_s^+/(D^0+D^+)$ \), are examined, along with measurements of the fragmentation fraction ratio of beauty quarks into strange and non-strange B mesons in pp collisions, to assess their universality across different collision systems. Comparisons with pQCD predictions and other theoretical models are also included. A machine-learning-based multiclass classification algorithm is employed to distinguish D mesons arising from beauty-hadron decays for these measurements.

Field of contribution:

Experiment

129

Multi-strange particle production with ALICE at LHC energies.

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The measurements in high-multiplicity proton-proton (pp)
collisions show several features that are similar to those observed in heavy-ion collisions. In
this
respect, strangeness
production may
provide a valuable investigative tool.
Baryon-to-meson ratios have been measured differentially in p_T and show an evolution with increasing charged particle multiplicity in small systems similar to the one observed with centrality in heavy-ion collisions, where this behavior is interpreted to be strongly related to the hydrodynamical evolution of the system. Furthermore, the production rate of strange and multi-strange hadrons relative to pions exhibits a significant increase with multiplicity in pp collisions, similarly to that observed in p-A collisions. This increase is observed to be more pronounced for hadrons with a larger strangeness content.
In this study, multi-strange (Ξ ,Ω) hadron production measurements at mid-rapidity, in pp $\sqrt{s}$ = 13
TeV
collisions , will be shown as a function of charged-particle multiplicity.

Field of contribution:

Experiment

130

Exploring particle collision dynamics by studying event shape variables in small systems

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Event shape variables are crucial in high-energy physics for characterizing the geometric and kinematic properties of particle collision events. These variables help to understand the underlying dynamics of the interactions that produce different particles and can provide insights into the nature of the forces involved.

This work presents calculations of event-shape observables, specifically transverse thrust and spherocity, measured in various transverse momentum (\ (p_{T}\)) bins for small collision systems. Using primary charged particles, these measurements are generated with the EPOS event generator. The analysis focuses on the sensitivity of transverse thrust and spherocity to the underlying event properties at different \(p_{T}\) ranges, providing insight into event dynamics in small collision systems. The results aim to contribute to a deeper understanding of the underlying event structure and to distinguish between different types of events (e.g., hard scatterings versus soft interactions).

Field of contribution:

Phenomenology

131

Performance study of a new type of bakelite RPC for future High-Energy Physics Experiments

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Single-gap RPC is among the family of gaseous detectors used in high-energy physics experiments. They are known for their fast response time, high efficiency and low fabrication cost per unit area. RPCs are typically constructed using glass or bakelite plates with high bulk resistivity in the range of approximately 10ˆ9 - 10ˆ12 Ω cm. In the present work, bakelite RPC prototype is built with a new technique of linseed oil coating and has been thoroughly characterized with different gas mixtures and operating in both the avalanche and streamer mode of operation using cosmic rays. The efficiency, noise rate, time resolution, long-term stability, radiation hardness are tested. The effect of ambient parameters on the performance of the chamber are also tested. Performance of the detector is also compared for operation in gas flow mode and fixed gas mode. The details of the detector fabrication procedure and the test results will be presented.

Field of contribution:

Experiment

132

Search for jet quenching with high p_{T} hadron azimuthal anisotropy using subevent cumulants in pPb collisions at CMS

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Measurements at the LHC have provided evidence for collective behavior in high-multiplicity proton-lead (pPb) collisions through multiparticle correlation techniques. Yet, no conclusive evidence of jet quenching, indicating the energy loss of high-p_{T} partons as they traverse the medium, has been detected in pPb. This raises the intriguing question: How can a medium described by hydrodynamics, and that significantly modifies the distribution of final-state hadrons, yet has no significant impact on the distribution of high-pT particles? To investigate this, a comprehensive study of differential Fourier coefficients (v_n) in particle transverse momentum (p_{T}) and event multiplicity is presented in pPb collisions recorded by the CMS experiment at a nucleon-nucleon center-of-mass energy $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV. In particular, new measurements of p_{T}-differential multiparticle cumulants using the subevent method probes an extended phase space region up to a high particle p_{T}.

Additionally, we compare the results between pPb and PbPb collisions in the same multiplicity window. This comparison will help assess similarities and differences in the medium's interaction with high-p_T particles in these two collision types.

Field of contribution:

Experiment

133

The role of QCD-inspired model in deciphering semileptonic and radiative B_c decays

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We conduct an analysis of electromagnetic and semileptonic decay modes of B_c mesons using a QCD-inspired phenomenological model. In light of recent observations of anomalies in LHC involving the $\mathcal{R}$-Ratios, τ-polarization ($\mathcal{P}\tau$), and forward-backward asymmetry ($\mathcal{A}_{FB}$) —which are particularly sensitive to New Physics, we investigate observables for the decay channels: $B_c \to \eta_c(J/\psi)\tau\nu_\tau$ and $B_c \to D(D^*)\tau\nu_\tau$ within a potential model framework. We also study the radiative channel: $B_c^* \to B_c\gamma$ where we considered a typical case of $B_c^*(1S) \to B_c(1S)\gamma$, our predicted decay width is found quite sensitive to the mass difference between B_c^* and B_c mesons which may help in determining the mass of B_c^* experimentally. Additionally, we calculate the vector, pseudoscalar and electromagnetic form factors, examining their q^2 dependence for these transitions in both ground and radially excited states. Given the fluctuating appearance and disappearance of flavor anomalies in the Run 3 data collection period, this study seeks to identify different measurement tools, capable of probing the limited regions of theoretical parameter space

Field of contribution:

Phenomenology

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Strong Decay of Light Baryons

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The hypercentral Constituent Quark Model (hCQM) has been employed to obtain the resonance masses of light, strange baryons starting from N to Ω [1]. The model has linear potential with higher order correction terms with spin-orbit term to best possible predict the spectra of excited states. With these, the strong decays play a significant role towards the understanding of underlying properties for a given state. The pion decay channels have been dominantly observed in almost all the N^* states [2]. However, there are other meson exchange resulting in the decay of N with mesons η, ρ, ω etc.

Riska et al. have implemented chiral quark model to describe pion to nucleon coupling constant[3]. Experiments have shown a significant coupling of N^*(1535) to ηN channel. In constituent quark model, N(1535)$\frac{1}{2}^-$ is considered to be mixed state of $P^2\frac{1}{2}-$ and $P^4\frac{1}{2}-$. An attempt has been made towards the study of such decay channels through the established chiral quark model and coupling constants obtained therein for the$N^*(1535) \rightarrow N\eta$.
The results for decay widths have been obtained for the resonance masses predicted using the hCQM model.

References:
1. C. Menapara and A. K. Rai, Few-Body Syst 65, 10 (2024)
2. S. Navas et al., [Particle Data Group], Phys. Rev. D 110, 030001 (2024)
3. D. Riska and G. Brown, Nucl. Phys. A 679, 577 (2001)

Field of contribution:

Phenomenology

135

Search for high mass scalar decays to ZZ Final States using Run2 dataset of CMS experiment

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A search for a high mass scalar decays to a pair of Z bosons (H ⟶ ZZ) is performed using proton-proton collision data from the Run2 dataset of CMS experiment at the Large Hadron Collider, CERN. The ZZ final state provides a clean and sensitive probe for both Standard Model Higgs processes and potential new physics phenomena, such as heavy resonances decaying to Z boson pairs. Advanced techniques, including kinematic event categorization and machine learning methods, are employed to maximize the discovery potential and optimize the signal-to-background separation. The results are interpreted within the Standard Model framework and extended to set limits on new physics scenarios, including models predicting additional scalars.

Field of contribution:

Experiment

136

Characterization of MALTA Monolithic pixel detectors

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Future collider experiments demand pixel detectors capable of withstanding higher energy and luminosity. In response, MALTA, a novel monolithic active pixel detector, has been developed with a

cutting-edge readout architecture, offering exceptional radiation tolerance, high hit rates, superior spatial resolution, and precise timing. Developed with 180nm CMOS imaging technology. MALTA integrates both the sensor and readout electronics into a single silicon wafer, demonstrating significant potential as a next-generation detector. To optimize sensor performance prior to deployment, comprehensive electrical characterization has been conducted. This study includes comparative DAC analyses of the second generation of MALTA sensors (MALTA2) with varying thicknesses (300 µm and 100 µm), providing valuable insights for future performance improvements. The research has been conducted using the setup at IIT Madras.

Field of contribution:

Experiment

137

Resistive plate chamber-based tracking system for cosmic-ray muon radiography applications

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Muon radiography is an imaging technique based on the absorption of atmospheric muons. At NISER, we are building a muon telescope for muon radiography applications. The telescope is in modular form comprising four planes. Each plane is made of an acrylic chamber housing a Resistive Plate Chamber (RPC) as tracking element and PCB based readout boards to provide X and Y position of the muon hit. The design goal of this telescope is to be portable and autonomous, in order to take data in places that are not easily accessible, such as to investigate cavities/shafts present in railway tunnels, archaeological cultural heritage sites, etc.

A muon telescope of the proposed geometry has been simulated in Geant4. A Lead block of size 40 × 40 × 20 cm3 is placed 250 cm above the first plane of the muon telescope. At 10 cm above the Lead block cosmic-ray muons are generated using EcoMug generator. Two different muon counts are measured using the telescope, the number of muons with Lead block between muon generator and telescope, and without Lead block. The image of Lead block is produced by measuring the difference in these two counts.

For building the proposed muon telescope, four glass RPCs and four acrylic chambers have been built. The RPCs are operated in the avalanche mode and characterized using PCB based readout panel, which showed a muon detection efficiency > 95 %. The PETIROC and FPGA based data acquisition system will be used to count the muon tracks from the RPCs. The air-tightness studies of an acrylic chamber have been carried out. The design aspects of muon telescope, and results from simulation studies and RPC performance tests will be discussed in the symposium.

Field of contribution:

Experiment

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Connecting Dark Matter Signals from Lepton Colliders to Reheating Temperature

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Dark matter (DM) genesis via Ultraviolet (UV) freeze-in embeds the seed of reheating temperature and dynamics in its relic density. This talk presents a novel framework for deducing the Universe's reheat temperature from collider signals associated with DM production. Lepton colliders excel in DM searches due to their well-defined center-of-mass energy and low hadronic contamination, facilitating precise missing energy measurements essential for detecting DM candidates. The mono-photon signal from MeV-scale feebly interacting massive particles (FIMPs) at electron-positron colliders enables the inference of a low-scale reheating temperature, particularly under the assumption of instantaneous inflaton decay. A similar connection can be drawn when the inflaton decays with a finite width, extending the applicability of this framework to non-instantaneous decay scenarios.

Field of contribution:

Phenomenology

139

Investigating the Mass spectra of Fully strange tetraquark

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Co-authors: Ajay Kumar Rai [2]; Juhi Oudichhya

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This work investigates the mass spectra of fully strange tetraquarks ($ss\bar{s}\bar{s}$) using Regge Phenomenology, modeling these tetraquarks as diquark-antidiquark pairs. We employ a quasi-linear Regge trajectory ansatz in the $(,{}^2)$ plane, where J represents the total angular momentum, and □ denotes the mass. By focusing exclusively on strange quarks, we derive relations for the intercepts and slope ratios of Regge trajectories, aiding in the prediction of ground and excited states masses. This approach aims to illuminate the behavior of fully strange tetraquark states in terms of angular momentum and mass, offering new insights into the structure and dynamics of exotic hadrons within the strange sector. Our findings contribute to the broader understanding of multi-quark states and present a framework for interpreting possible resonance states observed in experimental data.

Field of contribution:

Phenomenology

140

ICARUS at the Short-Baseline Neutrino program: first results

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The ICARUS collaboration employed the 760-ton T600 detector in a successful three-year physics run at the underground Gran Sasso National Laboratory (LNGS), performing a sensitive search for LSND-like anomalous ν_e appearance in the CERN Neutrino to Gran Sasso beam. This contributed to the constraints on the allowed neutrino oscillation parameters to a narrow region around 1 eV^2. After a significant overhaul at CERN, in July 2017, the T600 detector was shipped and installed at Fermilab. In 2020, the cryogenic commissioning began with detector cooling, liquid argon filling and recirculation. ICARUS then started its operation, collecting the first neutrino events from the Booster Neutrino Beam (BNB) and the Neutrinos at the Main Injector (NuMI) beam off-axis, which were used to test the ICARUS event selection, reconstruction and analysis algorithms. ICARUS successfully completed its commissioning phase in June 2022, moving then to data taking for neutrino oscillation physics, aiming at first to either confirm or refute the claim by Neutrino-4 short-baseline reactor experiment. In addition, ICARUS will perform measurement of neutrino cross sections in liquid Argon with the NuMI beam and conduct several Beyond Standard Model (BSM) searches. After the first year of operations, ICARUS will search for evidence of sterile neutrinos jointly with the Short-Baseline Near Detector (SBND), within the Short-Baseline Neutrino (SBN) program. In this presentation, preliminary results from the ICARUS data with the BNB and NuMI beams are presented both in terms of performance of all the ICARUS subsystems and their capability to select and reconstruct neutrino events.

Field of contribution:

Experiment

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Probing a new regime of ultra-dense gluonic matter using high-energy photons with the CMS experiment.

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In ultraperipheral collisions (UPCs) involving relativistic heavy ions, the production of heavy-flavor coherent vector mesons through photon-nuclear interactions is a key focus due to its direct sensitivity to the nuclear gluon density. Experimental measurements, however, face a two-way ambiguity as each of the symmetric UPC nuclei can act as both a photon-emitter projectile and a target. This ambiguity hinders the separation of contributions from high- and low-energy photon-nucleus interactions, restricting our ability to probe the extremely small-\(x\) regime where nonlinear QCD effects are anticipated. We will be showing the measurement of coherent J/Ψ photoproduction, addressing the two-way ambiguity by employing a forward neutron tagging technique in UPC PbPb collisions at 5.02 TeV. Overall the study focuses on the dominance of gluons in nuclear matter probed at higher energies.

Field of contribution:

Experiment

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Connecting leptogenesis, dark matter and gravitational waves via discrete symmetry-breaking

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We investigate a model connecting the neutrino sector and the dark sector of the universe through a mediator ϕ. This mediator is stabilized by a discrete $\mathcal{Z}_4$ symmetry, which, upon ϕ developing a non-zero vacuum expectation value (v_ϕ), reduces to a remnant $\mathcal{Z}_2$ symmetry. Within this framework, the observed baryon asymmetry of the universe is explained by additional (scattering) contributions to the standard Type-I leptogenesis mechanism. The symmetry-breaking scale (v_ϕ) not only links the neutrino sector and the dark sector but also has the potential to produce gravitational wave signals (via domain wall annihilation) detectable by current and future experiments.

Field of contribution:

Phenomenology

143

New physics search via angular distribution of $B \to D^* \ell \nu_\ell$ decay in the light of the new lattice data

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In this article, we investigate the potential of the angular distribution of the $B \to D^* \ell \nu_\ell$ process to search for new physics signals. The Belle collaboration has analysed it to constraint V_{cb} and the $B \to D^*$ form factors, under the assumption of the Standard Model. With the newly released lattice QCD data, we can perform a simultaneous fit of the form factors, V_{cb} as well as new physics parameters. We use the Belle data and the lattice data to constrain right-handed new physics. In addition, we also generate unbinned pseudo-dataset and perform a sensitivity study on {more general new physics} models, using the lattice data.

Field of contribution:

Phenomenology

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Latest Constraints on Three-Flavor Neutrino Oscillation Parameters from the NOvA Experiment.

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NOvA, is a two-detector, long-baseline neutrino oscillation experiment located at Fermilab, Batavia, IL, USA. The NOvA experiment was designed primarily to constrain neutrino oscillation parameters by analyzing $\nu_\mu(\bar{\nu}_\mu)$ disappearance and $\nu_e(\bar{\nu}_e)$ appearance data observed at the far detector. The Neutrinos at Main Injector (NuMI) beamline at Fermilab provides a high purity beam of neutrinos and anti-neutrinos to the experiment. The NOvA experiment consists of two functionally identical, finely granulated liquid tracking calorimeters, both situated 14.6 mrad off-axis to the beam direction. The NOvA near detector, situated 100 meters underground and 1 kilometer from the beam source, detects the non-oscillated $\nu_\mu(\bar{\nu}_\mu)$ and beam $\nu_e(\bar{\nu}_e)$ events. The far detector, located in Ash River, MN, USA, 810 kilometers from the beam source, records the non-oscillated $\nu_\mu(\bar{\nu}_\mu)$ and the oscillated $\nu_\mu(\bar{\nu}_\mu) \to \nu_e(\bar{\nu}_e)$ events. The most recent measurements of three flavor neutrino oscillation parameters based on an analysis of the data collected from neutrino-beam exposure of 26.60×10^{20} POT and anti-neutrino beam exposure of 12.50×10^{20} POT including an additional low energy ν_e sample, will be presented in this talk.

Field of contribution:

Experiment

145

Linking Low and High-Energy CP Violation through Biunitary Parametrization

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This study connects low and high-energy CP violations within the biunitary parametrization framework, examining their correlations to bridge theoretical predictions and experimental observations. Through biunitary parametrization, low-energy observables are expressed in terms of high-energy parameters, and qualitative and quantitative analyses are conducted. Constraints from neutrinoless double beta decay ($0\nu\beta\beta$) and neutrino oscillation data are derived for θ_R and ϕ_R, enabling a structured examination of the leptogenesis scenario. By considering CP violation as a unifying element across energy scales, we visualize the CP asymmetry parameter for leptogenesis concerning the effective small neutrino mass ($\tilde{m}1$), identifying three potential washout regimes—weak, moderate, and strong—corresponding to ϵ_1 values between 10^{-11} and 1. Our quantitative findings suggest Dirac mass values for a common correlation of low and high-energy CP violation to be $m1 \approx 3 \times 10^6$ eV, $m_2 \approx 3 \times 10^8$ eV, and $m_3 \approx 1.9 \times 10^9$ eV, supporting a robust connection between energy scales. This framework strengthens the theoretical basis for CP asymmetry studies and provides specific Dirac mass predictions to guide experimental testing, offering new insights into the mechanisms underlying CP violation. These results enhance our understanding of how CP asymmetry operates in different washout scenarios, advancing a unified perspective on CP violation across particle physics and potentially guiding future experiments in probing the role of CP violation in the early universe.

Field of contribution:

Phenomenology

146

The Role of Adiabatic Sound Speeds in Neutron Star Radial Oscillations and Stability

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In gravitational wave astronomy, radial oscillations help to probe the internal structure and stability of neutron stars (NSs). This study examines static NS models with hadronic and hybrid equation of states (EOSs), focusing on the out-of-equilibrium fluid composition to analyze radial perturbations. Adiabatic sound speeds show smoother trends than equilibrium sound speeds, with the f-mode frequencies differing notably.
Our Mass-Radius analysis indicates that adiabatic conditions allow the stable branch to extend to higher masses, possibly explaining the radius measurements of high-mass NSs such as PSR J0740 + 6620. This extension of the stability limit for adiabatic cases solely depends on the compositions, the different EOSs carried with their models. These findings emphasize the importance of adiabatic effects on NS stability and dynamics, providing insights into observable properties and stability limits.

Field of contribution:

Phenomenology

147

Gauss-Bonnet AdS planar and spherical black hole thermodynamics and holography

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In this work, we extend the study in \href{https://link.springer.com/article/10.1007/JHEP11(2022)013}{JHEP11(2022)013 incorporating the AdS/CFT duality to establish a relationship between the local temperatures (Tolman temperatures) of a large (AdS) spherical and a (AdS) planar Schwarzschild black hole near the AdS boundary considering Gauss-Bonnet curvature correction in the gravitational action. We have shown that the higher curvature corrections appear in the local temperature relationship due to the inclusion of Gauss-Bonnet term in the bulk. By transforming the metric into Fefferman-Graham form, we have calculated the energy density of the conformal fluid at the boundary. The obtained result contains finite coupling corrections which are holographically induced by the Gauss-Bonnet curvature correction in the bulk theory. Following the well known approach of fluid/gravity duality, the energy density of the conformal fluid at the boundary is then compared with the black body radiation energy density. This comparison shows that the energy density is proportional to the temperature of the conformal fluid. The temperature of the conformal fluid is then shown to be related

to the Tolman temperature of the black hole which then eventually helps us to establish both the Hawking temperature and Tolman temperature relationship between large spherically symmetric and planar Schwarzschild black holes in Gauss-Bonnet gravity near the AdS boundary.

Field of contribution:

Theory

148

Effect of α-clustering on photon flow in O+O collisions at 7 TeV

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Co-authors: Pingal Dasgupta ; Rupa Chatterjee ; Sidharth Kumar Prasad [1]

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In relativistic nuclear collisions, spatial anisotropies characterized by initial eccentricity, triangularity, and higher-order eccentricities arise from the geometry of the collision and fluctuations in the initial energy density distribution. These spatial anisotropies subsequently manifest as momentum anisotropies in the final-state particles through the collective expansion of the hot and dense medium produced in such collisions. The presence of cluster structures in light nuclei, such as 7Be, 9Be, 12C, and 16O, induces nuclear deformities, leading to significant spatial anisotropies in the overlap region when collided at relativistic energies.

Recent studies have explored the potential to investigate α-cluster structures in light nuclei by examining final state observables in relativistic nuclear collisions. A recent proposal for dedicated 16O-16O collision runs at 7 TeV at the LHC offers the opportunity for experimental verification of cluster structures at such energies. Moreover, the system size of 16O-16O collisions is comparable to high-multiplicity proton-proton (pp) and peripheral lead-lead (Pb-Pb) collisions, providing a unique opportunity to investigate the origins of collective behavior in small collision systems.

In this work, we investigate the initial state produced in collisions of α-clustered oxygen nuclei at 7 TeV assuming tetrahedral structures. We use GLISSANDO initial conditions and study the resulting flow observables for photons within the framework of the MUSIC hydrodynamics model and state-of-the-art rate of photon production. Our study compares these results with those from unclustered 16O-16O collisions, revealing significant qualitative and quantitative differences in photon observables between the two cases.

We demonstrate that photon observables in 16O-16O collisions can serve as a valuable probe for investigating the nucleon-level geometry as well as the initial state produced in relativistic nuclear collisions.

Field of contribution:

Phenomenology

149

Study of net-kaon fluctuations in FAIR energies using the PHQMD model

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One of the primary objectives of high-energy nuclear collisions is to investigate the phase structure of strongly interacting nuclear matter and understand the Quantum Chromodynamics (QCD) phase diagram. This diagram is mapped by temperature (T) and baryon chemical potential (μ_B). Lattice QCD calculations at zero μ_B predict a smooth crossover between the hadronic phase and the Quark Gluon Plasma (QGP) phase. A critical point is expected to mark the boundary between the first-order phase transition and the crossover region. Event-by-event fluctuations in nuclear collisions allow us to probe the correlation length (ξ) of the system, which captures how variables change together over space and time. Near a critical point, this correlation length becomes significant, even diverging in an infinite system, making fluctuation measurements a powerful tool in the search for the QCD critical point. Fluctuations of conserved quantities like net-baryon (B), net-charge (Q), and net- strangeness (S) are key observables in the search for the QCD phase transition and the critical point. The Compressed Baryonic Matter (CBM) experiment at FAIR, Darmstadt, offers a unique opportunity to study the model-predicted first-order phase transition from hadronic matter to QGP with high precision by using its exceptionally high collision rates of up to 10 MHz, far surpassing previous experiments.

In this work, we present the results on net-kaon fluctuations for Au+Au collisions in the range of collision energy 3.5-19.6 GeV using the newly developed Parton-Hadron-Quantum-Molecular-Dynamics (PHQMD) model [1]. This study provides novel insights into net-kaon fluctuation behavior within the CBM energy range. The results have been compared with those obtained using the acceptance of Solenoidal Tracker at RHIC (STAR) experiment. PHQMD is a versatile model for studying heavy-ion collisions and cluster formation across diverse energies, integrating Parton-Hadron-String-Dynamics (PHSD) for QGP interactions and Quantum Molecular Dynamics (QMD) for baryon dynamics. These clusters form through dynamic potential interactions, with regions above 0.5 GeV/fm^3 knowing as the QGP phase where hadrons dissolve into quarks and gluons.

Our findings will help to establish a baseline for understanding net-kaon and net-strangeness fluctuations, which are crucial for probing potential critical behaviors near the critical end point in the CBM energy range.

Ref: 1. J. Aichelin et al., Phys. Rev. C 101 4, 044905 (2020)

Field of contribution:

Phenomenology

150

Study of heavy-quark production and hadronization in small collision system at the LHC with ALICE

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Heavy quarks (charm and beauty) have masses much larger than the QCD scale parameter. Due to this they are typically produced in hard scattering processes with large Q^2 in hadronic collisions, and offer a unique perspective to study the transition from quark to hadrons in these collision systems. Recent production measurements of heavy-flavour baryons and mesons in proton-proton collisions at midrapidity show heavy-flavour baryon-to-meson ratios significantly higher than those measured in e+e− collisions, which challenges the universality of fragmentation functions across different collision systems. Thus, further and more precise measurements of heavy-flavour production-yield ratios are crucial to study the heavy quark hadronization in a partonic rich environment like

the one produced in pp collisions at the LHC energies. In p–Pb collisions, a modification of the hadronization mechanisms could be present due to cold nuclear matter effects and possible collective
phenomena.
In this contribution, measurements of the meson-to-meson and meson-to-baryon ratios withALICE in pp and p–Pb collisions will be shown. A systematic comparison between data and models will help to understand heavy-quark hadronization in pp and p–Pb collisions. To conclude, the first studies of heavy-flavour hadron reconstruction using large data sample of pp collisions at $\sqrt{s}$ = 13.6 TeV from Run 3 will also be presented.

Field of contribution:

Experiment

151

Exploring the Effects of Dark Matter - Dark Energy Interaction on Cosmic Evolution in Viscous Dark Energy Scenario

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We explore the influence of interactions between dark matter and dark energy on the cosmic evolution of the Universe within a viscous dark energy (VDE) framework. Moving beyond traditional interacting dark energy (IDE) models, we propose a generalized IDE model adaptable to diverse IDE scenarios via IDE coupling parameters. In order to investigate deviations from ΛCDM across cosmic epochs by highlighting how viscous and the interaction between dark matter and dark energy impact cosmic density and expansion rates, we consider a model agnostic form of VDE. Eventually we perform a Bayesian analysis using the Union 2.1 Supernova Ia dataset and Markov Chain Monte Carlo (MCMC) sampling to obtain the optimal values of model parameters. This comprehensive analysis provides insights about the interplay between viscous and IDE in shaping the Universe's expansion history.

Field of contribution:

Phenomenology

152

Spectroscopy of hidden-bottom Pentaquarks.

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Considering the discoveries of pentaquark structures such as P_{\psi s}^\Lambda(4338)^0, P_c(4380), and P_c(4450), we conducted a spectroscopic analysis of hidden-bottom pentaquarks. Using special unitary group representations, we systematically classified these hidden-bottom pentaquarks into two distinct configurations within the SU(3) flavor representation: the octet and the decuplet. In this study, we utilized an extended form of the Gursey-Radicati (GR) mass formula and the effective mass scheme to estimate the masses of hidden-bottom pentaquarks. Additionally, our analysis extends to estimating the magnetic moments, employing the effective mass and screened charge schemes. Our findings, encompassing calculations of masses and magnetic moments, show a reasonable alignment with current theoretical predictions.

Field of contribution:

Theory

153

Study on fluctuation of fluctuations in pp collisions at LHC energy

Authors: Tumpa Biswas [1]; Dibakar Dhar[1]; Prabir Kumar Haldar[1]

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This study presents an analysis of the erraticity of produced particles in proton-proton (*pp*) interactions at a center-of-mass energy of √s = 13 TeV. We utilized datasets generated by PYTHIA v8.3 for our analysis. We calculated several parameters related to chaotic behavior in event space fluctuations, including $_q$, $_q$, and the entropy index $\tilde{}_q$. The results indicate the presence of erratic fluctuations. Additionally, our analysis suggests a potential quark-hadron transition and a non-thermal phase transition. The results from our study are also compared with previous experimental data sets of emulsion data at CERN SPS (i.e. A GeV/c) energy and during this comparison, we have found that the values of entropy index are quite high in the case of PYTHIA generated data indicating that at CERN LHC energies the choticity is significantly larger.

Field of contribution:

Phenomenology

154

Measurement of WZ production cross section at 13.6 TeV

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The inclusive WZ production cross section is measured in proton-proton collisions at a center-of-mass energy of 13.6 TeV, using 34.7 fb^{-1} of data recorded in 2022 with the CMS detector at the LHC. This analysis focuses on multileptonic final states and uses a simultaneous likelihood fit to the number of events in four different lepton categories. The WZ process is sensitive to triple gauge

couplings that could modify the WZ production cross section and provide evidence for beyond-the-Standard Model physics.

Field of contribution:

Experiment

155

MALTA2 Characterization

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The MALTA sensor is an advanced monolithic pixel detector created to withstand the rigorous conditions of high-energy physics experiments, like those at the Large Hadron Collider (LHC). Unlike conventional pixel sensors that rely on separate readout electronics, MALTA combines the sensor and readout circuitry on a single silicon wafer. This integrated monolithic design increases compactness, enhances resolution, and makes the sensor highly efficient in speed and radiation resistance. Extensive electrical testing has been undertaken to fine-tune these sensors before they are implemented in actual detectors. The findings from the electrical characterization and DAC analysis of the sensor, performed using the setup at IIT Madras, will be presented.

Field of contribution:

Experiment

156

Study of the strong decay of Ξ_c^' baryon.

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We present an analysis of the strong decay of the $\Xi_c^{'}$ baryon in the 1P state within the framework of Heavy Hadron Chiral Perturbation Theory (HHChPT), which effectively combines chiral and heavy quark symmetries. This theoretical approach well describes the strong decays of S-wave charmed baryons. Our calculations of the decay width of $\Xi_c^{'}$ demonstrate the validity of HHChPT, as our results show good agreement with empirically measured decay widths. Furthermore, the mass and decay width of the $\Xi_c(2923)$ provide the evidence for its spin-parity assignment of $\frac{3}{2}^-$. This work contributes to the ongoing understanding of charmed baryon states and their decay mechanisms.

Field of contribution:

Phenomenology

157

Exploring Neutrinoless Double Beta Decay in the 3+3 Model

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Sterile neutrinos, non-interacting fermion singlets, are crucial in BSM physics, addressing oscillation anomalies and facilitating neutrino mass generation via type-I seesaw mechanism. We investigate a model extending the SM with 3 sterile neutrino states, employing a specific (6×6) unitary mixing matrix. Analytically deriving the masses of added sterile states using the exact seesaw relation, we study their impact on
$lvertm_{ee}$
$rvert$, relevant to neutrinoless double beta decay $(0\nu\beta\beta)$ searches. Exploring the parameter space of
$lvertm_{ee}$
$rvert$ with consideration of the present and future sensitivity of $0\nu\beta\beta$ decay searches, we incorporate constraints from charged lepton flavor violation (cLFV) and non-unitarity effects, including additional CP-violating phases and active-sterile mixing angles. Our analysis also assesses the branching ratio of $\mu \to e\gamma$, a key cLFV process, within this framework.

Field of contribution:

Phenomenology

158

Lattice QCD study of quarkonia at finite temperature

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Quarkonia, the bound states of heavy quark-antiquark pairs, is an imortant probe for studying the quark-gluon plasma (QGP). We investigate the fate of in-medium quarkonia bound states in the QGP by studyng their spectral functions from lattice QCD. Specifically, we study the quarkonia correlators in the pseudoscalar and vector channels at temperatures $1.2T_{pc}$, $1.4T_{pc}$, and $1.6T_{pc}$. To regularize the ill-posed nature of spectral reconstruction, we utilize physics-motivated information. Near the threshold, the spectral function is obtained using a non-perturbatively determined complex potential, while in the ultraviolet (UV) limit, we used the vacuum spectral function. We find that this combination effectively describes the pseudoscalar correlator on the lattice. However, an additional transport contribution is needed in the infrared (IR) region to fully describe the vector correlator. In the bound state region, our results show that the charmonium state has already begun to melt within the temperature range considered, indicated by a large thermal decay width induced by the imaginary part of the complex potential. Conversely, the bottomonium state remains intact, as evidenced by a sharp bound state peak.

Field of contribution:

Theory

159

Resonant detectors of gravitational wave in the linear and quadratic generalized uncertainty principle framework.

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In this work, we consider a resonant bar detector of gravitational waves in the generalized uncertainty principle (GUP) framework with linear and quadratic momentum uncertainties. The phonon modes in these detectors vibrate due to the interaction with the incoming gravitational wave. In this uncertainty principle framework, we calculate the resonant frequencies and transition rates induced by the incoming gravitational waves on these detectors. We observe that the energy eigenstates and the eigenvalues get modified by the GUP parameters. We also observe non-vanishing transition probabilities between two adjacent energy levels due to the existence of the linear order momentum correction in the generalized uncertainty relation. We finally obtain bounds on the dimensionless GUP parameters using the form of the transition rates obtained during this analysis.

Field of contribution:

Theory

160

Search for higher mass exotic resonances through KK decay channel at $\sqrt{s} = 13.6$ TeV with ALICE

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The Standard Model (SM) of particle physics is the most successful theory in describing fundamental particles and their interactions. It characterizes ordinary hadronic matter as consisting of quark-antiquark pairs or three-quark combinations, forming mesons and baryons. Beyond this, the SM also allows the existence of exotic hadrons composed of more than three quarks or a bound state of gluons. One notable example is the glueball, which is made entirely of gluons arising from gluon self-interactions. Lattice QCD calculation predicts the mass of the lightest scalar glueball to be in the range of 1500–1700 MeV/c^2 having quantum numbers, J^{PC} = 0^{++}. However, the experimental search for glueballs is challenging due to their mixing with nearby mesonic states sharing identical quantum numbers. The large statistics data collected by the ALICE detector during Run 3 at the highest centre-of-mass energy offers a unique opportunity to explore the glueball hypothesis, study its properties and internal structure, and probe the standard model predictions. This report will present the invariant mass distributions of higher-mass resonances in the range 1000–3000 MeV/c^2. The analysis is performed through the decay channels $\mathrm{K^0_S K^0_S}$ and $\mathrm{K^+K^-}$ in pp collisions at $\sqrt{s}$ = 13.6 TeV using ALICE detector at midrapidity.

Field of contribution:

Experiment

161

New physics searches in exotica sector at CMS experiment

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The proposed talk aims to provide an overview of the research highlights from the CMS experiment at CERN-LHC to explore the exotic physics beyond the Standard Model of particle physics. The recent findings from new physics searches in the exotica sector will be presented using the LHC proton-proton collision dataset collected during the Run 2 and Run 3, corresponding to a center-of-mass energy of 13 TeV and 13.6 TeV, respectively.

Field of contribution:

Experiment

162

An overview of the CMS High Granularity Calorimeter

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Calorimetry at the High Luminosity LHC (HL-LHC) faces two enormous challenges, particularly in the forward direction: radiation tolerance and unprecedented in-time event pileup. To meet these challenges, the CMS Collaboration is preparing to replace its current endcap calorimeters for the HL-LHC era with a high-granularity calorimeter (HGCAL), featuring a previously unrealized transverse and longitudinal segmentation, for both the electromagnetic and hadronic compartments, with 5D information (space-time-energy) read out. The proposed design uses silicon sensors for the electromagnetic section and high-irradiation regions (with fluences above 10^{14} neq/cm^2) of the hadronic section , while in the low-irradiation regions of the hadronic section plastic scintillator tiles equipped with on-tile silicon photomultipliers (SiPMs) are used. The full HGCAL will have approximately 6 million silicon sensor channels and about 240 thousand channels of scintillator tiles. This will facilitate particle-flow-type calorimetry, where the fine structure of showers can be measured and used to enhance particle identification, energy resolution and pileup rejection. In this talk we present the ideas behind the HGCAL, the current status of the project, the lessons that have been learnt, in particular from beam tests as well as the design and operation of vertical test systems and the challenges that lie ahead.

Field of contribution:

Experiment

163

Application and Utilization of GEM Detectors in Radiation Imaging

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With its profound ability to detect particles efficiently and provide excellent timing and spatial resolutions, the Gas Electron Multiplier (GEM) detector has become a highly useful technology in the radiation imaging technique. The large-size imaging detectors can be easily fabricated with GEM detectors due to its low cost. These imaging detectors can be utilized for cargo imaging, soil and clay imaging for agriculture purposes, etc. In this work, we explore the application of the GEM detector in geophysical studies, particularly for the detection and analysis of the materials beneath the soil surface. The use of GEM detectors in clay studies offers a unique advantage due to their ability to identify minute variations in density and composition, which are crucial for identifying buried objects. Also, it proves valuable in agriculture by quantitative measurement of density and gauging moisture levels in soil, which is vital for crop health. We will discuss these practical applications of GEM detectors with initial results obtained from prototypes, which show that the GEM detector, renowned for its precision, plays a vital role in both security and agriculture.

Field of contribution:

Experiment

164

Advancements in Portable Gas Leakage Detection Systems for Enhanced Safety in Gaseous Detector

Author: Bhanu Thakurani[1]

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The gain of gaseous detectors like GEM detectors depends upon the concentration of gas mixtures, temperature, and pressure inside the gas volume. For this reason, it is important to know that the gas leakage from the detector can cause fluctuation in the pressure and temperature, and it can affect the gain of the detector. In this talk, we present the development of the high-sensitivity gas sensor aimed at ensuring the operational integrity of gaseous detectors. The sensor is designed to detect even minute variations in CO2 levels, allowing for precise leakage detection during detector operation. Its high precision and reliability make it an indispensable tool in maintaining the gas environment stability required for optimal detector performance. In addition to GEM, the sensor is applicable across a wide range of gaseous detectors used in particle physics experiments and other research fields. It is also widely used for safety purposes in industries. This sensor technology can significantly enhance detector safety, providing real-time monitoring and early warning of potential gas leaks, thus ensuring the integrity of experimental setups.

Field of contribution:

Experiment

165

Probing Final State Effects in Relativistic Heavy-Ion Collisions via Elliptic Flow and Production measurement of $K^{*0}(892)$ and $\phi(1020)$ Resonances in Pb-Pb Collisions with ALICE

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Hadronic resonances serve as valuable probes for investigating the late-stage evolution of the system formed in ultra-relativistic heavy-ion collisions. Since the lifespans of resonances are comparable to the lifetime of the hadronic phase, they are affected by the competing re-scattering and regeneration mechanisms, which may alter their momentum distributions and can result in the suppression and enhancement of their measured yields, respectively. These effects can be investigated by analyzing the yield ratio of resonances to their stable hadrons. Previous ALICE results on K^{*0} and ϕ measurements in Pb–Pb collisions at 5.02 TeV have suggested the dominance of the re-scattering effect.

Another crucial observable offering insights into final state effects is the measurement of elliptic flow, which characterizes the azimuthal anisotropy of particle emission in the transverse plane of non-central heavy-ion collisions. Late-stage hadronic re-scattering can modify the momentum distributions of resonances, affecting the observed elliptic flow. Therefore, measuring the elliptic flow of resonances like K^{*0} and ϕ, and comparing them with other hadrons enables a detailed study of re-scattering effects.

In this contribution, we present the latest ALICE results from Run 3. The measurement of elliptic flow and production of K^{*0} and ϕ resonances in Pb–Pb collisions will be shown. The results will be discussed with the ALICE findings from Run 2 data.

Field of contribution:

Experiment

166

Variation of SiPM signal shape as a function of over voltage and temperature

Author: Gobinda Majumder[1]

Co-authors: Mandar Saraf [2]; Raj Shah [2]; S. Pethuraj

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The prototype detector of the ICAL experiment at the India-based Neutrino Observatory, the mini-ICAL
is in operation at the IICHEP, Madurai. A Cosmic Muon Veto detector (CMVD) around the mini-ICAL was
planned using extruded plastic scintillators with embedded WLS fibers. A similar system is being commissioned at TIFR. The SiPM is used as a photo-transducer and that will be calibrated using an ultrafast LED driver. Other than the basic efficiency and gain study for the CMVD as a function of overvoltage (V_{ov}), an experimental setup was designed to characterise the SiPMs in a temperature controlled environment. The readout electronics involves trans-impedance amplifiers of combined gain 1.24 mV/μA and a digital storage oscilloscope for the data collection without much distortion of SiPM signal. From the point of view of avalanche formation, the rise time of the SiPM signals should be independent of the temperature and to some extent with the operational overvoltage (V_{ov}), but the observations show variations as a function of those two parameters. Various characteristics of the signal shape, recovery time etc were studied as a function of V_{ov} and the ambient temperature. This paper will cover the details of those results and possible explanations of those variations.

Field of contribution:

Experiment

167

Understanding the correlated and uncorrelated noise of SiPM

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The Silicon Photomultiplier (SiPM), a relatively new photo-transducer, has been developed since the last three decades ago. Though it has many advantages over conventional photomultiplier, till now
this has not been used for the precise energy measurements in nuclear and high energy physics, primarily due to its large intrinsic noise, particularly the correlated noise. The Hamamatsu SiPM (S13360-2050VE) is used for a systematic study of the (i) uncorrelated noise, the optically correlated (ii) prompt crosstalk, (iii) Decayed cross-talk and (iv) after-pulse.
The source of the last two noises also depends on the defect in the band structure of silicon sensors, which changes the number of trapping center and life-time of the excited state and consequently the fraction of those noises as well as its variation with the time gap.
All these noises are systematically studied as a function of ambient temperature, humidity, number of photoelectrons, and operational overvoltage (V_{ov}). The variation of different types of noises as a function of those parameters will be presented with possible explanations of those variations.

Field of contribution:

Experiment

168

Study of Cross-Talk Effects in Test Beam Studies of a High-Granularity Calorimeter (HGCAL) Prototype at CERN

Authors: Pravesh Sharma[1]; Shilpi Jain[1]; Rajdeep Mohan Chatterjee[1]

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This study investigates the cross-talk effects in the CMS High Granularity Calorimeter (HGCAL) using test-beam data and its comparison with GEANT4 simulation. The Study uses pion beam data on a two-module readout system with no absorbers. Cross-talk effects are studied using two different methods. Various noise mitigation methods have been applied. HGCROC chip-level charge injection is also studied for cross-talk.

Field of contribution:

Experiment

169

Test Beam analysis for 5mm Straw Tubes for DUNE ND-SAND at CERN

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DUNE (Deep Underground Neutrino Experiment) is a future long-baseline neutrino oscillation experiment hosted by Fermilab. Neutrinos will be produced by the PIP-II accelerator at Fermilab and detected in the Liquid-Argon Far Detector, 1300km away from Fermilab in the Sanford Underground Research Facility. DUNE will also host a Near Detector Complex 574m away from the neutrino source at Fermilab, which will contain three Near Detectors —ND-LAr, TMS, and SAND. The tracking detector for SAND is based on Straw Tubes (STT) with 5 mm diameter straws. A 1.2m $\times$ 0.8m STT prototype has been built to be tested using the particle beam at CERN. In this analysis, we describe a method to understand the performance of the STTs. We show that the overall resolutions are at par with the requirements for precision measurements of neutrino interaction in DUNE.

Field of contribution:

Experiment

170

Study of Photon-associated Top Quark Pair Production in Semileptonic Decay Channel at the CMS Experiment

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The top quark, being the heaviest known elementary particle, plays a crucial role in fundamental interactions. Predominantly produced through strong interactions, top quark events can include a photon in the final state due to an additional electroweak vertex. Investigating the production of top-antitop pairs(tt⁻) with an associated photon offers a unique opportunity to test the predictions of the Standard Model. Any deviation in the observed cross-section from theoretical expectations could indicate the presence of new physics beyond the Standard Model (BSM). This study focuses on events characterized by a well-isolated, high pT lepton (either an electron or a muon), at least three jets from quark hadronization, and an isolated photon. A very preliminary study with the LHC Run II dataset would be presented through this poster.

Field of contribution:

Experiment

171

Understanding charmonia production at the LHC: Insights from Proton-Proton collisions

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The heavy-quark symmetry of Non-Relativistic Quantum Chromodynamics (NRQCD) allows to generate the predictions of the cross-section for η_c production. However, when compared to LHCb data, the NRQCD predictions fail significantly. In contrast, modified NRQCD offers a neat solution to the η_c anomaly observed by the LHCb, successfully explaining all aspects of the η_c data. We also compare recent LHCb measurements of the integrated cross-section for h_c production at $\sqrt{s}$ = 13 TeV to theoretical predictions based on both NRQCD and modified NRQCD models. The modified NRQCD approach shows good agreement with the recent LHCb data.

Field of contribution:

Phenomenology

172

Study of bottomonia resonances at the LHC

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Corresponding Authors: sridhar.k@apu.edu.in, sudhansu.biswal@gmail.com, monalimohanty97@gmail.com

In this work, We compute the production cross-sections for bottomonia resonances in proton-proton collisions using both NRQCD and Modified NRQCD formalism. Additionally, we have analyzed the production cross sections of η_b and h_b, in both NRQCD and modified NRQCD approaches using heavy quark symmetry relation. Where the two models differ substantially is in their predictions for η_b and h_b production. The differences in predictions for η_b and h_b production could point to underlying dynamics that might be important for understanding bottomonium production.

Field of contribution:

Phenomenology

173

Study of the $B^0 \to \gamma\gamma$ decay at Belle and Belle II

Author: Shubhangi Krishan Maurya[None]

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The $B^0 \to \gamma\gamma$ proceeds through a flavor-changing neutral current transition involving electroweak loop diagrams. We report a study of the rare decay $B^0 \to \gamma\gamma$, using data accumulated by the Belle and Belle II experiments and corresponding to integrated luminosities of 694 fb^{-1} and 362 fb^{-1}, respectively. The datasets were collected through e^+e^- collisions at center-of-mass energy corresponding to the $\Upsilon(4S)$ resonance. We have analyzed the real data sets for this analysis, and the results will be presented at the symposium.

Field of contribution:

Experiment

174

Quantum correlated D meson measurements at BESIII

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Strong phase parameters measured for $D^0 \to f$ meson are performed studying quantum correlated $\psi(3770) \to D^0\bar{D}^0$ decay by BESIII collaboration for f final states. These parameters serve as an important input to constrain $D^0 - \bar{D}^0$ meson mixing parameters and constraining the direct measurement of unitary triangle angle γ/ϕ_3 from B meson decays. Measurement of coherence factor and strong phase parameters for quasi-flavor modes $D^0 \to K^-\pi^+\pi^-\pi^+$, $D^0 \to K^-\pi^+\pi^0$ and mixed CP modes $D^0 \to K^+K^-\pi^+\pi^-$, $D^0 \to K^0_S K^+K^-$, $D^0 \to K^0_S\pi^+\pi^-$ are presented in this talk.

Field of contribution:

Experiment

175

Mean p_{T} fluctuations in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE at the LHC

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Event-by-event fluctuations in the mean transverse momentum (Event-by-event fluctuations in the mean transverse momentum (p_{T}) of charged particles produced in high-energy proton-proton (pp) collisions are investigated. High-multiplicity data at $\sqrt{s}$ = 13 TeV collected by ALICE is analyzed for this purpose. The mean p_{T} fluctuations are studied in terms of the two-particle correlator, $\sqrt{C_m}/M(p_T)_m$, which measures the strength of such fluctuations in units of mean p_{T}. The primary objective of the present study is to explore whether these fluctuations are of dynamic origin and may indicate the formation of Quark–Gluon Plasma (QGP) droplets in small systems like pp. A decreasing trend of correlator values with increasing charged particle density is observed which follows a power-law pattern, similar to those reported for both small and large collision systems at lower energies. Furthermore, the analysis is extended by examining the dependence of $\sqrt{C_m}/M(p_T)_m$ on particle multiplicity by varying p_{T} window widths and positions. Such a study would help distinguish potential thermal influences, like jets and minijets, from non-thermal effects such as radial flow. The results are compared with predictions of Monte Carlo models, like PYTHIA and EPOS, to examine how well these models can reproduce the observed fluctuation patterns.

Field of contribution:

176

Probing the chirality of heavy gauge bosons using tau polarization

Authors: Sudhansu S. Biswal[1]; P.S. Bhupal Dev[None]; Vinay Krishnan MB[None]; Aruna Kumar Nayak[None]; Lopamudra Sahoo[None]

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New heavy gauge bosons appear in many BSM extensions. For a new SU(2) symmetry, the corresponding charged vector boson W' can be either left handed or right handed. Therefore, it is crucial to devise some observables that can distinguish the pure left handed versus pure right handed case provided the heavy W' discovered at the LHC in order to pinpoint the underlying gauge structure of the BSM. Here, we investigate the role of τ polarization in determining the chirality of W' boson in the context of left right symmetric model. We analyze the purely leptonic mode of W' where W' decays to a final state τ and neutrino. Assuming the existence of right handed heavy neutrino, we further analyze this process on the basis of Majorana neutrino decays. Here, we construct various observables and kinematical distributions to discriminate the chirality of W' bososn as well as to understand the underlying gauge structure of BSM physics.

Field of contribution:

Phenomenology

177

Barrow Holographic Dark Energy: Reconstruction within Saez-Ballester theory in Kantowski-Sachs Universe

Author: Khandro Kalsang[None]

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Motivated by the great interest in holographic dark energy models, this study reconstructs Barrow Holographic Dark Energy (BHDE) within the Saez Ballester framework in a homogeneous and anisotropic Kantowski Sachs universe. Interacting and non-interacting scenarios are considered, with the future event horizon serving as the infrared cut-off. Our analysis examines the evolution of the Equation of State parameter and the phase space trajectories for both cases. The inflationary dynamics of a universe filled with BHDE are further explored by plotting the slow roll parameters. Additionally, we establish a connection between BHDE and the canonical scalar field, which is often linked to inflationary processes. Finally, the tensor to scalar ratio is plotted and found to lie within the acceptable range.

Field of contribution:

178

Time-dependent CP violation measurements in radiative penguin decays of B mesons at Belle and Belle II

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The left-handed chiral structure of the W boson in Standard Model implies that CP violation parameters measured in radiative penguin decays of B mesons should be close to zero due to the suppression of right-handed polarised photon in the final state. Hence these decays are sensitive to physics beyond the standard model through new particles in the loop that can enhance the right-handed contribution. Measurements of decay time-dependent CP violation parameters in these decays can thus be an excellent probe for new physics. K* (Ks pi0) gamma modes have the largest branching fraction of these decays and hence offer the best sensitivities to these parameters. We present the latest status of time dependent measurement of these parameters in Ks pi0 gamma decays of B mesons from the Belle and Belle II experiments.

Field of contribution:

Experiment

179

Measurements of inclusive and differential Higgs boson production cross sections at 13.6 TeV in the $H \rightarrow \gamma\gamma$ decay

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A measurement of inclusive and differential fiducial cross-sections for the production of the Higgs boson decaying into two photons is performed using 34.7 fb−1 of proton-proton collision data recorded at √s = 13.6 TeV by the CMS experiment at the Large Hadron Collider in 2022. The inclusive cross-section in a fiducial region closely matching the experimental selection, is measured to be 78 ± 11(stat.)+6−5(syst.) fb in agreement with the standard model prediction of 67.8 ± 3.8 fb. Differential cross sections are measured as a function of the Higgs boson transverse momentum, rapidity, and

the number of jets in the event. The differential cross-sections also agree with the standard model predictions within the uncertainties.

Field of contribution:

180

CMS Outer Tracker Module Production and Integration at NISER

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In the coming year, the LHC will upgrade to the High-Luminosity LHC (HL-LHC), with operations projected to commence in 2029. This ambitious upgrade introduces significant challenges, most notably increased interaction rate. The CMS collaboration plans to enhance its tracking system by 2026 to address the high radiation environment. The upgraded CMS outer tracker (OT) will feature advanced, granular silicon-based pixel-strip (PS) and strip-strip (2S) detector modules with cutting-edge track-triggering capabilities. At NISER, a dedicated effort is underway to assemble a large number of 2S modules, with each module comprising ~4K readout channels and integrating sophisticated technologies such as radiation-resistant sub-micron ASICs, high-granularity silicon strip sensors, and high-speed optical data transmitters. Every module undergoes thorough electronic noise characterization at 20℃ and -35℃ to ensure optimal performance. Once characterized, these modules are integrated into larger mechanical structures called ladders, where additional readout tests and temperature cycling validate their durability before shipment to CERN for commissioning. This multi-stage assembly process is guided by stringent quality control measures. It relies on state-of-the-art machinery, including high-precision glue dispensers, high-resolution optical metrology, and automatic ultrasonic wire bonders. Together, these efforts underscore our commitment to ensuring the success of the HL-LHC project

Field of contribution:

Experiment

181

Exploring Z Portal Production of Axion-Like Particles at the LHC with Machine Learning Approaches

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Axion-like particles (ALPs) are predicted by various extensions of the Standard Model, such as composite models, and are potential candidates for new physics. We investigate the production of ALPs at the LHC (14 TeV) through a Z boson decay, where the Z boson couples to an axion and a photon. We further decay the axion into two bottom quarks, resulting in a distinct final state consisting of two b-tagged jets and an isolated photon. Our analysis focuses on utilizing these decay products to distinguish signal events from background processes.

We begin by examining kinematic features and spatial distributions of the decay products as discriminating variables. Key observables include the transverse momentum of the photon, the angular separation (Delta R) between the b-tagged jets, the invariant mass of the jet-photon system, etc. Initial attempts using a simple Boosted Decision Tree (BDT) did not achieve sufficient discrimination. Given the expected distinct pattern in the spatial distribution of the signal events compared to the background, we represent events as images in the pseudorapidity (η) and azimuthal angle (φ) plane.

This representation motivates the use of image-based classification models of Machine Learning, such as Convolutional Neural Networks(CNNs), where we started with the AlexNet architecture to leverage the spatial patterns in the η-φ representation of events. Additionally, we are exploring Graph Neural Networks(GNNs) where the spatial correlations are represented in the form of graph-based structures.

Our preliminary results indicate that the image-based approach improves classification accuracy and increases signal sensitivity. The analysis aims to establish new upper bounds on ALP production that could surpass existing limits.

Field of contribution:

Phenomenology

182

Spectroscopic exploration of charmed-strange meson using Regge phenomenology

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In recent years, the experimental discovery of charmed mesons has significantly increased. The latest report from the Particle Data Group (PDG) lists 10 observed excited strange-charmed mesons identified by various experimental collaborations. In this study, we conduct a systematic analysis of the $D_s^{\pm}$ meson by utilizing Regge theory, a widely adopted framework for investigating hadron spectra. By assuming quasilinear Regge trajectories, we derive several relationships between the Regge slope, intercept, and meson masses. Using these relationships, we calculate the Regge slopes for the 1^1S_0 and 1^3S_1 trajectories in the (J, M^2) plane to determine the masses of orbitally excited states. Furthermore, we evaluate the Regge parameters in the (n, M^2) plane for each Regge line, allowing us to predict the masses of radially excited charmed-strange mesons on these trajectories. These predicted masses are then compared with both available experimental results and theoretical predictions from other models.
Looking forward, we anticipate that more candidates for excited charmed-strange mesons will be observed with advancements at experimental facilities such as LHCb, BABAR, and BESIII. Our predictions could provide valuable insights for future experimental studies and verification.

Field of contribution:

Phenomenology

183

Pion and Kaon Structure using Distribution Function

Author: Satyajit Puhan[1]

Co-author: Harleen Dahiya [2]

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We have investigated the pseudo-scalar meson structure in the form of transverse momentum-dependent parton distribution functions (TMDs) and generalized parton distribution (GPDs) in the light-front based quark model. Starting from leading order, we have calculated all the time-reversal even TMDs for pion and kaon up to twist-4. The parton distribution functions (PDFs) of pseudo-scalar mesons have been compared with the experimental result through NLO DGLAP evolution. The sum rules, TMD transverse dependence, inverse moments and Gaussian transverse dependence have also been studied. Further, the transverse quark densities have also been analyzed in the momentum space plane. The electro-magnetic form factors (FFs) have also been calculated for both the particles through unpolarized GPDs. The FFs of pion and Kaon found to be matches with experimental results. The nuclear medium modifications effect has also been studied in this work to study the PDFs and TMDs.
Reference Paper-
(1) S. Puhan, et.al, JHEP 02 2024.
(2) S. Puhan, et.al, PRD 110 2024.

Field of contribution:

Phenomenology

184

Quark and Gluon Wigner distributions for non-zero skewness

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Generalized transverse momentum dependent parton distributions (GTMDs) capture most of the information about quarks and gluons in both position and momentum space. The Fourier transform of GTMDs yields the Wigner distribution, which provides parton densities in momentum space, position space, or a combination of both. Most previous studies related to GTMDs and Wigner distribution have assumed the momentum transferred to the target state to be purely transverse, with zero longitudinal component, simplifying the calculations. The amount of longitudinal momentum transfer is characterized by the parameter skewness, denoted by ξ. Here, we present for the first time a comparative study of quark and gluon GTMDs and Wigner distributions when the momentum transfer to the target state includes a non-zero longitudinal component, i.e., for non-zero skewness.

Field of contribution:

Phenomenology

185

Cosmic accelerators in an extreme external field

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The compact astrophysical objects like rotating neutron star are considered to be the universal charge particle accelerators and the prominent source of high energy photons. Their axial rotation cause the co-rotation of their magnetosphere. As a result the dipole magnetic field B of the compact star induces the strong electric field $E_{\parallel}$ parallel to B. Such strong $E_{\parallel}$ field pulls out the charge particles from the surface of the star and accelerate them relativistically along the B field\cite{Usov}. These highly accelerated particles emits high energy photons in an extreme B field.
The photon emission takes place at each point of dipole field lines.

In this article we discuss about the evolution of Lorentz factor Γ with respect to the photon path length z inside the light cylinder of radius R_{ls} of the star. The relation between Γ and z is evaluated from a differential equation known by the name as {\it{ Lorentz-Abraham-Dirac}} (LAD) equation\cite{beskin-book}. The LAD equation takes care of the energy loss (due to radiation reaction) and energy gained (due to Coulomb interaction) by the charge particles during their journey along the B field lines. We plotted the dependency of Γ vs z in fig. [1]. It turned out that Γ being position dependent shows minima corresponding to the point (denoted by P_0 in fig. [1]) where the energy loss by the charge particle due to radiation reaction is compensated by the energy gained powered by the rotational energy of the star.
Our analysis provides a non-trivial parameter space (i.e., the photon energy ω, Lorentz factor $\Gamma(z)$ for a typical neutron star model having $B \sim 10^{12}$ Gauss, rotational time period $\sim$ 83 mins.) for carrying out the investigation of polarization of photon in highly magnetized plasma co-rotating with the compact star. We will incorporate the results obtained in this study for the investigation of high energy photon-axion interaction in the magnetosphere of the compact star.

\vskip 5cm
\begin{figure}[h!]
\hskip 5 cm\includegraphics[scale=1.0]{Gamma_vs_z_DAE_final.pdf}
\caption{Plot of Γ (along y-axis) vs photon path length z that is scaled by the radius of light cylinder R_{lc} (along x-axis). The y-axis has been scaled by the factor 10^{-7}.}
\end{figure}

Field of contribution:

Theory

186

Glass RPC Detector Performance with CO2-Based Gas Mixtures

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Resistive Plate Chambers (RPCs) play a vital role in high-energy physics experiments, offering excellent particle detection efficiency and time resolution across large areas. Usually, Freon-based gas mixtures facilitate these performance attributes but pose significant environmental concerns due to their high Global Warming Potential (GWP). In light of growing ecological awareness and stricter regulations, this study investigates eco-friendly alternatives aimed at preserving the performance standards of RPCs.

We present an evaluation of a glass-based RPC detector utilizing CO2-based gas mixtures as a substitute for traditional C2H2F4/i-C4H10/SF6 mixtures. Key performance indicators –count rate, cluster size, and detection efficiency –were assessed across varying CO2 concentrations and benchmarked against standard gas compositions. A 64-channel ASIC-based front-end electronics named HARDROC has been used for data extraction.

Field of contribution:

Experiment

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Assessment of Outgassing and Ageing in Resistive Plate Chambers Using Gas Chromatography

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Resistive Plate Chambers (RPCs) are widely used in high-energy physics experiments to detect charged particles. However, their performance can degrade over time due to outgassing and ageing effects, impacting long-term detector reliability. This study aims to investigate these potential outgassing and ageing effects in RPCs, which can compromise sustained high-performance operation.

Data were collected in two phases, in 2018 and 2024, using Gas Chromatography (GC) to examine the gaseous environment within the detectors as the gas exits the system. In addition, both the input gases and the output from the gas mixing unit (GMU) were analyzed for impurities, moisture, and other potential outgassing sources.

Key performance metrics of the RPC detectors, including operating voltage, efficiency, leakage current, and dark count rate, were compared between the 2018 and 2024 datasets to assess any signs of ageing over time. Furthermore, GC analysis was conducted in both phases to identify any additional peaks indicative of outgassing in the 2024 data relative to the 2018 baseline.

Field of contribution:

Experiment

188

Heavy quark energy loss in Proton-Lead Collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

Authors: Deependra Singh Rawat[1]; Harish Chandra Chandola[2]; Kapil Saraswat[3]; Manoj Kumar Singh[3]; Prashanta Kumar Khandai[4]; Venktesh Singh[5]

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In the current work, We calculate the heavy quark (charm and bottom) energy loss due to elastic collisions and gluon radiation in proton-Lead (pPb) collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV. We use the Peigne and Peshier formalism to calculate the collisional energy loss and generalised dead cone approach and DGLV formalism to calculate the radiative energy loss. We also calculate the fluctuations. Nuclear modification factors including shadowing, energy loss and fluctuations are calculated for B and D mesons in pPb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV and are compared with the measured CMS and ALICE data.

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(1) Kapil Saraswat et. al., Nucl. Phys. A 1022 (2022) 122441.
(2) CMS Collaboration, CMS-PAS-HIN-14-004.
(3) CMS Collaboration, Phys. Rev. Lett. 116 (2016) 032301.
(4) ALICE Collaboration, Phys. Rev. C 94 (2016) 054908.

Field of contribution:

Phenomenology

189

Precision measurement of (Net-)proton Number Fluctuations in Au+Au Collisions from BES-II Program at RHIC-STAR

Author: Bappaditya Mondal[1]

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Higher-order cumulants of (net-)proton multiplicity distributions are sensitive observables for studying the QCD phase structure. At low baryon chemical potential (μ_B), lattice QCD calculations establish the quark-hadron transition to be a crossover, while at large μ_B, QCD-based models predict a first-order phase transition that ends at a critical point.

Here, we focus on the search for the possible existence of the QCD critical point. We report precision measurements of cumulants (C_n) and factorial cumulants (κ_n) of (net-)proton multiplicity distribution upto fourth order in Au+Au collisions measured in the STAR experiment during BES-II at RHIC. Using the high statistics data collected with upgraded detectors, we select protons and antiprotons at mid-rapidity $|y| < 0.5$ within $0.4 < p_T(GeV/\mathrm{c}) < 2.0$. The dependence of measured cumulants and factorial cumulants on the collision energy and centrality will be presented. The measured data

will be compared with calculations from lattice QCD, and expectations from various non-critical point models, such as the transport model UrQMD and the thermal model HRG.

Field of contribution:

Experiment

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The Light Dark Matter eXperiment (LDMX)

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The constituents of dark matter are still unknown, and the viable possibilities span a very large mass range. Specific scenarios for the origin of dark matter sharpen the focus on a narrower range of masses: the natural scenario where dark matter originates from thermal contact with familiar matter in the early Universe requires the DM mass to lie within about an MeV to 100 TeV. Considerable experimental attention has been given to exploring Weakly Interacting Massive Particles in the upper end of this range (few GeV –˜TeV), while the region ˜MeV to ˜GeV is largely unexplored. Most of the stable constituents of known matter have masses in this lower range, tantalizing hints for physics beyond the Standard Model have been found here, and a thermal origin for dark matter works in a simple and predictive manner in this mass range as well. It is therefore an exploration priority. If there is an interaction between light DM and ordinary matter, as there must be in the case of a thermal origin, then there necessarily is a production mechanism in accelerator-based experiments. The most sensitive way (if the interaction is not electron-phobic) to search for this production is to use a primary-electron beam to produce DM in fixed-target collisions. The Light Dark Matter eXperiment (LDMX) is a planned electron-beam fixed-target missing-momentum experiment that has unique sensitivity to light DM in the sub-GeV range. This contribution will give an overview of the theoretical motivation, the main experimental challenges and how they are addressed, as well as projected sensitivities in comparison to other experiments.

Field of contribution:

Experiment

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Investigating the mass spectra of Di-hadronic molecule by potential model.

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In this study, we aim to understand the interactions that govern hadronic molecules. To calculate the mass spectra, we use a One Boson Exchange potential combined with a Yukawa-like screened potential for their relative s-wave state. We propose that two color-neutral hadrons interact through

a dipole-like interaction, resulting in the formation of a hadronic molecule. To differentiate these molecules from other hadronic states, we apply Weinberg's compositeness theorem. Using the proposed interaction potential, we compute the mass spectra for various di-mesonic states and compare our results with other theoretical models and experimental data.

Field of contribution:

Phenomenology

192

Polarized charged lepton induced DIS process off polarized nucleon target at moderate Q^2

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In this study, we have theoretically evaluated the polarized nucleon structure functions $g_{1N,2N}(x,Q^2)$, via longitudinally
polarized charged lepton induced deep inelastic scattering (DIS) off longitudinally polarized nucleon target~\cite{Zaidi:2024obq},
using DSSV14 parameterization~\cite{DeFlorian:2019xxt} for the polarized parton density distribution functions (PPDFs) in the 3-flavor (u,d,s) $\overline{\text{MS}}$ scheme at next-to-the-leading-order (NLO) incorporating the nonperturbative effects like
target mass correction (TMC) and twist-3 ($\tau=3$) corrections. Furthermore, the unpolarized nucleon structure functions $F_{1N,2N}(x,Q^2)$ are also evaluated using
the MMHT PDFs parameterization~\cite{Harland-Lang:2014zoa} in the 3-flavor $\overline{\text{MS}}$ scheme, and by taking into account
the higher order perturbative evolution of parton densities upto NLO and the nonperturbative QCD corrections viz. TMC
and higher twist (HT: $\tau=4$) effects~\cite{Zaidi:2019mfd}.
These unpolarized structure functions are required to study the nucleon spin asymmetries: {\bf (i)} $A_{1N}(x,Q^2)\left(=\frac{g_{1N}(x,Q^2)-\gamma^2\, g_{2N}(x,Q^2)}{F_{1N}(x,Q^2)};\ \gamma=\sqrt{\frac{4M^2x^2}{Q^2}}\right)$ which is important to understand the role of valence quarks and
their orbital angular momentum contribution to the proton spin,
and {\bf (ii)} $A_{2N}(x,Q^2)\left(=\frac{\gamma\,\left(g_{1N}(x,Q^2)+g_{2N}(x,Q^2)\right)}{F_{1N}(x,Q^2)}\right)$ that is important to obtain the information about
the transverse polarization of quark spins. Moreover, we have studied the model dependence of $g_{1N,2N}(x,Q^2)$ and $F_{1N,2N}(x,Q^2)$ using various PDFs parameterizations available
in the literature as well as analyze the effect of the center of mass energy (W) cut required to demarcate the
resonance production and deep inelastic regions. The obtained numerical results for
$g_{1N,2N}(x,Q^2)$ and $A_{1N,2N}(x,Q^2)$ have been compared
with some of the experimental results from SLAC, DESY, JLab and CERN collaborations and will be presented in the
forthcoming DAE High Energy Physics Symposium'2024. This study shed light on how the higher order perturbative and
nonperturbative corrections impact the quark parton model (QPM) results for $g_{1N,2N}(x,Q^2)$ and $A_{1N,2N}(x,Q^2)$. This work may also be useful to
understand the contribution of polarized quarks and antiquarks in consituting the nucleon spin as well as the anticipated
experimental results from JLab, EIC, and CERN collaborations in the wide range of x and Q^2.

Field of contribution:

Theory

193

Vacuum structure including higher order corrections in ALRM

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Discovery of Higgs particle around 125 GeV at the LHC leads to the result that the standard model does not have a stable vacuum to Plank scale. As, for a light higgs boson, SM can be perturbative all the way to Plank scale. So, new physics or new models to be sought. In this work, we focus on a different version of left right model, called Alternative Left Right Model (ALRM), where we study the vacuum structure of this model in 1- loop level. We derive the renormalization group equations and study the behavior of the scalar quartic couplings that satisfies vacuum stability, perturbativity, unitarity up to plank scale. We also cross checked the tree level constraints on parameters in loop level.

Field of contribution:

Phenomenology

Poster / **194**

Evolution of a Thunderstorm-Induced Muon Event: Insights from the Ooty Muon Telescope, Electric Field, and Lightning Observations

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The GRAPES-3 tracking muon telescope in Ooty, India, equipped with high angular resolution and statistical precision, records short-term variations in muon intensity during major thunderstorms, termed thunderstorm-induced muon events (TIMEs) [1]. Recent multidisciplinary investigations of TIMEs have examined seasonal variations [2], connections with the global electric circuit [3], climate interactions [4], and long-term patterns observed during Boreal summers [5].
In this study, we extend these analyses to explore the evolution of a thunderstorm-induced muon event recorded on March 20, 2020. We integrate data from the Ooty muon telescope with lightning observations from four electric field mills (EFMs) at Ooty, the Indian Lightning Location Network (ILLN), and cloud-top temperature data from the INSAT-3DR geostationary satellite. The combined

spatiotemporal data from cloud-top temperatures, ILLN, and EFM readings, together with the evolution of the TIME, provides a novel cross-disciplinary perspective. This first-of-its-kind analysis will be presented in detail at the symposium.

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Field of contribution:

Experiment

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Lepton proton two photon exchange with soft photon approximation

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We present an improved evaluation of the two-photon exchange correction to lepton proton scattering using heavy baryon chiral perturbation theory at next-to-leading order using elastic intermediate state and adhering to soft photon approximation. A more systematic approach is applied to the loop integrations, eliminating some of the crude approximations from previous work.

Field of contribution:

Theory

196

Dark matter searches with the CMS detector @LHC

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Numerous cosmological observations supporting the remarkable fact that baryonic matter which form stars, galaxies, and clusters consist only 15% of the total matter in the universe and ˜ 85%

amount to a non-radiating form of matter(known as dark matter(DM)) that cannot originate from any Standard Model (SM) particle, has made it one of the most interesting topic at the frontier of particle physics today. While the existence of dark matter in the universe is established by a compelling body of experimental evidences, little is known about the nature of dark matter, though a popular candidate for dark matter has been the so-called weakly interacting massive particles. Should it exist in the form of particles, it may be possible to be produced at colliders like LHC as well. The CMS experiment has developed a broad program to search for DM candidates, including searches with mediators which would couple the dark sector to the visible side. In this presentation, some of the latest searches for DM particles with the CMS detector on 13 TeV pp data at LHC will be discussed.

Field of contribution:

Experiment

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Probing QGP with Charmonium in $p-p$ Collisions at the LHC energies

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Recent observations on the high-multiplicity proton-proton ($p-p$) collisions, similar to the phenomenon observed in heavy-ion collisions, provide a glimpse into the possible formation of the strongly interacting quark-gluon plasma (QGP) in such small systems. Unlike nucleus-nucleus (A−A) collisions, the transverse and longitudinal dimensions in $p-p$ collisions are comparable, leading to rapid cooling of the medium and, consequently, affecting the charmonium states. To analyze this phenomenon, we adopt a bottom-up thermalization framework to model the pre-equilibrium stage, followed by a Gubser-type hydrodynamic expansion. We observe that the resulting temperature evolution is fast, inducing rapid changes in the Hamiltonian of the system, which causes the transition from J/ψ to ψ(2S) state. This transition between charmonium states is obtained by considering the non-adiabatic framework for evolving charmonium states. Furthermore, the present study incorporates the QGP-induced suppression effects, such as collisional damping, which arises because of the energy loss due to interactions of the charmonium with the medium and gluonic dissociation as the consequence of quarkonium states into a color octet lead interactions with gluons. It also includes the regeneration of charmonium states within the medium due to the transition from the color octet state to the color singlet state. Through these combined effects, we explore the dependence of charmonium yield on transverse momentum (p_T) and event multiplicity in $p-p$ collisions at $\sqrt{s}$ = 13 TeV, providing new insights into the dynamics of strongly interacting matter and serving as a potential probe for the existence of a thermalized QCD medium in small collision systems.

Field of contribution:

Theory

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Characterization of MALTA monolithic pixel detectors using X-rays.

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The MALTA monolithic active pixel detector has been developed to address the challenges anticipated in future high-energy physics detectors. As part of its characterization, we conducted fast-timing studies necessary to provide a figure of merit for this family of monolithic pixel detectors. However, conventional Laser techniques are limited due to reflection on the metal layers of the sensor leading to low material penetration. To overcome this we designed a triggered micro-X-ray setup that enables precise timing measurements using X-rays. This setup employs a micro-X-ray source to generate short pulses from a Cu-Cr target, meticulously synchronized with an input trigger source. We validated the setup using an LGAD and subsequently characterized the timing response of a MALTA and MALTA2 pixel detector prototype, yielding insights into their timing performance.

Field of contribution:

Experiment

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Measurement of collider independent asymmetries in the top quark pair production at CMS experiment

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In top quark pair production, interference between the tree-level and box diagrams, along with interference between initial-state and final-state radiation in quark-initiated processes, induces an asymmetry in the angular distribution of the resulting top and anti-top quarks. Several observables have been proposed in the literature to quantify this asymmetry, including the Forward-Backward asymmetry measured at Tevatron and Charge asymmetry at the LHC, each capturing distinct aspects of parton-level interactions. In this work, we aim to measure the fundamental, collider-independent, parton-level components of this asymmetry using data collected by the CMS experiment.

Field of contribution:

200

CMB signature of self interacting dark matter

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We propose a novel particle physics framework that addresses multiple cosmological tensions and anomalies by incorporating self-interacting dark matter (SIDM) and dark radiation (DR) within an abelian gauge extension of the Standard Model. Our model features a $U(1)_D$ gauge symmetry that accommodates SIDM candidates which interact through the exchange of the $U(1)_D$ gauge boson. The velocity-dependent self-interactions of DM help alleviate the small-scale structure problems of the standard cosmological model.
Due to the presence of a light mediator and strong DM coupling, the thermal DM relic abundance is suppressed. To achieve the correct DM density, we consider a non-thermal production mechanism involving the decay of a long-lived scalar field that acts as a Pseudo-WIMP. This scalar decays to produce both DM and dark radiation. The DR produced from the scalar decay, occurring after Big Bang Nucleosynthesis but before recombination, can contribute a significant $\Delta N_{\rm eff}$ that may help resolve the Hubble tension. The DR component can be probed by future cosmic microwave background (CMB) experiments. The gauge kinetic mixing and scalar portal interactions between the visible and dark sectors make this scenario testable at various dark photon search experiments, as well as DM direct and indirect detection experiments.

Field of contribution:

Phenomenology

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Next-to-Soft-virtual resummation for SIDIS to NNLO + $\overline{\text{NNLL}}$

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Semi inclusive deep inelastic scattering (SIDIS) process can provide insight into the internal structure of hadrons and also the dynamics of fragmentation of parton into hadrons. Often the perturbative predictions contain large threshold logarithms that need to be resummed to all orders in order make the predictions stable. In this work, we develop a formalise that will allow us to resum not only leading threshold logarithms but also subleading ones to all orders. We use renormalisation group equations and sudakov differential equations to obtain the results that are sensitive to these logarithms. We study their numerical impact at SIDIS experiments by performing the computations in two dimensional Mellin space. Our results improve the predictions.

Field of contribution:

Phenomenology

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Investigation of Electromagnetic Properties of Neutrinos with sub-keV Sensitive Germanium Detectors in the TEXONO Experiment

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The discovery of non-zero neutrino masses has triggered intensive studies on nontrivial electromagnetic properties of neutrinos, which emerge from electroweak radiative corrections. Despite numerous experimental efforts to detect neutrino electromagnetic interactions, no conclusive evidence has yet been observed. These interactions are characterized by different energy dependencies: the interaction rates for neutrino magnetic moment interactions are inversely proportional to recoil energy, whereas those for millicharge interactions decrease with the square of the recoil energy. As a result, experiments with ultra-low-energy thresholds, especially in the sub-keV range, are particularly well-suited to exploring these elusive properties. The current data from ultra-low-energy thresholds aligns with the atomic scale of the target. In order to account the atomic responses in the analysis, we employ the ab-initio multiconfiguration relativistic random-phase approximation (MCRRPA) to calculate differential cross-sections, which accurately account for the many-body effects in atomic germanium. This approach significantly reduces the uncertainties associated with atomic effects, making our results more robust. This work presents new preliminary constraints on the millicharge and magnetic moment of reactor antineutrinos using 200eV threshold data from the TEXONO experiment at the Kuo-Sheng Neutrino Laboratory, Taiwan.

Field of contribution:

Experiment

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Measurement of Cosmic Muon-Induced Low-Energy Gamma Background Spectroscopy with a HPGe Detector for CEvNS Experiment in India

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In rare-event physics experiments, such as searches for elusive interaction like the coherent elastic neutrino-nucleus scattering, comprehensive background understanding and effective mitigation are absolutely necessary. The background levels within the region of interest (ROI) significantly impact measurement sensitivity, where the signal from neutrino-induced nuclear recoils is expected to appear as an excess above the background. In CEvNS experiments, the primary background comes from radioactive gamma radiation, with additional irreducible contributions from secondary gamma rays and neutrons generated by cosmic muon interactions with the shielding surrounding the detector. Therefore, the implementation of advanced and highly effective background suppression techniques is imperative for optimizing the sensitivity of experiment and ensuring its success.

This work presents a detailed characterization of a high-purity germanium (HPGe) gamma spectrometer, focusing on its detector response to various gamma and neutron radioactive sources. We also evaluate the rate of cosmic muon-induced secondary low energy backgrounds upto 10 keVee , utilizing HPGe surrounded by 10 cm lead and 2 cm copper shielding. We observed that the integration of an active muon-veto system, comprising plastic scintillator paddles coupled with photomultiplier tubes and utilizing an average muon veto window of 150 µs, enables us to effectively discriminate these backgrounds, thereby improving the detector's sensitivity to rare event detections.
Additionally, Monte-Carlo simulations using Geant4 are employed to benchmark experimental results and optimize detector response.

Field of contribution:

Experiment

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Investigation of Charged Particle Multiplicity Distributions and KNO Scaling in Proton-Proton Collisions at LHC Energies Using PYTHIA

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High-energy proton-proton (pp) collisions at the Large Hadron Collider (LHC) produce a variety of subatomic particles. Charged particle multiplicity (Nch) is a key observable in hadronic collisions, offering insight into particle production mechanisms and the hadronization process. Partonic interactions such as Multi-Parton Interactions (MPI), Initial State Radiation (ISR), Final State Radiation (FSR), and Color Reconnection (CR), collectively define the intricate structure of hadronic collisions. MPI contributes through multiple simultaneous parton-parton scatterings within a single pp collision, while ISR and FSR represent Quantum Chromodynamic (QCD) emissions occurring before and after the primary hard scatter, respectively. CR impacts hadronization by altering color flow connections between partons, affecting the fragmentation process and thus modifying particle multiplicity. The study of Koba-Nielsen-Olesen (KNO) scaling reveals universal patterns in particle multiplicity distributions, advancing our understanding of particle production scalability across various collision energies. In our study, we simulated pp collisions using the Monte Carlo (MC) event generator PYTHIA8 with the default Monash tune. We analysed the influence of MPI, ISR, FSR, and CR on the Nch spectra, conducting a comparative study of charged particle multiplicity for each interaction type. Additionally, Nch spectra were examined across different pseudorapidity regions ($|\eta|<0.5,1,1.5,2$ and 2.5) and at pp collision energies of $\sqrt{s}$ = 0.9, 2.36, 7, 8, 13, and 14 TeV. KNO scaling was performed at these energies and within these pseudorapidity regions. Finally, we validated the multiplicity distribution by comparing data from the Compact Muon Solenoid (CMS) experiment at the LHC with the generated MC results.

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Field of contribution:

Phenomenology

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The Phase Diagram of AdS5 Black Holes with Four Derivative Corrections

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Motivated by recent studies of supersymmetric black holes, we revisit the phase diagram of both non-BPS and BPS AdS_5 black holes in grand canonical ensemble using recently constructed four derivative effective action. In the universal two derivative theory, for non-BPS AdS_5 black holes, three distinct limits exist where the phase diagrams change qualitatively. In the sub critical electric potential limit ($0 \leq \Phi < \sqrt{3}$), the phase diagrams resemble those of Schwarzschild black holes, featuring branches for small and large black holes, with the latter undergoing a Hawking-Page (HP) transition. Considering the four derivative (α) corrections to be small, the Schwarzschild-like behavior remains intact. For temperatures below T_{HP}, α corrections destabilize both small and large black holes; however, for temperatures above T_{HP}, they continue to destabilize the small black hole while stabilizing the large one. In the critical electric potential limit ($\Phi = \sqrt{3}$), only large black holes with negative Gibbs free energy exists, with no HP transition occurring and α corrections stabilize these large black holes. In the maximum angular velocity limit ($\Omega = 1$), only small black holes with positive Gibbs free energy exist, and α corrections destabilize them. Finally we present four derivative corrected phase diagram of BPS AdS_5 black holes with $\varphi' = 0$. The two derivative BPS phase diagram are Schwarzschild kind, hence as expected the effect of α corrections are similar to sub critical electric potential limit of non-BPS AdS_5 black holes.

Field of contribution:

Theory

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Sterile fermion extension and dark matter in Left-Right Symmetric Model

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In the current work, we have extended Left-Right Symmetric Model (LRSM) with a sterile fermion per generation, the lightest of which acts as a suitable dark matter candidate for the present model under consideration. Incorporating the sterile fermion, we realise LRSM with the help of modular group of level 3 that is, $\Gamma(3)$ and weight 2. Then, we calculate the dark matter relic density and also the decay rate of the dark matter candidate. In the current work, we also study a correlation between the different phenomenology like neutrino less double beta decay ($0\nu\beta\beta$) , Lepton Flavor Violation (LFV) and the results have been discussed and analysed in the current work within the framework of inverse seesaw mechanism which is the extension of LRSM.

Field of contribution:

Phenomenology

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Restricting CP Violating Phases in Tribimaximal Mixing Limit

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In this study, we perform a comprehensive analysis of the perturbed TBM scenario for deriving the numerical constraints on Leptonic CP phases from the parameter space, allowed by the neutrino mixing angle data. We investigate the corrections of the types $U^l_{ij} \cdot U_{TBM} \cdot U^r_{kl}$, $U^l_{ij} \cdot U^r_{kl} \cdot U_{TBM}$, and $U_{TBM} \cdot U^l_{ij} \cdot U^r_{kl}$ for normal and inverted hierarchy scenario. Here U_{TBM} is tribimaximal mixing matrix and U is a 2 dimensional unitary correction matrix that can be parametrized by a mixing angle and a phase parameter. This study investigates all the possible cases that are consistent with the neutrino mixing data in the vanishing rotation angle limit. We find the characteristics features of viable parameter space and evaluate the bounds on CP violating phases. We show that the allowed regions are tightly constrained by neutrinoless double beta decay and cosmological constraints.

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Field of contribution:

Phenomenology

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Bulk Viscosity near QCD phase transition and Dark Matter effect

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We consider a strongly interacting fermionic matter that is in direct interaction with the fermionic dark matter via the exchange of Standard Model Higgs boson. Invoking quasi-particle description for strongly interacting fermions with dynamic quasi-particle excitations we evaluate the thermodynamic properties of this matter in relativistic mean-field approximation. Taking into consideration Boltzmann transport equations in relaxation time approximation we evaluate the transport properties of this medium. It is found that due to the coupling of fermionic quasi-particle excitations and Higgs boson ζ/s can get singular near transition region both along O(4) transition line and in Z(2) universality class.

Field of contribution:

Theory

209

Characterization of flavor dependance of Chiral Magnetic Effect with multiple correlators

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We study the flavor dependance of the Chiral Magnetic Effect (CME) using two of the primary correlators used to characterize the charge separation effect. These are the correlator $\Delta\gamma$ and the correlator R_{ψ_2}. We use the AMPT (A Multiphase Transport Model) model to study the sensitivity of these correlators to two and three flavors of quarks. The AMPT model used has a centrality dependent charge separation introduced in the initial stage. We find that both the correlators indicate a strong flavor dependence in $(30-50)\%$ centrality bins. We then create a classification model with a neural network architecture and train the model using numerous combinations of the final state particle distributions. We evaluate patterns of error distribution and determine which observables are best suited for precise and accurate CME flavor estimation. We additionally implement the model to estimate the R_{ψ_2} correlator from the final state particle distribution and minimize the flow-related background effects. This method represents a novel approach to characterizing the CME flavors while reducing the background effect.

Field of contribution:

Phenomenology

210

Gamma Ray light curves from cosmic string wakes .

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We study the Gamma Ray light curves which occur from magnetic reconnection in cosmic string wakes. As the string moves, the reconnection points in the cosmic string wake give rise to shocks with relativistic velocities. Since the shock waves arise from different points of magnetic reconnections, they have different velocties and therefore different relativistic gamma factors. As the shocks move out, collisions between these shocks give rise to bursts of energy. We model these energy bursts using a simple model based on the timescales involved in the process. We obtain the temporal structure of the expected light curves. This model can be used to look for signals of gamma ray bursts in cosmic string wakes.

Field of contribution:

Theory

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Neutrino Phenomenology in Scoto-Seesaw mechanism with Modular A_4 Symmetry

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In this work, we study a hybrid scoto-seesaw mechanism based on modular A_4 symmetry, which has many interesting phenomenological implications. In this scoto-seesaw framework, the type-I seesaw mechanism generates the atmospheric mass square difference (Δm^2_{atm}) at the tree level. Additionally, the scotogenic contribution plays a crucial role in obtaining the other mass square difference (Δm^2_{sol}) at loop level, providing a clear understanding of the two distinct mass square differences observed in neutrino oscillations. The non-trivial transformations of Yukawa couplings under the A_4 modular symmetry facilitate the exploration of neutrino phenomenology, offering a specific flavor structure for the mass matrix. This model not only makes predictions regarding neutrino mass ordering, mixing angles, and CP phases, but it also yields precise predictions for Σm_i as well as $|m_{ee}|$. Specifically, the model predicts Σm_i within the range of (0.073, 0.097) eV and $|m_{ee}|$ in (3.15, 6.66)$\times 10^{-3}$ eV. Furthermore, our model shows promise in addressing lepton flavor violations, such as $l_\alpha \to l_\beta \gamma$, $l_\alpha \to 3 l_\beta$, all while remaining consistent with current experimental limits.

Field of contribution:

Theory

212

Investigating Dark Photon Interactions Using a Germanium Detector at the Kuo-Sheng Nuclear Reactor

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In various extensions of the Standard Model (SM) that incorporate an additional U(1)′ gauge symmetry, the dark photon (A′) emerges as a compelling candidate for dark matter. This hypothetical particle can interact with Standard Model particles via kinetic mixing with the standard photon, thus serving as a potential portal to the dark sector. Theoretical interest in dark photons is driven by their potential to explain dark matter's observed gravitational effects and their implications for new physics beyond the SM. Nuclear reactors, being intense sources of photons, provide a promising environment to search for dark photons. Reactor-based experiments offer unique opportunities to study these interactions, significantly enhancing our ability to probe the fundamental properties of dark matter. A particularly effective approach is to investigate Compton-like scattering processes, facilitating both the production and detection of dark photons through electron interactions. These interactions are particularly promising to study because they could yield observable signals in the form of ionization events within the sub-keV energy range, where modern detectors, such as high-purity germanium, are highly sensitive. In this work, we investigate dark photon interactions and presents preliminary constraints on the coupling strength and mass of the dark photon at the 90% confidence level, using sub-keV threshold data collected with a germanium detector at Kuo-Sheng Neutrino Laboratory, Taiwan.

Field of contribution:

Experiment

213

Probing the hadronic phase and strangeness production in high energy collisions with EPOS4 hydrodynamical model

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The measurement of strangeness production is an important tool for understanding the hot, dense matter created in relativistic heavy-ion collisions. The strange hadron production is enhanced in heavy-ion collisions due to thermal gluon saturation, while it is suppressed in smaller systems as predicted by canonical models. Although strangeness enhancement is among the earliest proposed signatures of quark-gluon plasma formation, it remains a subject of debate till today. Hadronic resonances such as $\rho(770)^0$, $K^*(890)^0$, $\phi(1020)$, $\Sigma(1385)^{\pm}$, $\Lambda(1520)$, and $\Xi(1530)^0$ serve as sensitive probes of the hadronic phase —the stage between chemical and kinetic freeze-out. Their yields relative to stable hadrons alter with collision centrality or multiplicity, depending on their lifetimes, and provide insight into the hadronic phase properties. Additionally, baryon-to-meson ratios reveal information about the various production mechanisms involved in hadron formation, and require further theoretical investigations. This study presents the yield ratios of strange to non-strange hadrons, resonance to stable hadron yield ratios, estimates of hadronic phase lifetime, and p_{T}-differential baryon-to-meson yield ratios in pp collisions at $\sqrt{s} = 13.6$ TeV and Pb−Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.36$ TeV using the EPOS4 hydrodynamical model. These are the highest energies at which collisions are being recorded at the LHC, providing a foundation for future data comparisons.

Field of contribution:

Theory

214

Test of the universality of \tau and \mu lepton couplings in W-boson decays at CMS

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The standard model (SM) assumes identical couplings of electroweak bosons to the three lepton generations, a property known as lepton flavor universality (LFU), whose violation implies the presence of new physics. LFU implies W boson decay rates equal across the three generations. We report a measurement of the LFU ratio $R(\tau/\mu)$ performed using leptonically decaying top quark pairs recorded by the CMS experiment during 2016–2018.

Field of contribution:

Experiment

215

Studies with a Threshold Cherenkov Detector

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Cosmic muons are capable of producing Cherenkov radiation, a form of electromagnetic radiation that
is produced when a charged particle travels superluminal through a transparent dielectric medium. A
Cherenkov detector which ignores the directionality of the radiation and solely integrates all particles moving
above a set threshold velocity is known as a threshold Cherenkov detector. Since, the minimum particle
energy required to produce Cerenkov radiation is a function of the index of refraction of the radiating
material; the threshold particle energy can be varied if the radiating material is a gas. A gas threshold
Cherenkov detector thus offers a direct and convenient means of measuring the integral intensity of cosmic
ray muons at different energies by varying the pressure in the chamber.
To determine the shape of a portion of the cosmic ray muon energy distribution, we have constructed a
threshold Cherenkov detector sensitive to muons with energies between 1 and 5 GeV. We are measuring the
integral muon intensity at nitrogen pressures of 0.5 to 15 atm. The data is fitted on the prediction of

the
CORSIKA simulation package. Through this, we will be able to infer the feasibility of using a threshold
Cherenkov detector to accurately measure the shape of the cosmic ray muon energy distribution from 1 to
5 GeV.

Field of contribution:

216

Characterizing Neutrino-induced Neutral Pion Production in MINERvA with GiBUU

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The neutral pion production significantly contributes to the hadronic final state in neutrino interactions. Robust oscillation analyses increasingly depend on Monte Carlo event generators to accurately model these interactions on nuclear targets. With systematic uncertainties expected to play a prominent role in future oscillation measurements, integrating pion production models into these generators is essential to ensure precise and dependable predictions. This work explores the measurement of the struck nucleon's momentum using the transverse kinematic imbalance method by analyzing the neutral pion production in charged current neutrino interaction with the Carbon nucleus in MINERνA. GiBUU's prediction for single π^0 production shows a significant agreement with MINERνA data in lower and higher initial nucleon momentum regions.

Field of contribution:

Phenomenology

217

The Phase-2 upgrade of the Electromagnetic Calorimeter

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The Compact Muon Solenoid (CMS) electromagnetic calorimeter (ECAL) is made of about 75000 scintillating lead tungstate crystals arranged in a barrel and two end caps. The scintillation light is read out by avalanche photodiodes (APDs) in the barrel and vacuum phototriodes in the end caps. The fast signal from the photodetectors is amplified and sampled at 40 MHz by the on-detector electronics. This enables precise measurements of both the energy and timing of electromagnetic showers. The high Luminosity upgrade of the LHC (HL-LHC) at CERN will provide unprecedented instantaneous and integrated luminosities of around 5.0 − 7.5 × 1034 cm−2 s−1 and 3 ab−1, respectively. An average of 140–200 collisions per bunch-crossing ('pileup') is expected as a result. This poses a major challenge to the CMS event reconstruction. Under HL-LHC conditions timing information can be used to "separate"pileup vertices that otherwise appear to be "merged"in 3D space coordinates.

The CMS detector is therefore undergoing an extensive Phase-2 upgrade program to prepare for these demanding conditions. In the barrel region of the CMS ECAL, the lead tungstate crystals will continue to perform well. The APDs will also continue to be operational, with some increase in noise, which will be mitigated by reducing the temperature at which ECAL is operated. However, the entire readout and trigger electronics will need to be replaced to cope with the harsh conditions and increased trigger latency requirements at the HL-LHC. The upgraded detector will have a 25 times higher readout granularity, at hardware trigger level, and a sampling rate increase by a factor of 4. The upgraded ECAL will preserve the calorimeter energy resolution, and will significantly improve the time resolution for photons and electrons with energies above 20 GeV.

Field of contribution:

Experiment

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Study of inclusive B meson decays to Ds meson

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The dominant process for the decay of a b quark is $b \to cW^{*-}$, resulting in a flavor correlated c quark and a virtual W. The decay of W boson produces either a $\bar{u}$d or $\bar{c}$s quark pair,both processes are Cabibbo-allowed and $\bar{c}$s is suppressed only by a phase-space factor. We present an analysis of inclusive B^- and $\bar{B}^0$ meson decays to correlated D_s^+X and anti-correlated D_s^-X using Belle II simulated data sample corresponding to integrated luminosity of 1 ab^{-1} at the $\Upsilon(4S)$ resonance. Events are selected by completely reconstructing one B meson and searching for a bound state with charm quark in the rest of the event. Reconstruction and selection of reconstructed B are performed in FEI (Full Event Interpretation). This study provides the evidence for correlated D_s^+ production, which is not well-understood and less common process. This will help us deepen our understanding and improve old measurements on $\bar{B} \to D_s X$.

Field of contribution:

Experiment

219

Challenges and novel reconstruction techniques for the CMS High Granularity Calorimeter for HL-LHC

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The high-luminosity era of the LHC will pose unprecedented challenges to the detectors. To meet these challenges, the CMS detector will undergo several upgrades, including the replacement of the current endcap calorimeters with a novel High-Granularity Calorimeter (HGCAL). Developing a reconstruction sequence that fully exploits the granularity to achieve optimal electromagnetic and hadron identification, as well as a good energy resolution, in the presence of pileup, is a challenging problem. To cope with this task and to make optimal use of this innovative detector, novel algorithms are being devised within a dedicated modular reconstruction framework, The Iterative Clustering (TICL), within CMS Software (CMSSW). This new framework, crafted with heterogeneous computing in mind, is designed to fully exploit the high spatial resolution and precise timing information provided by HGCAL along with information from other subdetectors such as Tracker and Mip-Timing-Detector. Dedicated 2D and 3D pattern recognition algorithms have been developed to retain the physics information while significantly reducing the problem complexity. These algorithms aim to reconstruct single particle showers in 3D and link multiple showers originating from the same particle (e.g bremsstrahlung, hadrons), maximizing efficiency and object purity, while minimizing contamination from pile-up. Advanced machine learning algorithms are also employed in key areas of the reconstruction chain. This presentation will introduce the TICL framework, highlight its physics and computational performance, include validations with test beam data, and showcase the approach being adopted to address the challenges of HL-LHC.

Field of contribution:

Experiment

220

Collider Search of Light Long Lived Charged Scalar in the Alternative Left-Right Symmetric Model

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After the observation of the SM-like Higgs boson at the LHC, the search for the charged Higgs boson is among the prime objectives of beyond the SM (BSM) phenomenology. Depending on the particle nature of charged Higgs, it can decay promptly or remain as a long-lived particle (LLP) at the collider experiments. In this work, we are exploring a long-lived particle (LLP) scenario of a singly charged Higgs boson in the framework of the Alternative Left-Right Symmetric Model (ALRSM). We are considering a below Electroweak symmetry breaking scale (EWSB) massive charged scalar and performing collider phenomenology in the context of 13 TeV LHC.

Field of contribution:

Phenomenology

221

Exploring Non-Standard Interactions: LGt Inequality Violations in NOνA and T2K Anomalies

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The recent anomalies observed in NOνA and T2K experiments within the standard three-flavor neutrino oscillation model suggest the possibility of physics beyond the Standard Model (SM). To address this, we explore Non-Standard Interaction (NSI) parameters that could explain these anomalies by analyzing the violation of Leggett-Garg-type inequalities (LGtI) in the framework of three-flavor neutrino oscillations. Specifically, we examine LGtI violations in scenarios involving complex NSI parameters, focusing on $\epsilon_{e\mu}$ and $\epsilon_{e\tau}$ couplings in long-baseline accelerator experiments, under both normal (NO) and inverted mass ordering (IO). Our findings indicate that LGtI violations are enhanced in the NO scenario for the $\epsilon_{e\tau}$ coupling in experiments like T2K, NOνA, and DUNE. Additionally, in the DUNE setup for IO, LGtI violations above 8.5 GeV could suggest the presence of new physics associated with the $\epsilon_{e\tau}$ NSI scenario.

Field of contribution:

Phenomenology

222

Exploring TeV-Scale Vector Leptoquarks as Solutions to Magnetic Dipole Moment Anomalies

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Precision measurements of charged lepton dipole moments provide valuable insights into physics beyond the Standard Model. We explore the parameter spaces of TeV-scale vector leptoquarks (LQs) relevant to these observables, focusing on the magnetic moment discrepancy ($a_\mu^{\rm exp} - a_\mu^{\rm SM}$) and constraints from the LHC. Our analysis shows that only the U_1 and V_2 LQ models can explain the observed positive shift in the muon magnetic moment anomaly through chirality-flipping contributions with order-one LQ-quark-lepton couplings at one loop level. Additionally, we examine how these two LQ types align with recent electron dipole moment and Atomic Parity Violation(APV) measurements, demonstrating their compatibility with current experimental bounds.

Field of contribution:

Phenomenology

223

Hadronic FEI calibration studies with $B \to D^{(*)}\pi$ samples in Belle II

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Belle II provides an excellent environment to study missing energy modes. These studies need a complete reconstruction of one of the two B mesons produced in the collision. Belle II has a dedicated algorithm called Full Event Interpretation(FEI) for reconstructing a B meson. FEI follows a hierarchical approach employing multivariate analysis at each stage to reconstruct the exclusive B meson decays. FEI depends on Monte Carlo(MC) samples for the BDT training. However, the FEI reconstruction suffers from significant data-MC discrepancy due to limited knowledge of B meson decays and incorrect MC models. To correct this, a calibration can be performed by measuring a well-known decay with sufficient statistics. Here, calibration factors are calculated to correct the efficiency of hadronic modes using $B \to X\pi(X = D, D^{(*)})$ decays in 362 fb^{-1} of Belle II data.

Field of contribution:

Experiment

224

Study of strangeness production at top SIS100 energy

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The prime focus of relativistic heavy ion collisions is to study the nuclear matter under extreme conditions to explore the QCD phase diagram. There are various observables to study such matter. One of the important observables is rapidity or transverse momentum dependent strangness production. The strangeness production are studied extensively at RHIC, LHC energies. Researchers observed that strangeness is enhanced in heavy ion collisions at such high relativistic energies. Plenty of studies are reported on strangeness production at AGS and SPS energies. The same needs to be studied for SIS18 and SIS100 energies as well. The future Compressed Baryonic Matter (CBM) experiment at the Facility for Anti-proton and Ion Research (FAIR), Darmstadt, Germany, is dedicated to studying the nuclear matter at SIS18 and SIS100 energies. In this study, an attempt has been made to study strangeness production and particle ratios in the CBM detector acceptance using hybrid UrQMD-hydro generated Monte Carlo(MC) data at 10 AGeV Au+Au collisions. The results have been compared with those from strangeness production from the hadronic approach of UrQMD.

Field of contribution:

Phenomenology

225

Holographic Dual of Driven Conformal Field Theories

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Driven Conformal Field Theories (CFTs), where Hamiltonians alternate periodically (Floquet CFTs) or change abruptly (Quench), have emerged as a versatile platform for exploring non-equilibrium phenomena in soluble systems. We investigate the holographic dual of a large c CFT in two-dimensions, initialized in a thermal state and subject to a generic deformation by $SL^{(q)}(2, R)$ generators. We analyze the evolution of the corresponding event horizons and energy densities across the phases

- heating, non-heating – as well as on the phase boundary. The black hole horizon evolution mirrors the energy density behavior, revealing the underlying correspondence between the bulk and the boundary dynamics. Furthermore we examine the Killing horizons of CFT quenches driven by elliptic, parabolic, hyperbolic hamiltonians, observing distinct behaviours in the norm of the killing vectors. We also extend this analysis for geometries which are asymptotically AdS_3 and observe the same behavior in the norm of the asymptotic killing vectors.

Field of contribution:

Theory

226

A Comparative Study of High Energy Hadronic Interaction Models at TeV-PeV Energies Using Cosmic Ray Muons at the GRAPES-3 Experiment

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The interaction of high-energy cosmic rays with Earth's atmosphere initiates a cascade of secondary particles known as an Extensive Air Shower (EAS). The Gamma Ray Astronomy at PeV EnergieS Phase-3 (GRAPES-3) experiment is a ground-based cosmic ray observatory, comprising approximately 400 plastic scintillators to detect the electromagnetic component and a large-area muon telescope to monitor the muonic component of EASs. Muon properties, including multiplicity and energy, provide critical insights into the primary cosmic ray composition. However, the current hadronic interaction models such as QGSJET II-04, EPOS LHC, and SIBYLL 2.3d vary significantly in their predictions for muon characteristics. In this contribution, we present a comparative analysis of these high-energy hadronic interaction models through simulations of cosmic ray muons in TeV–PeV monoenergetic showers, conducted using CORSIKA (Version 7.7550). Our analysis highlights discrepancies among model predictions, specifically focusing on muon multiplicity and energy distributions from 100 TeV, 500 TeV, and 1 PeV monoenergetic showers under GRAPES-3 conditions. We consider a range of primary cosmic ray nuclei, including protons, helium, carbon, nitrogen, oxygen, aluminum, and iron, to better understand model-dependent variations in shower characteristics and improve interpretation of GRAPES-3 data.

Field of contribution:

Experiment

227

Neutrino Masses and Mixing in a $\Delta(27)$ Symmetric Dirac Model

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Amid uncertainty about the fundamental nature of neutrinos, we adopt the Dirac framework and construct a model based on the $\Delta(27)$ symmetry. The model successfully explains the hierarchical structures of both charged lepton and neutrino masses. The resulting neutrino mass matrix features four texture zeros, and the corresponding mixing scheme, governed by a single parameter, aligns well with experimental data.

Field of contribution:

228

Examining hadronic interaction models through Muon Lateral Distributions at the GRAPES-3 Experiment

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Studying cosmic ray-induced air showers in Earth's atmosphere provides valuable insights into the primary cosmic rays, offering an indirect approach to analysing these high-energy particles. The muonic component in air showers is particularly informative for determining the mass composition of primary cosmic rays, underscoring its significance. Hadronic interaction models, such as EPOS-LHC, QGSJET II-04, and SIBYLL 2.3, are employed to describe air shower development, predicting key observables like muon content and the lateral shower profile. However, discrepancies persist between these model predictions from Monte Carlo (MC) simulations and experimental data indicating muon deficit, suggesting further refinements are needed in current models. The GRAPES-3 Muon Telescope (G3MT), located at 2200 meters above sea level, is a large-area ($560m^2$) ground-based detector comprising 3,712 gaseous proportional counters sensitive to muons. A larger telescope, with a 70% increase in field of view, is currently under construction to expand observational capabilities. In this contribution, we will present a comparative analysis of the three hadronic models EPOS-LHC, QGSJET II-04, and SIBYLL 2.3 and by examining simulation results with data from the GRAPES-3 experiment to assess the models' effectiveness in the higher energy range. Focusing on muon lateral distribution and its dependence on cosmic ray composition, we investigate primary particles, including protons, helium, nitrogen, aluminium, and iron, across the TeV to PeV energy spectrum, aiming to enhance our understanding of model performance at higher energies and refine interpretations of muon observables in GRAPES-3 experiment.

Field of contribution:

Experiment

229

Electric Field Simulation of the GRAPES-3 Proportional Counter

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The GRAPES-3 experiment in Ooty, Tamil Nadu, operates the world's largest muon telescope, consisting of 3,776 proportional counters (PRCs) as its primary detectors. These PRCs are cuboidal iron tubes filled with P10 gas, a mixture of 90% Argon and 10% Methane. Each PRC has dimensions of 6mx 0.1m x 0.1m and contains a 100-micron diameter tungsten wire anode, placed exactly at the centre of the cathode maintained at 3000 V. This configuration creates a strong electric field within the tubes, leading to an avalanche of electrons and ions whenever an ionizing particle passes through, enabling precise detection of cosmic ray muons. Studying the electric field inside the PRCs provides deeper insights into the detector's response to different particles, enhancing our understanding of how the GRAPES-3 collaboration measures various cosmic ray components. It also helps optimize the detector's performance and accuracy in particle identification and energy measurement. In this contribution, we will present a study on the reconstruction of a GRAPES-3 PRC and its electric field simulation using Python libraries such as SciPy, NumPy, Matplotlib, and MayaVi-3D. We will present the effects of electric field strength as a function of radial distance from the centre of the counter in the transverse plane, along with the longitudinal variation of the electric field strength. We will present how the electric field strength varies with changes in the anode radius and the calculation capacitance per unit length of the PRC. The results are then compared with the electric field simulation results of Geant4 interfaced with Garfield++. This analysis provides a critical insight into the operational characteristics of the PRCs in GRAPES-3, influencing their efficiency and accuracy in detecting and measuring cosmic ray particles.

Field of contribution:

Experiment

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Impact of κ-deformation on particle geodesics around Schwarzschild black hole

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A fundamental length scale is a key feature of all quantum gravity theories, and non-commutative space-time provides a pathway to incorporate this length scale naturally in the theory. In our study, we investigate the geodesic motion of a test particle around a Schwarzschild black hole in a specific non-commutative space-time (κ-deformed space-time). We compute a modified Lagrangian to obtain the κ-deformed effective potential and determine particle trajectories based on constants of motion. Significant deformation is observed in particle orbits due to the non-commutativity of the κ-deformed space-time, especially at higher angular momentum, resulting in smaller radii and decreased velocities compared to the commutative case. Despite these modifications, the radius of the innermost stable circular orbit (r_{ISCO}) remains unchanged. We also study a large number of freely streaming particles in this deformed space-time, focusing on those with different angular momenta. The results show that due to the non-commutativity of space-time, the particles remain closer to the black hole for longer periods. This may lead to the modifications in the accretion process around the black hole.

Keywords: κ-deformed space-time, non-commutative space-time, particle concentration.

Field of contribution:

Theory

231

Debye mass and Binding Energy of Heavy quark potential in presence of magnetic field

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In this study we investigated the behavior of heavy Quarkonia in hot and magnetized quark-gluon plasma, incorporating the phenomena of Inverse Magnetic Catalysis (IMC). Specifically we modified the effective quark masses by incorporating the magnetic field-dependent Debye mass, which affects the screening of the quark-antiquark potential. Previous studies on Debye screening mass in magnetized medium overlooked a crucial aspect : the impact of Inverse Magnetic Catalysis near transition temperature. In this work, we address this gap by incorporating both Magnetic Catalysis (MC) and IMC effects through a medium-dependent constituent quark mass.
Our analysis yielded the real and imaginary parts of the heavy quark potential in this magnetized environment. We then evaluated the binding energy to comment on the dissociation temperatures of these bound states in the presence of magnetic field.

Field of contribution:

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”Exploring the Mass Spectra of Heavy Pentaquarks with Enhanced Hyperfine Interactions”

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In this study, we analyse the mass spectra of all heavy pentaquarks using the Hyper-central Constituent Quark Model (hCQM) within a non-relativistic framework. Our focus is on computing the ground-state masses of pentaquarks that contain charm and beauty quarks, examining various spin-parity configurations JˆP. This analysis employs two different confining potentials, complemented by an enhanced hyperfine interaction. By evaluating the spectra across a range of states with their associated spin-parity, we gain insights into the behavior of these masses. Our calculated masses are then compared with both experimental data and theoretical predictions to evaluate accuracy and consistency.

Field of contribution:

Phenomenology

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A new parametrization scheme for the neutrino mass matrix.

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We explore a new parametrization scheme, known as exponential parametrization, for the Majorana neutrino mass matrix. In this framework, the elements of the mass matrix are represented in terms of their absolute values and arguments. We propose a neutrino mass matrix texture that highlights four correlations among its elements under this parametrization scheme. For normal ordering, the mixing scheme derived from the proposed texture aligns with experimental observations, whereas the texture is ruled out for inverted ordering. Additionally, we derive the proposed texture from the seesaw mechanism, associated with the $SU(2)_L \times U(1)_Y \times A_4 \times Z_{10}$ group.

Field of contribution:

Phenomenology

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Multiplicity and rapidity dependent study of (multi)-strange hadrons in small collision system using the STAR detector

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Strangeness enhancement has long been considered as a signature of the quark-gluon plasma formation in heavy-ion collisions. Strangeness enhancement has also been observed in small systems at the LHC, but the underlying physics is not yet fully understood. This motivates studies of strange hadron production in small systems at RHIC, where the energy density of the created system is expected to be smaller than that at the LHC and therefore a hot and deconfined medium is less likely to be created. Results on the multiplicity dependence of strange hadron production in small systems can be compared to peripheral heavy-ion collisions, and help to understanding the role of event multiplicity in strange hadron production. Study of rapidity asymmetry ($\mathrm{Y_{Asym}}$) of the strange hadron production and nuclear modification factors ($\mathrm{R_{dAu}}$) in d+Au collisions can also give insight on cold nuclear matter effects.

We present measurements of (multi)-strange hadrons (K^0_S, Λ, Ξ and Ω) in d+Au collisions at $\sqrt{\mathrm{s_{NN}}}$ = 200 GeV, collected by STAR in 2016. We investigate the multiplicity dependence of (multi)-strange hadron transverse momentum (p_T) spectra, p_T-integrated yields dN/dy, average transverse momentum ($\langle p_\mathrm{T} \rangle$), and yield ratios to pions. $\mathrm{R_{dAu}}$ and $\mathrm{Y_{Asym}}$ for these particles will be presented. The implications of these measurements on the possible formation of a hot and deconfined medium and the origin of strangeness enhancement in small systems will be discussed.

Field of contribution:

Experiment

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Estimating the Sensitivity of IceCube-Gen2 to Cosmic Ray Mass Separation

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IceCube-Gen2 is a proposed extension to the existing IceCube Neutrino Observatory at the South Pole. Here we study the sensitivity of this future detector to the mass separation of primary cosmic rays, using CORSIKA Monte Carlo simulations of air showers initiated by H, He, O and Fe primaries. IceCube-Gen2 will have mainly three components: an optical array instrumenting ten times the in-ice volume of the present detector with 120 optical strings made up of the digital optical modules (DOMs), a proportionally larger surface array on top of the optical array, and a radio array for ultra-high-energy neutrinos. The surface array will be composed of 130 hybrid stations, each with eight scintillators and three radio antennas, the latter are not yet considered in this study. IceCube/IceCube-Gen2 detects cosmic rays indirectly via the observation of particle cascades in the Earth's atmosphere. Here we investigate a set of variables for both, the scintillators of the surface array and the full optical array, to identify those which have the highest mass discrimination power. Among the various variables studied, the energy loss of in-ice muons in the optical array is found to have the highest discrimination power provided that the cosmic-ray energy is known, e.g. from the surface array.

Field of contribution:

Experiment

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A novel jet substructure approach to polarization measurement in boosted hadronic W bosons

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In this work, we introduce a novel technique for measuring the longitudinal and transverse polarization fractions of boosted hadronic W boson decays. We propose a jet substructure observable, p_θ, derived from subjet energies, serving as a proxy for the
W boson's parton-level decay polar angle in its rest-frame. This observable is sensitive to W boson polarization and offers lower reconstruction errors than existing proxies, especially for highly boosted W bosons. Looking forward to an optimistic scenario with $10\,\mathrm{ab}^{-1}$ of data at the High Luminosity LHC, our technique could achieve a 20% error in measuring the transverse W polarization fraction. Although detecting longitudinal polarization consistent with the Standard Model at the 2σ level may remain challenging, this method holds potential for identifying enhancements in Beyond Standard Model scenarios, thereby contributing to unitarity restoration studies.

Field of contribution:

Phenomenology

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Mass spectroscopy of bottomonium using a QCD motivated potential model

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In this work, we estimate the mass spectra and decay properties of heavy quarkonia, specifically bottomonium ($b\bar{b}$), using a non-relativistic potential model. We employ a potential model incorporating a Coulomb like term $(-1/r)$, representing one gluon exchange at short distances, and a confining term ($\sqrt{r}$), representing quark confinement at long distances. Spin dependent corrections are also added perturbatively. Our results are compared with available experimental data to assess the validity and accuracy of the model. Results were showing good agreement with the experiential results and other theoretical results.

Field of contribution:

Phenomenology

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Probing sub-TeV higgsino mass in a trilinear RPV SUSY scenario using GNN-based boosted top tagger

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The small production cross-section of higgsinos poses a persistent challenge for detection at the LHC. We focus on a simplified R-parity violating supersymmetric model, where existing ATLAS limits on higgsino mass are around 450 GeV—significantly weaker than those for wino and bino counterparts. In this study, we investigate the potential to probe higgsino masses in the range of 400 to 1000 GeV. We employ a Graph Neural Network(GNN)-based LorentzNet classifier to tag boosted fat jets originating from top quarks and integrate data from tracker detectors to enhance classification accuracy.For each benchmark point, we trained separate Boosted Decision Trees (BDTs) in two mutually exclusive signal regions to distinguish signal from background effectively. By combining the statistical significance across both signal regions, we demonstrate that our methodology allows for probing higgsino masses up to 800 GeV at the high-energy, high-luminosity LHC.

Field of contribution:

Phenomenology

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Diffuse Neutrino Flux from Choked and Low-Luminosity GRBs

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Gamma-ray bursts (GRBs) are cataclysmic astrophysical events, classified into long-duration (lasting ≥ 2 seconds) and short-duration bursts. We investigated two subcategories of GRBs: choked and low-luminosity (LL) GRBs, focusing on their potential to emit high-energy neutrinos. Our analytical approach incorporates pion and kaon decay mechanisms, taking into account cooling effects such as synchrotron and hadronic cooling. For choked GRBs, we found that the neutrino flux is dominated by kaon decay, due to kaons' heavier mass and shorter decay time compared to pions. We found that p-p mechanism produces lower neutrino fluxes compared to the Ice-Cube detected diffuse neutrino flux. Our model parameters are informed by simulation results for choked GRBs, and fine-tuning these parameters or considering distinct scenarios for hidden jets could potentially explain the observed neutrino flux.

In the case of LL GRBs, our calculations suggest that their contribution to the diffuse neutrino background is significant at high energies. Notably, the results for LL GRBs are highly sensitive to variations in GRB parameters, which can significantly influence the neutrino flux. As neutrino detectors such as IceCube, ANTARES, and KM3NeT gather more data, the potential to refine theoretical models and place constraints on neutrino production mechanisms in astrophysical sources becomes increasingly promising. The upcoming IceCube-Gen2 observatory will be instrumental in identifying individual neutrino sources.

Field of contribution:

Theory

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Advancing Confinement Studies in QCD: Meson Spectra Analysis with New Potentials in Light-Front Holography

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Quantum Chromodynamics (QCD) is the fundamental theory that describes strong interactions, which is an interesting problem in the non-perturbative regime due to the quark confinement and strong coupling of interactions. In Light-front holography (LFH), a favorable approach is studied to acknowledge these intricacies by mapping QCD onto a higher-dimensional anti-de Sitter (AdS) space, allowing an effective 4-dimensional description of hadron physics. In this study, we investigate the introduction of novel confining potentials, such as Coulomb and Yukawa, into an updated hadron model within the LFH framework. We consider the importance of these potentials by computing the longitudinal eigenmass and examining the resulting Regge trajectories for selected mesons. The theoretical predictions are then compared with observed values from the Particle Data Group (PDG) to test the consistency of the model. The research utilizes computational tools, including Python for numerical analysis and Mathematica for symbolic calculations, to solve the model equations and to conduct a rigorous analysis. Our goal is to understand the alignment of these potentials with the meson mass spectra, potentially improving the interpretation of confinement mechanisms in QCD.

Field of contribution:

Theory

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Methodologies for Investigating Discrepancies in Simulated Low-Energy Background Response of HPGe Detectors

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We have developed a background model for a High-Purity Germanium (HPGe) detector using Monte Carlo simulations, focusing on accurately representing low-energy interactions within the 0 to 100 keV range. Initial simulations revealed discrepancies between experimental and simulated spectra, with peaks at 63 keV, 77 keV, and 87 keV appearing in simulations but absent in experimental data. To address this, we optimized the capping thickness of the HPGe crystal and refined the position of the front-end electronics relative to the crystal. By adjusting the capping thickness to 4 mm, the simulated 63 keV peak was successfully suppressed, improving agreement with the experimental spectrum. Further position refinements of the front-end electronics were performed to minimize discrepancies, enhancing the model's accuracy in the low-energy region.

Field of contribution:

Experiment

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Measurements of p-Λ Correlation Function in Au+Au Collisions at 200 GeV from UrQMD model

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Two-particle femtoscopy is a powerful technique for investigating both the emission source and the interaction potentials between particle pairs. The primary observable in femtoscopy is the two-particle correlation function, which provides crucial insights into the space-time characteristics of the emitting source, as well as the effects of final-state interactions. By analyzing correlations between non-identical particles, particularly hyperon-nucleon (Y-N) pairs like Λ-p, we gain valuable information that can help address the neutron star puzzle and deepen our understanding of the equation of state (EoS) of dense stellar objects. In this study, we present the femtoscopic correlations between proton and lambda pairs in the Au+Au events simulated using the Ultra-relativistic Quantum Molecular Dynamics (UrQMD) model at $\sqrt{s_{NN}}$ = 200 GeV analyzed with the CRAB (Correlation AfterBurner) model by incorporating final-state interactions between the pairs that would be present in real data. The p-Λ correlation function obtained from CRAB afterburner will be fitted using models like Lednicky-Lyuboshitz (L-L fit), allowing extraction of critical interaction parameters such as the particle emission source size, scattering length (f_0), and effective range (d_0) of the Y-N interactions in the high energy nuclear collisions. Moreover, the model results will be compared with the published STAR results to validate the UrQMD simulations against data from experiments.

Field of contribution:

Theory

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Parameter space sampling using Simulation Based Inference

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This study examines parameter space sampling for Beyond the Standard Model (BSM) physics, a computationally intensive task in High Energy Physics (HEP). Simulation-Based Inference (SBI) offers a promising alternative to traditional likelihood-based methods by circumventing the need for explicit likelihood calculations, which are often intractable for BSM scenarios. We apply SBI techniques—Neural Posterior Estimation (NPE), Neural Likelihood Estimation (NLE), and Neural Ratio Estimation (NRE)—to the Higgs sector of the phenomenological Minimal Supersymmetric Model (pMSSM). Our findings reveal that only NPE effectively samples the pMSSM parameter space, while NLE and NRE face limitations. Using the Tests of Accuracy with Random Points (TARP) test, we evaluate posterior accuracy and explore how observables shape feasible parameter regions, highlighting SBI's utility in complex HEP models.

Field of contribution:

Phenomenology

244

Study of the nature of neutrinos in the presence of environmental decoherence

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In this work, we examine the scope of determining the nature of neutrinos in a dissipative environment at long baseline neutrino oscillation experiments. Assuming an open quantum system framework, we analyze the flavor transition probabilities of the neutrinos and anti-neutrinos at different baselines and study the effect of Majorana phase on these probabilities. Additionally, we explore the sensitivity of T2K, ESSnuSB, NOvA, T2HKK and DUNE to differentiate between Dirac and Majorana neutrinos.

Field of contribution:

Phenomenology

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An MCMC analysis to probe the trilinear R-parity violating supersymmetric models with neutrino oscillation and other data

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We investigate a well-motivated Trilinear Lepton Number Violating Supersymmetric model with both LLE and LQD couplings to account for neutrino oscillation data. Our analysis includes neutrino mass splittings, mixing angles from oscillation data, and additional experimental constraints such as the Higgs mass, coupling modifiers, and low-energy flavor-violating observables. To achieve a good fit, we conduct a chi-square-based likelihood analysis using Markov Chain Monte Carlo (MCMC). We explore scenarios with different lightest supersymmetric particles (LSPs), specifically bino-LSP and stop-LSP, to constrain the model's viable parameter space. Finally, we evaluate the capability of the High-Luminosity LHC (HL-LHC) to probe these parameter regions.

Field of contribution:

Phenomenology

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Reconstruction of LMVMs via Dimuon decay channel using Machine Learning Technique for the CBM Experiment at FAIR

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The Compressed Baryonic Matter (CBM) experiment, being developed at the Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany, is focused on exploring the phase diagram of strongly interacting matter at high net baryon densities and moderate temperatures. The, SIS-100 accelerator ring at FAIR accelerator facility will deliver accelerated beam with kinetic energies reaching 29 GeV for protons and up to 11 A GeV for heavy ions. A critical physics observable for examining the hot, dense matter produced in collisions is the identification of muon pairs, resulting from the decay of Low Mass Vector Mesons (LMVMs). The Muon Chamber (MuCh)[2] detector system is being built to identify the muon pairs in a background mostly populated by muons from weak decay of pions and kaons produced in the collisions.

Simulation studies on reconstructing LMVMs (ω, η, φ) through the di-muon decay channel will be presented for Au+Au collisions at 10 A GeV using various machine learning models. These results will be compared with those obtained through traditional cut-based analysis. The traditional method relies on track selection criteria, including the number of hits in the Silicon Tracking System (STS), Muon Chamber (MuCh), Transition Radiation Detector (TRD), and Time of Flight (TOF) detector, as well as χ^2 values for the Vertex, STS, and MuCh, along with a 2σ TOF mass cut. These parameters are also used in training and testing machine learning models. The performance of the Boosted Decision Tree Gradient (BDTG) model in improving reconstruction efficiency (ϵ) of LMVMs while maintaining the Signal-to-Background ratio (S/B) will be reported.

Field of contribution:

Experiment

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Study of jet-hadron correlation in pp collisions at 13 TeV using PYTHIA

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The collisions of small systems at LHC energies exhibit remarkable similarity with heavy-ion collision by far the collectivity concerned. Measurements of anistropic flow coefficients in pp and p-Pb collision at top LHC energies have shown significant magnitude flow coefficients even at low multiplicity, which is generally attributed to collective dynamics in strongly interacting quark-gluon plasma (QGP) produced in heavy-ion collision. However, at low multiplicity non-hydrodynamic components can not be ignored.
Another fascinating signature in heavy-ion collisions that measures the suppression of jet energy as it passes through the medium is the jet quenching. Jets are collimated sprays of particles originating from the fragmentation of highly energetic partons produced in the initial stages of a heavy-ion

collision. The suppression of the jet energy is a consequence of the interaction of jets with the Quark-Gluon-Plasma(QGP) medium which reflects the energy loss mechanisms and transport properties of the medium. This phenomena has not been observed in small system collisions till date which has triggered debate whether the observation of anisotropic flow in small systems is actually a manifestation of collective dynamics.
Besides the measurements of modifications of jet yields in heavy-ion collision, measurements of jet-hadron correlations provide a link between the high-momentum probes and the bulk medium which can be used to probe modification of jet fragments, if any due to jet medium interactions. In this work we use multiple parton interaction (MPI) enabled PYTHIA 8 to study near and away side yields and widths of jet-hadron correlations as function of charged particle multiplicity. In absence of any medium, which is the case for PYTHIA8, one would naively expect little or no modifications in the correlation structures, like yields or width as a function of multiplicity thereby providing a baseline expectations for how these quantities would behave in the absence of medium. Any deviation observed in data may indicate other physical processes beyond the standard picture of MPI in pp collisions.

Field of contribution:

Phenomenology

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Including fermion vacuum fluctuations in finite volume Polyakov chiral SU (3) mean field model

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The influence of fermion vacuum fluctuations on the thermodynamic properties of strongly interacting quark matter is examined within a finite volume Polyakov chiral SU(3) quark mean field (PCQMF) model at finite temperatures and chemical potentials. A lower momentum cutoff is used to introduce finite volume effects to investigate scaled thermodynamic quantities: pressure p/T^4, energy density ϵ/T^4, entropy density s/T^3, and trace anomaly $(\epsilon - 3p)/T^4$. Along with this, the effect of the fermion vacuum term on quantities such as the square of the speed of sound (c_s^2) and the specific heat (c_v) at a constant volume is computed. The model predictions are compared to QCD lattice simulations. The inclusion of finite size effects in the vacuum term results in a reduction of the effective quark masses with diminishing system size at lower temperatures, substantially influencing the thermodynamic quantities.

Field of contribution:

Phenomenology

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Investigation of the Quenching Factor for Silicon and Germanium using Molecular Dynamics Simulations

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The quenching factor is a crucial parameter for accurately analyzing nuclear recoil data in dark matter searches, as well as in neutron and coherent neutrino scattering experiments. In this study, we investigate nuclear and electronic stopping powers in self-irradiated silicon and germanium matrices to understand energy loss behaviors. Using the LAMMPS molecular dynamics package with a (3x3x3 Å) simulation cell, we calculated stopping powers for silicon and germanium targets at kinetic energies ranging from 1 eV to 10 keV. Our calculated stopping powers for both nuclear and electron interactions in silicon and germanium were compared with available experimental measurements to validate our results. We also discuss the systematic uncertainties associated with this approach, which are crucial for reliable quenching factor evaluation and interpretation of experimental data in related fields.

Field of contribution:

Experiment

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Impact of Dark Matter on the properties of static and rotating Neutron Star

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This research explores the combined effects of dark matter (DM) and rotation on the structural and dynamical properties of neutron stars (NSs). Utilizing a self-interacting dark matter model inspired by the neutron decay anomaly, the study integrates DM within the relativistic mean-field (RMF) framework, modeling static and rotating NSs to observe the impact of varying DM interaction strengths and angular velocities. The Hartle-Thorne formalism is employed to model rotating stars, examining key properties, including mass, radius, central energy density, and eccentricity, across a range of DM and rotation conditions.

Results reveal that DM significantly influences the neutron star's equation of state (EOS), generally softening it and reducing the star's mass and radius. In contrast, rotational effects increase mass and radius due to centrifugal forces. Higher DM fractions reduce the NS's eccentricity, indicating less deformation from rotation compared to DM-free stars. Additionally, variations in the DM interaction strength alter the star's mass-shedding limit, with low DM fractions allowing higher rotational speeds before mass-shedding occurs, thus supporting larger mass and radii under rotation. For fixed DM fractions, high angular velocities lead to positive deviations in mass and radius from the baseline (DM-free) values, indicating enhanced deformation, while low angular velocities result in reduced mass and radius due to DM's influence.

By comparing DM-admixed and DM-free models, the study also examines the relative deviations in maximum rotational mass and equatorial radius, showing that both DM and rotation substantially modify these properties. The findings underscore the interplay between DM content and rotation in defining NS characteristics, offering insights for interpreting observations of highly dense, rotating

astrophysical objects. The results align well with current observational constraints, including NICER and XMM-Newton data, providing an avenue for future studies on DM's role in the behavior of ultra-dense matter within NSs.

Field of contribution:

Phenomenology

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Study of transverse polarization asymmetry $\Lambda_b \to n l^+ l^-$ with non-universal Z' model

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Baryonic decays which involve $b \to d$ are very sensitive to new physics effects. Recent experimental observations of $\Lambda_b^0 \to p K^- \mu^+ \mu^-$ decay motivate the theorist to study baryonic decay [1]. The $\Lambda_b \to n l^+ l^-$ decays are forbidden at the tree level in SM. It provides opportunities to test NP models like the leptoquark model [2], two-Higgs doublet model (2HDM) [3], non-universal Z' model [4] and fermion fourth generation model [5]. In the theoretical background, many attempts have been made in different approaches like light cone sum rule (LCSR), lattice quantum chromodynamics (LQCD), the 2HDM and the Bethe-Salpeter equation approach. In the Bethe-Salpeter equation approach the obtained branching ratios $Br(\Lambda_b \to n l^+ l^-) \times 10^8$ are $6.79^{+8.66}_{-1.82}$ (for $l = e$), $4.08^{+5.44}_{-1.19}$ (for $l =$) and $(2.9)^{+3.7}_{-0.78}$ (for $l =$) [6]. In the context of LQCD and LCSR [7] branching ratios $Br(\Lambda_b \to n l^+ l^-) \times 10^8$ are obtained as (3.19±0.32),(3.79±0.46) (for $l = e$), (3.15±0.29),(3.76±0.42) (for $l =$) and (1.42±0.32),(1.65±0.19) (for $l =$) respectively. Later on these results are updated in LCSR [8] $Br(\Lambda_b \to n l^+ l^-) \times 10^8$ as (8±2) (for $l = e$), (7±2) (for $l =$) and (2±0.4) (for $l =$). In the relativistic quark-diquark model of baryons, the branching ratios $Br(\Lambda_b \to n l^+ l^-) \times 10^8$ are 3.81 (for $l = e$), 3.75 (for $l =$) and 1.21 (for $l =$) [9]. In this work, we intend to study $\Lambda_b \to n l^+ l^-$ decays in non-universal $Z^{'}$ model. We will estimate the transverse polarization asymmetry for $\Lambda_b \to n l^+ l^-$ decays. To determine new physics, we will use quark coupling from $B_d^0 - B_d^0$ mixing. We hope these results will help the experimental community to explore these kinds of decays at the LHCb/Belle II detector in the upcoming time.

Acknowledgement
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Field of contribution:

Phenomenology

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Logarithmic corrections to the black hole entropy

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We discuss logarithmic corrections to the Bekenstein-Hawking entropy of black holes by taking into account thermodynamic fluctuations at finite temperature. In particular, for frameworks where the cosmological constant is regarded as a thermodynamic pressure, we show that the results match with those obtained from the holographic side.

Field of contribution:

Theory

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Coherency Effects in Neutrino-Nucleus Elastic Scattering

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Neutrino nucleus elastic scattering (νAel) is a direct test of electroweak theory in the Standard Model of particle physics [1]. The νAel cross-section has been measured with the stopped pions neutrinos, whereas the cross-section measurement for low-energy solar and reactor neutrinos has not yet been accomplished [2]. Using state-of-the-art point contact Germanium detector technology, the TEXONO research program at Kuo-Sheng Neutrino Laboratory (KSNL) explores this interaction at reactors [3]. We will highlight the status and results of the νAel searches at the TEXONO experiment. The studies of analytical formulation of coherence parameters and their constraints will be presented.

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Field of contribution:

Experiment

254

New physics effects of Z' boson on $D\to\rho e^+e^-$ decays

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The charm sector offers considerable scope for exploring new physics (NP) beyond standard model (SM). Rare charm decays which proceed through the flavour changing neutral current (FCNC) transitions are effectively suppressed due to the Glashow-Iliopoulos-Maiani mechanism. This makes charm decays sensitive to NP effects [1]. Several phenomenological studies have been done to look for NP in the charm sector. The experimental upper limits of some decays undergoing $c\to ul^+l^-$ transition such as $D^+\to\pi^+\mu^+\mu^-$, $D_s^+\to K^+\mu^+\mu^-$, $D^+\to\rho^+\mu^+\mu^-$ are of the order of 10^{-8}, 10^{-7} and 10^{-4} respectively [2]. These charm decays have been explored for NP effects through leptoquark model [3, 4], SUSY models [4] and Z' model [3-5]. In non-universal Z' model, the rare FCNC decays occur at tree level and they are mediated by a new gauge boson particle, the Z' boson. In this work, we shall look for possibilities of NP due to the effects of Z' boson on the rare charm decays $D\to\rho e^+e^-$, which proceed through $c\to ul^+l^-$ quark transition. The Z' boson couples with both quarks as well as leptons. We shall modify the Wilson coefficients by incorporating the NP couplings. We shall estimate the branching fractions and forward backward asymmetries in Z' model and compare them with their corresponding SM values. Since $D\to\rho e^+e^-$ decays are FCNC decays undergoing $c\to ul^+l^-$ transition, we expect these decays to be sensitive to the effects of Z' boson.

Acknowledgement
M. Mandal acknowledges Department of Science and Technology, Govt. of India for providing the INSPIRE Fellowship (IF200277) during her research.

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Field of contribution:

Phenomenology

255

Searches for exotic decays of the 125 GeV Higgs boson in the CMS experiment

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After the Higgs boson discovery in 2012, the experiments at the LHC are continuing to study this particle and look for physics beyond the standard model. Some of the Higgs boson properties, such as

the mass, has been measured with sub-percent level accuracy. Yet the present integrated luminosity is still a limiting factor for measuring the Higgs boson self- coupling or the first generation Yukawa couplings. The current constraints on the Higgs boson couplings would still allow for a sizeable branching fraction into undetected final states, which motivates the direct searches for exotic decay modes. This presentation discusses several new results from these searches utilizing advanced online selection methods or analysis techniques with the entire Run 2 data.

Field of contribution:

Experiment

256

Implication of lepton flavour universal and non-universal new physics couplings on $B_s \to (\eta, \eta')\mu^+\mu^-$ decay

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Recent collider's results in B meson decays introduce some disagreement with the SM predictions. The LHCb results for the total branching fractions $Br(B \to K\mu^+\mu^-)$, $Br(B_s \to \phi\mu^+\mu^-)$ and the angular observable P_5' of $B_s \to K^\star\mu^+\mu^-$ decay, which are governed by the flavour changing neutral current (FCNC) $b \to s\mu^+\mu^-$ transition, show inconsistencies with the SM predictions [1]. Another important parameter is lepton flavour universality (LFU) ratio $R_{K^{(\star)}}$. The previous experimental results [2, 3] of R_K and $R_{K^\star}$ differed from the SM prediction, indicating the violation of flavour universality. But the recent LHCb results [4] of $R_{K^{(\star)}}$ supersede their previous measurements and coincide with the SM predictions. Despite these new results, lepton flavour non-universality cannot be ruled out completely, since only R_K measurement does not provide the complete picture, measurement of CP asymmetries in $B \to K\mu^+\mu^-$ and $B \to Ke^+e^-$ is also essential [5]. The authors of Ref. [5] have constrained the Wilson coefficient C_{9e} using the new R_K measurement, keeping $C_{9\mu}$ fixed. As per this recent experimental context of $R_{K^{(\star)}}$, we will consider four possible NP scenarios [6, 7] to study $B_s \to (\eta, \eta')\mu^+\mu^-$ decay. The first scenario involves universal NP couplings, the second and third scenarios have both universal and non-universal NP couplings while the fourth scenario incorporates only non-universal NP couplings. We will examine the sensitivities of the scenarios for the branching fraction and LFU ratio $R_{\eta^{(\prime)}}$. Finally, the outcome from these NP scenarios will be compared with the SM predictions to recognize which scenario will be more reliable to study $b \to s\mu^+\mu^-$transition.

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Field of contribution:

Phenomenology

257

Wormholes in Non-commutative space-time

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We construct and study traversable wormhole solutions in κ-deformed space-time. The metric of a traversable wormhole is generalized to κ-deformed space-time and the field equations are constructed. Using the field equations and conditions necessary for a wormhole to be traversable, we find constraints on the components of the metric and the velocity of
the traveller. Further, Casimir Energy is considered a possible candidate for exotic material and its implications on the wormhole solutions are studied in κ-deformed space-time.

Field of contribution:

Theory

258

Generalization of SU(N) gauge theory in quantized space-time.

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In this study, we constryuct and analyse SU(N) gauge theory in quantized space-time. Starting from κ-deformed Wong's equation and using Jacobi identities involving the κ-deformed space-time coordiantes and velocities, we derive the Yang-Mills equation.

Field of contribution:

Theory

260

A quantum infromatic approach to analyse Neutrino oscillation parameters for DUNE

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Numerous neutrino experiments have confirmed the phenomenon of neutrino oscillation,providing direct evidence of the quantum mechanical nature of neutrinos. In this work, we investigate the entanglement properties of neutrino flavor states within the framework of three-flavor neutrino oscillation using two major entanglement measures: entanglement of formation (EOF) and concurrence, utilizing the DUNE experimental setup. Our findings indicate that the maximally entangled state appears between ν_μ and ν_τ whereas, ν_e behaves as a nearly separable state. To further explore the nature of bipartite entanglement, we introduce the concept of the monogamy of entanglement, which allows us to investigate the distinction between genuine three-flavor entanglement and bipartite entanglement. Our analysis confirms that the three-flavor neutrino system forms a bipartite entanglement structure, adhering to the Coffman-Kundu-Wootters (CKW) inequality. Additionally, we implement a minimization procedure to find the best-fit values of the oscillation parameters that correspond to the concurrence minima at the two specific energy points where the concurrence reaches its lowest values. Using these best-fit values, we probe three fundamental unknowns in neutrino oscillation: CP violation sensitivity, neutrino mass hierarchy, and the octant issue of θ_{23}, across two distinct energy points. Our results manifest that while the best-fit values obtained through concurrence minimization show slightly reduced sensitivity to CP violation compared to current best-fit values, they exhibit greater sensitivity to the mass hierarchy. Furthermore, the study reveals a maximal mixing angle for the atmospheric sector.

Field of contribution:

Phenomenology

261

Polarimetric investigation of high energy photons carrying imprints of axions

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Axions, hypothetical particles proposed to resolve several fundamental issues in cosmology and particle physics, in the presence of magnetic fields [1-3], leading to significant implications for astrophysical observations [4-6]. In this study we investigate the interaction of pseudoscalar axion with photons in a magnetized medium background medium.

We focus on a compact star magnetosphere in the region ($0.8R_{lc} < z < R_{lc}$). Here R_{lc} is the light cylinder radius equal to $\left(\frac{\Omega}{c}\right)$ when Ω is the angular speed of the compact star.

We analyze the polarimetric observables (for $\frac{eB}{m_e^2} << 1$) like polarization angle (ψ_p) of photons as a function of their path length (z) through a magnetized plasma, taking into account the oscillation between photons and axions [7-9].

The resulting changes in polarization with photon pathlength provide critical insights into the properties of the magnetic field B and the axion-photon coupling strength $g_{\phi'\gamma\gamma}$. By executing both analytical and numerical methods, we explore the impact of various parameters, such as magnetic

field B, photon energy ω and plasma frequency ω_p on the polarization angle. Following the methods of [10] our findings suggest that measuring the polarization angle in this context can serve as a powerful tool for probing the nature of axions and the magnetic environments of compact stars, contributing to the broader understanding of dark matter and fundamental physics.

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Field of contribution:

Theory

262

Probing new physics effects of Z' boson on rare charm baryon Λ_c decay

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In the Standard Model (SM), flavour-changing neutral-current (FCNC) decays in the charm sector are highly suppressed since they do not occur at the tree level due to the Glashow-Iliopoulos-Maiani (GIM) mechanism. So we can perform several phenomenological studies in these decays to look for new physics (NP). Here, we shall analyse the rare charm baryon decay $\Lambda_c \to p\mu^+\mu^-$ in the non-universal Z' model. In non-universal Z' model, rare FCNC decays can occur at the tree level, facilitated by the new Z' gauge boson. This Z' particle introduces interactions that differ across generations of quarks and leptons, bypassing the usual SM suppression mechanisms and allowing these rare decays to happen more readily. As per the recent results from LHCb collaboration the upper limit on the branching fraction of the $\Lambda_c \to p\mu^+\mu^-$ decay is determined to be $2.9(3.2)\times 10^{-8}$ at 90% (at 95%) confidence level [1]. With the inclusion of long distance processes involving intermediate vector-meson resonances the result can be enhanced up to 10^{-6}. In this work, we will calculate the branching fractions and forward-backward asymmetries within the Z' model framework and then compare these results with their corresponding values predicted by the SM. We shall follow the phenomenological approach of Refs. [2-5] for our analysis. We hope our results will provide some information about new physics in the above decay.

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Field of contribution:

Phenomenology

263

The CMS Electromagnetic Calorimeter

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The CMS electromagnetic calorimeter (ECAL) at the CERN Large Hadron Collider (LHC) is a high granularity, homogeneous detector composed of scintillating lead-tungstate crystals. Designed to provide exceptional energy resolution for electrons and photons, the ECAL was pivotal in the discovery of the Higgs boson, particularly in the two-photon and two Z boson decay channels. With the upcoming transition to the High Luminosity LHC (HL-LHC), the CMS detector is undergoing a significant Phase-2 upgrade to handle the increased instantaneous and integrated luminosity in a more challenging environment. This talk will review the original design considerations of the CMS ECAL, emphasizing its high energy resolution capabilities and its critical role in various physics analyses. We will briefly introduce the precise calibration methods and energy reconstruction algorithms developed and refined during LHC Run III to ensure the stability of the energy scale and resolution. Additionally, we will describe the operation details involving the trigger, handling of spikes, and data quality monitoring (DQM) with machine learning.

Field of contribution:

Experiment

264

Exploring Neutrino Decay and Decoherence in Neutrino Oscillation

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Experimental observation on neutrino oscillation confirms the fact that neutrinos have non-zero mass. Thus, there is a possibility of decaying heavy neutrinos to lighter one. Additionally, due to some external factors (like environmental interactions, quantum mechanical uncertainty, quantum fluctuations etc.), the quantum phases between the neutrino mass eigenstates lose their correlation, resulting "quantum decoherence". In our work, we explore the effect of both neutrino decay and quantum decoherence in neutrino oscillation considering open quantum system framework. The inclusion of neutrino decay in Hamiltonian of neutrino oscillation changes the nature of Hamiltonian from hermitian to non-hermitian. On the other hand, the addition of decoherence makes the final Hamiltonian in a more complicated form. We formulate the appearance and disappearance probabilities in three flavour neutrino framework by considering both these effects.

Field of contribution:

Phenomenology

265

Entropy dimensions and fractal spectra in pp collisions from several GeV to LHC energies

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The observation of collectivity and traces of deconfinement in high multiplicity pp events produced at LHC energies has drawn considerable attention towards the smaller collision systems, like pp and pPb. Studies involving statistical moments and scaling laws are expected to provide new insights into understanding the production dynamics. After the observation of KNO scaling violation at SPS energies, scaling of multiplicity distributions (MDs) was tried to revive in terms of a new quantity 'entropy.' The entropy scaling was observed to hold good from $\sqrt{s} \sim 19$ GeV to TeV range. The variable, entropy, it can also be used to study the multifractal characteristics of multiparticle production. The advantage of this method of studying the fractal features is that it is not related to the phase space bin width or the detection resolution.

Scaling of information entropy obtained from chaotically produced particles in pp collisions at SPS and LHC energies are examined in varying phase space bins and compared with the Monte Carlo model PYTHIA-8 (Monash). The findings reveal that experimental data show that the entropy scaling is valid from low energy, $\sqrt{s} = 19$ GeV up to 13 TeV. The PYTHIA model predictions also support the experimental observations. Using Renyi's order q information entropy, the multifractal characteristics of particle production are studied by estimating the generalized dimensions, D_q, which, in turn, permits to look for the fluctuations in MDs by constructing the multifractal spectra. Nearly constant values of multifractal specific heat, c, obtained from 19 GeV to LHC energies suggest that the parameter c may be regarded as a universal characteristic of particle production. The findings reveal, too, that Renyi's order q entropy could be another way to study the fluctuations in MDs in terms of spectral function, which has been argued to be a convenient function for comparing the results not only from different experiments but also between the data and MC models.

Field of contribution:

Phenomenology

266

Event-by-event identified particle ratio fluctuations at LHC and RHIC energies

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Particle ratio fluctuation is one of the observables which is expected to be enhanced during the phase transition that passes close to the critical point. The investigations involving particle ratio fluctuations may reveal the degrees of freedom of the strongly interacting matter created in heavy-ion collisions. Fluctuations in identified particle ratios, $[\pi, k]$, $[\pi, p]$, $[k, p]$ at RHIC and LHC energies is studied in the framework of HYDJET++ model using the fluctuation measure ν_{dyn} and the findings are compared with the experimental results reported earlier. Events corresponding to Pb-Pb collisions at $\sqrt{s}_{NN}$ = 2.76 and 5.02, Xe-Xe collisions $\sqrt{s}_{NN}$ = 5.44 TeV and Au-Au collisions at $\sqrt{s}_{NN}$ = 39, 100 and 200 GeV are simulated and analysed. The observed centrality dependence of the $\nu_{dyn}[a, b]$ for the three combination of particle pairs agree fairly well with those observed in ALICE experiments except for the peripheral collisions. At LHC energies, for peripheral collisions ν_{dyn} values for the three pairs are larger as compared to those reported for the data. However, at RHIC energies, ν_{dyn} values for $[k, p]$ and $[\pi, p]$ pairs, for peripheral collisions are negative, which indicate a correlation between these pairs. For central collisions, however, the values of the three pair combinations are positive and nearly energy independent. This is consistent with the poissonian expectation within 2σ. The scaled values of ν_{dyn}, plotted against charge particle density, exhibit a kind of scaling for $[\pi, k]$ and $[\pi, p]$ pairs for semi−central and central collisions, but exhibit somewhat different trend of variation than what has been observed with the model of independent nucleon-nucleon collisions.

Field of contribution:

Phenomenology

267

Hadron size dependence on the location of QCD critical point

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The physics regarding the existence and exact position of the critical end point (CEP) on the quantum chromodynamics (QCD) phase boundary is ambiguous and remains an open question. In this work, we have used a hadron resonance gas (HRG) model that incorporates finite-sized baryons, antibaryons, and mesons. This hard-core radius (\textit{r}) plays a crucial role in the existence of the CEP. We have used a thermodynamically inconsistent model for the hadron gas (HG) and the Bag model equation of state (EoS) for the QCD plasma, both constructed through Gibbs'equilibrium conditions to achieve the deconfinement transition. A demarcation line exists, differentiating the HRG and QGP phases over the entire $T - \mu_B$ plane when treating hadrons as point-like particles. We found the appearance of a first-order phase transition when a hard-core size is assigned to each hadron in the HRG phase, leading to a phase boundary that ends at the CEP, beyond which a smooth supercritical crossover region appears. This indicates that the presence of a putative CEP in the $T - \mu_B$ plane of the QCD phase diagram implies the emergence of a Widom line in the supercritical region, providing a continuous extension of critical behavior beyond the CEP. The mean-field approach also supports this work, as the CEP does not emerge on the QCD boundary without incorporating excluded-volume effects. This study offers an insightful explanation for the origin of the CEP and the crossover transition on the QCD phase boundary.

Field of contribution:

Phenomenology

268

Measurement of the W boson mass at CMS

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The W boson mass is measured using proton-proton collision data at $\sqrt{s} = 13$ TeV corresponding to an integrated luminosity of 16.8 fb^{-1} recorded during 2016 by the CMS experiment. The W boson mass is extracted using single-muon events via a highly granular maximum likelihood fit of the transverse momentum, pseudorapidity, and charge distribution of the selected muons, yielding one of the most precise measurements of the W mass to date.

Field of contribution:

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Probing Neutrino Mass through Scalar NSI in Neutrino Oscillation Experiment

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In the standard interaction framework, neutrino oscillations are sensitive only to mass-squared differences, making it challenging to directly measure absolute neutrino masses via neutrino oscillation experiments. However, scalar non-standard interactions (SNSI) can introduce sub-dominant terms in the neutrino oscillation Hamiltonian that directly influence the neutrino mass matrix, offering a unique method for probing absolute neutrino masses [1–4]. In this study, we present the constraints on absolute neutrino masses by probing SNSI. We investigate the constraints on the lightest neutrino mass for various values of δCP and θ23 with both normal and inverted neutrino mass hierarchies. Our results indicate that, in the presence of SNSI at DUNE [5], a bound on the neutrino mass can be established, particularly with the parameter ητ τ in normal hierarchy, independent of the octant of θ23 and the CP phase δCP . This work highlights SNSI as a promising avenue for constraining absolute neutrino masses through long-baseline neutrino oscillation experiments [6].

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Field of contribution:

Phenomenology

270

Scalar NSI and Neutrino Mass Ordering Sensitivities in Long-Baseline ν–Experiments

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Neutrino mass and mixing cannot be explained with the Standard Model which leads to the exploration of frameworks beyond the Standard Model (BSM). The possibility of neutrinos interacting with fermions via a scalar mediator is one of the interesting prospects. These new interactions can modify the neutrino oscillation probabilities leading to observable effects in experiments. The effects of SNSI appear as a matter-dependent correction to the neutrino mass matrix which allows for the exploration of absolute neutrino masses via oscillation experiments. SNSI can also affect the physics sensitivities in long-baseline experiments. We will present our study on the impact of a scalar-mediated NSI on the neutrino mass ordering (MO) sensitivities at long-baseline neutrino experiments, i.e., DUNE and HK. We study the effects on MO sensitivities at these experiments assuming that SNSI parameters are present in nature and are constrained from other non-LBL experiments. The presence of SNSI can affect the mass ordering sensitivities of these experiments. Furthermore, we analyze the potential synergy by combining data from DUNE with HK. This approach allows for a more extensive exploration of the parameter space, potentially uncovering synergistic effects that enhance the MO sensitivities.

Field of contribution:

Phenomenology

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Meron Cluster Algorithm for Spin-1/2 U(1) Quantum Links Coupled with Fermions

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Quantum Monte Carlo simulations of strongly interacting fermionic models face significant challenges due to the sign problem, which complicates efficient configuration sampling. The Meron Cluster algorithm has proven effective in resolving the sign problem for both non-relativistic and relativistic fermions, as well as for fermions coupled with U(1) gauge links in (1+1)D. In this study, we implement the Meron Cluster algorithm for (2+1)-dimensional spin-1/2 U(1) gauge theory coupled with fermions, which can potentially be realized in cold atom systems. We simulate this setup, incorporating appropriate four-fermion interactions, and employ exact diagonalization methods for small lattices for comparison. We will also demonstrate the emergence of Gauss's law sectors at different temperature regimes.

Field of contribution:

Theory

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Dark Non-Standard Interaction and CP-phase measurement at DUNE

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The coupling of neutrinos with complex scalar dark matter particles can have interesting phenomenological signatures in neutrino oscillation experiments. For time-averaged data, it appears as an energy-dependent correction to the mass-squared term in the neutrino Hamiltonian. We study the effect of neutrino scattering with scalar dark matter termed dark Non-Standard Interaction (dark NSI) in the context of the long baseline experiment DUNE. The phases associated with the off-diagonal elements of the dark NSI matrix can act as additional sources of CP violation apart from the genuine Dirac CP phase, hampering the measurement of δ_{CP}. We will present the phenomenological consequences of dark NSI in neutrino oscillation and its effect on the CP violation sensitivity of DUNE.

Field of contribution:

Phenomenology

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Effect of scalar NSI on neutrino oscillations: An Analytic Approach

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Scalar non-standard interaction (SNSI) is the interaction of neutrinos with standard model fermions mediated by a scalar particle. SNSI is an interesting beyond the Standard Model (BSM) scenario as it appears to be a density-dependent perturbation to neutrino mass, introducing absolute mass dependence to neutrino oscillations. In this work, we present compact analytic expressions for neutrino oscillation probabilities in the presence of diagonal SNSI elements. The expressions obtained have explicit matter dependence and they enable us to bring out absolute mass dependence through terms having the form $m_1 + m_2$, $m_2 - m_1$, $m_1 c_{12}^2 + m_2 s_{12}^2$, $m_1 s_{12}^2 + m_2 c_{12}^2$ and m_3. These terms behave differently in different mass ordering scenarios and consequently, changing the mass ordering changes the SNSI contribution non-trivially. Our analytic approximations are applicable for all scenarios where constant density approximation holds and can be used for upcoming experiments like DUNE, T2HK, and T2HKK.

Field of contribution:

Phenomenology

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Probing CP-violation Sensitivities at DUNE in presence of Off-Diagonal Scalar NSI

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New physics scenarios can be probed via neutrino oscillation experiments as it provide direct evidence of physics beyond the Standard Model. Neutrino oscillations which is the transition between different $\nu-$flavors during long-distance propagation can serve as a tool for probing new physics scenarios. One of the possibilities is the interaction of neutrinos with matter fermions via a scalar mediator also termed as scalar non-standard interactions (SNSI). These new interactions can affect the standard neutrino oscillation probabilities and potentially lead to detectable effects in neutrino experiments. A unique feature of SNSI is the dependence of oscillation probabilities on the absolute neutrino masses.

This study investigates the impact of off-diagonal SNSI elements ($|\eta_{\alpha\beta}|e^{i\phi_{\alpha\beta}}$) on oscillation probabilities, with a particular focus on the long-baseline experiment i.e. Deep Underground Neutrino Experiment (DUNE) as a case study. An analytical understanding of the dependence of the effects of SNSI on the absolute neutrino mass and other fundamental oscillation parameters is explored. We also examine the impact of these interactions on DUNE's CP-violation (CPV) sensitivities, which could be notably altered by the introduction of SNSI phases. We also explore the impact of the lightest neutrino mass on the CPV sensitivities. An exploration of SNSI effects promises valuable insights into the landscape of neutrino oscillations and CP violation.

Field of contribution:

Phenomenology

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Search for Higgs boson decays to 2 light pseudo-scalars in the 4b final state using Run-2 data in CMS

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A search is presented of SM Higgs boson decaying to 2 light pseudo-scalars "a"each of which decays to a bottom anti-bottom (bb¯) pair. The search is performed in the pseudo-scalar "a"mass range of 10 −50 GeV and uses data collected by the CMS experiment at center-of-mass energy (√s) equals to 13 TeV corresponding to an integrated luminosity of 59.83fb^(-1) in 2018. The large mass of Higgs (125 GeV) boosts all the four b-quarks in a single fat jet which gives us a handle to reduce the large quark/gluon mediated jet background. We will overview the search strategy, channels and background estimation techniques used in this search including state of the art machine learning techniques like GNNs to enhance signal over background discrimination.

Field of contribution:

Experiment

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Physics Sensitivity Projections at the Future ESS: A Study with Coherent Elastic Neutrino-Nucleus Scattering

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The European Spallation Source (ESS), currently under construction in Sweden, will generate an intense pulsed neutrino flux, enabling high-statistics measurements of Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) with advanced detection systems. The exceptional precision and large statistics anticipated from ESS-CEνNS measurements present a unique opportunity to explore physics both within and beyond the Standard Model (SM) with higher accuracy, surpassing current experimental capabilities. In this presentation, we will discuss projected sensitivities for determining the

weak mixing angle and neutron root mean square charge radius through precision CEνNS measurements at ESS, utilising various detector technologies and experimental configurations provided by the collaboration |1|. We will further explore potential constraints on new physics, including neutrino non-standard interactions and the broader framework of neutrino generalised interactions, focusing on the prospects for detecting light mediators via precision CEνNS measurements at the future ESS.

|1| D. Baxter et al., "Coherent Elastic Neutrino-Nucleus Scattering at the European Spallation Source," JHEP 02 (2020) 123, arXiv:1911.00762 \[physics.ins-det\].

Field of contribution:

Phenomenology

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Development of Portable Neutron Detectors: Integrating Organic Scintillators and Silicon Photomultipliers for Enhanced Radiation Monitoring

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The demand for portable neutron detectors is rapidly increasing in fields such as medical diagnostics, environmental monitoring and, and nuclear safety, where precise detection of neutron radiation is crucial in areas with potential radioactive exposure. This study presents the detection efficiency of neutrons using boron-loaded plastic scintillators, analyzed through Monte-Carlo simulations. We also highlight recent developments that focus on integrating organic liquid scintillators with silicon photomultipliers (SiPMs) to enhance detection capabilities. This combination of simulation of detector development aims to improve sensitivity and response time of plastic scintillators, ultimately leading to more effective radiation monitoring solutions in diverse application.

Field of contribution:

Experiment

279

Indirect detection of dark matter annihilating into long-lived mediators from dwarf spheroidal galaxies

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Several astrophysical and cosmological observations suggest the existence of dark matter (DM) through its gravitational effects, yet its nature remains elusive. Despite the lack of DM signals from direct detection experiments, efforts continue to focus on the indirect detection of DM from massive astrophysical objects. Dwarf spheroidal galaxies (dSphs) are among the most promising targets for these searches. In this work, we aim to investigate the expected DM capture rate from 10 nearby DM-rich dSphs, assuming that the accumulated DM eventually annihilates into light, long-lived mediators which decay into gamma rays outside the dSphs. We analyze nearly 16 years of Fermi-LAT data to probe these gamma rays and, from the observed stacked flux upper limit, set limits on the DM-nucleon scattering cross-section. Additionally, we incorporate the Sommerfeld effect into the DM annihilation process, obtaining bounds on the DM-nucleon scattering cross-section of $\sim\ 10^{-36}\ \mathrm{cm}^2$ for DM masses around 100 GeV. This model-independent study allows us to directly compare our results with the bounds reported by direct detection experiments.

Field of contribution:

Phenomenology

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CP asymmetries in $\Lambda_b \to \Lambda^*(\to pK^-)\mu^+\mu^-$ decays

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Although the recent measurements of \(R_{K^{(*)}} \) in \(b \rightarrow s\ell\ell \) transitions are consistent with standard model predictions, there exist several other observables such as \(P'_5 \), \(\mathcal{B}(B_s \rightarrow \phi \mu^+ \mu^-) \), and \(\mathcal{B}(B_s \rightarrow \mu^+ \mu^-) \) that show deviations from the SM predictions. In this context, we employ an effective theory framework and explore the possibility of CP-violation in the $\Lambda_b \to \Lambda^*(\to pK^-)\mu^+\mu^-$ decays in the standard model and beyond. We give predictions of several CP violating observables in the standard model and in case of various new physics couplings.

Field of contribution:

Phenomenology

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Measurement of B -> Ds*D0 using the recoil mass method at Belle II

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We present the two body decay of $B^+ \to D_s^{*+}\bar{D}^0$ that can help us improve our understanding of heavy quark dynamics, hadronic interactions. These decays also help in refining our experimental knowledge in flavor physics. The study is performed using 1ab^{-1} of Belle II simulated e^+e^- collision data at $\Upsilon(4S)$ mass resonance. Instead of reconstructing the signal B meson exclusively, we follow a missing mass approach. Using the fact that $\Upsilon(4S)$ almost every time decays to two B mesons,

one of the two is reconstructed from several hadronic final states along with a D^0 meson , and we look for another charm-strange meson in the recoil. The approach allows for the investigation of less-understood, excited charm-strange mesons that become hard to reconstruct exclusively due to their unknown decay processes. Notably, as the meson is not directly reconstructed, all modes share the same reconstruction efficiency, simplifying our analysis

Field of contribution:

Experiment

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Associated production of $K\Lambda$ off the nucleon

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We examine the $K\Lambda$ production induced by real/virtual photons on the nucleon target, covering an energy range from threshold to photon energies of 3 GeV. This process provides vital insights into nucleon resonances, particularly those in higher resonance regions. Key objectives in studying kaon photo- and electroproduction on nucleons include investigating the baryon resonance spectrum and exploring interactions within hyperon-meson systems. Additionally, accurately modeling the fundamental production mechanisms is critical for reliable predictions of cross-sections in hypernucleus production.
With advanced photon and electron beams available at facilities like the Electron Stretcher System (ELSA) in Bonn, Super Photon Ring - 8 GeV (SPring-8) in Osaka, the European Synchrotron Radiation Facility (ESRF) in Grenoble, the Mainz Microtron (MAMI), and CEBAF at Jefferson Lab, precise cross-section measurements of the $K\Lambda$ channel are now feasible, renewing interest in this area. Our theoretical model accounts for contributions from both non-resonant background terms, constructed using chiral Lagrangian formalism to encompass all essential diagrams and resonance terms, specifically resonances $S_{11}(1650)$, $P_{13}(1720)$, and $P_{13}(1900)$ via the s-channel. We rely on the MAID ansatz for resonance form factors. We present differential and total cross-section results and fine-tune resonance parameters to align with electro- and photoproduction data. A comparison of our findings with existing CLAS, SAPHIR, and MAMI experimental data was also made.
Our study on photon-induced $K\Lambda$ production could provide valuable insights for upcoming experiments at TJNAF, SPring-8, and MAMI in this energy range. We also plan to theoretically examine weakly associated production cross-sections driven by charged current (CC) and neutral current (NC) interactions, which are particularly relevant for current neutrino oscillation studies. Remarkably, few recent investigations have addressed these processes, aside from the work by Adera et al., despite their importance for (anti)neutrino cross-section modeling.

Field of contribution:

Phenomenology

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Signal simulations and trigger emulation of Heavy Neutral Leptons in the ProtoDUNE.

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Exploring Beyond the Standard Model (BSM) physics remains a critical frontier in particle physics, with the ProtoDUNE experiment leading efforts to uncover new phenomena. My project, as a summer student at CERN, involved a comprehensive analysis of simulated BSM signals on the CERN neutrino platform (NP04) of ProtoDUNE, focusing on Heavy Neutral Lepton (HNL) signal simulations and trigger emulation. I successfully conducted signal simulations using LArSoft for various masses of HNL, examining distinct decay patterns, which includes pion-muon and muon-muon channels.

A significant aspect of this research involves determining the threshold cut value for triggering by computing efficiencies. I am glad that I could contribute to the team by providing efficiencies of HNL signal for different cut values, which aided in selecting optimal cut value for the real experiment!

Field of contribution:

Experiment

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Inertial force on Casimir energy in non-commutative space-time

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In this study, we investigate the influence of the noncommutativity on the centripetal force on a rotating Casimir apparatus in κ-deformed space-time. We set up the Casimir apparatus rotating with constant angular speed using appropriate κ-deformed coordinates. We compute the κ-deformed centripetal force on the Casimir energy associated with parallel plates. We show that the Casimir energy experiences centripetal forces exactly like a conventional mass in accordance with the equivalence principle in the κ-space-time.

Field of contribution:

Theory

285

CMS High Level Trigger(HLT) performance in Run 3

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The CMS experiment at CERN operates a two-stage trigger system to efficiently filter and record events of potential physics interest. The system consists of a hardware-based Level 1 (L1) trigger, which processes detector data at 40 MHz using fast electronics such as FPGAs and ASICs, reducing the data rate to around 110 kHz. This is followed by a software-based High-Level Trigger (HLT), which runs on large computer farms and further reduces the event rate to approximately 7 kHz for storage. To handle the higher center-of-mass energy, increased luminosity, and new physics challenges in Run 3, advanced trigger algorithms and technologies, such as heterogeneous computing with GPUs, have been developed. This talk summarizes the performance of the CMS HLT during the Run 3.

Field of contribution:

Experiment

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A framework for studying the dispersion of CMEs

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Coronal Mass Ejections (CMEs) are massive eruptions of plasma along with strong magnetic fields that have the potential to significantly affect Earth's magnetosphere, producing geomagnetic storms (GMSs) when high-energy particles in the plasma interact. Thus, it is essential to investigate the basic dynamics of CME evolution, propagation, and interaction with the ambient solar wind, to forecast space weather impacts, and reduce the CME hazards to contemporary infrastructure. In this work, we attempt to create a framework to model the CME propagation in the interplanetary medium, and its subsequent interaction with Earth's magnetosphere. This work is motivated by the increasing demand for safeguarding the vast technological infrastructures such as power grids, navigation systems, and satellite operations ground-based and satellite technologies from GMSs caused by CMEs that endanger by advancing the current understanding in space weather studies.

Field of contribution:

Phenomenology

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Anatomy of the Real Higgs Triplet Model

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We examine the $Y = 0$ real Higgs triplet model. In addition to the SM Higgs, it contains a CP-even neutral Higgs (Δ^0) and two charged Higgs bosons ($\Delta^\pm$), which are quasi-degenerate in mass. We first study the theoretical constraints from vacuum stability and perturbative unitarity and then calculate the decay widths of Δ^0 and $\Delta^\pm$, including the loop-induced modes $\gamma\gamma$ and $Z\gamma$. In the limit of a small mixing between the SM Higgs and Δ^0, the latter decays dominantly to WW and can have a sizable branching ratio to photons. The model predicts a positive definite shift in the W mass, which is in agreement with the current global electroweak fit. At the LHC, it leads to a (i) stau-like signature from $pp \to \Delta^+\Delta^- \to \tau^+\tau^-\nu\bar{\nu}$, (ii) multi-lepton final states from $pp \to \gamma^* \to \Delta^+\Delta^- \to W^+W^-ZZ$ and $pp \to W^* \to \Delta^\pm\Delta^0 \to W^\pm ZW^+W^-$ as well as (iii) associated di-photon production from $pp \to W^* \to \Delta^\pm(\Delta^0 \to \gamma\gamma)$. Concerning (i), the reinterpretation of the recent stau search by ATLAS and CMS excludes $m_{\Delta^\pm} < 110$\,GeV at 95\% CL. From (ii), some of the signal regions of multilepton searches lead to bounds close to the prediction cross-section, but electroweak scale masses are still allowed. For (iii), the recast of the associated di-photon searches by ATLAS by performing a combined log-likelihood fit of signal and background to data finds that out of the 23 signal regions provided by ATLAS, 8 provide relevant limits on Br$(\Delta^0 \to \gamma\gamma)$ at the per cent level. Interestingly, 6 signal regions show excesses at around 152\,GeV, leading to a non-zero di-photon decay rate with $\approx 4\sigma$ significance.

Field of contribution:

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Neutrino Phenomenology with Two-Zero Textures in Left-Right Asymmetric Model: $0\nu\beta\beta$, LFV, and Resonant Leptogenesis

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In this work, we investigate the two-zero textures of the light neutrino mass matrix within the framework of a Left-Right Asymmetric model. The model is constructed using the modular group Γ_3, which is isomorphic to the A_4 discrete group, and the light neutrino masses are generated via an extended seesaw mechanism by introducing an additional sterile fermion. After assigning the appropriate A_4 charges to the particle content, we identify five classes of two-zero textures. We perform a comprehensive analysis of the phenomenological consequences of these textures. We explore the implications for neutrinoless double beta decay, lepton flavor violation (LFV) processes. Furthermore, we analyze the potential for resonant leptogenesis in each texture class. A detailed comparison between the different two-zero texture classes is conducted, considering their predictions for neutrino oscillation parameters, LFV observables, and baryogenesis. The results are discussed in light of current experimental data, providing insight into the viability of each texture within this extended seesaw framework.

Field of contribution:

Phenomenology

289

A non mu-tau symmetric texture for neutrino masses with a non zero reactor angle

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In the field of neutrino physics, the tribimaximal (TBM) mixing scheme and its associated $\mu - \tau$ symmetric texture have garnered a lot of attention due to their predictability of mixing angles and simple structures.Recent experiments, however, shown that the TBM scheme is only partially valid, particularly due to its prediction of a vanishing reactor mixing angle ($\theta_{13} = 0$).This also implies that the $\mu - \tau$ symmetric texture is not a valid texture anymore as it too assumes the same value for θ_{13}. To accommodate a non-zero θ_{13}, many approaches use a perturbation term to break the $\mu - \tau$ symmetry, allowing a minor correction to θ_{13} while keeping the other predictions of the TBM scheme intact.
In our work, we propose a novel texture that is fundamentally different from $\mu - \tau$ symmetry, allowing θ_{13} as a free parameter instead of a correction. Our texture aligns with the TBM scheme for the predictions of other mixing angles, but is irreducible o a $\mu - \tau$ symmetric form when the perturbation is removed.The texture can predict six observational parameters using only three independent real parameters. The texture is obtained in the framework of $SU(2)_L \otimes T^{/}$ group via a type-1 seesaw mechanism.

Field of contribution:

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Optimizing Scintillator Strip Detectors for Enhanced Muon Tomography: A Geant4 Simulation Study

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Muon tomography is a imaging technique that reconstructs an object's internal structure by examining cosmic ray muon trajectories as they contact with various materials. This study focuses on the design and simulation of a Geant4-based scintillator strip detector for muon tomography. The detector is made up of 15 mm-wide scintillator strips that are optimized for spatial resolution and exact imaging. Key design considerations include the choice of scintillator material, strip dimensions, and arrangement to spatial resolution and detector sensitivity. A novel layered strip configuration, including reference and filtered layers, allows for enhanced positional resolution by minimizing gaps and reducing noise. This study provides insights into improving scintillator strip detectors for muon tomography by investigating the influence of strip shape and arrangement, opening the way for improved imaging systems applicable in a wide range of scientific areas.

Field of contribution:

Experiment

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Dirac neutrino in inverse seesaw framework using A4 modular symmetry

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We propose a model based on A_4 modular symmetry in the Inverse seesaw framework to realise light Dirac neutrino mass. This requires extension of SM fermionic sector by three right-handed neutrinos $(_R)$, three heavy right-handed fermion field (S_R) and three heavy left-handed fermion field (S_L). The scalar sector of SM is also extended by $SU(2)_L$ singlet ψ. The application of modular symmetry restricts the use of additional flavon fields. The Yukawa couplings are transformed non-trivially under the modular symmetry and it enables the study of neutrino phenomenology with a specific flavor structure of mass matrix. We investigate the phenomenology of neutrino mass and mixing and all are found to be compatible with the observed 3σ limit of current neutrino oscillation data.

Field of contribution:

Phenomenology

292

Unveiling the role of new physics in lepton flavour violating decays $b \to s\mu^{\pm}\tau^{\mp}$ through SMEFT approach

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Motivated by the recently observed anomalies associated with several observables in the decay modes mediated through flavor-changing neutral current (FCNC) transitions $b \to s\ell^+\ell^-$, we undertake a comprehensive investigation of the lepton flavor violating decay modes mediated through $b \to s\ell_1\ell_2$ (where $\ell_1 \neq \ell_2$) transitions. Adopting Standard Model Effective Field Theory approach, in this work we perform a comprehensive study of LFV decay modes, i.e., $B_{(s)} \to (\phi, K^*, K_2^*)\ell_1\ell_2$ and $\Lambda_b \to \Lambda\ell_1\ell_2$, where ℓ_1, ℓ_2 represent μ or τ. Assuming the new physics couplings are real, the upper bounds of the branching fractions of the $B_s \to \tau\mu$ and $B \to K\tau\mu$ processes are used to constrain the new physics parameters. Next, we examine the important observables, including the longitudinal polarisation fractions, branching fractions, and forward-backward asymmetries of the $B \to (K^*, \phi, K_2^*)\tau^{\pm}\mu^{\mp}$ decays. We also look into how the new physics couplings affect the baryonic $\Lambda_b \to \Lambda\tau^{\pm}\mu^{\mp}$ decay channels, which are mediated via the $b \to s$ quark level transition. We also predict the upper bounds of the aforementioned observables based on the experimental prospects at Belle II and the LHCb upgrade, which may be interesting for the new physics search in these channels.

Field of contribution:

Phenomenology

293

Probing the muon g-2 anamoly through precision hadronic cross section measurements at the Belle II.

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The study aims to precisely measure the $\pi^+\pi^-$ and $\pi^+\pi^-\pi^0$ cross sections from e^+e^- collision data at Belle II. These measurements are intended to improve the theoretical predictions of the muon's anomalous magnetic moment, currently showing a 5.1-sigma deviation from Standard Model expectations—a hint of possible new physics. Using high-luminosity data at Belle II, we employ the initial-state radiation (ISR) technique to achieve continuous cross-section measurements across energy ranges starting from the dipion threshold, reducing systematic uncertainties. The three-pion cross-section has recently been measured, and we are now targeting 0.5% precision in the two-pion cross-section. These results are essential for calculating the hadronic vacuum polarization (HVP) contribution, the largest source of uncertainty in muon anomaly predictions due to the complexities of QCD. This work pushes the boundaries of the Standard Model and offers insights that may guide potential extensions to current theories.

Field of contribution:

Experiment

294

Neutrino Oscillation in a Core-Collapse Supernova: The Impact of Spacetime Geometry

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Neutrino flavor evolution inside a core collapse supernova is a topic of active research at present. The core of a supernova is an intense source of neutrinos and antineutrinos. The self-interaction among the neutrinos (as well as antineutrinos) gives rise to a rich phenomenology which is not seen in terrestrial situations. In studies of dynamics of flavor evolution in such environments, the gravitational effects are generally ignored. Although the curvature outside a dense core does not deviate much from a flat space, the spin of the neutrinos can still couple to the torsion of the spacetime. These extra degrees of freedom of curved spacetime have interaction strengths which are proportional to the density of the neutrinos and the other fermions [1, 2] as well as the coupling constants of the spin-torsion interaction. We have studied the effects of such interactions in flavor evolution inside a core collapse supernova [3]. The self interaction gets modified by the spin-torsion interaction and the oscillation dynamics is modified. We have seen that there are noticeable changes in the flavor dynamics when the neutrino density is uniform. We have also studied the effects of such interaction in a realistic core collapse suepernova (CCSN). As the neutrino astronomy enters the precision era, this study will shed light on the potential of neutrino fluxes from CCSN to probe the neutrino-neutrino interaction.

References:
1 S. Chakrabarty and A. Lahiri, Eur. Phys. J. C 79, 697 (2019), arXiv:1904.06036 [hep-ph].
2 R. Barick, I. Ghose, and A. Lahiri, Eur. Phys. J. Plus 139, 461 (2024), arXiv:2302.10945 [hep-ph].
[3] I. Ghose and A. Lahiri, Manuscript under preparation (2024).

Field of contribution:

Phenomenology

295

π, K and p production in high multiplicity pp collisions at $\sqrt{s}$ =13 TeV

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High-multiplicity proton–proton and proton–lead collisions at LHC energies exhibit similar signatures to those observed in Pb–Pb collisions (i.e. strangeness enhancement, collective expansion effects etc.), that are traditionally attributed to the formation of the quark–gluon plasma. In this contirbution the measurements of $\pi^{\pm}$, $K^{\pm}$, and p($\bar{p}$) transverse momentum spectra in the rapidity region $|y| < 0.5$ for high multiplicity pp collisions at $\sqrt{s}$ =13 TeV with the ALICE detector will be presented. Particles are identified using the specific energy loss (dE/dx) in the Inner Tracking System (ITS) detector and Time Projection Chamber (TPC), and using the time-of-flight information from the Time of Flight (TOF) detector. Measurements in high multiplicity pp collisions will allow to study the system-size dependence of light flavor particle prdouction by extending the measurements up to the multiplicity of peripheral Pb–Pb collision. Integrated particle yields and their ratios will be presented as a function of charged particle multiplicity and compared to the expectation from QCD-based pp event generators.

Field of contribution:

Experiment

296

Behavior of Pion in Asymmetric Nuclear Medium

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We investigate the in-medium properties of π meson in the light-front quark model (LFQM), using the in-medium quark masses computed by chiral SU(3) quark mean field (CQMF) model. We calculate the decay constant and distribution amplitude (DAs) of the pion in an asymmetric nuclear medium. Utilizing these findings, we then derive the transition form factor (TFF) for the process $\gamma^{*}\gamma \to \pi^{0}$. We compare our results with experimental TFF results to ensure consistency with the established experimental data. This work contributes valuable insights into the behavior of pion within nuclear environments.

Field of contribution:

Phenomenology

297

Model independent effective dimension six operators and scattering unitarity

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The effects of physics beyond the Standard Model may be parametrized by a set of higher-dimensional operators leading to an effective theory. The introduction of these operators makes the theory non-renormalizable, and one may reasonably expect a violation of unitarity in 2 ⟶ 2 scattering processes, depending on the values of the Wilson coefficients of the higher dimensional operators. Bounds on these coefficients may be obtained from demanding that there be no such unitarity violation below the scale of the effective theory. We show, at the lowest level, how the new operators affect the scattering amplitudes with longitudinal gauge bosons, scalars, and tt in the final state, and find that one may expect a violation of unitarity even at the LHC energies with small values of some of the new Wilson coefficients. For most of the others, such a violation needs large coefficients, indicating nonperturbative physics for the ultraviolet-complete theory, although a proper treatment necessitates the inclusion of even higher-dimensional operators. However, deviations from the Standard Model expectations may be observed with even smaller values for these coefficients. We find that W W ⟶ W W , W W ⟶ ZZ, and ZZ ⟶ hh scatterings are the best possible channels to probe unitarity violations.

Field of contribution:

Phenomenology

298

Anisotropic flow predictions for identified and strange hadrons in $O + O$ collisions at $\sqrt{s_{\rm NN}}$ = 7 TeV at the LHC

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The upcoming $O + O$ collision run at the Large Hadron Collider (LHC) at $\sqrt{s_{\rm NN}}$ = 7 TeV offers a unique opportunity to explore the behavior of matter under extreme conditions, bridging the gap between small and large collision systems. In this study, we provide predictions for the transverse momentum (p_T) spectra and flow observables for different centrality classes in $O+O$ collisions. Our predictions utilize two different approaches, including hydrodynamic and transport models, to analyze the behavior of the particle spectra and flow coefficients for identified (pions, kaons, protons) and strange hadrons. We explore particle-by-particle flow behavior and compare the response of the system to initial conditions across various models, which provide insights into the underlying partonic and hadronic dynamics. The study presents comparisons of flow harmonics (i.e, v_n, n=2, 3, …) with the existing experimental measurements and demonstrates how $O+O$ collisions can serve as a benchmark to understand the transition from small to large systems, contributing to our knowledge of the Quark-Gluon Plasma (QGP) and collective phenomena in heavy-ion collisions.

Field of contribution:

Phenomenology

299

Quasilocal First Law and Boost Charge in Einstein-Gauss-Bonnet Gravity

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We study the covariant phase space for Einstein- Gauss- Bonnet gravity, admitting weak isolated horizons as inner boundary. We find out that the Hamiltonian charge corresponding to residual Lorentz boosts on the horizon matches exactly with the Wald entropy. We also give a derivation for quasilocal first law of black hole mechanics in Einstein-Gauss- Bonnet gravity.

Field of contribution:

Theory

300

Viscous Universes with Positive Cosmological Constant

Authors: Akriti Garg[1]; Ayan Chatterjee[1]

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In this paper, we study the inhomogeneous continuous gravitational collapse of spherical viscous matter configurations in a universe with a positive cosmological constant. Using matter fields with a wide variety of initial density and velocity profiles, we observe the evolution of spherical marginally trapped surfaces. This allows us to track the local black hole horizon during the collapse process.

Field of contribution:

Theory

301

Unveiling the role of new physics in lepton flavor violating decays $b \to s\ell_1\ell_2$ through model independent analysis

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Driven by the recent anomalies observed in various measurements related to flavor-changing neutral current (FCNC) transitions like $b \to s\ell^+\ell^-$, we conduct a thorough examination of lepton flavor-violating (LFV) decay modes through $b \to s\ell_1\ell_2$ transitions (where $\ell_1 \neq \ell_2$). While LFV transitions are not permitted in the Standard Model, they can naturally arise in many extensions of the model, such as those featuring additional vector-like fermions or extra Z' bosons. Although LFV has been extensively investigated in mesonic decays, similar baryonic decays that involve the same quark-level transitions have largely been overlooked. By considering the most general effective Hamiltonian for $b \to s\ell_1\ell_2$ transitions—which includes vector, axial-vector, scalar, and pseudo-scalar operators—we derive the angular decay distribution for these processes. Taking a model-independent approach, we explore LFV decay modes such as $B \to K^*\ell_1\ell_2$, $B \to \phi\ell_1\ell_2$, $B \to K_2^*\ell_1\ell_2$, and $\Lambda_b \to \Lambda\ell_1\ell_2$. In particular, we establish bounds on the branching ratios and analyze the parameters related to leptonic forward-backward asymmetry.

Field of contribution:

Phenomenology

302

Baryophilic gauge and Gravitational Wave effect

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We investigate a minimal extension of the Standard Model that includes an additional baryophilic Abelian gauge symmetry. In these classically conformal models, the thermal phase transition, driven by the Coleman-Weinberg mechanism, is strongly first-order with significant supercooling, producing observable stochastic gravitational wave signals. Our analysis reveals a substantial parameter space within these models that can be probed by future gravitational wave observatories, such as LISA, BBO, DECIGO, and Cosmic Explorer.

Field of contribution:

Theory

303

Mass modification of ϕ meson in non-strange resonance matter

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In this investigation, we calculate the in-medium mass of ϕ meson in hot and dense non-strange resonance matter using the effective Lagrangian framework for $\phi K\bar{K}$ interactions at one loop level. The mean-field effective approach is utilized within the chiral SU(3) hadronic mean-field model to incorporate medium modification of kaon-antikaon masses. we have considered nucleons (n, p) and delta baryons ($\Delta^{++}, \Delta^{+}, \Delta^{0}$, and Δ^{-}) as the degree of freedom within the medium. To address the issue of ultraviolet divergence, we employ a dipole form factor to regulate the self-energy loop integral, and the impact of varying the cutoff mass within this form factor on the results is examined. At finite temperatures, the effective masses of ϕ mesons undergo substantial modifications due to the presence of resonance baryons within the medium. Examining the ϕ masses within the medium is anticipated to be essential for understanding experimental results from heavy-ion collisions, which may produce hot and dense matter.

Field of contribution:

Phenomenology

304

SU(3) Dual QCD thermodynamics at finite temperature and chemical potential

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In terms of dual gauge potentials, a Dual QCD formulation for the SU(3) colour gauge has been established, which takes into account the dynamics of the colour gauge group's topological and local structure. The dynamical configuration of the resulting dual QCD vacuum and its flux tube configuration have been studied in order to investigate the nonperturbative properties of QCD. In order to study the kinetics of the quark-hadron phase transition at finite chemical potential, the thermal behaviour of the nonperturbative QCD vacuum has been examined. The dual QCD-based hadronic bag, which ensures the necessary parameters and related critical points for quark-hadron phase transition, has also been used to explore related thermodynamic quantities and the equation of state (EoS) to characterise quark matter. It is anticipated that these thermodynamic values will be crucial in determining the order of quark-hadron phase transitions and will probably be able to forecast the characteristics of a first-order quark-hadron phase transition for limiting chemical Furthermore, by building the free energy change and the corresponding surface tension for the quark-hadron phase transition, we have examined the bulk properties of quark matter. We also compared our results with known lattice QCD results and the most recent three-loop Hard Thermal Loop perturbative results for consistency and compatibility checks, and we found that they were reasonable agreements.

Field of contribution:

Theory

305

Automated Efficiency Plot Comparison for GEM detector

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This project aims to automate the comparison of GEM efficiency plots, replacing the current manual inspection process. Each run generates efficiency plots that must be assessed for efficiency. Our proposed solution involves developing a Python script that utilizes OpenCV for automated image comparison based on defined metrics.The system evaluates the comparison against predefined criteria to determine the acceptance or rejection of GEM events. This automation not only streamlines the comparison process but also enhances accuracy and efficiency in analyzing GEM efficiency plots.

Field of contribution:

306

Muon multiplicity determination at the GRAPES-3 experiment using pulse width for precision measurements at PeV Energies

Author: Ronald Scaria[1]

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Primary cosmic rays (PCRs), on entering the Earth's atmosphere, interact and create particle showers known as extensive air showers (EAS). EAS produced by heavier mass PCRs are observed to contain more muons than those created by lighter PCRs. As a result, muon multiplicities in EAS have often been used as an indicator for estimating the PCR composition. Thus, an accurate determination of the muon multiplicity in an EAS is imperative for composition studies. The GRAPES-3 experiment located at Ooty, Tamil Nadu, samples the muon content above 1 GeV energy in an EAS using a large area muon telescope. So far, muon multiplicities have been estimated from the number of hits in the proportional counters. We present a new method of determining muon multiplicity in an EAS based on the energy deposited by particles in the proportional counters. This energy is stored as pulse width and recorded along with the hit information. The preliminary simulation results of the analysis show that the dynamic range of detecting muons is increased by up to two orders of magnitude. Such an increase in the dynamic range is important to determine the PCR composition accurately beyond the Knee region ($\sim$ 3 PeV) of the cosmic ray spectrum using the GRAPES-3 array.

Field of contribution:

Experiment

307

Capability of the proposed long-baseline experiments to probe large extra dimension

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Future long-baseline experiments will play an important role in exploring physics beyond the standard model. One such new physics concept is the large extra dimension (LED), which provides an elegant solution to the hierarchy problem. This model also explains the small neutrino mass in a natural way. The presence of LED modifies the standard neutrino oscillation probabilities. Hence, the long-baseline experiments are sensitive to the LED parameters. We explore the potential of the three future long-baseline neutrino experiments, namely T2HK, ESSnuSB, and DUNE, to probe the LED parameter space. We also compare the capability of the charged and neutral current measurements at DUNE to constrain the LED model. We find that T2HK will provide more stringent bounds on the largest compactification radius (R_{ED}) compared to the DUNE and ESSnuSB experiments. At 90% C.L., T2HK can exclude $R_{\mathrm{ED}} \sim 0.45$ (0.425) μm for the normal (inverted) mass hierarchy scenario.

Field of contribution:

Phenomenology

308

Vector D meson masses in hot and dense Δ resonance matter.

Author: Shalvik Khanna[1]

Co-authors: Sachin . [1]; Manpreet Kaur [1]; Arvind Kumar [1]

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Our aim of study is to investigate the mass modification of vector D mesons in the baryonic medium consists of nucleons and Δ resonances employing the chiral SU(3) Model and QCD sum rules.
The primary objective is to understand the influence of finite density and temperature on the in-medium masses of spin-1 vector D mesons.
In QCD sum rules, the effective masses of D mesons are expressed in terms of chiral quark and gluon condensates.
We evaluate these condensates using chiral SU(3) model and use as input in QCD sum rules to obtain temperature and density dependent masses of D mesons.

Field of contribution:

Theory

309

Analysis of $B_{d(s)} \to M_{(c\bar{c})}(1S, 2S)K_s$ decays in RIQM

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Within the framework of relativistic independent quark (RIQ) model based on a flavor-independent interaction potential in scalar-vector harmonic form, we analyze the exclusive two-body nonleptonic decays of $B_{d(s)}$ meson to ground as well as radially excited $2S$ charmonium state with a light meson K_s, induced by the $b \to c\bar{c}s(d)$ transition. We calculate the weak form factors from the overlapping integrals of meson wave function obtained in this model. Using the factorization approximation, we predict the branching fractions for the $B_{d(s)} \to \psi(1S, 2S)K_s$ and $B_{d(s)} \to \eta_c(1S, 2S)K_s$, which can be compared with future theoretical predictions. Branching fraction for $B_s \to J/\psi K_s$ decay is found to be in good agreement with the data from LHCb Collaboration, whereas for $B_s \to \psi(2S)K_s$, it is found to be within the detection ability of the CMS Collaboration. We also predict the ratios of branching fractions (
$calR$), which are in broad agreement with the data from LHCb Collaboration. These results indicate that the present approach works well in the description of exclusive nonleptonic $B_{d(s)}$ decays within the framework of the RIQ model.

Field of contribution:

Phenomenology

310

In-medium masses of scalar D mesons in Δ resonance matter

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This research investigates the influence of dense non-strange resonance matter, consisting of nucleons and delta baryons (Δ^{++}, Δ^{+}, Δ^{0}, and Δ^{-}), on the masses of scalar D mesons (D_0^{+}, D_0^{0}) under finite temperature conditions.The modifications of the above mesons in this medium arise from changes in the quark and gluon condensates. Using the chiral SU(3) mean-field model, we obtain the in-medium chiral condensates, which subsequently employed in QCD sum rules to evaluate the effective mass of D mesons.

Field of contribution:

Theory

311

Threshold Corrections and An Optimal SU(5)

Authors: Ketan Patel[1]; Saurabh K. Shukla[1]

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The $SU(5)$ grand unified model, unifying standard model quarks and leptons into $\overline{5}$ and 10-dimensional representations, and incorporating only a five-dimensional representation Higgs in the Yukawa sector, yields the observationally inconsistent relation $Y_d = Y_e^T$. We demonstrate that this equality can be modified by introducing quantum corrections in the presence of one or more gauge singlet fermions. One-loop threshold corrections, originating from heavy leptoquark scalar and vector bosons present in the model, along with heavy singlet fermions, can generate realistic fermion mass spectrum including leptonic spectrum, provided their masses differ by atleast two orders of magnitude. Importantly, our findings highlight the feasibility of the simplest Yukawa sector when accounting for quantum corrections and substantial threshold effects.

Field of contribution:

Phenomenology

312

Threshold resummation for Vector-boson pair production to NNLO+NNLL at the LHC

Authors: Chinmoy Dey[1]; M.C. Kumar[1]; Pulak Banerjee[2]; Vaibhav Pandey[1]

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We perform the threshold resummation for massive vector boson pair production processes (ZZ and W^+W^-) at the Next to Next to Leading Log accuracy matched with Next to Next to Leading Order fixed order results. We perform the Resummation in the Mellin space, and present our results for

the invariant mass distribution to NNLO+NNLL accuracy in QCD for the current LHC energies. We find that in the high invariant mass region, the NNLL contribution enhances the cross section by an additional few percent.
We find that in the high invariant mass region ($Q = 1TeV$), the conventional scale uncertainties in the fixed-order results get reduced substantially after including the resummation contributions.

Field of contribution:

Phenomenology

313

Temporal correlations in two flavor neutrino oscillations with quantum decoherence effects and the nature of neutrino

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The nature of neutrinos, i.e, whether they are Dirac or Majorana fermions is one of the most intriguing questions in present day particle physics. In the standard oscillation framework, the Majorana phase does not appear in the expression for oscillation probability and hence it is generally believed that it is difficult to probe the nature of neutrino via oscillation experiments. It turns out that in the presence of quantum decoherence effects, the neutrino oscillation probability may carry explicit dependence on the Majorana phase appearing in the mixing matrix. For the simple case of two neutrino flavors, we show that the temporal correlations of the Leggett-Garg type allow us to deduce the nature of neutrino via the Majorana phase dependent terms in the probability.

Field of contribution:

Theory

314

Quark distribution inside π and ρ mesons

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We have investigated the valence quark parton distribution functions (PDFs) associated with spin-0 π meson and spin-1 ρ meson, utilizing light-front dynamics at leading twist. The π meson is characterized by a single unpolarized quark PDF, $f_1(x)$, whereas the ρ meson is represented by four distinct PDFs: the unpolarized $f_1(x)$, the helicity distribution $g_1(x)$, the transversity distribution $h_1(x)$, and the tensor PDF $f_{1LL}(x)$. Additionally, an examination of the PDF sum rules and their associated positivity constraints have been conducted. The PDFs are also evolved to higher values of Q^2 through next-to-leading order (NLO) DGLAP evolution, facilitating meaningful comparison with predictions from alternative models. Moreover, the structure function can be calculated based on these PDFs, thereby enhancing the understanding of mesonic structures.

Field of contribution:

Phenomenology

315

Scalar Fields from Affine Connections and Quantum Theory

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In this talk, we will use the affine connections to introduce new fields that can be helpful to explain a few cosmological observations.
We have previously introduced two massless scalar fields using connections more general than the Levi-Civita connections in the Einstein-Palatini action. These fields contribute positive and negative stress tensors to Einstein's equation and can be useful to explain inflation and dark energy.
In this article, we will develop a scheme to add suitable potential terms for these fields. We will construct a Lagrangian formalism to include these scalar fields in a theory of gravity coupled with ordinary matter and radiation. These fields need not to be present in the Lagrangians of gauge theories with conserved fermionic vector currents. The same remains valid for scalar fields. We will discuss a generalization of this aspect. We will discuss a model that includes the right-handed neutrinos in the electroweak theory in curved spacetime even with the Levi-Civita connections. This is required to have conserved vector currents for the neutrinos.
Axial vector currents for different Dirac fields can remain anomalous depending on the theory. The right-handed neutrinos can be useful to explain neutrino oscillation or dark matter.

Field of contribution:

Theory

316

Majorana CP Violation Insights from Decaying Neutrinos

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It is well-known that within the standard three flavor neutrino oscillation formalism, the Majorana phases appearing in the neutrino mixing matrix cannot have any effect on neutrino oscillation probabilities thereby evading testability at neutrino oscillation experiments. We consider an effective non-Hermitian Hamiltonian describing three flavor neutrino oscillations with the possibility of neutrino decay and demonstrate that the two Majorana phases can entangle with the off-diagonal decay terms and appear at the level of oscillation probabilities. Using the Cayley-Hamilton theorem, we derive approximate analytical expressions for three flavor neutrino oscillation probabilities in the presence of neutrino decay, taking into account matter effects. In the context of a long baseline neutrino experiment, we then analyse the impact of Majorana phases on the oscillation probabilities for different channels as well as on observables related to CP violation effects in neutrino oscillations. Finally, we discuss the effect of Majorana phases on the parameter degeneracies in the neutrino oscillation framework.

Field of contribution:

Phenomenology

317

Scalar modes of polarization in gravitational waves

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We study Gravitational Waves (GWs) in modified gravity theory. We choose metric $f(R)$ gravity to explore the characteristics of GWs in the presence of an additional scalar field. We examine additional polarization modes (longitudinal and breathing modes) beyond standard ''plus" and ''cross" modes of polarization, predicted by general theory of relativity. The study also focuses on the nature of scalar field using chameleon mechanism in different density regions.

Field of contribution:

Theory

318

Axion effects on the nonradial oscillations of neutron stars

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We investigate the effects of including strong charge parity violating effects through axion field on the structure and the oscillation modes of the neutron stars with the possibility of a quark matter core. The effects of axions in quark matter is described through a t Hooft determinant interaction in the flavor space within the ambit of a three flavor Nambu–Jona-Lasinio model. The presence of axions seem softens the equation of state with having a larger core of quark matter compared to the case when their absence. This leads an enhancement of the f mode oscillation frequencies in hybrid stars.

Field of contribution:

319

Probing intractable BSM parameter spaces armed with Machine Learning

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This research introduces an innovative machine learning (ML)-assisted nested sampling approach aimed at exploring Beyond the Standard Model(BSM) parameter spaces more efficiently. Traditional methods like Markov Chain Monte Carlo (MCMC) and Hamiltonian Monte Carlo (HMC) often face limitations in high-dimensional, multi-modal spaces,leading to computational bottlenecks. Our method combines actively trained deep neural networks (DNNs) with nested sampling,dynamically predicting higher-likelihood regions to accelerate convergence and improve sampling accuracy.This scalable framework holds promise for addressing computational challenges in high-energy physics(HEP) research,offering a comprehensive solution for BSM parameter analysis.

Field of contribution:

Phenomenology

320

Parity nonconservation induced by spacetime geometry

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The coupling of fermions with gravity can be non-universal, leading to a current-current four-fermion interaction beyond the Standard Model that also generically has different couplings for different chiralities of fermions. Such an interaction is found to break discrete symmetries like parity and charge conjugation. We calculate the contribution of this interaction to parity-violating electron scattering processes and arrive at an estimate of an upper bound on the coupling constants.

Field of contribution:

Phenomenology

321

Charged Lepton Flavour Violating Meson Decays in Seesaw Models

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The phenomenon of the neutrino oscillations has established that at least two neutrinos possess non-zero masses, which necessarily leads to the existence of the flavor violation in charged lepton sector. The relationship among branching ratios of different charged lepton flavor-violating (CLFV) decay modes is closely tied to the specific characteristics of the underlying neutrino mass model. In this study, we examine the three fundamental types of seesaw mechanisms for neutrino masses, which emerge from the ultraviolet (UV) completion of the unique dimension-5 Weinberg operator, and investigate the correlations between radiative CLFV decays and meson-induced CLFV decays. Our findings reveal that, within the type-II seesaw mechanism, the branching ratios for meson CLFV decays are negligibly small. Conversely, in the type-I (type-III) seesaw mechanism, meson CLFV decay branching ratios are constrained to be at least three (two) orders of magnitude lower than those for radiative CLFV decays. Analyzing the relationships between these two CLFV decay channels offers valuable insights into distinguishing among different seesaw mechanisms. Notably, if the branching ratios for CLFV decays in mesons exceed those for radiative CLFV decays, it strongly suggests that the mechanism responsible for neutrino mass generation may involve a more complex structure than the simple seesaw framework.

Field of contribution:

Phenomenology

322

Sensitivity of direct photon production to isolation cut criteria in relativistic nuclear collisions

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Direct photons are considered as one of the most versatile and clean tools to study relativistic nuclear collisions. These include all photons except the ones from hadron decays. The direct photon spectrum produced in relativistic heavy ion collisions is dominated by prompt photons in the larger transverse momenta ($p_{\mathrm{T}} > 3$ GeV) region. Whereas, the thermal photons from the quark gluon plasma and hot hadron gas are the dominant contribution at relatively lower p_{T} range.

Measurements of direct photons are complicated due to the presence of a large decay background, especially from 2-γ decay of π^0 and η mesons. A selection called 'isolation criterion', which is based on a threshold on the contributions of transverse energy/momentum from particles inside a cone around the candidate photon, is applied to suppress the decay as well as the fragmentation photons. This has led to the prescription of 'isolated photons'.

In this contribution, we will present the dependence of the isolated photon cross section on the isolation criteria as studied using JETPHOX which is a parton level generator used to estimate the prompt photon production.

Field of contribution:

Phenomenology

323

Microquasars to AGN: An uniform Jet variability

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Active Galactic Nuclei (AGN) are astrophysical sources powered by the accretion of material onto supermassive black holes at the centers of galaxies, emitting energy across the entire electromagnetic spectrum. AGNs often exhibit significant variability at different wavelengths, spanning timescales from minutes to years. Micro-variability can occur on minute scales, intra-day variability over hours, and long-term variability over months or even years. Rapid changes in brightness can be driven by various mechanisms, such as magneto-hydrodynamic instabilities in the accretion disk or jets, shocks, or magnetic reconnections within the jets, and even relativistic effects influenced by the jet's orientation. A clear trend was observed when the variability time scale of AGN was plotted as a function of their black hole mass. This highlights a link between the accretion disc and the relativistic jet, a connection similarly observed in microquasars. In our study, we analyzed AGNs, including 7 blazars, 1 radio galaxy, 1 narrow-line Seyfert 1 galaxy, 2 unclassified blazar candidates, and 2 microquasars, using gamma-ray data. Our findings provide indirect evidence supporting a universal scaling law, suggesting that the mechanism responsible for jet production is independent of black hole mass.

Field of contribution:

Theory

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Enhancing the capability through Recycling: Doubling GRAPES-3 Muon Telescope with almost-buried Iron tubes

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The GRAPES-3 experiment, housing the world's largest muon telescope at 2200 m above sea level in Ooty, is designed to study cosmic-ray effects on Earth. To double the telescope's capability, we have refurbished nearly the same number of proportional counters using iron pipes that are over half a century old. Before their utilization, these pipes were almost-buried 2300 meters underground at the Kolar Gold Field experiment following its decommissioning. The present work outlines various methods employed for repurposing these pipes, using several non-destructive characterization techniques, including X-ray Diffraction, Infrared Spectroscopy, Scanning Electron Microscopy, and Energy Dispersive X-ray techniques, to identify iron-bearing phases and conversion products. The results obtained from these instrumental techniques have been presented, along with a brief methodology for integrating the materials into the experiment. This extension of the experiment serves as an exemplary demonstration of reducing, reusing, and recycling the iron tubes that would otherwise be discarded on a large scale.

Field of contribution:

Experiment

325

Exploring New Physics with scalar NSI at the DUNE and P2SO experiments

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In today's precise age of neutrino physics, non-standard interactions (NSI) and other subdominant new physics scenarios are highly intriguing for delving into physics beyond the standard model (BSM). The study of scalar NSI (SNSI), which is mediated by a scalar field, has been an intriguing topic of interest in the recent years. In contrast to vector NSI, SNSI alters the standard neutrino mass matrix via Yukawa couplings and presents itself as an extra mass matrix with real and complex components. We explore the impact of off-diagonal SNSI parameters, distinguished by their magnitudes $\eta_{\alpha\beta}$ and unique phases $\phi_{\alpha\beta}$. We have examined two upcoming LBL experiments, DUNE and P2SO, in order to constrain these these SNSI parameters. We also examined how they impact the measurement of standard oscillation parameters. We subsequently found that the new CP phases ($\phi_{\alpha\beta}$) can greatly affect the the unknowns in the neutrino sector. We found that the oscillation parameter Δm^2_{31} exhibits non-trivial behaviour in presence of SNSI. We observed that $\phi_{\mu\tau}$ has significant effects on determining the several oscillation parameters.

Field of contribution:

Phenomenology

326

Study of the background Xe-137 for the neutrinoless double-beta decay search in a liquid xenon

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Neutrinos true nature is yet to be known, i.e., Dirac or Majorana. The most practical way to probe Majorana neutrino is by observing the neutrinoless double-beta ($0\nu\beta\beta$) decay. The observation not only confirms the Majorana nature but also constraints the effective Majorana neutrino mass ($m_{\beta\beta}$) and shows the total lepton number is not a conserved quantity. Several experiments are planned to observe the $0\nu\beta\beta$ decay. However, the detection of $0\nu\beta\beta$ decay is extremely challenging as the region of interest is largely populated by various backgrounds. ^{136}Xe is an attractive candidate for $0\nu\beta\beta$ decay search with a $Q_{\beta\beta} = 2457.83 \pm 0.37$ keV. Liquid xenon experiments− LUX-ZEPLIN, nEXO, KamLAND2-Zen, XENONnT, etc., are sensitive for $0\nu\beta\beta$ decay search of ^{136}Xe. The KamLAND2-Zen experiment sets the most stringent lower limit on the half-life of $0\nu\beta\beta$ decay: $T^{0\nu}_{1/2} > 3.8\times10^{26}$ yr at 90% C.L. and upper limit on $m_{\beta\beta}$ are in the range 28-122 meV. Neutron-capture with ^{136}Xe induces the radioactive ^{137}Xe, which could cause a background for the signal region. In this work, we simulate the production of ^{137}Xe in a cryostat filled with liquid xenon. Different neutrons of various resonance energies are confined in a cryostat and determine the production of ^{137}Xe.

Field of contribution:

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Analyzing the transverse spherocity dependence of forward-backward correlations using PYTHIA8 and HERWIG7 models in pp collisions at √s = 13 TeV

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This analysis investigates forward-backward (FB) multiplicity correlations in proton-proton (pp) collisions at $\sqrt{s} = 13$ TeV, using two prominent event generators: PYTHIA8, based on the Lund String model, and HERWIG7, which utilizes the Cluster Hadronization model. Simulated events were analyzed within varying pseudorapidity (η) windows, applying a transverse momentum (p_{T}) range of 0.2–2.0 GeV/c. The study focuses on FB multiplicity correlations across different transverse spherocity regions, classifying events as jetty, intermediate, or isotropic. The results reveal that FB correlations systematically decrease with increasing pseudorapidity separation (η_{sep}), with Herwig consistently producing stronger correlations than Pythia. Among the spherocity regions, isotropic events exhibit the highest correlations, while jetty events display the weakest. These insights enhance our understanding of the relationship between event topology and particle production mechanisms in high-energy collisions.

Field of contribution:

Phenomenology

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Nuclear Dependence of Charged Current Inclusive $\bar{\nu}_\mu - A$ Cross Section Measurements at 6 GeV at MINERvA

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MINERvA stands for Main Injector Neutrino Experiment for $\nu - A$ scattering, located in the NuMI(neutrinos at the Main Injector) beamline sitting 100 m underground on-site at Fermilab in Batavia, Illinois. The detector uses fine-grained plastic scintillator detector. It used 3 GeV(LE) and 6 GeV(ME) neutrino beams from the NuMI beam facility, on different nuclear targets(C, Fe, Pb and water) in the same neutrino beam. The analysis reported here measures inclusive double differential charge current antineutrino-nucleus cross sections in the nuclear targets carbon, iron, lead and also the active tracker region made of scintillator(CH). The cross section measurement is done against the variables bjorken x and four momentum transfer squared(Q^2), invariant mass(W) and Q^2 and the transverse and longitudinal momentum components of the outgoing muon p_z and p_t. Ratio of the extracted cross sections in the nuclear targets to the tracker region gives a direct measurement of the nuclear dependence of the cross section, thus pointing towards nuclear medium effects coming into play when we move from lighter(C) to heavier nuclei(Pb). We shall present the cross section measurement results along with the nuclear target to tracker cross section ratios, for highlighting the nuclear dependence of the $\bar{\nu}_\mu - A$ scattering cross section.

Field of contribution:

Experiment

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Stability and Phase Plane Analysis with Power Law Potential for Cosmological Scaling Solutions

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The nature of dark energy, which constitutes about 68% of the universe's total energy, remains one of the most profound mysteries in cosmology. Scalar fields with power law potentials are promising candidate for dark energy. For understanding the dynamics of scalar fields we begin with a general form of power law potential V (ϕ) =V0 ϕ n and try to determine critical points and analyze their stability. Further we analyze the phase plane by plotting the trajectories around the critical points which provide insights into possible evolutionary paths of the scalar field and reveals attractor solutions that can drive prolonged periods of inflation or accelerate the late-time expansion of the universe.

Field of contribution:

Theory

330

Large neutrino asymmetry from forbidden decay of dark matter with first-order phase transition

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Despite being stable or long-lived on cosmological scales, dark matter (DM) can decay in the early Universe due to finite-temperature effects. In particular, a first-order phase transition (FOPT) during this period can create a finite window for such decay, ensuring DM stability at lower temperatures, consistent with observations. The FOPT may also produce stochastic gravitational waves (GW) with peak frequencies that correlate with the DM mass. Additionally, early DM decay into neutrinos can lead to a significant neutrino asymmetry, impacting cosmology by increasing the effective relativistic degrees of freedom, $N_{\rm eff}$, and potentially addressing the recently observed Helium anomaly, among other effects. To prevent excessive baryon asymmetry production, DM decay must occur below the sphaleron decoupling temperature, meaning the FOPT must happen at sub-electroweak scales. This brings the resulting stochastic GW within the detection range of experiments like LISA, μARES, and NANOGrav.

Field of contribution:

Phenomenology

331

Cogenesis of baryon and dark matter from ultra light PBH with memory burden effect

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The conventional semi-classical study of quantum evaporation of a black hole assumes the self-similarity of the black hole throughout its entire lifetime. However, this assumptions ignores the effect of back-reaction of the emission on the black hole itself. Recent studies have suggested that the back-reaction may lead to a new effect called "memory burden" that slows down the evaporation processes and hence increases the black hole lifetime significantly. In this work, we study the possibility of producing the observed baryon asymmetry and dark matter (DM) from the evaporation of primordial black hole (PBH) taking into account of memory-burden effect. We consider PBHs to dominate the energy budget in the early universe and evaporate away before Big Bang Nucleosynthesis. Although successful cogenesis is not viable with hierarchical right handed neutrino (RHN) due to structure formation constraint on DM, we show the possibility of successful cogenesis with resonant leptogenesis. Moreover, we also explore the possibility of successful cogenesis in a simple baryogenesis model without taking the leptogenesis route. Due to the possibility of generating asymmetry even below the sphaleron decoupling era, new mass window of memory-burdened PBH opens up. Finally, we also discuss the possibility of distinguishing the two scenario from produced stochastic gravitational waves (GWs) due to PBH density fluctuations.

Field of contribution:

Phenomenology

332

Measurement of branching fraction, direct CP asymmetry, and longitudinal polarisation of the decay B+ -> K*+ omega at Belle II

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We present preliminary MC results from a search for the decay $B^+ \to K^{*+}\omega$ using the data collected by the Belle II detector at the SuperKEKB asymmetric-energy e^+e^- collider, operating at the $\Upsilon(4S)$ resonance. This analysis focuses on the decay of B meson into two non-leptonic charmless vector mesons. The production of vector mesons in different polarization states leads to distinct polarization fractions. An enhancement in the transverse polarization fraction has been observed in penguin-dominated decays, which still remains to be understood. Investigating this decay mode experimentally is crucial, as it can significantly advance our understanding of these processes. The current experimental upper limit on the branching ratio of $B^+ \to K^{*+}\omega$ is 7.4×10^{-6} at 90% confidence level (CL), which was set by the BaBar collaboration. BaBar also measured the longitudinal polarization fraction of this decay to be 0.41 ± 0.18. This analysis will be the first attempt to search for this decay mode and aim to measure the branching fraction, direct CP asymmetry, and longitudinal polarization using the Belle and Belle II dataset.

Field of contribution:

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COSMOLOGICAL SCALING SOLUTION AND STABILITY ANALYSIS FOR CONSTANT COUPLING INTERACTION USING LOGARITHAMIC POTENTIAL.

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As the universe is dynamic, the best way to treat with the cosmological models are of course with dynamical systems. This work studies cosmological scaling solutions and their stability in models involving a scalar field with constant coupling interaction. We consider logarithmic potential for the scalar field and analyse its impact on the dynamics of the universe. We find scaling solutions where the scalar field energy density follows the background fluid by using phase plane analysis. The stability of these solutions is examined to reveal the conditions under which they act as late-time attractors. Our study may provide a insight into the role of logarithmic potential form in cosmological evolution.

Field of contribution:

Theory

334

Investigating the effect of magnetic field on baryon-charge correlations in Pb−Pb collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV with ALICE

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Correlations among net-conserved quantities such as net-baryon, net-charge, and net-strangeness play a crucial role in studying the QCD phase structure, as they are directly related to thermodynamic susceptibility ratios in lattice QCD (LQCD) calculations. Recent LQCD studies indicate a significant influence of the magnetic field (eB) on the susceptibility ratio associated with baryon-charge correlation, $\chi^{11}_{\mathrm{BQ}}/\chi^{2}_{\mathrm{Q}}$, highlighting the potential of using fluctuations and correlations of net-conserved charges to investigate the magnetic field produced in peripheral heavy-ion collisions. This presentation introduces new results focusing on correlation between net-charge and net-proton, with the net-proton serving as a proxy for the net-baryon number. The measurements are performed as a function of centrality in Pb–Pb collisions at 5.02 TeV using data recorded by the ALICE detector. Theoretical predictions from the Hadron Resonance Gas model (Thermal-FIST) without a magnetic field are compared with experimental results, to understand the influence of other dynamical factors leading to correlations, like resonance decays and conservation laws. The centrality dependence of the measured observable shows good alignment with the eB dependence predicted by LQCD, which also could not be explained by the no-magnetic-field Thermal-FIST model results.

Field of contribution:

Experiment

335

Feasibility of CEνNS Search at APSARA-U

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Coherent Elastic Neutrino Nucleus Scattering (CEνNS) offers exciting opportunities to probe new physics within and beyond the Standard Model. The process occurs when the scattering amplitudes of nucleons interfere constructively, leading to the scattering of the entire nucleus. Detecting CEνNS provides deeper insights into neutrino properties, such as the neutrino magnetic moment, millicharge, and potential new force mediators. CEνNS enables the exploration of the neutrino spectrum below approximately 1.8 MeV, a region inaccessible through Inverse Beta Decay. Studying CEνNS also sheds light on the neutrino fog, an irreducible background for Dark Matter searches.

Despite the enhanced cross-section of CEνNS compared to other neutrino interactions, CEνNS signals are challenging to detect due to their low recoil energy up to $\mathcal{O}(\mathrm{keV})$. However, cryogenic dark matter detectors, with thresholds in the $\mathcal{O}(10\,\mathrm{eV} - 100\,\mathrm{eV})$ range and excellent energy resolutions around $\mathcal{O}(10\,\mathrm{eV})$, are sensitive enough to measure these small recoil signals. Reactor facilities, with their abundant neutrino flux in the $\mathcal{O}(\mathrm{MeV})$ range, provide an ideal environment for studying CEνNS. At NISER, we are investigating the feasibility of conducting
CEνNS studies at research reactors, such as the 2 MW APSARA-U. We will present simulation results of background studies and shielding optimization for a cryogenic detector-based experiment at APSARA-U for CEνNS detection.

Field of contribution:

Experiment

336

Study of photonuclear interactions in ultra-peripheral Pb-Pb collisions with ALICE

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Ultra-peripheral collisions (UPCs) of relativistic heavy ions are a tool for studying the photonuclear interactions at the highest LHC energy. UPCs occur when the impact parameter between two colliding nuclei is greater than the sum of the nuclear radii. In UPCs, the photon emitted from one nucleus can fluctuate to a quark-antiquark pair (dipole), which then elastically scatters off the target nucleus, emerging as a vector meson or an oppositely charged pseudoscalar meson pair, and both nuclei remain intact. Changes made to the ALICE experimental setup before Run 3 enable us to study inelastic collisions, a particular class of UPCs, where the target nucleus breaks up.
In this talk, we present the results of vector mesons in photon-nucleus interactions measured at midrapidity in Pb–Pb UPCs collisions. We will show recent results on coherent ρ^0 photoproduction, exclusive four pion photoproduction, as well as photoproduction of K^+K^- pairs in Pb–Pb UPCs collisions at $\sqrt{s_{\rm NN}}$ = 5.02 TeV with Run 2 ALICE data. Latest results on inclusive photoproduction of resonances (ρ^0, ϕ and K^{*0}) in inelastic Pb-Pb UPCs collisions at $\sqrt{s_{\rm NN}}$ = 5.36 TeV with Run 3 ALICE data will be discussed.

Field of contribution:

Experiment

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Investigating skewness effects in proton GPD $\tilde{H}_{2T}^{\nu}$ with the light-front quark-diquark model

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We present an analysis of generalized parton distribution (GPD) $\tilde{H}_{2T}^{\nu}$ of the proton with non-zero skewness, using the light-front quark-diquark model (LFQDM).
This study examines how skewness shapes the internal structure of the proton at higher-twist, particularly through the unintegrated quark-quark GPD correlator with the Dirac matrix structure $\Gamma = \gamma^j$. By systematically solving this correlator and aligning our results with the standard parameterization equations, we derive explicit expressions for the GPD $\tilde{H}_{2T}^{\nu}$. These findings may offer insights that are relevant to experimental studies of Compton form factors (CFFs), which can be observed in scattering cross-sections, and suggest the potential of the LFQDM framework to aid in the understanding of three-dimensional hadron structure.

Field of contribution:

Phenomenology

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Development and Optimization of a Hybrid Muon Tomography Prototype Setup

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High-energy cosmic muons, produced in the upper atmosphere through the decay of particles like pions and kaons, descend to the Earth's surface. Leveraging the interaction of these high-energy muons with matter offers a powerful technique for non-invasive imaging, as they can penetrate dense materials. Depending upon the energy, muons either scatter or are absorbed when passing through objects. The characteristics of this interaction, specifically the scattering angle is influenced by the atomic number and density of the materials encountered. This scattering angle can be determined by reconstructing the muon trajectories, enabling a method similar to other radiography but with a unique sensitivity to material density and composition.

A prototype muon tomography setup is being developed with a vertical stack of position sensitive detectors that serve as precise muon trackers. This work explores the integration of various detector types, including gaseous and scintillator detectors, within a hybrid muon stack to enhance imaging capabilities. Special emphasis is given to a scintillator-SiPM strip detector prototype, considered as a potential layer in the stack. A cost-effective, multi-channel, FPGA based data acquisition (DAQ) system has been developed for this setup, featuring direct LVDS signal processing with a 500 MHz sampling frequency. It consists of a front-end electronics stage built around the NINO ASIC and back-end electronics utilizing the Altera MAX-10 FPGA board. The DAQ has been designed for high precision in timing and signal processing across multiple detector channels, enhancing the tracking accuracy for both gaseous and scintillator-SiPM detectors. The study presents progress in developing and testing this configuration, focusing on optimizing detector parameters to achieve maximum detection efficiency. Preliminary results indicate several promising design improvements that could significantly boost the performance and versatility of muon tomography systems in practical applications.

In this presentation, we will discuss our experience in optimizing detector stacks, doing efficiency studies on the detectors employed, and weighing the benefits and drawbacks of various exploration techniques.

Field of contribution:

Experiment

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Silicon Sensor Module Assembly at TIFR for the CMS experiment

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The CMS Collaboration is preparing to build replacement endcap calorimeters for the High-Luminosity phase of the LHC. The new high-granularity calorimeter (HGCAL), as its name suggests, is a very fine-grained sampling calorimeter. It is made up of 47 layers of absorbers, mostly made of lead and steel, and active elements, namely silicon sensors in the areas with the most radiation and scintillator tiles with on-tile SiPMs in areas with less radiation. The front 26 layers constitute an electromagnetic section and use silicon as an active medium. Each of these layers is built using Silicon modules, which comprise a stackup of a thermally-conductive CuW baseplate, a silicon sensor, and a front-end readout board. A layer of Kapton foil is added between the baseplate and sensor to electrically insulate the baseplate. Our group at TIFR is involved in the development of silicon detector modules for the electromagnetic section of the HGCAL. The module assembly is performed with a precision gantry system, and automated wirebonding of individual cells of the silicon sensor to the bonding pads on the readout board is done with an ultrasonic wire bonder. In this presentation, we will describe the design of such detector modules, the assembly procedure, and delve into the tasks involved in assembling and testing these modules at a Module Assembly Center.

Field of contribution:

Experiment

340

TCAD simulation study to understand the behaviour of proton irradiated thin LGADs

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The high luminosity operation of the Large Hadron Collider (HL-LHC) requires radiation hard silicon detectors for precise particle tracking and accurate time stamping of traversing particles. Low Gain Avalanche Detectors (LGADs) offer radiation hard characteristics and excellent time resolution, hence, are planned to be used in future HL-LHC. However, recent studies indicate that the multiplication capability due to the additional gain layer in LGADs significantly degrades with increasing particle fluence, primarily due to trap formation and the acceptor removal mechanism. This degradation is particularly severe due to proton irradiation.

To address this issue, we extended our simulation efforts by applying the Proton Damage Model, initially developed by Delhi Group for PIN diodes, to thin (50 μm) LGADs. The simulated geometry and doping profile are fine tuned to obtain measured gain layer depletion voltage (V_{GL}), full depletion voltage (V_{FD}), active thickness (t), end capacitance (C_{end}) and gain over a wide range of bias voltages. Our simulation shows that just considering trap defects and the acceptor removal process isn't enough to accurately predict the gain with respect to the PIN diode for a proton-irradiated LGAD. As a result, optimizing the impact ionization parameters for the irradiated case is necessary as different impact ionization models and their coefficients influence the detector gain. The present simulation study tends to establish the proton damage model for thin LGADs in conjunction with the analytically introduced acceptor removal mechanism and optimized impact ionization coefficients at different levels of neutron equivalent fluence of proton irradiation viz., (4.3×10^{14}, 1.18×10^{15} and 1.55×10^{15}) 1 MeV $n_{eq}cm^{-2}$. This will enhance the ability to predict detector performance

in high-radiation environments and contribute to the development of radiation-hard silicon detectors.

Field of contribution:

Experiment

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Probing Chiral Magnetic Wave in isobar collisions at √sNN = 200 GeV at RHIC-STAR

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Chiral anomalies in Quantum Chromodynamics (QCD) can lead to phenomena such as the Chiral Magnetic Wave (CMW), which is a collective excitation of chiral charges in the presence of a magnetic field. Investigating this effect could provide valuable insights into the interaction between magnetic fields and chiral anomalies during heavy-ion collisions. The CMW is expected to induce charge-dependent elliptic flow in heavy-ion collisions. In this study, we explore the CMW by examining the difference in elliptic flow (v_2) between positively and negatively charged particles in Ru+Ru and Zr+Zr collisions at $\sqrt{s_{textupNN}}$ = 200 GeV at STAR. We analyze the covariance of v_2 and charge asymmetry (A_{ch}) for positive and negative charge particles, as well as their dependence on collision centrality, to detect the CMW signal. The results from both systems are compared to determine whether there is an enhanced signal in Ru+Ru collisions compared to Zr+Zr collisions, due to the presence of four additional protons in Ru and thereby stronger B-fields in Ru+Ru collisions.

Field of contribution:

Experiment

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Electric Sachs form factors of low-lying octet baryons in a diquark spectator model

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Electromagnetic properties of a hadron are analyzed to elucidate the distribution of charge and magnetization within a hadron. Sachs form factors are the fundamental quantities used to study these properties. We have adopted the light-cone formalism to analyze the electric Sachs form factors

$G_E(Q^2)$ of strange and non-strange low-lying octet baryons in a diquark spectator model. All possible polarization states of a diquark are considered with the dipolar form factor of the baryon-quark-diquark vertex. The computed results of $G_E(Q^2)$ are presented with the comparison of available data for both types of low-lying octet baryons.

Field of contribution:

Phenomenology

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Track finding using GNNs and GPUs for the J-PARC muon g-2/EDM experiment.

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Recent discrepancies between the Standard Model prediction of the anomalous magnetic moment of the muon, a_μ^{SM}, and experimental measurements, a_μ^{Exp}, suggest the possibility of new physics and unknown particles. The proposed J-PARC muon g-2/EDM experiment aims to measure the muon's anomalous magnetic moment with a precision of 460 ppb(sys + stat). This will be achieved by using reaccelerated ultracold muons injected into a magnetic storage ring. A crucial aspect of the g-2/EDM experiment is the accurate reconstruction of positron tracks from muon decays, which is currently performed using the hough-transformation technique. However, the current track-finding process is computationally slow, and a speedup factor of 10 is currently required. To address this issue, alternate strategies have been proposed, one that uses Graphical Processing Units (GPUs) and another using Graph Neural Networks (GNNs). We present an overview and the current status of our efforts in this direction.

Field of contribution:

Experiment

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Investigating One Zero Texture in Neutrino Mass Matrix with Generalized CP Symmetry

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The textures in the neutrino mass matrix refer to specific patterns and structures, these textures have the ability to constrain various neutrino parameters such as mixing angles, Dirac and Majorana

phases, and mass eigenstates. In this work, we investigate one zero texture within the framework of generalized CP symmetry associated with the complex tribimaximal matrix. The generalized CP symmetry extends the traditional CP symmetry by incorporating additional transformations that can affect the neutrino mass matrix. When we impose generalized CP symmetry on the neutrio mass matrix, it transforms the neutrino mass matrix into its complex conjugate. By combining these approaches, we derive predictive neutrino mass matrices and elucidate correlations between various parameters. Additionally, we analyze neutrinoless double beta decay in the context of one zero texture in the light of current and future experimental data. Furthermore, we include the constraints from Planck data on the sum of neutrino masses, $\Sigma m_i \leq 0.12\,\text{eV}$ and the DESI/SDSS+Pantheon+DES-SN($\leq 0.17\,\text{eV}$) to assess the compatibility of one zero texture within this framework.

Field of contribution:

Phenomenology

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One-Loop Leptogenesis: Unraveling Extra CP Phases Incorporating Dark Sectors

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One-Loop Leptogenesis: Unraveling Extra CP Phases Incorporating Dark Sectors

Despite the success of the Standard Model (SM), the observed baryon asymmetry (BA) of the Universe remains an unresolved issue, motivating exploration beyond the Standard Model (BSM). The leptogenesis mechanism provides a plausible explanation, proposing that an asymmetry generated in the lepton sector is transferred to baryons through sphaleron processes. However, the traditional leptogenesis mechanism typically involves high-energy scales, posing challenges for experimental detection. This work investigates how introducing additional phases can lower the required energy scale, enabling us to explore relevant collider signatures at the 13 TeV LHC. Additionally, we discuss the implications for dark matter phenomenology, offering a more accessible experimental framework for probing baryogenesis.

Field of contribution:

Phenomenology

346

Cosmic ray composition studies at the GRAPES-3 experiment using machine learning techniques

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Accurate determination of the nuclear composition and energy spectrum of primary cosmic rays, particularly in the region around the knee ($\sim$ 3 PeV), is crucial for understanding their origin, acceleration mechanisms, and interactions with the interstellar medium. The GRAPES-3 experiment, located in Ooty, India, utilizes a dense array of plastic scintillator detectors, along with a large-area tracking Muon Telescope, to observe cosmic rays over a wide energy range, from several TeV to ~ 10

PeV. In this work, we employ multivariate analysis techniques, particularly Boosted Decision Trees (BDTs), to classify light cosmic ray primaries—specifically protons and helium from heavier nuclei. To further disentangle protons from helium nuclei, we propose a second classifier optimized for this task. After training and validating our models on Monte Carlo simulation data, we will apply them to GRAPES-3 observational data to extract the relative composition of the primaries and probe their corresponding energy spectra. This analysis aims to provide new insights into the mass composition and energy distribution of cosmic rays around the knee region, contributing to the understanding of their astrophysical origins and propagation.

Field of contribution:

Experiment

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Simulation study of different pitch sizes GEM detectors and their performance comparison

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Gas Electron Multiplier (GEM) based detectors are planned to be used in future collider experiments like the High Luminosity Large Hadron Collider (HL-LHC), Electron Ion Collider (EIC) and Apparatus for Meson and Baryon Experimental Research (AMBER) because they have proven effective for tracking particles in recent experiments. In this context, we have conducted a comparative study through simulation to assess the performance of small-pitch GEM foils (90 μm and 60 μm) in comparison to the standard GEM foil with a pitch size of 140 μm. Using ANSYS and Garfield++, we have carried out single GEM simulations and confirmed the results with experimental data. The comprehensive simulation study suggests that GEM foils with smaller pitch sizes provide higher effective gain, improved spatial resolution and stable performance as GEM potential increases, which will be advantageous for future collider experiments.

Field of contribution:

Experiment

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Search for Gamma Ray sources with GRAPES-3

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The GRAPES-3 experiment, situated in Ooty, Tamil Nadu (11.4°N, 76.7°E, 2200 m a.s.l.), is an array of 400 plastic scintillator detectors arranged in a hexagonal grid spanning 25,000 m², complemented by a muon detector made of proportional counters covering 560 m². The latter enables extensive air showers originating in gamma rays from Galactic and extragalactic sources within the TeV–PeV energy range to be distinguished from Cosmic Ray primaries. In this work, we explore machine learning techniques to enhance this capability and carry out a search for point sources of gamma rays using an unbinned maximum likelihood method that incorporates both directional and energy dependencies. This approach is particularly applied in our search for gamma-ray emissions from the Crab Nebula.

Field of contribution:

Experiment

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Nova-T2k tension in the light of non-isotropic LIV

Authors: Shashank Mishra[1]; Saurabh Shukla[2]

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This study addresses the tension observed between the NOνA and T2K long-baseline accelerator experiments in determining the standard CP phase, exhibiting more than 90% confidence level with two degrees of freedom. We explore the potential for new physics beyond the standard model, specifically focusing on non-isotropic Lorentz Invariance Violation (LIV) as a means to resolve this discrepancy. Our analysis examines the effects of LIV on both appearance and disappearance channels individually, as well as in combination. We focus on specific LIV parameters, \(a^X \) and \(c^{XY}\). Additionally, we demonstrate that the sidereal effect and the differing orientations of T2K and NOνA can help reduce this tension. Furthermore, we investigate a hypothetical scenario involving a 3% variation in the number of protons on target (POT) for both experiments, highlighting its role in causing discrepancies. This work emphasizes the significance of sidereal studies and their impact on standard three-flavor fits.

Field of contribution:

Phenomenology

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The Mu2e Experiment for Charged Lepton Flavor Violation Search at Fermilab.

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One of the many probes for Beyond Standard Model (BSM) studies is the search for Charged Lepton Flavor Violation (CLFV). The Mu2e experiment at Fermilab will search for the neutrinoless muon-to-electron conversion in the nuclear field. In Aluminum, the experimental signature of this process is a 104.97 MeV mono-energetic electron conversion. 1. The Mu2e experiment plans to measure the ratio of muon-to-electron conversion with respect to all muon captures with a precision of 3×10^{-17}. This would be an improvement of four orders of magnitude over the current best limit of 7×10^{-13} (90%

CL) by the SINDRUM-II experiment 2. The proposed talk introduces the Mu2e design strategy, detectors, and background rejection techniques unique in this research area. Installation of components, recent R&D work, and a plan for a possible successor Mu2e-II will also be highlighted.

1. L. Bartoszek et al. [Mu2e Collaboration], "Mu2e Technical Design Report", https://arxiv. org/abs/1501.05241arXiv:15
2. W. Bertl et al., "Search for ⊠ – ⊠ conversion in muonic gold", https://link.springer. com/article/10.1140/epjc/s2006-02582-xEur Phys J C (2006) 47:337–46

Field of contribution:

Experiment

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Impact of Non-isotropic LIV on Standard neutrino oscillation parameters in DUNE

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Lorentz invariance violation (LIV) is a significant factor that can influence the determination of standard unknown oscillation parameters in neutrino physics. This study examines how non-isotropic LIV, particularly with sidereal effects, impacts neutrino oscillation dynamics in the Deep Underground Neutrino Experiment (DUNE). Our analysis reveals that LIV presents considerable challenges in accurately determining key oscillation parameters, including the leptonic CP phase, mass hierarchy, and the mixing angle θ_{23}. While the sensitivity to mass hierarchy remains largely intact, it is notably influenced by the $c_{\mu\tau}^{XY}$ parameter. In contrast, the parameters $c_{e\mu}^{XY}$ and $c_{e\tau}^{XY}$ significantly diminish CP sensitivity. Furthermore, the presence of non-isotropic LIV complicates DUNE's ability to resolve the octant ambiguity of θ_{23} and exacerbates the degeneracy between the Dirac CP phase and θ_{23}. These findings underscore the importance of incorporating LIV effects, especially those with sidereal variations, into the design and analysis of future neutrino experiments.

Field of contribution:

Phenomenology

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Study of Lorentz invarianece violation through Sideral effect in Long-baseline experiment

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Lorentz Invariance Violation (LIV) presents a fascinating opportunity to explore fundamental symmetries, with neutrinos serving as particularly effective probes of this phenomenon. Long-baseline neutrino experiments, such as the Deep Underground Neutrino Experiment (DUNE), are particularly well-suited for investigating non-isotropic LIV, especially through the detection of sidereal effects. This study provides a comprehensive analysis of the full parameter space for non-isotropic, non-diagonal LIV parameters that exhibit sidereal dependence, focusing on two specific flux scenarios: low-energy flux and tau-optimized flux. Our findings yield more stringent constraints on LIV parameters, suggesting that DUNE could achieve greater sensitivity for certain LIV parameters, surpassing all previously established limits and representing a significant advancement in LIV research.

Field of contribution:

Phenomenology

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Isospin analysis of Cabibbo suppressed two body weak hadronic decays of Bottom Mesons

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Isospin analysis of Cabibbo suppressed two body weak hadronic decays of Bottom Mesons

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The weak interactions in the heavy flavor sector are not yet fully understood, though the standard model provides a viable approach and deep insight into their basic structure. We have carried out an analysis of CKM-suppressed two-body hadronic decays $\bar{B} \to KD/K^*D/KD^*$, which involve two isospin states in the decay products, while including nonfactorizable contributions arising due to part of the weak Hamiltonian involving the colored currents. Since the nonfactorizable contributions are non-perturbative, they are difficult to calculate at present from the theory of strong interactions. Therefore, we have employed the isospin formalism in the phase independent manner. Using the experimental measurements for their branching fractions and extracting the strong interaction phases and factorizable decay amplitudes, we estimate the nonfactorizable isospin reduced amplitudes corresponding to these isospin states. We identify that in all the decay modes, the nonfactorizable isospin reduced amplitudes A_0^{nf} bears the same ratio with A_1^{nf} consistently, with in the experimental errors. The universality of this ratio may be exploited to estimate various parameters in weak decays of heavy mesons. We have also observed that present experimental data for B decays clearly shows the presence of FSI strong phases.

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Field of contribution:

Phenomenology

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Development of cost-effective Indigenous Resistive Coatings for Resistive Plate Chamber

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This study presents the development of indigenous resistive paints for application in high-energy physics (HEP) experiments, particularly in resistive plate chambers (RPCs). The aim is to create an affordable and effective conductive coating to enhance the efficiency and positional resolution of RPC detectors. Observations indicate that the resistance of the paint fluctuates during drying, attributed to the evaporation of the dispersing agent and graphite settling, eventually stabilizing when dry. Lower graphite concentrations result in higher resistivity, affected by measurement variability and external factors, while increased graphite content progressively reduces resistivity, showing saturation at higher concentrations. This work also investigates the impact of environmental parameters, such as temperature and humidity, on the resistivity of the coating, as well as the effect of varying thickness on coating resistivity. Additionally, this novel coating demonstrates the potential for applications in EMI/RFI shielding, expanding its utility across diverse technological fields. To further enhance consistency and performance, advanced application techniques, such as spin and dip coating, alongside optimized mixing methods, are being also explored.

Field of contribution:

Experiment

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Optimizing Gas Flow Dynamics to enhance the performance of Resistive Plate Chamber

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Resistive Plate Chambers (RPCs) are essential in particle physics for their high performance and cost-effectiveness. However, maintaining a consistent and uniform gas flow is crucial for optimizing RPC efficiency and preventing contamination, which can compromise detector integrity. This study investigates gas flow dynamics within RPCs using COMSOL Multiphysics simulations, focusing on velocity, pressure, and vorticity profiles under various conditions. Our findings reveal a non-linear relationship between gas flow saturation time and applied pressure, with notable variations in saturation times. Additionally, we examine the effects of gas uniformity and purity across different RPC dimensions, essential for minimizing operational costs and extending detector lifespan. The study further analyzes the impact of inlet and outlet positioning and the influence of multiple nozzles on gas distribution. This work advances RPC performance and sustainability in particle physics, promoting both operational efficiency and environmental responsibility.

Field of contribution:

Experiment

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Phase Transition-Driven Leptogenesis via a Dynamically Evolving Vacuum

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A phase transition in the early Universe, at a critical temperature T_*, induces a temperature dependent mass for right handed neutrinos (RHNs) that eventually stabilizes to a constant value through the Higgs vacuum expectation value (vev) after electroweak symmetry breaking (EWSB). This dynamical variation in the mass of RHNs with temperature enables us to achieve RHN mass below the electroweak scale (~ 100 GeV) at zero temperature while generating a sufficient amount of lepton asymmetry near T_*, which, through the sphaleron process, can account for the observed baryon asymmetry of the Universe (BAU). Therefore, such a low mass of RHNs at zero temperature enhances its detection probability. Notably, this framework also has the potential to predict a primordial lepton asymmetry generated after EWSB, as hinted by measurements of helium abundance, shedding light on a potential link to the early phase of leptogenesis.

Field of contribution:

Phenomenology

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Cancellation of Infrared Divergences in e +e – to q\bar{q}g in Light Front Coherent State Formalism

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We address the issue of cancellation of infrared (IR) divergences at the amplitude level in Light Front Quantum Chromodynamics (LFQCD) using the coherent state formalism. We consider the process $e^+e^- \to q\bar{q}g$ upto $\mathcal{O}(g^3)$ in light-cone-time-ordered Hamiltonian perturbation theory and show that IR divergences in S-matrix elements appear due to vanishing energy denominators. We construct the coherent state formalism for LFQCD and explicitly show that these divergences are cancelled when a coherent state basis is used for calculating the S-matrix elements.

Field of contribution:

Theory

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Probing a five dimensional Lmu-Ltau model through elastic electron-neutrino scattering: the scope of the DUNE near detector

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The extension of the Standard Model (SM) by a $U(1)_{L_\mu - L_\tau}$ gauge group is well studied in the literature to address the discrepancy in the muon anomalous magnetic moment. In this study we consider the $U(1)_{L_\mu - L_\tau}$ gauge group is five dimensional where multiple associated massive gauge bosons appear and these bosons contribute to the muon $(g-2)$ with other processes. We focus on the elastic electron-neutrino scattering to probe our model in the MeV-scale regions with the help of CHARM-II, BOREXINO and upcoming DUNE near detector (DUNE ND) experiment. We find even with small kinetic mixing parameters, much of the parameter space, including those satisfying muon $(g-2)$, can be probed using several years of data from DUNE ND experiment. In our scenario, interference effects among intermediate-state gauge bosons play an important role. Our results show the comparisons between flat and warped extra dimensions as the sensitivity from the experiments can substantially depend on the geometry of the compactification . In continuation of this work, we are studying the constraints from high energy colliders, and if feasible, will present some of these results.

Field of contribution:

Phenomenology

360

Mapping critical region in the on-shell renormalized 2+1 flavor Polyakov quark meson model

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The critical region around the critical end point (CEP) has been mapped in the 2+1 flavor renormalized Polyakov quark meson (RPQM) model. The consistent treatment of the quark one-loop vacuum fluctuations, gives the improved chiral effective potential of the renormalized quark meson (RQM) model, where the parameters are fixed by relating the counterterms in the on-shell (OS) scheme to those in the minimal subtraction $\overline{\text{MS}}$ scheme. The $U_A(1)$ anomaly strength gets significantly stronger and the light (strange) explicit chiral symmetry breaking strength becomes weaker by a small (relatively large) amount after renormalization in the RQM model. The effect of the above novel features, on the extent of critical fluctuations around the critical end point, has been quantified by drawing the contours of enhanced quark number susceptibility in the presence as well as the absence of the Polyakov loop potential. The results thus obtained, have been compared with the existing studies where the quark one-loop vacuum fluctuations are included but the model parameters get fixed by using the curvature masses of the mesons.

Field of contribution:

Phenomenology

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Investigating criticality in the on-shell parameterised two flavor quark meson model augmented with Polyakov loop potential

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The quantum chromodynamics (QCD) like framework of the renormalized Polyakov quark-meson (RPQM) model has been obtained after combining the exact chiral effective potential of the two flavor renormalized quark meson (RQM) model with the improved Polyakov-loop potential that accounts for the quark back reaction. The consistent treatment of the quark one-loop vacuum fluctuations and the on-shell renormalization of the parameters, gives the exact vacuum chiral effective potential of the RQM model. The critical fluctuations around the critical end point (CEP) has been quantified in the RPQM model by computing the contours of the enhanced quark number susceptibilities in the μ and T plane of the QCD phase diagram. The effect of the Polyakov-loop potential on the nature of the contours of critical fluctuations, has been compared by computing the quark number susceptibility contours in the presence and absence of the Polyakov-loop potential. The QCD phase diagram for the RPQM model has been calculated and the tri-critical point (TCP) has been found in the chiral limit of the massless pions. The contours of the enhanced quark number susceptibilities, have also been drawn around the TCP to find the extent of criticality. The proximity of the CEP to the TCP has been determined and the overlap of the quark number susceptibility contours around the TCP and CEP has been found.

Field of contribution:

Phenomenology

362

Exploiting ChPT to find consistent path to the chiral limit in the renormalized quark meson model

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The present work builds upon the new results of our very recent studies in Ref. Phys. Rev. D 108, 074002 (2023) and Phys. Rev. D 109, 034025 (2024) where the divergent quark one-loop vacuum fluctuations have been consistently included in the 2+1 flavor renormalized quark meson model (RQM) and parameters are correctly renormaized by relating the counterterms in the on-shell (OS) scheme to those in the minimal subtraction $\overline{\text{MS}}$ scheme.~The axial $U_A(1)$ anomaly gets significantly stronger in the RQM model while the strength $h_x(h_y)$ at the physical point gets reduced by a small (relatively large) amount after renormalization.~Consistent path to chiral limit as the π and K meson masses approach zero has been obtained by combining the RQM model with the Chiral perturbation theory (ChPT) scaling of the pion,~kaon decay constants f_π, f_K and $M_\eta^2 = m_\eta^2 + m_{\eta'}^2$.~The left side of the Columbia plot is generated free from any ambiguity or heuiristic adjustment in the model parameter fixing away from the physical point.~Quantifying the softening effect of quark one-loop vacuum fluctuation on the chiral transition and comparing our results with those of the recent QM model study in the functional renormalization group (FRG) framework,~we find that it is overestimated in the FRG study performed under local potential approximation.

Field of contribution:

Phenomenology

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Quarkonium polarization measurement in hadronic and nuclear collisions at forward rapidity

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Quarkonium production in ultra-relativistic collisions is an essential probe for understanding the deconfined phase of QCD matter. Further, quarkonium suppression in heavy-ion collisions supports the existence of the deconfined, thermalized, and strongly interacting QCD medium known as quark-gluon plasma (QGP). However, phenomena like collective flow, which is assumed to be another crucial feature of QGP, have been recently observed in relativistic pp collisions at the LHC energies. As pp lacks the baseline, the measurement of quarkonium suppression becomes infeasible in the conventional way. However, polarization measurements of quarkonium states may serve as a baseline-independent probe for investigating the QGP medium because it depends on the shape of the angular distribution of dileptons along a quantization axis. Analyzing quarkonium polarization in these collisions constrains the underlying production mechanisms and sheds light on the formation of bound states. Recently, the finite spin alignment of J/ψ in Pb-Pb collisions at $\sqrt{s}_{NN}$ = 5.02 TeV advocates the possible existence of spin-vorticity coupling in thermally rotating media 1. Although a range of sources could potentially contribute to this phenomenon, it is assumed that the primary contribution arises due to the vorticity field, electromagnetic field and the strong vector meson force field. In this presentation, we summarize the quarkonium polarization measurement obtained so far using the muon spectrometer of ALICE at forward rapidity in Pb-Pb and pp collisions at LHC energies for helicity, Collins-soper and the event plane frames [1-4]. Additionally, the comparison of various theoretical model predictions with respect to experimental observation will be presented. With the help of newly built Muon Forward Tracker the precise measurements of quarkonia polarization in hadronic and nuclear collisions along with the separation of prompt and non-prompt quarkonium states can be performed using the high statistics Run 3 data.

Field of contribution:

Experiment

364

A study of forward backward correlations of identified particles using UrQMD hadronic transport model at FAIR energies

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In high-energy collisions of hadrons or heavy-ions , conservation laws play an important role in particle production, most relevant being the conservation of electric charge, strangeness, and baryon quantum numbers. The phenomenological modeling of particle production has two primary approaches; statistical hadronization model (SHM) and string fragmentation. These models handle

conservation laws differently. In SHM the conservation laws apply within a finite correlation volume, whereas in string fragmentation, quantum numbers are conserved locally. As a consequence, in SHM, the correlation strength between two particles, whether they have the same or opposite quantum numbers, decreases as the correlation volume increases. In contrast, the string fragmentation model shows a strong correlation predominantly between oppositely charged hadrons due to the imposition of conservation laws on each string breaking.

The event-by-event measurements of correlation between different hadron species can be used to probe this difference in the quantum number conservation between these two models. In this work, we use a strongly intensive quantity called Σ_{FB} to study the forward(F)-backward(B) multiplicity correlations between different hadrons. Here F and B refers to forward and backward pseudorapidity (η) intervals, symmetrically placed around η=0. To test the sensitivity of this observable to the correlation strength between different particles, we use particles simulated from a model called Ultra relativistic Quantum Molecular Dynamics (UrQMD). UrQMD is a hadronic transport model, where particles are produced from resonance decays and fragmentation of excited strings. We study the role resonance decays on this observable and extend this study as a function of beam energy to decipher whether any change in the particle production mechanisms can be traced from this particular measure of forward-backward correlation.

Field of contribution:

Phenomenology

365

Klein Tunneling in Graphene with Superperiodic Potentials

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We used the transfer matrix method to investigate relativistic particles in superperiodic potentials of arbitrary order. We analytically explore the behavior of experimentally realizable massless Dirac electrons encountering rectangular potential barriers with a super-periodic pattern in a monolayer of graphene. In monolayer graphene, the transmission probability, conductance, and Fano factor are evaluated as a function of the number of barriers, the order of superperiodicity, and the angle of incidence. For normal incidence (indicating that the electron is incident perpendicular to the barrier), we observed that, the transmission coefficient equals unity and does not depend on the number of electrostatic barriers for both periodic and super-periodic cases. This behavior confirms the Klein-tunneling effect, which states that the system is completely transparent for normal incidence, even for large barrier widths. We also find that the transmission probability exhibits a series of resonances that depend on the number of barriers and the order of superperiodicity. Further, the conductance converges to its minimum value, while the Fano factor reaches its maximum value of $\frac{1}{3}$ at the Dirac point for superperiodic potentials of any order.

Field of contribution:

Theory

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Nonmonotonic specific entropy on the transition line near the QCD critical point

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We investigate the effect of the quantum chromodynamics (QCD) critical point on the isentropic trajectories in the QCD phase diagram. We point out that the universality of the critical equation of state and the third law of thermodynamics require the specific entropy (per baryon) along the coexistence (first-order transition) line to be nonmonotonic at least on one side of that line. Specifically, a maximum must occur. We show how the location of the maximum relative to the QCD critical point depends on the parameters of the critical equation of state commonly used in the literature. We then examine how the isentropic trajectories followed by adiabatically expanding heavy-ion collision fireballs behave near the critical point. We find that a crucial role is played by the sign of the isochoric temperature derivative of pressure at the critical point; this sign determines on which side of the coexistence curve the specific entropy must be nonmonotonic (i.e., has a maximum). We classify different scenarios of the adiabatic expansion that arise depending on the value of the discriminant parameter and the proximity of the trajectory to the critical point.

Field of contribution:

Theory

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Transition magnetic moments of Decuplet to Octet transition in symmetric nuclear matter

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In this study, we have calculated the transition magnetic moments of the decuplet $\left(J^p = \frac{3}{2}^+\right)$ to octet $\left(J^p = \frac{1}{2}^+\right)$ baryon transitions as a function of density for symmetric nuclear matter at different values of the temperature. The impact of the density and temperature has been realized through the chiral SU(3) mean field model ($\chi CQMF$) which considers quarks as the fundamental degrees of freedom. Within the framework of $\chi CQMF$, the impact on the properties of baryons (including mass) is defined through effective masses and energies of the constituent quarks which are modified through the exchange of exchange of scalar and vector fields. The impact thus calculated is then used as an input in this first study on the calculation of effective transition magnetic moments for decuplet to octet transitions using constituent chiral quark model (χCQM). The explicit effective contributions coming from valence quarks, sea quark and orbital angular momentum of quark sea have been included in total value of effective transition magnetic moments. The values of the effective transition magnetic moments have also been compared with available experimental results and other theoretical studies as well. Magnetic moments of the baryons serve as an important candle in scrutinizing the structure and the properties of light baryons.

Field of contribution:

Phenomenology

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Studies of Astrophysical Phenomena with the NOvA Experiment

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The NOvA experiment, primarily designed to study neutrino oscillations, has also proven to be a valuable tool for investigating various astrophysical phenomena. With its near detector situated 100 meters underground at Fermilab and its far detector, spanning 4,000 m² at Ash River, NOvA offers unique capabilities for probing astrophysical properties. This talk presents an overview of recent studies utilizing NOvA's detectors to explore cosmic muon rate variations, search for dark matter and magnetic monopoles, and detect atmospheric neutrinos. Additionally, the combination of NOvA's near and far detectors enables it to serve as a powerful supernova neutrino flux detector and facilitates the search for multi-messenger signals associated with LIGO/Virgo gravitational wave events.

Field of contribution:

Experiment

369

Medium Modifications of Magnetic Moments and Transition Properties of Low-Lying $J^P = 1/2^-$, $3/2^-$ Λ Resonances

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This study investigates the medium modifications of the magnetic moments and transition properties of low-lying spin-parity $J^P = 1/2^-$ and $3/2^-$ Λ resonances, such as $\Lambda(1405)$ with $1/2^-$ and $\Lambda(1520)$ with $3/2^-$, in hot and dense hadronic matter using the chiral SU(3) quark mean field model. In this model, quarks confined inside the baryons are modified
through the exchange of scalar fields σ, ζ, and δ and vector fields ω, ρ, and ϕ which results in shift in quark masses and interaction energies. By analyzing these field-induced modifications, the model enables us to calculate the effective masses and magnetic moments of the quarks and to estimate the impact on the magnetic moments and transition properties of Λ resonances in high density environments.

Field of contribution:

Phenomenology

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Connecting ⍰CDM Models with Different Functional Form and Common Density Parameter

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ABSTRACT

CDM models for dark energy are proposed using various functional forms to represent different cosmological models and solve the mysteries of the universe. In the present article keeping the concept of varying fine structure constant, two such basic models with function of scale factor are correlated to produce a common condition for the $, _m, _m o$. The novelty of this work is that it can unify two different models or create the common conditions which are very essential to solve such problems.

Key words. CDM model, Density Parameter, Scale Factor.

Field of contribution:

Theory

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CPL Parameterized Equation of State of Cubic, Quadratic and Linear Terms of CDM models

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ABSTRACT

Generally the cosmological CDM models are constructed with () a^3. Considering a cubic function (), the vacuum energy density is calculated and corresponding constraints are tuned with Chevallier-Polarski-Linder (CPL) equation of state parameterization. During the construction of the Problem the function () is assumed to be carrying cubic, quadratic and liner terms, so that the model behaves to carry a comparatively complex system to and accommodate different possible conditions to represent dark energy.
Keywords:- CPL Parameterization, CDM model, Scale Factor

Field of contribution:

Theory

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Observation of Branching Fraction and Time-dependent CP Violation in B0 → ωγ Decay at Belle II

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The decay $B^0 \to \omega\gamma$ provides a unique probe into flavor-changing neutral current processes, where the b-quark transitions to a d-quark via a one-loop radiative process. This rare channel, sensitive to potential new physics contributions, enables the search for virtual particles that could influence the branching fractions and polarization observables. Standard Model predicts the branching fraction to be $\mathcal{O}(10^{-6})$, while prior searches by the Belle and BaBar collaborations have set upper limits with 90% confidence levels at 0.4×10^{-6} and 0.9×10^{-6} respectively.

We present preliminary results from the analysis of this rare radiative decay using simulated data from the Belle II detector at the SuperKEKB collider, with an accumulated dataset exceeding 427.8 fb^{-1}. This study aims for the first observation of $B^0 \to \omega\gamma$, with a projected statistical significance above 3σ. The findings will contribute valuable insights into quark flavor dynamics, CKM matrix elements, and potential New Physics effects, advancing our understanding of such rare decay processes.

Field of contribution:

Experiment

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Investigation of forward-backward multiplicity correlations for proton-proton collisions at $\sqrt{s}$ = 7 TeV using Pythia8

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The forward-backward multiplicity correlations between particles produced at different pseudorapidities provide valuable insights into the underlying dynamics of multi-particle production in high-energy collisions. These correlations, believed to be largely unaffected by final-state effects, offer a unique window into the initial stages of the collision. This study investigates the correlation strength (b_{corr}) between forward (n_F) and backward (n_B) charged particle multiplicities. The dependence of b_{corr} on the pseudorapidity gap and window width separating the forward and backward regions is systematically explored. Furthermore, the analysis extends to correlations between positively and negatively charged particles in the respective forward and backward intervals.

To quantify the presence and strength of inter-particle correlations, the strongly intensive fluctuation measure (Σ) is employed. Σ, which reduces to unity in the absence of correlations, is calculated using n_F and n_B as extensive variables. The influence of color reconnection on these correlations is also considered. The proton-proton collisions at Large Hadron Collider (LHC) energy ($\sqrt{s}$ = 7 TeV) are simulated using the Pythia8 event generator to assess the impact of these processes on the observed correlation patterns. These results have been compared with the ALICE experimental results.

This comprehensive analysis aims to shed light on the complex interplay of mechanisms governing multi-particle production in high-energy collisions, ultimately contributing to a deeper understanding of the Quark-Gluon Plasma and the fundamental nature of strong interactions.

Field of contribution:

Phenomenology

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Spherical trapped surfaces in pure Gauss Bonnet Gravity

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The Gauss- Bonnet theory arises as a truncation of the Lovelock action. We use this action to understand the gravitational collapse of spherical shell of matter. The gravitational collapse of spherical symmetrical dust and viscous fluid matter is detailed by taking different density profiles as initial data.

Field of contribution:

Theory

375

Shedding the light on $B_{d,s} \to K^{(*)}K^{(*)}$ non-leptonic puzzle

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The current data on several observables in $b \to s\mu^+\mu^-$ transitions reveal certain discrepancies with Standard Model (SM) predictions. Considering the possibility that these deviations could stem from new physics, we explore the scenario where a non-universal Z' boson may be responsible. Additionally, we hypothesize that its couplings with quarks could influence an observable known as the non-leptonic puzzle $L_{K^*\bar{K}^*}$, related to rare $B_{s(d)} \to K^{(*)}K^{(*)}$ processes. By incorporating constraints from various $b \to s(d)\mu^+\mu^-$ measurements, we analyze the potential impact of the Z' model on this observable.

Field of contribution:

Phenomenology

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Relativistic second-order spin hydrodynamics: A correlation function approach using Zubarev's non-equilibrium statistical operator

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Utilizing Zubarev's nonequilibrium statistical operator, we derive the second-order expression for the dissipative tensors in relativistic spin hydrodynamics, namely the rotational stress tensor ($\tau_{\mu\nu}$), boost heat vector (q_μ), shear stress tensor ($\pi_{\mu\nu}$), and bulk viscous pressure (Π). The emergence of the first two terms, $\tau_{\mu\nu}$ and q_μ, is attributed to the inclusion of the antisymmetric part in the energy-momentum tensor. In this work, we also treat the spin density ($S^{\mu\nu}$) as an independent thermodynamic variable alongside energy density and particle density, leading to an additional transport coefficient characterized by the correlation between $S^{\mu\nu}$ and $\tau_{\mu\nu}$. Finally, we derive the evolution equations for the aforementioned tensors—$\tau_{\mu\nu}$, q_μ, $\pi_{\mu\nu}$, and Π.

Field of contribution:

Theory

377

Low scale thermal leptogenesis and gravitational waves from breaking of a discrete symmetry

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In a canonical type-I seesaw scenario, the SM is extended with three singlet right-handed neutrinos (RHNs) $N_i, i = 1, 2, 3$ with masses $M_i, i = 1, 2, 3$ to simultaneously explain sub-eV masses of light neutrinos and baryon asymmetry of the Universe. In this paper, we show that a relatively low-scale thermal leptogenesis accompanied by gravitational wave signatures is possible when the type-I seesaw is extended with a singlet fermion (S) and a singlet scalar (ρ), where S and ρ are odd under a discrete Z_2 symmetry. At a high scale, the Z_2 symmetry is broken spontaneously by the vacuum expectation value of ρ and leads to : (i) mixing between RHNs (N_2, N_3) and S, and (ii) formation of Domain walls (DWs). In the former case, the final lepton asymmetry is generated by the out-of-equilibrium decay of S, which dominantly mixes with N_2. We show that the scale of thermal leptogenesis can be lowered to $M_S \sim 4 \times 10^8$ GeV. In the latter case, the disappearance of the DWs gives observable gravitational wave signatures, which can be probed at NANOGrav, EPTA, LISA, etc. We also add a vector-like fermion doublet Ψ and impose a Z_2' symmetry under which both N_1 and Ψ are odd while all other particles are even. This gives rise to a singlet-doublet Majorana fermion dark matter in our setup.

Field of contribution:

Phenomenology

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Effects of Higher Order QCD corrections in Gluphilic dark matter model

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In this work, we present phenomenological studies of higher order QCD corrections in a simplified model of gluphilic dark matter. The model contains a scalar dark matter (DM) candidate which interacts with standard model (SM) particles via a scalar mediator. In particular we consider quarks and gluons as final state SM particles. At leading order, the annihilation of DM candidates into the SM particles is a loop induced process. The obvious constraints on the parameters of the model are from the required relic abundance. We try to improve the feasible parameter space of the model by considering the effects of higher order QCD corrections in the DM-SM interaction at leading as well as at next to leading order.

Field of contribution:

Phenomenology

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Leptogenesis assisted by triplet Fermion in connection to Muon $g-2$.

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We propose extending the minimal scotogenic model with a triplet fermion and a singlet scalar. All the fields change non-trivially under an additional $Z_4 \times Z_2$ symmetry. The $Z_4 \times Z_2$ symmetry allows only diagonal Yukawa couplings among different generations of SM leptons and right-handed singlet neutrinos. The one-loop radiative diagrams generate neutrino mass. The Yukawa coupling of the triplet fermion with the inert doublet positively contributes to the muon anomalous magnetic moment. The imposed $Z_4 \times Z_2$ symmetry forbids the conventional leptogenesis from the lightest right-handed neutrino decay N_1. The decay of triplet fermion and right-handed neutrino N_2 can generate a net lepton asymmetry in the muonic sector. Involvement of the Yukawa coupling both in leptogenesis and in the anomalous magnetic moment of the muon results in a strong correlation between leptogenesis and the recent Fermi lab result. We show a viable parameter space for leptogenesis while explaining the Fermi lab results. The inert scalar is the dark matter candidate in this model.

Field of contribution:

Phenomenology

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Supersymmetry and Quantum Phase Transition in a matrix model of SU(2) gauge theory

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For decades supersymmetric matrix models of $SU(N)$ gauge theories has been a subject of particular interest. We consider a matrix model of $SU(2)$ gauge theory coupled with a Weyl fermion transforming in the adjoint representation of the gauge group. This model depicts $\mathcal{N} = 1$ SUSY with anomalous global $U(1)_R$ symmetry. The matrix model, being quantum mechanical, provides a simplified computational platform to study the properties of the system in both weak and strong coupling regimes (g is the dimensionless Yang-Mills coupling constant). Here, we use a Rayleigh-Ritz variational technique to diagonalize the Hamiltonian and construct the color-singlet spin-0 and spin-1/2 energy eigenstates. In the weak coupling regime ($0 < g < 1$), we show that the ground state is a unique spin-0 state. We find that there is a level crossing in the ground state at $g = g_c \approx 0.225$. Such a level crossing in the ground state is a signature of a quantum phase transition (QPT). Except near g_c, the ground state is always a SUSY-singlet. Also, in both phases away from the critical coupling g_c, the low-lying spin-1/2 doublets are degenerate with two spin-0 states. Such manifolds of degenerate states constitutes the $\mathcal{N} = 1$ supermultiplets and in both phases at weak coupling the Witten index is $W = 1$. In the vicinity of the QPT, the rearrangement of the states breaks supersymmetry: the ground state is unique but not a SUSY-singlet and the excited spin-0 states are not paired with superpartners.

In the extreme strong coupling regime (i.e. $g = \infty$), the classical potential has flat directions and the spectrum of the quantum Hamiltonian is expected to be continuous. In our numerical work with finite bosonic cut-off N_{max} in the varitational ansatz, we find that the energy eigenvalues at $g = \infty$ has power-law dependence on N_{max}. This is a signature of the emerging continuous spectrum.

For $1 \ll g < \infty$, the numerical error due to the finite cut-off shows a power-law behavior on N_{max} and in this case, the spectrum remains discrete. However, here the degeneracy between the superpartners is lifted. This corresponds to a crossover from the supersymmetric weak coupling phase to a SUSY-broken strong coupling phase (with possibility of SUSY being restored only at $g = \infty$).

Field of contribution:

Theory

381

The matrix model of two-color one-flavor QCD: The ultra-strong coupling regime

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A matrix model of Yang-Mills theory coupled to fundamental fermions, which captures key topological features of the full quantum field theory, has been proposed as a numerical approach to study the strong coupling regime of QCD, where nonperturbative effects dominate. Due to its quantum mechanical framework, this model is computationally less intensive than commonly used methods like Lattice QCD, while still preserving fundamental aspects of QCD, such as the chiral anomaly. Notably, the model has succeeded in accurately describing the mass spectrum of glueballs in the low-energy regime of pure Yang-Mills theory and predicting the light hadron spectrum with surprising precision.

The matrix model for the two-color QCD coupled to a single quark (matrix-$QCD_{2,1}$) exhibits novel features, such as the Pauli-Gursey symmetry. Using variational methods, we numerically investigate matrix-$QCD_{2,1}$ in the limit of ultra-strong Yang-Mills coupling ($g = \infty$). The spectrum of the model has superselection sectors labelled by baryon number B and spin J. We study sectors with $B = 0, 1, 2$ and $J = 0, 1$, which may be organised as mesons, (anti-)diquarks and (anti-)tetraquarks. For each of these sectors, we study the properties of the respective ground states in both chiral and heavy quark limits, and uncover a rich quantum phase transition (QPT) structure. We also investigate the division of the total spin between the glue and the quark and show that glue contribution is significant for several of these sectors. For the $(B, J) = (0, 0)$ sector, we find that the dominant glue contribution to the ground state comes from reducible connections. Finally, in the presence of non-trivial baryon chemical potential μ, we construct the phase diagram of the model. For sufficiently large μ, we find that the ground state of the theory may have non-zero spin, indicating a phase reminiscent of the LOFF phase in two-color QCD.

Field of contribution:

Theory

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Probing Neutrino Mass Ordering with Supernova Neutrinos in NOνA with Active-Active vs. Active-Sterile Scenarios

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In this work, we have explored the possibility of determining neutrino mass ordering from the supernova neutrinos at currently running long-baseline neutrino experiment NOνA in active-active and active-sterile neutrino framework. Mixing between the three active neutrinos are referred to as the active-active scenario, while mixing between an active neutrino and a sterile neutrino is known as the active-sterile framework. We have studied with four main channels of NOνA to assess how the mass-ordering sensitivity changes with supernova distance. Notably, this is the first study to examine sensitivity in the neutral current (NC) channel, revealing differences between active-active and active-sterile scenarios. Our findings show a clear difference in sensitivity values depending on the presence of sterile neutrinos. Additionally, we account for the effects of systematic errors and smearing matrices on sensitivity.

Field of contribution:

Phenomenology

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NSI effects on tripartite entanglement measures

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Quantum correlation measures are extensively studied in neutrino systems as some measures show nonclassical features in neutrino oscillation. Entanglement is also a splendid measure to study in neutrino system. Recently it was shown that entanglement of formation (EoF) and concurrence are better entanglement measures than negativity. We analyze the effects of non-standard interaction (NSI) on some entanglement measures in the context of various experimental setups for three flavor neutrino oscillation scenario. We find that the impact of NSI can be maximum in the long baseline experiment DUNE. Further, we show that negativity is a weaker measure still it is more sensitive for NSI than concurrence for higher energy range.

Field of contribution:

Phenomenology

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Matrix model of 2-color 2-flavor adjoint QCD: QPT and fate of chiral symmetry

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A $SU(2)$ gauge theory coupled to the fermions transforming in the adjoint representation has many intriguing features. With Weyl fermions of two flavors, the system has $SU(2)_B \times U(1)_A$ global symmetry 1. In this model of 2-color 2-flavor adjoint-QCD, there is a long-standing debate whether the low-energy dynamics is confining with spontaneously broken $SU(2)_B$ (this $SU(2)_B$-symmetry is referred to as chiral symmetry and its breaking as chiral symmetry breaking). The multiple lattice QCD simulations and theoretical studies suggest that $SU(2)_B$-symmetry remains unbroken in the strong coupling regime.

Here, we consider a matrix model of 2-color 2-flavor adjoint-QCD. Being a quantum mechanical model, this provides a simplified framework to numerically probe the status of the $SU(2)_B$-symmetry in the strong coupling limit (g is the dimensionless Yang-Mills coupling constant and large g implies strong coupling). We construct the low-lying energy eigenstates belonging to different representations of $SU(2)_B$ using a variational calculation. We find that the ground state in the extremely strong coupling limit is a) $SU(2)_B$-singlet and b) two-fold degenerate (as a result $U(1)_A$ is broken to $\mathbb{Z}_4$ and is consistent with findings in 1). The lightest $SU(2)_B$-triplet is the 1st excited state of the system in the extremely strong coupling regime. As a consequence, the ground state in the strong coupling limit do not break the $SU(2)_B$ symmetry 2.

If we include a chiral chemical potential term $c\bar{\psi}\gamma^5\gamma^0\psi$ to the Hamiltonian, the system undergoes one or two quantum phase transitions (QPTs) if we tune c. For strong coupling g $gtrsim 3.5$, there is a single QPT and in this case, both phases has $SU(2)_B$-singlets as ground state. For weaker coupling, there are two QPTs separating three distinct phases and one of this phases has a $SU(2)_B$-triplet as ground state – the ground state in this case breaks $SU(2)_B$-symmetry spontaneously.

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Field of contribution:

Theory

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Radiation hardness study of MALTA2 sensor

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MALTA2, the second generation of the MALTA family Depleted Monolithic Active Pixel Sensor, is a small collection electrode prototype fully fabricated using Tower's 180nm CMOS Imaging Sensor process. Various improvements have been implemented in MALTA2 higher doping concentration of the n− blanket layer or the manufacturing on Czochlraskli substrates. Extensive radiation hardness studies have been conducted using proton beams at CERN SPS to check their suitability for future high-energy physics experiments. In this talk, the results of the radiation hardness study of the MALTA2 sensor from the 2023 CERN SPS test beam campaign will be presented. Sensors manufactured with a high-doping of the n− layer irradiated to 1×10^{15} $1-$MeV neq/cm^2, a maximum efficiency of 99% and an average cluster size of 2 was achieved. At the higher fluence level of 3×10^{15} $1-$MeV neq/cm^2, the sensor achieved a maximum efficiency of 90% and an average cluster size of 1.3. Sensors fabricated on Czochralski substrates with a very high doping of the n– layer and backside metalization, irradiated to 3×10^{15} $1-$MeV neq/cm^2, exhibit a maximum efficiency of 99%.

Field of contribution:

Experiment

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Radiative decays of B_c to vector mesons in the final state

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We present a comprehensive analysis of tensor (current) form factors for B_c to vector (V) meson transitions within the framework of the self-consistent covariant light-front quark model (CLFQM). Utilizing CLFQM, we calculate tensor form factors and predict radiative weak decays of B_c mesons involving vector mesons. We also investigate the interplay of short-distance and long-distance effects in these decays within a relativistic approach.

Field of contribution:

Phenomenology

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Radiative transition of hc(1P)) → ηc(1S) + γ in light-front quark model

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In this work we have investigated the $h_c(1\mathcal{P})) \rightarrow \eta_c(1\mathcal{S}) + \gamma$ decay in Light Front Quark Model (LFQM) .The transition from factor(TFF) and decay width for this decay has been calculated and compaired with experimental result along with other model predictions. This kind of decay gives a visual representation of radially excited states of charmonia(c$\bar{c}$).

Field of contribution:

Phenomenology

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Measurement of differential cross section of $t\bar{t}$ production in boosted phase space with the dileptonic final state at 13 TeV with CMS experiment

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The top quark pair production ($t\bar{t}$) is an extremely vital process as that constitutes a major background for many new physics searches. Although it is a well-understood process, CMS and ATLAS experiments have reported a difference in the top quark momentum spectrum compared to theoretical predictions, particularly at large transverse momentum. We are measuring $t\bar{t}$ production cross section in final states with two light leptons targeting the phase space with highly energetic top quarks, leading to the merging of their decay products into large-radius jets, using the data collected by the CMS experiment at a center-of-mass energy of 13 TeV during LHC Run 2. A machine learning based method is developed to reconstruct energetic top quarks decaying to leptonic final states. In this talk, I will present the details of the top tagging method and share preliminary results of the measurement.

Field of contribution:

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Scaling properties of charged particles generated in Xe–Xe collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.44 TeV using ALICE data

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Properties of multiplicity fluctuations in charged particles produced in Xe–Xe collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.44 TeV were studied using normalized factorial moments F_{q} in the framework of intermittency. A fundamental characteristic of the critical behaviour of a system undergoing phase transition is that it exhibits fluctuations of all scales. Study of fluctuations is thus one of the important techniques to explore phases of the QCD matter and to search for the critical end-point of the hadron–quark or quark–hadron phase boundary. Scaling properties of the multiplicity fluctuations of hadrons produced in the high-energy heavy-ion collisions are therefore significant to understand the system created in these collisions.
A study of the scaling behaviour of the normalized factorial moment $F_{\mathrm{q}}(M)$ with the number of bins (M) in (η, ϕ) phase space was performed. A power-law scaling was observed for the charged hadrons recorded in the midrapidity region of the ALICE detector that indicates the self-similar particle production and the fractal nature of multiplicity fluctuations. The scaling exponent (ν) obtained from the power-law scaling of F_{q} with F_2 specifies the scaling properties and characterizes the system under study.
Within the framework of Ginzburg-Landau (GL) formalism for second-order phase transition and for the two-dimensional Ising model simulated for quark–hadron phase transition, a universal value of scaling exponent (ν) was obtained as 1.316 ± 0.012 and 1.41 for Successive Contraction and Randomization (SCR) model simulated for high particle density fluctuations. Observations and results on the behaviour of the normalized factorial moments and the dependence of the scaling exponent on the transverse momentum bin width and its comparison with the Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 2.76 TeV will be presented.
The dependence of ν on the centrality for two different p_{T} intervals shows a weak centrality dependence. Dependence of fractal dimension (D_{q}) on the order parameter (q) hints at the multifractal system. Whereas, variation of the fractal parameter λ_{q} as a function of q hints formation of single phase system. Observations and results are limited by low statistics and motivate for further investigations to get an insight about the multiparticle production in the heavy-ion collisions.

Field of contribution:

Experiment

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A Study of Chemical Freeze-Out in Ultra-Relativistic Nucleus-Nucleus Collisions Using the van der Waals Type Model Approach

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In this study, we examine the chemical freeze-out curve in ultra-relativistic nucleus-nucleus collisions by extracting freeze-out parameters from particle ratios within the van der Waals hadron resonance gas (VDWHRG) framework. We analyze data from high-energy collision experiments, including the Super-Proton-Synchrotron (SPS), Relativistic Heavy Ion Collider (RHIC), and the Large Hadron Collider (LHC). Employing a best-fit approach, we systematically derive these parameters using established relationships between temperature and chemical potential across varying collision energies. Our analysis contrasts the derived freeze-out line with recent parameters from statistical thermal models of particle ratios. This work advances the understanding of hadron production dynamics and the thermodynamic freeze-out conditions in heavy-ion collisions.

Field of contribution:

Phenomenology

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Does thermal leptogenesis rely on initial memory?

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It is a common lore that in the thermal leptogenesis in the type-1 seesaw scenario with the conventional hierarchy of the heavy right-handed neutrinos (RHNs), that the CP violating, out of equilibrium decay of the lightest RHN (N_1) is the only relevant source of $B-L$ asymmetry. Any asymmetry produced by the heavier RHNs get washed out by the lepton number violating processes mediated by N_1. In this paper, we examine this assumption comprehensively, considering decay and inverse decay processes as well as the inclusion of scatterings. We find that in order to satisfy the neutrino masses and mixing given by the low energy neutrino oscillation data, not more than one heavy RHN can be in a weak washout regime ($\Gamma_D(z=\infty)/H(z=1) \ll 1$, where Γ_D is the decay rate of heavy RHNs, H is the Hubble parameter and $z = M_1/T$ with M_1 being the mass of N_1 and T being the temperature of the thermal bath). This implies that if N_2 or N_3 is in weak washout regime, then N_1 will have to be in strong washout ($\Gamma_D(z=\infty)/H(z=1) \gg 1$), and thereby washing out any pre-existing asymmetry. So in this case the thermal leptogenesis doesn't rely on any initial memory. On the other hand, if N_2 and N_3 are in strong washout regime, then there is a possibility that N_1 can be in weak washout. As a result, the final $B-L$ asymmetry will have a strong dependency on the initial memory. A detailed analysis will be presented by taking different benchmark points.

Field of contribution:

Phenomenology

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Particle identification with the ePIC dRICH detector: analysis of separation powers

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The Electron Ion Collider (EIC) is an approved project in the USA, to be built at Brookhaven National Laboratory (BNL) with a joint effort from Jefferson Lab (JLab). In the EIC, the contribution of the quarks and gluons to the macroscopic properties of nucleon and nuclei will be studied in an unexplored kinematic phase space. The key physics questions, viz. emergence of the hadronic mass, the full 3D tomography of the partons inside the nucleon, the region dominated by gluons and its saturation will be studied with unprecedented accuracy. EIC will, therefore, be the ultimate facility to study precision QCD physics. The physics programme of EIC calls for strict requirements in the collider and detector construction.

Highly polarised (˜70%) electrons, protons and light nuclei and unpolarized heavy nuclei will be collided at a wide centre of mass energy (20-141 GeV). To achieve high statistical accuracy within one year of physics data taking, a high luminosity of 1034 cm2s-1 will be required. On the detector side, an almost hermetic detector is needed to provide nearly 4π coverage with efficient tracking, calorimetry and particle identification capabilities.

The ePIC detector at EIC, is capable of supporting the entire EIC physics programme. Particle identification is central to many EIC physics channels. In the forward or hadron going direction, where high momentum final state hadrons are to be identified a dual radiator RICH (dRICH) is considered to perform π/K/P identification from a few hundreds of MeV and up to 50 GeV without any gap in the momentum range. The detector covers a wide pseudorapidity range. Apart from hadron identification the dRICH provides excellent pion rejection to boost the calorimeter and tracking systems to identify scattered electrons from the Deep Inelastic Scattering like event reconstruction up to 15 GeV. The dRICH is based on focusing technology, where spherical mirror segments focus the Cherenkov photons generated in the aerogel and gas radiator to an array of SiPM sensors.

In this work, we highlight the performance of the ePIC dRICH detector by estimating the separation power from the reconstructed Cherenkov angle and resolution of Cherenkov photon ring resolution. The numbers are extracted from a simulation study using the full ePIC simulation framework. We also present the results of our analysis with two different types of aerogel with n=1.019 and n.1.026 and compare them based on their performance in the context of the PID capability of the dRICH.

Field of contribution:

Experiment

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Hadronic vaccum polarization discrepancy between lattice QCD and data-driven approaches and one possible new physics scenario resolution.

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We present the latest lattice results for the hadronic vacuum polarization from lattice QCD. In order to isolate the different origin of systematic errors in lattice computations, the observable is decomposed into several windows. The latest discrepancy between the data-driven theory prediction of the intermediate and long distance window of the hadronic vacuum polarization using the experimental input of e+e- to hadrons cross-section and the lattice predictions have sparked several new physics scenarios. We elaborate on the Mainz results for the intermediate and long distance windows and discuss one such new physics scenario, a new baryon number gauge boson (Z') which can explain the discrepancy. We briefly illustrate the new model parameter landscape and various bounds from other relevant experiments.

Field of contribution:

Theory

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Octant sensitivity in presence of a ev/sub-eV scale sterile neutrino in long baseline experiments

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The octant of θ_{23} is one of the unknown parameters of the standard three flavor neutrino oscillation framework. In this work, we explore the octant sensitivity in the presence of a light sterile neutrino corresponding to mass-squared difference $[10^{-4} : 10^{-2}]\text{eV}^2$ along with the degenerate solutions in the test $\theta_{23} - \delta_{CP}$ planes. Our analysis has been performed in three upcoming accelerator neutrino experiments Deep Underground Neutrino Experiment (DUNE), Portvino to ORCA (P2O), and Tokai to Hyper-Kamiokande (T2HK). We also analyze the synergy between these experiments in the combined analysis.

Field of contribution:

Phenomenology

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Probing Lorentz Invariance Violation via Neutrino Oscillations at DUNE

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Lorentz Invariance Violation (LIV) represents a potential violation in Lorentz symmetry, a fundamental symmetry underlying all physical laws. LIV may exist inherently, even in vacuum. Analyzing the effects of LIV on neutrino oscillation probabilities provides a promising avenue for evaluating potential violations of Lorentz invariance. Since the contribution of LIV is expected to be sub-dominant, it can be incorporated as a small perturbation to the standard matter Hamiltonian. The effective Hamiltonian for Lorentz Invariance Violation (LIV) can be studied using the Standard Model Extension (SME) framework. In our study, we implement this effective LIV Hamiltonian to numerically calculate the altered neutrino oscillation probabilities. We independently examine the effects of the LIV CPT-odd ($a_{\alpha\beta}$) and CPT-even ($c_{\alpha\beta}$) terms on neutrino oscillations, with the Deep Underground Neutrino Experiment (DUNE) serving as a case study for long-baseline experiments. Our analysis explores potential correlations among different LIV parameters and other oscillation parameters. The energy dependence of the CPT-even term in LIV looks particularly interesting, and we investigate how its influence contrasts with that of the CPT-odd term. We further explore the impact of LIV parameters on the sensitivities of CP measurements.

Field of contribution:

Phenomenology

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Long Range Forces and Neutrino Oscillations in Future Experiments

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Neutrinos, elusive subatomic particles, hold significant potential for advancing our understanding of physics. They exhibit minimal interaction with matter and have the ability to transition between various "flavors" as they propagate, a process referred to as neutrino oscillation. The Mikheev-Smirnov-Wolfenstein (MSW) mechanism describes how neutrino flavor evolution is influenced by their interactions with matter, particularly the electron number density. Modifying the matter potential through interactions like flavor-dependent Long Range Force (LRF) alters neutrino oscillations. LRF can be incorporated into the Standard Model by extending it with an additional $U(1)$ symmetry like $L_e - L_\mu$, $L_\mu - L_\tau$ or $L_\mu - L_\tau$, leading to the introduction of a new neutral vector boson, Z', that mediates novel interactions. In our work we assume Z' mediator mass as $lesssim 10^{-16}$eV, which could mediate the force between matter in the Sun and neutrinos on the Earth. This study examines the potential contributions of upcoming long-baseline neutrino experiments, such as P2SO and T2HKK, in constraining the parameters of the LRF. Our specific aims are to assess how LRF affects the determination of standard oscillation parameters and to determine the capacity to set limits on the LRF parameters. In addition, we derive the constraints on the mass of the new gauge boson as well as the value of the new coupling constant that governs LRF, based on the matter density of the Sun. Based on our analysis, the P2SO experiment establishes strict constraints on the LRF parameters, specifically mass of Z' and new gauge coupling. Moreover, our results demonstrate that LRF plays a critical role in determination of standard neutrino oscillation parameters including θ_{23}, δ_{CP}, and δm^2_{31}. It is noteworthy that the precision of Δm^2_{31} remains strong and is not impacted by the presence of LRF in the P2SO and T2HKK experiments.

Field of contribution:

Phenomenology

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Study of Event Shape Observables in $Z \to \ell^+\ell^-$ Events in pp Collisions Using Pythia 8

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Event shape observables are essential tools for probing Quantum Chromodynamics (QCD) and deepening our understanding of its dynamics. In this contribution, we present a study of charged-particle event-shape observables, specifically transverse thrust and transverse sphericity, measured in inclusive Z boson events where the Z decays into electrons or muons. Given that the Z boson is an object without colour charge, it does not affect with hadronic activity in the collision, making it an ideal benchmark. Event-shape observables are calculated using charged particles, excluding the decay products of the Z boson, to isolate the underlying event (UE) contributions. In proton-proton collisions, UE activity particularly multi-parton interactions (MPI) significantly influences the structure and topology of the events. We simulate events using the Pythia 8 Monte Carlo event generator, with MPI effects toggled on and off, to provide a direct comparison of MPI's impact on event-shape distributions. This study offers valuable insights for refining event modelling, improving the accuracy of QCD simulations, and enhancing theoretical precision in particle measurements at the LHC.

Field of contribution:

Phenomenology

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A comparative study of identified particle production in ^{16}O$-^{16}$O collisions at $\sqrt{s_{NN}}$ = 7 TeV using HYDJET++ and Angantyr models

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In recent years, a lot of interest has been generated in the exploration of small collision system dynamics due to the observation of anisotropic flow coefficients (v_n) and enhanced production of (multi-) strange hadrons in high multiplicity p−p collisions at ALICE experiment. These observations imitate the characteristics of the deconfined quark-gluon plasma (QGP) matter formed in heavy-ion collisions. In an effort to understand the transition of these effects from large to small colliding systems, LHC RUN 3 has a plan for ^{16}O$-^{16}$O collisions at $\sqrt{s_{NN}}$ = 7 TeV which have a final state multiplicity range overlapping with both p−Pb and Pb−Pb collisions. \par
In this work, the dynamics of identified particle production in ^{16}O$-^{16}$O collisions at $\sqrt{s_{NN}}$ = 7 TeV using Monte Carlo event generators will be presented. Further, a comparison between the results obtained by HYDJET++ and Angantyr models will be discussed.

Field of contribution:

Phenomenology

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Toward the radio-upgradation of the GRAPES-3 Experiment.

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The GRAPES-3 (Gamma Ray Astronomy at PeV EnergieS phase-3) is a globally recognised experiment that detects cosmic rays over 10 TeV to 10 PeV. It has an unprecedented core-reconstruction resolution of approximately 0.5 meter at 1 PeV. We are planning for a radio-extension to the GRAPES-3 experiment which would demonstrate the state-of-the-art of radio-detection (RD) of cosmic rays in India. We are designing an array of 60-70 antennas which has been envisaged to function along with the array of particle detectors (PDs), to detect cosmic rays over the PeV energy range. With the beamforming (BF) approach, the RD-threshold may be brought down to few tens of PeV. Therefore, the successful implementation would demonstrate the state-of-the-art of near-field beamforming approach in the radio-detection of cosmic rays. We have used a sophisticated BF-framework and developed tools to optimize the design of our radio-array. A hierarchical array-geometry has elucidated discernibly interesting results compared to a variety of other array-geometries investigated so far. In simulations, we have been able to demonstrate the BF-detection of 10 PeV air-shower events, at 4σ detection threshold. The advent of the radio-detection facility at the GRAPES-3, would likely to enhance its overall detection threshold and facilitate observation of higher energetic particles.

Field of contribution:

Experiment

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Recent Highlights from the GRAPES-3 Experiment on Galactic Cosmic Ray Measurements

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The GRAPES-3 experiment located at an altitude of 2200 m in Ooty, India, employs a dense array of plastic scintillator detectors complemented with a large-area tracking muon detector. It is designed to observe shower particles which mostly include gamma rays, electrons and muons produced by interactions of primary cosmic rays and gamma rays in Earth's atmosphere in TeV-PeV energies. Recently, GRAPES-3 successfully measured the cosmic ray proton spectrum in the energy range of 50 TeV to 1.3 PeV, overlapping with space-based detectors and bridging the gap between space and ground-based observations. The experiment discovered a spectral hardening beyond 166 TeV, challenging the single power-law model that applies below the knee energy (at ˜ 3 PeV). Furthermore, GRAPES-3 identified two significant small-scale anisotropic structures in cosmic ray arrival distributions at a median energy of 16 TeV, confirming the observations from the HAWC and ARGO-YBJ experiments. This presentation will highlight these results and discuss the progress on the upgrade of the experiment (For the GRAPES-3 Collaboration).

Field of contribution:

Experiment

401

Investigation of a sliced-hadron absorber layout for the Moun Chamber(MuCh) system of CBM experiment

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The CBM experiment will investigate strongly interacting matter at high baryon density and moderate temperature. One of proposed key observable is the measurement of low mass vector mesons(LMVMs), which can be detected via their di-lepton decay channel.
The experimental challenge for muon measurements in heavy-ion collisions at FAIR energies is to identify low-momentum muons in an environment of high particle densities. The CBM strategy is to track the particles through a hadron absorber system, and to perform a momentum-dependent muon identification. This concept is realized by an instrumented hadron absorber, consisting of staggered absorber plates and tracking stations. The hadron absorbers vary in material and thickness, and the tracking stations consist of detector triplets based on different technologies.
At SIS100 energies, low-mass vector mesons can be identified with a MuCh system consisting of 4 absorber layers and 4 tracking stations. Simulation have been performed in order to optimize the absorber system under realistic beam conditions. As a result, the actual design of the full version of MuCh system consists of 4 hadron absorber layers (60 cm carbon and iron plates of 2 x 20 cm and 30 cm) and 4 gaseous tracking chamber triplets behind each absorber slice.

Owing to technical constraints in building a monolithic absorber layer, options on having sliced absorber layers are being considered. This results into gaps within the absorber layers which may affect the particle hit density on any detector plane. Investigations have been carried out through simulations to study the effect of this approach of fabricating the Fe-absorber layers.
Detailed simulations have been performed to optimize the detector system with respect to efficiency, signal-to-background ratio, and phase-space coverage. The event generator UrQMD and the transport code GEANT3 have been used within the CBMroot framework to simulate for central Au+Au collisions at 8 AGeV. The results for different case scenario have been compared in this study.

Field of contribution:

402

Investigating the effects of exotic α-clustered nuclear density profiles on medium anisotropy in p–O and p–C collisions at the LHC

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One of the major motivations for the planned p–O and O–O collisions at the LHC is to explore the possibilities of small system collectivity. Such transverse collective expansion results in the appearance of long-range azimuthal correlation and is quantified via the coefficients, $v_{\rm n}$, of Fourier expansion of the azimuthal momentum distribution of the final-state particles. These flow coefficients serve as the medium response to the initial spatial anisotropy and are sensitive to the density profile of the colliding nuclei. Light nuclei such as ^{12}C and ^{16}O are theorized to possess extra stability due to the presence of an α-clustered arrangement of its nucleons. In this context, studies on ultra-relativistic p–A collisions involving ^{12}C or ^{16}O nuclei can serve a dual purpose: exploring small system collectivity along with investigating the effects of a clustered nuclear geometry on the medium anisotropy. With this motivation, for the first time, we study p–O and p–C collisions at $\sqrt{s_{\rm NN}}$ = 9.9 TeV through a multi phase transport model (AMPT) simulations. We attempt to explore how an initial α-clustered nuclear structure of ^{16}O and ^{12}C influences the production yield, initial eccentricities and flow coefficients in the final state, in comparison to an unclustered density profile, Sum-Of-Gaussians (SOG). The flow coefficients are estimated via a two-particle Q-cumulant method.

The results show that $\langle\epsilon_2\rangle$ varies with centrality in a unique manner for α-clustered p–O and p–C collisions, similar to O–O collisions. However, the centrality dependence of $\langle\epsilon_2\rangle$ and $\langle\epsilon_3\rangle$ is not effectively carried forward to the final state v_2 and v_3, owing to lesser participants. We also see that the dependence of v_2 on centrality is much less in comparison to v_3, which is reflected in the v_3/v_2, $v_2/\langle\epsilon_2\rangle$ and $v_3/\langle\epsilon_3\rangle$ ratios studied in our work. We notice that the α-clustered case shows almost a flatter trend of v_3 with centrality than the corresponding collisions with a SOG profile, possibly indicating the discretized internal structure of an α-clustered nucleus. Thus, by probing the effects of the nuclear structure employing ultra-relativistic collisions, this work serves as a transport-model-based prediction for the upcoming p–O collisions in the LHC Run 3.

Field of contribution:

Phenomenology

403

f-mode universal relation of dark matter admixed quarkyonic stars.

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The study of neutron stars (NSs) with dark matter (DM) admixture has gained interest due to its potential to reveal insights into exotic matter and fundamental interactions. Understanding how DM influences NS properties, particularly oscillatory behaviors like f-mode oscillations, is crucial, as these modes could provide observational signatures of DM's presence in such extreme environments. Quarkyonic matter, a phase that includes both quarks and nucleons in a crossover transition, satisfies key NS constraints, including maximum mass and radius, making it an suitable candidate for NS interiors. DM trapped within the NS's gravitational field, offers an opportunity to probe deeper into the internal structure of these compact objects and refine our understanding of the NS equation of state (EOS). In this work, we examine f-mode oscillations in NSs with DM-admixed quarkyonic star, investigating the influence of DM on oscillatory behavior and universal relations. We derive an EOS for DM-admixed quarkyonic stars, assuming nucleon-quark equilibrium within the relativistic mean-field (RMF) formalism. Key parameters, such as transition density (n_t), QCD confinement scale ($\Lambda_{\rm cs}$), and DM Fermi momentum ($k_f^{\rm DM}$), are varied to assess their impact on NS properties. Universal relations in the systematic study of f-mode oscillations (for $l = 2$) of dark matter admixed quarkyonic stars by using the Cowling approximation in linearized general relativity are found to persist.

Field of contribution:

Phenomenology

404

Dark Matter Effects on Neutron Star Curvature in the Quarkyonic Model Using a Relativistic Mean Field Approach

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This study investigates the formulation of quarkyonic matter in neutron stars (NS), where both quarks and nucleons are treated as quasi-particles, facilitating a cross-over transition between these phases. Building on early quark matter (QM) theories, this approach aligns with observational constraints on NS properties, such as maximum mass and canonical radius. To enhance the model, we incorporate dark matter (DM), which is gravitationally trapped within the NS. Quarkyonic matter stiffens the equation of state (EOS), while DM softens it, producing results that match observational data on NS macroscopic properties. DM's effects on NS curvatures are analyzed, with results indicating significant influence on radial curvature profiles, particularly surface curvature in massive stars, while the impact on maximum mass compactness is comparatively minor. In this work, we explore the impact of fermionic DM on NS structure by deriving the EOS under nucleon-quark equilibrium with the relativistic mean-field (RMF) formalism. Using the G3 and IOPB-I parameterizations, we calculate NS properties by varying three parameters: the transition density (n_t), QCD confinement scale ($\Lambda_{\rm cs}$), and DM Fermi momentum ($k_f^{\rm DM}$) . Curvature quantities, including the Ricci scalar, Kretschmann scalar, and Weyl tensor, are evaluated to understand spatial variations in curvature across baryonic, quarkyonic, and DM-admixed quarkyonic stars. Results indicate an inverse relationship between EOS stiffness and curvature, while quarkyonic matter increases EOS stiffness and reduces curvature.

Field of contribution:

Phenomenology

405

The liquid-gas phase transition in a rotating hadron resonance gas

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Understanding the phases of quantum chromodynamics (QCD) matter has become one of the important research areas for both theoretical and experimental high-energy physics community. In the

QCD phase diagram, which is characterised by temperature (T) and baryochemical potential (μ_B), a first-order phase transition is expected at high μ_B and low T, which ends at a possible critical point. This is followed by a crossover transition from hadron to quark matter as predicted by lattice QCD calculations. In addition to the magnetic field, a huge amount of vorticity is expected to be produced in a non-central heavy ion collision. This vorticity or rotation (ω) can affect the evolution of the system and, hence, the phase diagram of the QCD matter. In this work, we study the effect of rotation on the phase diagram of hadronic matter. We find that rotation plays a similar role to baryochemical potential on the thermodynamic properties of hadron gas. The rotation adds a new kind of chemical potential called rotational chemical potential. Therefore, the phase transition can occur not only in the $T-\mu_B$ plane but also in the $T-\omega$ plane. We use an interacting hadron resonance gas model with van der Waals kind of attractive and repulsive interaction among the hadrons. We observe a liquid-gas phase transition under the effect of rotation, even at zero baryochemical potential. These results allow us to reinvestigate at the QCD matter properties under the effect of rotation and study the phase diagram in the $T-\mu_B-\omega$ plane.

Field of contribution:

Phenomenology

406

Searching for neutrinos and photons from sub-GeV dark matter interacting with quarks

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In this work, we look at a model of sub-GeV dark matter interacting with quarks via a vector current coupling. In the present day, these low-energy interactions are implemented using the chiral Lagrangian framework and result in effective couplings to light mesons. We have calculated the rates of dark matter annihilation into these mesons, and obtained the expected secondary photon and neutrino spectrum using publicly available tools. We have evaluated the limits from existing gamma ray telescopes as well as large volume neutrino experiments. We also forecast the sensitivity of future experiments in both channels, highlighting the discovery reach for such dark matter models in the multi-messenger era.

Field of contribution:

Theory

407

Neutral to charged particle yield fluctuations in proton-proton collisions at LHC energies

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The event-by-event fluctuations in particle yields in heavy-ion collisions are sensitive to the quark-gluon plasma (QGP) susceptibilities. The measurement of such fluctuations is of interest as they may show critical behavior in the proximity of phase boundary of hadron gas-QGP phase diagram. The ν_{dyn} correlator is generally used to study the magnitude of fluctuations of the relative yields of particles. The recent observation of heavy-ion like features in high multiplicity proton-proton (pp) collisions reported by ALICE experiment has motivated high energy physics community to better understand the underlying events in small collision systems.\par
Recently, ALICE has reported the first measurement of $\nu_{\mathrm{dyn}}[\mathrm{K^0_S}, \mathrm{K^{\pm}}]$ in Pb−Pb collisions at $\sqrt{\mathrm{s_{NN}}}$ = 2.76 TeV. The $\nu_{\mathrm{dyn}}[\mathrm{K^0_S}, \mathrm{K^{\pm}}]$ shows a significant deviation from $\nu_{\mathrm{dyn}}[\mathrm{K^+}, \mathrm{K^-}]$ scaling. In this contribution, the results for $\nu_{\mathrm{dyn}}[\mathrm{K^0_S}, \mathrm{K^{\pm}}]$ and $\nu_{\mathrm{dyn}}[\ , \mathrm{p(p)}]$ as a function of multiplicity for a selected kinematic region in pp collisions at LHC energies using PYTHIA event generator will be presented.

Field of contribution:

Phenomenology

408

A Unified Potential Model Framework for Charmonium and Bottomonium

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We present a unified non-relativistic framework to study the charmonium and bottomonium systems. We utilize the Cornell potential, along with spin-dependent interactions, and optimize the parameters to simultaneously describe the spectra of both systems. We analyze the impact of these "uniform fit"parameters and individual interactions on the mass spectra, including the non-linearity in Regge trajectories. Furthermore, we predict annihilation decay widths and investigate their scale dependence, considering the wave function at the origin. Our findings are compared with experimental data.

Field of contribution:

Phenomenology

409

Production of muons decaying from open heavy-flavour hadrons at forward rapidity with ALICE at the LHC

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The measurements of heavy-flavour (charm and beauty) production in proton-proton (pp) collisions at the LHC provides stringent test for perturbative Quantum Chromodynamics (pQCD) calculations. Furthermore, studies in pp collisions serve as a necessary baseline for the same measurement in proton-nucleus (p-A) and nucleus-nucleus (A-A) collisions in order to investigate the influence of cold- and hot-nuclear-matter effects on heavy-flavour production. In ALICE, measurements of open heavy-flavour can be performed at midrapidity and forward rapidity via semi-electronic and semi-muonic decays of heavy-flavour hadrons, respectively. The presence of Muon Forward Tracker in the upgraded ALICE detector for the LHC Run 3 provides vertexing capabilities to the Muon Spectrometer and enables to separate the open charm and beauty components. The impact of medium formed in heavy-ion collisions on heavy quark production and dynamics can be quantified via the nuclear modification factor (R_{AA}) of muons from heavy-flavour hadron decays. The results in the measurement of R_{AA} point toward a significant heavy-quark energy loss at intermediate p_{T}. In this contribution, the latest measurements from Run 2 and the status from Run 3 of open heavy-flavour decay muon production at forward rapidity with ALICE will be presented.

Field of contribution:

Experiment

410

Bc to A transition form factors and semileptonic decays in self-consistent covariant light-front approach

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We study the semileptonic weak decays of the Bc meson decaying to axial-vector (A) mesons in the final state for bottom-conserving decay modes. We use the self-consistent covariant light-front quark model (CLF QM) to eliminate the inconsistencies in the traditional type-I CLF QM. We establish the self-consistency for Bc ⟶ A meson transition form factors and ensure that these form factors are free from zero-mode contributions. Further, we show that the problems of inconsistency and violation of covariance of CLF QM are resolved in self-consistent CLF QM for Bc ⟶ A transitions. We employ a vector meson dominance-inspired q2 dependence to determine the form factors within the space-like region and then extrapolate these form factors into the time-like region. Additionally, we predict the branching ratios of the semileptonic weak decays of Bc meson to quantify the effects of self-consistency in these decays. Furthermore, we evaluate the lepton mass effect on these branching ratios and other experimentally important physical observables.

Field of contribution:

Phenomenology

411

Searches for high-scale SUSY dark matter through NLO corrections to the direct detection cross-section

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The minimal supersymmetric standard model (MSSM) with R-parity conservation identifies the lightest neutralino ($\tilde{\chi}_1^0$) as a viable dark matter (DM) candidate. We consider a Wino-dominated lightest neutralino serving as a DM candidate, which accommodates "new physics" at a relatively higher scale, typically beyond the reach of the LHC. We compute all the significant radiative corrections to the DM-nucleon cross-sections through the renormalization of neutralino-Higgs interactions at the next-to-leading (NLO) order. An extensive numerical scan over the parameter space shows that the NLO corrections to the spin-independent direct detection cross-section may reach above $\sim 100\%$ compared to the leading order (LO) value. Therefore, these corrections play an important role in testing neutralino DM in upcoming direct detection experiments.

Field of contribution:

Phenomenology

412

Performance of the ECAL upgrade prototype in beam tests at the CERN SPS

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The High-Luminosity phase of the Large Hadron Collider at CERN, will pose new challenges for the detectors. The Barrel Electromagnetic Calorimeter (ECAL) of the CMS experiment will be equipped with a completely new readout electronics to cope with increase in the number of proton-proton collisions per bunch crossing, as high as 200, and higher noise induced by large radiation doses.
Beams tests are required for the testing and validation of each of these design parameters for the planned upgrade. Thus, several on-beam integration tests were performed during the last few years at the CERN H4 test-beam facility using near-final components. It is a process carried out in steps to ensure precision. The timing resolution studies with the 2021 beam test data and the comparison with simulation with Geant4 are presented here.

Field of contribution:

413

Centrality dependence of forward-backward multiplicity correlations in Pb–Pb collisions at LHC energies using HYDJET++ Model

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Centrality dependence of forward-backward ({\footnotesize FB}) multiplicity correlations in Pb-Pb collisions at LHC energies, $\sqrt{s}_{NN} = 2.76$ and 5.02 TeV are studied with the HYDJET++ Model and the finding are compared with the those reported for the ALICE data. Sensitivity of correlation strength on the centrality bin width and method of centrality selection are also looked into. It is observed that the effect of impact parameter fluctuations should be dealt properly in order to make some meaningful conclusions. The findings reveal that the centrality selection using reference multiplicity or the V0M detector criteria of ALICE would be a better choice rather than that estimated using the impact parameter cuts.
Assuming that the distribution of events on the $n_B - n_F$ plane of different centrality bins within $0 - 60\%$ are two-dimensional (2D) Gaussian, the values of the half-widths σ_a and σ_b and hence eccentricity $e (= 1 - \frac{{\sigma_b}^2}{{\sigma_a}^2})$ is estimated; n_B and n_F being the multiplicities of charged hadrons in F and B regions. It is observed that the data points of e vs b_{corr} plots for centrality classes of different width at the two energies tend to form a smooth curve, which is nicely reproduced by the theoretical curve $b_{corr} = \frac{1}{\frac{2}{e^2}-1}$. This includes the presence of positive correlations between b and e. It is also observed that the wider centrality bin is equivalent to larger σ_a which would give higher e and b_{corr}.

The findings reveal too that the FB correlations due to hard jet components are stronger than the ones arising from the soft hydrodynamic components, particularly in central collisions. However, for a correct dependence of correlation strength on the collision centrality, contributions from both the components should be taken into account simultaneously.

Field of contribution:

Phenomenology

414

Azimuthal Anisotropy Studies in the CBM Energy Range Using the PHQMD Model

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The study of azimuthal anisotropy in heavy-ion collisions provides critical insights into the properties of the medium created in such interactions. We use the Parton-Hadron-Quantum-Molecular-Dynamics (PHQMD) model to study the azimuthal anisotropy of particle generation in the context of the FAIR CBM experiment. This approach enables us to analyze the collision dynamics across a broad range of energies relevant to the CBM framework. We present a detailed comparison of the azimuthal anisotropy coefficients as a function of transverse momentum and centrality, highlighting the dependence on energy and the multiplicity of produced particles. The PHQMD model' s capabilities for simulating the evolution of the system from the initial state to particle freeze-out allow us to explore the interplay between thermalization and transport properties. Our findings are compared to current experimental data and and theoretical predictions, providing deeper insights into the collective behavior of the medium. This approach not only improves our understanding of the QCD phase diagram, but also provides the framework for future CBM experiments.This work opens new avenues for studying the emergent phenomena in heavy-ion collisions, with implications for the understanding of the quark-gluon plasma and related phases of matter.

Field of contribution:

415

Magnetic Moment of the Σ_b^0 Baryon in Asymmetric Nuclear Matter

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The magnetic moment of the Σ_b^0 baryon provides critical insights into the underlying quark dynamics and interactions within heavy-flavor baryons. Previous studies have calculated the valence quark contributions using theoretical models. In this work, we employ the chiral SU(3) quark mean field model for the first time to calculate the magnetic moment of the Σ_b^0 baryon. We initially focus on the valence quark contributions from its udb quark content, achieving high precision and demonstrating the robustness of the chiral SU(3) framework for baryonic magnetic moment calculations. To further enhance accuracy, we propose extending our analysis to include the contributions from sea quarks and orbital angular momentum. This comprehensive approach aims to yield a more precise value for the Σ_b^0 magnetic moment, facilitating refined theoretical predictions that closely align with experimental observations.

Field of contribution:

Phenomenology

416

Magnetic Moment of Decuplet baryons in dense nuclear matter using chiral SU(3) quark mean field model.

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In this study, we have calculated the effective magnetic moments of decuplet baryons as a function of density for different values of the magnetic fields. The impact of the magnetic field has been realised through the chiral SU(3) mean field model which considers quarks as the fundamental degrees of freedom. We have studied the impact of varying the magnetic fields on the quark masses and hence the masses of the decuplet baryons and have used these masses as an input to calculate individual contributions coming from valence quarks, quark sea and orbital angular momentum of the quark sea towards the total magnetic moment of the decuplet baryons. These individual contributions have been calculated using chiral constituent quark model. Studying the magnetic moment of baryons provides crucial insights into their internal quark structure and interactions, helping to refine models of strong force dynamics.

Field of contribution:

Phenomenology

417

Study of MPGD based Micromegas Detectors using Ansys and Garfield++

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Micro pattern gaseous detectors (MPGDs) represents cutting edge technology in particle detection that is crucial for applications in medical imaging, security screening, and particle physics. These detectors improve the accuracy and efficiency of gas-based particle detection by using electrodes with fine scale patterns, usually on the range of tens to hundreds of micrometers. One kind of MPGD that provides a high level of sensitivity and spatial resolution is called MICRO MEsh GAseous Structure (MICROMEGAS). The detector is made up of two areas divided by a micromesh, a type of metal mesh. The micromegas detector's control parameters include the kind of gas, shape, and materials employed. The detector has a number of issues that need to be fixed, including ion backflow, gain stability, discharge, and lower transparency. Geometry of micromegas has been replicated with the help of simulation software Ansys Maxwell and Ansys Mechanical APDL. Analysis related to the electric field has been done using Ansys Maxwell. For the study related to ion-backflow and gain of the detector, Mechanical APDL and Garfield^{++} has been used. Variation of electric field is studied for the different geometrical parameters like hole diameter, pitch size and strip width. Same analysis has been done for the ion-backflow and the gain of the detector. These findings provides insights into optimizing the detector's geometry for improved performance.

Field of contribution:

Experiment

418

Magnetic Moments of Octet Baryons: A Quark-Level Approach in External Magnetic Fields

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In this study we have investigated the magnetic moments of octet baryons by examining the direct impact of external magnetic fields on their constituent quarks. Strong external magnetic fields can influence chiral symmetry breaking or its restoration, leading to changes in effective quark masses. We have calculated the effective masses of constituent quarks and the octet baryons in the nuclear and strange matter within the chiral SU(3) quark mean field model and have used these as the input in SU(4) constituent chiral quark model to compute the effective magnetic moments of octet baryons. Unlike approaches that treat the baryons as single entity, the current approach treats quarks as the degrees of freedom hence, we have calculated and incorporated the individual contributions coming from valence quarks, quark sea and orbital angular momentum of quark sea towards the total magnetic moment of baryons in the varying values of external magnetic fields. Similar calculations have been done using other theoretical model like method of QCD sum rules. Studying quark magnetic moments in external fields unveils the complex interplay of baryon structure, QCD dynamics, and matter's response under extreme conditions.

Field of contribution:

Phenomenology

419

Temperature effects and implication to the dark matter annihilation cross-section

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Dark Matter (DM), assumed to be thermally produced in the early Universe, stayed in thermal equilibrium until the temperature of Universe dropped due to its expansion, leading to freeze out. Since the temperature was high at this time, the thermal contributions to relic density can be of crucial importance. Working with bino-like models of DM pertaining to WIMP paradigm, and assuming the freeze out to occur after the electroweak phase transition, we estimate the finite temperature corrections to DM annihilation cross-section at NLO, employing the generalized polarization rearrangement technique of Grammer and Yennie at finite temperature. The generalized thermal Feynman's identities help us immensely to isolate the finite pieces; after a resummation of divergent terms. We initially begin with evaluating the thermal effects, in the regime in which the mediator is extremely heavy, followed by expanding the momentum into the next higher order; realizing that modes with high momenta are suppressed in a thermal theory. Followed by this, we proceed to estimate the thermal corrections in both non-relativistic (around freeze out) and relativistic limits. In both the cases, we find the leading thermal corrections to be quadratic, followed by sub-leading quartic corrections to the annihilation cross-section. Both the quadratic and quartic terms were found to be helicity suppressed when only the higher order virtual corrections are taken into account.

Field of contribution:

Theory

420

Boosting Electroweakino Searches at the LHC in Baryon Number Violating MSSM using Machine Learning

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Data from LHC Run-I and Run-II have placed strong constraints on the electroweakino masses in R-parity conserved supersymmetric scenarios. However, in R-parity violating (RPV) scenarios, these constraints can vary depending on the specific RPV decay modes of the lightest supersymmetric particles (LSP). In this work, we explore the potential implications of the baryon-number-violating $\lambda''_{ijk} U^c_i D^c_j D^c_k$ RPV coupling, that allows the LSP to decay into three quarks, on the chargino-neutralino pair production processes at the High Luminosity LHC ($\sqrt{s} = 14$ TeV, $\mathcal{L} = 3000$ fb^{-1}). We employ Machine Learning techniques to enhance the sensitivity of the search.

Field of contribution:

Phenomenology

421

Fully Heavy Tetraquarks and Pentaquarks in the Flux Tube Model

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Inspired by the recent discovery of the fully charm tetraquark state $X(6900)$, this study examines the properties of fully heavy tetraquark and pentaquark states. Using the flux tube model with finite quark masses, we analyze the Regge trajectories of these states, which are found to be highly non-linear. Additionally, the estimated masses of these multiquark hadrons are compared with existing theoretical studies, showing strong agreement and providing further insights into heavy multiquark systems.

Field of contribution:

Phenomenology

422

On the common origin of flavour hierarchies and strong CP

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We propose a class of models based on the parity invariant Left-Right Symmetric Model (LRSM) which incorporates the mechanism of radiative generation of fermion masses while simultaneously possessing the solution to the Strong CP problem. A flavour non-universal gauged abelian symmetry is imposed on top of LRSM, which helps in inducing the masses of second and first-generation fermions at one-loop and two-loop, respectively, and thereby reproduces the hierarchical spectrum of the masses. Parity invariance sets the strong CP parameter vanishing at the zeroth order and the non-zero contribution arises at the two-loop level which is in agreement with the experimental constraints. The minimal model predicts flavour symmetry breaking scale and the $SU(2)_R$ symmetry breaking scale at the same level. Flavor non-universality of the new gauge interaction leads to various flavour-changing transitions both at quarks and leptonic sectors and, therefore, has various phenomenologically interesting signatures. The model predicts a new physics scale near 10^8 GeV or above for phenomenological consistent solutions.

Field of contribution:

Phenomenology

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State Integral Partition function of knots and links

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We briefly review $SL(2,\mathbb{C})$-Chern-Simons partition function $Z[\mathcal{M}]$ on a closed three-manifold $\mathcal{M}$ obtained from Dehn fillings on a link complement $\mathbf{S}^3\backslash\mathcal{L}$. We focus on links $\mathcal{L}$ which are connected sum of a knot $\mathcal{K}$ with a Hopf link H ($\mathcal{L} = \mathcal{K}\#H$). Motivated by our earlier work on topological entanglement and the reduced density matrix σ expression for such link complements, we wanted to determine a choice of Dehn filling so that $\mathrm{Tr}\ \sigma = Z[\mathcal{M}]$.
Using \texttt{SnapPy}, we deduce a choice of the Dehn fillings which gives the
imaginary part of the leading order term in the perturbative expansion of $Z[\mathcal{M}]$ to be the hyperbolic volume of the knot $\mathcal{K}$. We have given explicit results for knots $\mathcal{K} = 4_1, 5_2, 6_1, 6_2$ and 6_3.

Field of contribution:

Theory

424

Outer Tracker Upgrade for the High Luminosity LHC: Beam Test Results and Recent Advances

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The CMS experiment is preparing for the High Luminosity phase of the Large Hadron Collider (HL-LHC), set to begin in the late 2020s. To cope with the significantly harsher operational conditions expected during this phase, including an unprecedented increase in instantaneous luminosity and particle fluence, the CMS collaboration has planned a comprehensive upgrade of its tracking system. The current silicon tracker will be replaced during the upcoming LHC shutdown prior to HL-LHC to maintain excellent tracking and vertexing performance.

The upgrade introduces a new tracker architecture, specifically designed to endure the extreme radiation environment and increased occupancy. The Outer Tracker (OT) will play a key role in the upgrade, featuring an innovative design with two types of pT modules: 2S and PS modules. The 2S modules consist of two closely spaced silicon strip sensors, while the PS modules combine pixel and strip sensors. These pT modules enable the first-level trigger to identify high transverse momentum (pT) tracks, optimizing data reduction and improving trigger efficiency.

This talk will focus on the development and performance of the 2S and PS modules, highlighting key results from recent beam tests at CERN that validated their functionality under realistic conditions, including radiation exposure and high particle densities.

Field of contribution:

Experiment

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Future Prospects of Coherent Elastic Neutrino-Nucleus Scattering for Physics Studies at the Upcoming European Spallation Source Facility

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The European Spallation Source (ESS), under development in Sweden, is set to provide a high-intensity pulsed neutrino beam, offering unprecedented opportunities for high-statistics studies of Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) using state-of-the-art detection technologies. The anticipated statistical reach and precision at ESS will enable us to probe both Standard Model (SM) parameters and potential beyond-the-Standard Model (BSM) physics with enhanced sensitivity compared to current experiments. In this talk, I will present the projected sensitivities for low-energy SM precision measurements at ESS, including determinations of the weak mixing angle and neutron root mean square charge radius, exploiting the collaboration's array of detector technologies and experimental setups |1|. Additionally, we explore the implications of these measurements for constraining BSM physics, such as Non-Standard Interactions (NSI) and broader frameworks like Neutrino Generalized Interactions (NGI), emphasizing prospects for light mediator detection. Further, we investigate potential signals of lepton unitarity violation and production of light sterile neutrinos, specifically examining: (a) short-baseline active-sterile neutrino oscillations, (b) sterile neutrino production via transition magnetic moments, and (c) production of sterile neutrinos via the upscattering of active neutrinos on nuclei, involving various Lorentz-invariant, non-derivative couplings (scalar, pseudoscalar, vector, axial-vector, and tensor).

Reference:
|1| *D. Baxter et al.*, **"Coherent Elastic Neutrino-Nucleus Scattering at the European Spallation Source,"** JHEP 02 (2020) 123, arXiv:1911.00762 [physics.ins-det].

Field of contribution:

Phenomenology

426

Monitoring the upper atmospheric temperature and the interplanetary magnetic field with the GRAPES-3 muon telescope

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Galactic cosmic rays (GCRs) are deflected by the Sun's magnetic field, resulting in significant energy-dependent temporal and spatial variations in their intensity. The muons observed at GRAPES-3 arise from extensive air showers of cosmic ray secondaries originating in the interactions of primary cosmic rays with the upper atmospheric particles. We observed strong correlations between the muon flux recorded by GRAPES-3, the upper atmospheric temperature, and the solar magnetic field at the Lagrange point L1. These correlations allowed us to measure the temperature coefficient (α_{T}) as -0.23 ± 0.02 $\%\mathrm{K}^{-1}$ and the magnetic field coefficient (γ_{M}) as -0.57 ± 0.03 $\%\mathrm{nT}^{-1}$. This indicates that atmospheric muon flux could serve as a promising tool for real-time monitoring of both the upper atmospheric temperature and the solar magnetic field. We will present the detailed analysis techniques and results from 22 years of operation (2001–2022) of the GRAPES-3 muon telescope.

Field of contribution:

Experiment

427

Scalar Leptoquarks and Neutrinoless Double Beta Decay

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We perform a comprehensive analysis of neutrinoless double beta decay and its interplay with low-energy flavor observables in a radiative neutrino mass model with scalar leptoquarks $S_1(\bar{3}, 1, 1/3)$ and $\widetilde{R}_2(3, 2, 1/6)$. We carve out the parameter region consistent with constraints from neutrino mass and mixing, collider searches, as well as measurements of several flavor observables, such as muon and electron anomalous magnetic moments, charged lepton flavor violation and rare (semi)leptonic kaon and B-meson decays, including the recent anomalies in $R_{D^{(*)}}$ and $B \to K\nu\bar{\nu}$ observables. We perform a global analysis to all existing constraints and show the (anti)correlations between all relevant Yukawa couplings satisfying these restrictions. We find that the most stringent constraint on the parameter space comes from $\mu \to e$ conversion in nuclei and $K^+ \to \pi^+\nu\bar{\nu}$ decay. We also point out a tension between the muon and electron $(g-2)$ anomalies in this context. Taking benchmark points from the combined allowed regions, we study the implications for neutrinoless double beta decay including both the canonical light neutrino and the leptoquark contributions. We find that for normal ordering of neutrino masses, the leptoquark contribution removes the cancellation region that occurs for the canonical case. The effective mass in presence of leptoquarks can lie in the desert region between the standard normal and inverted ordering cases, and this can be probed in future ton-scale experiments like LEGEND-1000 and nEXO.

Field of contribution:

Phenomenology

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Measurement of Time-Dependent CP asymmetries in the decay channel $B^0 \to K_S^0\eta\gamma$ at Belle and Belle II

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The measurement of time-dependent CP asymmetries in radiative penguin decays of B^0 mesons allows us to search for signs of New Physics through new particles in the loop, which can enhance the contribution of right-handed polarized photons. The decay channel $B^0 \to K_S^0 \eta\gamma$ is one such example, where a photon is emitted through loop-level processes involving virtual particles. This analysis targets a larger dataset, including the complete Belle data of 772 million events and nearly 700 million events from Belle II (expected 2025 dataset) collected at the $\Upsilon(4S)$ resonance, providing significant potential to improve upon previous results. To enhance the sensitivity of the analysis, we have integrated an upgraded Graph Neural Network-based flavor tagger and plan to use a more robust fit model along with certain other analysis improvements for background rejection to obtain more precise measurements of CP violation parameters. We present the latest status of time-dependent measurements of these parameters in $B^0 \to K_S^0 \eta\gamma$ decays from the Belle and Belle II experiments.

Field of contribution:

Experiment

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Sensitivity of LFV couplings at Muon Collider

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We estimate the accuracy with which the coefficient of the lepton flavor violating dimension six operators can be measured at the proposed $\mu^+\mu^-$ collider.
Cuts-based analysis is performed to compute the signal significance at the center of mass energies of 3 and 10 TeV respectively, with an integral luminosity of 10 ab^{-1}. Using the optimal observables method for the kinematic distributions, we study the sensitivity of the effective couplings at the 3-sigma level. We also study the impact of the initial muon beam polarization.

Field of contribution:

Phenomenology

430

Implication on neutrino masses and mixing at fixed point $\tau = i$ in modular symmetries

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We explore the implications of unbroken symmetries at the self-dual point $\tau = i$ within the framework of modular invariant theories. Assuming that lepton doublets transform under a finite modular group and that light neutrino masses stem from the Weinberg operator expressed in modular form, we identify a distinct residual flavor symmetry for neutrinos that depends on the modular weight. In cases with antisymmetry, one neutrino remains massless, while the other two can be degenerate

if the mass matrix is real. These findings do not depend on the level Γ_N. If charged leptons display a corresponding residual symmetry, they affect a column of the leptonic mixing matrix, leading to specific relationships between the mixing angles and the Dirac CP phase. The presence of these (anti)symmetries facilitates the use of conventional flavor symmetry techniques.

Field of contribution:

Phenomenology

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Corrected Thermodynamics of Regular Phantom Black hole

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Regular phantom black holes (RPBHs) hold theoretical and observational significance due to their incorporation of the phantom scalar field, an alternative to the cosmological constant, and some of their thermodynamical properties have also been studied. Several RPBH properties, such as the horizon radius, entropy, etc., rely on the scale parameter ⊠⊠. Because of the distinct structure compared to Schwarzschild-like metrics, a novel function of the scale parameter is necessary to articulate the relationships between thermodynamic variables. In this work, we have calculated the quantum corrections due to small statistical thermal fluctuations in various thermodynamic quantities of RPBH, such as entropy, Helmholtz free energy, internal energy, etc. The thermodynamic quantities of regular phantom black holes are perturbed because of minute statistical fluctuations around the equilibrium; in the present work, we have calculated the corrected thermodynamics of RPBH because of small statistical thermal fluctuations. We have plotted curves of several thermodynamical quantities, such as entropy, free energy, specific heat, etc., against the RPBH event horizon radius and then analysed the behaviour and variation of these curves of corrected thermodynamical quantities as a function of black hole event horizon radius.
Keywords: Regular phantom black holes; horizon radius; Statistical thermal fluctuations.

Field of contribution:

Theory

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Sensitivity of LFV couplings at Muon Collider

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We estimate the accuracy with which the coefficient of the lepton flavor violating dimension six operators can be measured at the proposed $\mu^+\mu^-$ collider.
Cuts-based analysis is performed to compute the signal significance at the center of mass energies of 3 and 10 TeV respectively, with an integral luminosity of 10 ab^{-1}. Using the optimal observables method for the kinematic distributions, we study the sensitivity of the effective couplings at the 3-sigma level. We also study the impact of the initial muon beam polarization.

Field of contribution:

Phenomenology

433

Spontaneous breaking of non-invertible symmetry in a frustration-free spin chain

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Recently, the topic of non-invertible symmetry has attracted a lot of interest. The symmetry elements in such a case cannot be implemented by transformations that form groups. In this work, we study a local, frustration-free spin chain, where the ground state is found to be doubly degenerate, resembling the ferromagnetic states in the XXX spin chain. The ground states are connected by a non-invertible symmetry, which is broken spontaneously. We study the symmetry breaking via algebraic quantum theory methods. The local terms in the Hamiltonian are constructed using projectors, making them non-invertible on their own. We further demonstrate the system is gapped using the Bravyi-Gosset condition. At the end, we show the integrability of the model and discuss the conserved charges.

Field of contribution:

Theory

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Assembly and Testing of Straw Tubes for Neutrino Detection

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Gaseous ionization detectors are essential instruments in particle physics for detecting ionizing particles and measuring radiation in protection applications. One notable type is the straw tube, which consists of gas-filled cylindrical tubes with a conductive inner layer serving as a cathode and an anode wire along the cylinder's axis. These detectors facilitate the reconstruction of neutrino interactions in targets, enabling accurate tracking of charged particles and particle identification. The Deep Underground Neutrino Experiment (DUNE) features a far detector located at the Sanford Underground Research Facility (SURF) in South Dakota and a Near Detector (ND) complex at Fermilab. Within the ND, the System for on Axis Neutrino Detection (SAND) employs tracking modules composed of straw tubes. Here at Panjab University , we assembled two straws which were tested using a prototype we designed. The gas leak tests, efficiencies and some physical properties of the assembled straw tube have also been studied.

Field of contribution:

435

”Enhanced Neutrinoless Double Beta Decay Signatures in a Left-Right Symmetric Model with Heavy Neutrino Contributions”

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We explore a left-right symmetric model utilizing a double seesaw mechanism to generate Majorana masses for both light and heavy neutrinos, which facilitates significant lepton number violation, including contributions to neutrinoless double beta decay. The Higgs sector in this model includes two Higgs doublets, H_L, and H_R, while the fermion sector consists of the usual quarks and leptons, along with an $SU(2)$ singlet fermion S_L. A bare Majorana mass term for this sterile neutrino induces a large Majorana mass for the heavy right-handed neutrinos, leading to substantial new contributions to neutrinoless double beta decay. Detailed analysis of these contributions reveals that the normal hierarchy for light neutrinos is more likely to be detectable, especially if evidence of $0\nu\beta\beta$ decay is observed and cosmological constraints on Σm_i are considered.

Field of contribution:

Phenomenology

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Optical inverse potentials for Proton-Proton scattering up to 1GeV

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Background: Phase shift analysis of nucleon-nucleon elastic scattering has been conducted up to 350 MeV by various research groups, employing realistic interaction potentials based on pion and meson exchange.
Purpose: Objective of this research is to develop inverse potentials for both real and imaginary scattering phase shifts by utilizing the optical potential for proton-proton interactions up to 1 GeV.
Methodology: A combination of various smoothly connected Morse components over different regions of interaction is selected as the reference potential. The reference potential comprises of two regular Morse functions to account for short- and medium-range interactions and an inverse Morse function to represent long-range interactions. Such a combination ensures that one need not include the long-range coulomb interaction separately. The potential parameters are optimized by solving the phase equation using the RK-5 method iteratively, in order to minimize the mean squared error between the calculated and experimental phase shifts using genetic algorithm.
Results: The final real and imaginary scattering phase shifts obtained using our methodology demonstrates excellent agreement with the expected ones up to 1GeV.

Field of contribution:

Phenomenology

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Investigating Hadron Production and the Onset of Color Glass Condensate in d-Au, p-Pb, Pb-Pb, and Xe-Xe Collisions at RHIC and LHC via an Analytical Solution to the BK Equation

Author: Pragyan Phukan[1]

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An exact analytical solution to the nonlinear Balitsky-Kovchegov equation is proposed, requiring very few parameters to describe the nonlinearity of gluon evolution. Using this solution, along with the concept of color glass condensate, we achieve a good description of RHIC and LHC data on differential yields for d-Au, p-p, and p-Pb collisions. Quantitative predictions for nuclear modification factors in p-Pb, Pb-Pb, and Xe-Xe collisions relevant to LHC Run 2 are provided

Field of contribution:

Phenomenology

439

”Spectroscopic analysis of doubly charm pentaquarks”

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Motivated by the discovery of the Ξ_{cc}^{+} doubly charmed baryon and the T_{cc}^{+} tetraquark states, we have conducted a comprehensive exploration of doubly charmed pentaquarks, encompassing all possible configurations. This investigation was carried out using effective quark mass and shielded charge schemes. The classification of doubly charmed pentaquarks was achieved using the Young Tableaux technique, employing Young Yamonauchi bases. Additionally, we computed the mass spectra and magnetic moments for doubly charmed pentaquarks with various spin-parity quantum numbers ($J^P = \frac{1}{2}^{\pm}, \frac{3}{2}^{\pm}$ and $\frac{5}{2}^{\pm}$). These findings are anticipated to offer valuable insights into the assignment of spin-parity quantum numbers and configurations, informing and guiding future experimental endeavors. The analyses presented here aim to deepen our understanding of the internal structure of pentaquark states and pave the way for the potential discovery of doubly charmed pentaquarks in forthcoming experiments.

Field of contribution:

Phenomenology

440

Light and Charge Calorimetry for Enhanced CP Violation and Mass Hierarchy Sensitivities in DUNE

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We explore the potential of light calorimetry in liquid argon time projection chambers (LArTPCs) and its intrinsic self-compensation properties, highlighting its merits alongside established charge calorimetry. We find that light calorimetry can achieve energy resolution on par with advanced charge-based methods, utilising GeV neutrinos as a benchmark. We also examine how the independent use of light calorimetry is complementary to charge calorimetry for precise measurement of standard unknowns, mainly CP violation and mass hierarchy sensitivities in the Deep Underground Neutrino Experiment (DUNE). Advanced charge imaging calorimetry shows marked improvement in CP resolution over light calorimetry, while light calorimetry itself shows significant insights on CP violation and mass hierarchy sensitivities. Moreover, the CP violation sensitivity with exposure reveals that 5σ sensitivity can be achieved earlier in charge calorimetry compared to light calorimetry.

Field of contribution:

Phenomenology

441

Investigation of Gamma Spectra unfolding with EJ-315 Liquid Organic Scintillator.

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In the present work, we measured the response of the EJ-315 liquid organic scintillator to gamma rays. The EJ-315 detector was calibrated using Compton edges obtained from standard gamma sources, the calibration accuracy verified through Monte Carlo simulations. To facilitate gamma spectra unfolding, a response matrix was calculated using GEANT4, and a procedure was developed to determine the unfolded spectra from the measured pulse height spectra using Gravel iterative algorithm. The pulse height resolution of the scintillator was also estimated to improve the precision of gamma flux measurements. This study provides a framework for accurate gamma detection and spectra unfolding for coverage of large area, supporting applications in radiation monitoring.

Field of contribution:

Experiment

442

Forms of BRST symmetry on a Prototypical First-Class System

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We obtain the various forms of BRST symmetry by using the Batalin-Fradkin-Vilkovisky formalism in a prototypical first class system. We have shown that the various forms of symmetry can be obtained through canonical transformation in the ghost sector. The BRST symmetries have also been discussed in configuration space. The so called "dual-BRST" symmetry which is claimed to be an independent symmetry due to its roots in differential geometry is obtained from usual BRST symmetry by making a canonical transformation in the ghost sector. On the other hand, a canonical transformation in the sector involving Lagrange multiplier and its corresponding momentum leads to a new form of BRST. Some other forms of BRST have also been discussed.

Field of contribution:

Theory

443

Kaons structure in dense nuclear medium

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In the present work, we investigated the impact of finite density of nuclear medium on the electromagnetic properties of kaons and antikaons. We employed the combined approach of chiral SU(3) quark mean field (CQMF) model and light cone quark model (LCQM). In the LCQM, the properties of kaons, for example, weak decay constant, distribution amplitude (DA) and parton distribution functions (PDFs) of valence quarks are expressed in terms of constituent quark masses. We evaluated the in-medium masses of constituent quarks in the dense nuclear matter using CQMF model and used those as input in LCQM to investigate the medium modified properties of $K(K^+, K^0)$ and $\bar{K}(K^-, \bar{K^0})$ mesons. The impact of finite isospin asymmetry and temperature is also explored.

Field of contribution:

Phenomenology

444

ISCOs and the weak gravity conjecture bound in higher derivative theories of gravity

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We study circular orbits of charged particles in spherically symmetric AdS black holes in general higher derivative theories of gravity in arbitrary dimensions, and their limiting ISCOs (innermost stable circular orbits). The dual interpretation is in terms of heavy-light double twist conformal field theory (CFT) operators in the large spin limit, whose anomalous dimensions can be extracted from the binding energy of charged probes in the bulk, in a certain large orbit limit. We relate our result of anomalous dimension with the Weak Gravity Conjecture (WGC) bound known for self-repulsive particles. The ISCOs exist until the limit set by the WGC bound.

Field of contribution:

Theory

445

Lepton flavor and number violating $K \to \pi\mu^+\mu^+(\nu\bar{\nu})$ decays

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The rare decays $K \to \pi\nu\bar{\nu}$ are crucial for exploring physics beyond the Standard Model. Our investigation focuses on these decays in the context of leptoquarks, exploring both lepton flavor conserving and violating channels. Furthermore, we explore the potential to detect lepton number violating operators in $K \to \pi\nu\bar{\nu}$ decays.

Field of contribution:

Phenomenology

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On pulsating strings in NS5 and I- brane background

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We investigate pulsating strings in the background of a single stack of NS5-branes as well as in an I-brane configuration, which consists of two orthogonal stacks of NS5-branes, employing the Polyakov formulation of the fundamental string action. For the I-brane setup, we utilize a symmetry that effectively decouples the dynamics of the two spheres from the flat space components. This allows us to analyze pulsating string solutions on each sphere independently and simultaneously on both spheres. We subsequently derive expressions for the energy of these pulsating strings as a function of the adiabatic invariant oscillation number under the short string limit and consider the cases when energy is equally and unequally distributed among the spheres of the I-brane. We observe that when the energy is equally distributed between the spheres, a string with equal winding numbers on both spheres pulsates simultaneously on both spheres with the same amplitude and when energy is unequally distributed, the string pulsates with larger amplitude on the sphere bearing higher energy.

Field of contribution:

Theory

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In-Medium Modification of Baryons Properties in a Relativistic Potential Model

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In this study, We first obtain the effect of density of medium on modifying masses of baryons using relativistic potential model. Using this medium modified mass which enables us to calculate the medium dependent nuclear properties- such as charge radius, magnetic moment and axial vector. These obtained in-medium properties of baryons are helpful in understanding matter under extreme conditions, providing significant insights into both theoretical and experimental nuclear physics as well as high energy physics. We obtain this properties under different scenarios of isospin asymmetry and strangeness fraction that helps to model complex systems, from neuton stars to heavy-ion collisions.

Field of contribution:

Phenomenology

448

Unveiling the role of color reconnection and QCD radiation in forward-backward multiplicity correlations in pp Collisions at LHC energies

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Event-by-event density fluctuations in the initial stages of hadron-hadron, hadron-nucleus, and nucleus-nucleus collisions are believed to produce correlations among the final state particles in forward and backward regions of the collision beam axis. Diving deep into the study of forward-backward (FB) correlations can reveal insights into the underlying dynamics of particle production mechanisms. In the present investigation, we explore the FB multiplicity correlations in pp collisions utilizing the PYTHIA8 framework. The FB multiplicity correlation strength, $b_{\mathrm{corr}}(mult.)$ have been estimated as a function of pseudorapidity gap (η_{gap}), pseudorapidity width ($\delta\eta$), and center-of-mass energy ($\sqrt{s}$). The correlation strength, $b_{\mathrm{corr}}(mult.)$, is also estimated across different azimuthal sectors. Our study concludes that the azimuthal sectors with $\varphi_{\mathrm{sep}} > \pi/4$ are predominantly affected by long-range correlations (LRCs), whereas sectors where $\varphi_{\mathrm{sep}} < \pi/4$ are primarily driven by short-range correlations (SRCs). Furthermore, the CR range 1.8 fails to explain ALICE results quantitatively across all azimuthal sectors. Overall, CR range 5.4 offers a reasonably good description of the data at $\sqrt{s}$ = 7 TeV, while both CR ranges 3.6 and 5.4 are consistent with the ALICE data at $\sqrt{s}$ = 0.9 and 2.76 TeV. This work further conducts a detailed analysis of the influence of MPI, as well as Initial and Final State Radiation (ISR and FSR), on the correlation strength. Our results indicate that MPI and CR play crucial roles in shaping correlations, with ISR having a more significant effect than FSR.

Field of contribution:

Phenomenology

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Angular analysis of heavy hadronic decays to explore signatures beyond SMEFT

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Angular distributions of heavy hadronic decays can serve as valuable observables for testing the Standard Model and identifying potential signals of new physics. In cases where new physics (NP) effects are not apparent in branching ratios or are obscured by hadronic uncertainties, these effects may still be detectable in the angular distributions.

In our study, we focus on the $b \to c$ and $b \to s$ channels, where several observations already suggest possible deviations from the Standard Model. We analyze the angular distributions in $\Lambda_b \to \Lambda_c(\to \Lambda\pi)\tau\bar{\nu}_\tau$ and $B \to K^{*0}\tau^+\tau^-$ decays and identify observables sensitive to NP contributions. Our focus is particularly on observables that could reveal deviations in the relations among Wilson coefficients within the low-energy effective field theory (LEFT), as predicted by the $SU(2)_L \times U(1)_Y$ invariance of the Standard Model Effective Field Theory (SMEFT). Both decay modes we discuss involve tau leptons in the final state, making experimental reconstruction challenging.. To address this, we propose a comparative analysis of the experimental sensitivities and NP search potentials between angular observables reconstructed from the tau distribution and those reconstructed from the muon distribution arising from the tau decays.

Field of contribution:

Phenomenology

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Energy-Dependent Inverse Potentials for Neutron-Proton Elastic Scattering at energy up to 1050 MeV Using a Piecewise Morse Function

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In this study, we have constructed the inverse potentials for s-wave neutron-proton (n-p) elastic scattering in the 1S0 and 3S1 channels, utilizing a piecewise Morse function as the reference function within the phase equation framework. We have optimized the model parameters of the reference function by minimizing the mean absolute percentage error (MAPE) between the simulated and expected phase shifts within a machine learning paradigm. The phase shifts were calculated independently for two distinct energy ranges, up to 350 MeV and 1050 MeV, by solving the phase equation using a fifth-order Runge-Kutta (RK5) method. This approach enabled us to systematically construct the inverse potential, tailored specifically for each energy limit, allowing for detailed analysis of the energy-dependent characteristics of the n-p interaction. The constructed potentials for 1S0 and 3S1 state exhibit distinct profiles across the examined energy ranges. For the 350 MeV case, the potential displays a well-defined attraction at short distances, with a depth Vd =−101.67 MeV at a distance of rd= 0.88 fm, aligning with observed phase shifts at lower energies. In contrast, the potential constructed for 1050 MeV exhibits a more pronounced well depth of Vd = −114.56 MeV at rd=0.83 fm, indicating an increased attractive interaction with rising energy in the 1S0 state. For the 3S1 state, the potential depth is Vd=−107.83 MeV at rd=0.94 fm for energies up to 350 MeV, while for energies up to 1050 MeV, the depth increases to Vd=−136.31 MeV at a distance of rd=0.86 fm. This variation in the depth and shape of the potential well highlights the sensitivity of the interaction to higher energy scales, as the increased kinetic energy of the scattering particles requires a deeper potential to reproduce the observed phase behavior accurately. These findings not only suggest that the piecewise Morse function serves effectively as a reference in constructing accurate inverse potentials that capture the energy-dependent dynamics of s-wave n-p elastic scattering but also underscore the methodology's relevance to high-energy physics, where precise modeling of scattering interactions at energies up to the GeV scale is essential. The methodology and results thus provide a refined framework for modeling nuclear scattering potentials, enhancing our understanding of elastic scattering processes across a wide energy range, including those relevant to high-energy physics.

Field of contribution:

Theory

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An Investigation of Jet Mass Distributions with Grooming in Pythia

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The Large Hadron Collider (LHC) at CERN operates at a center-of-mass energy of 13.6 TeV, well above the electroweak scale. This energy enables the production of particles such as W and Z bosons, the Higgs boson, top quarks, and any new particles with masses near the electroweak scale. The high energy results in large boosts, causing their hadronic decays to become collimated and allowing them to be reconstructed as single large-radius jets. Jet substructure techniques play a crucial role in identifying boosted jets at the LHC, and their importance is expected to grow in future runs and at higher-energy colliders. These techniques enhance our understanding of jet radiation patterns, enabling the development of algorithms to separate signal jets from the QCD background. Jet grooming techniques, such as trimming, pruning, and soft drop, reduce noise by removing soft, wide-angle radiation, thereby enhancing the hard substructure of jets for both Standard Model studies and new physics searches. Currently, pileup (PU) events contribute significantly to the noise in jet measurements at LHC experiments, with an average of up to 60 PU events occurring alongside the primary interaction. In this contribution, we present a phenomenological study of the invariant mass distribution of hadronic jets in proton-proton collisions, employing grooming algorithms such as trimming, pruning, and soft drop with varying parameters to assess their effectiveness in preserving jet structure by reducing PU under high-pileup conditions. Large-radius jets are reconstructed using the anti-kT algorithm with a cone radius of 0.8 in various Monte Carlo simulated event samples, including hard QCD, Z+jet, and W+jet events, at center-of-mass energies of 13.6 and 14 TeV, using the Pythia 8 event generator and the FastJet package.

Field of contribution:

Phenomenology

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Pionic properties in hot QCD from an effective field theory approach

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Effective field theories (EFTs) can encapsulate quite successfully the physics of QCD; in presence of a realizable separation of scales. At very low and high temperatures respectively; theory of pions, and an effective weak coupling expansion describe the physics successfully. Because of the dependence on hierarchy of scales, these EFTs usually become unsuitable around cross over temperature. With global symmetries of the QCD as our guiding principle, we thus build an EFT of thermal QCD near cross-over temperature. Vector and axial symmetries help us to organize the theory. After treating this EFT in mean field theory, we are left with handful of low energy couplings. The pionic fluctuations around the mean field theory are then inspected up to one loop in fermions of the original EFT. The static correlators in the pionic theory become related to, the physical parameters of the same theory. The dependence of these physical parameters of the pionic theory, with the variation of temperature are predicted. The agreement of the results to the lattice data is encouraging.

Field of contribution:

Phenomenology

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Electric field studies in Gas Electron Multiplier using ANSYS

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Micro-Pattern Gas Detectors (MPGDs) are a class of gaseous ionization detectors that involve micro-electronics. In the gas-filled medium, anode and cathode electrodes are separated by a small space at large potential differences. Electrons and ions are produced when charged particles interact with the gas medium. With the avalanche mechanism, deflected electrons cause further ionization and the creation of electron-ion pairs. One type of MPGD is the Gas Electron Multiplier (GEM) utilized in High Energy Physics. GEM detectors consist of GEM foil, which is used to measure the momentum and position of particles in order to track them. It consists of two metal layers held at different potentials and a polyimide layer sandwiched between them. The foil's microscopic holes allow electrons to avalanche. The electrons are collected at the readout, where the signal is processed. GEM has been modelled using ANSYS electronics software to study the different configurations of GEM holes. The electric field is calculated in the detector region which plays an important role in the gain of detector. GEM is then modelled with Mechanical APDL(Ansys parametric design language) to further study the geometry in details. This study aims to achieve the best possible configuration of GEM foil to get optimal electric field, higher gain and lesser back-flow of ions without compromising the detector's capability.

Field of contribution:

Experiment

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Future collider prospect study of Vector Like Lepton through Leptoquark decay at the HL-LHC

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Vector-like leptons (VLLs) are hypothetical heavy partners of Standard Model (SM) leptons and are present in many extensions of the SM. In specific quark-lepton unification theories, VLLs coexist with leptoquarks (LQs), another proposed colored particle that connects the quark and lepton sectors. Because VLLs are color-neutral particles, their production is primarily governed by weak interactions, making them generally suppressed. In this study, we propose an interesting production mechanism for VLLs via the decay of LQs. We explore the prospect of producing VLLs at the High-Luminosity Large Hadron Collider (HL-LHC) through various production channels involving LQs. We consider VLL production from the decay of both scalar and vector LQs. We also combine various production channels to enhance the sensitivity.

Field of contribution:

Phenomenology

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Gravitational Waves in Horndeski Action as a tool for solving Hubble Tension

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Gravitational waves (GWs) have recently emerged as a crucial tool for investigating unresolved cosmological phenomena. A key finding from our study is the discovery of speed variations for GWs predicted by the Horndeski action, which extends our understanding beyond simpler models such as $f(R)$ gravity and Brans-Dicke theory. These variations arise from the Weyl curvature tensor, which introduces distortions in the scalar-tensor field. Thus, we observe that, these distortions also affect the propagation speed of the waves.

By analyzing these speed variations in modified gravity theories—especially those that include the Horndeski action, in the influence of the Weyl curvature tensor we underscore the potential of the Stochastic Gravitational-Wave Background (SGWB) as a valuable cosmological tool. The detection of these SWGB will result in the solving the one of the most important cosmological problem i.e Hubble Tension and σ_8 tension.

Field of contribution:

Theory

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Simulation of GEM detector using Ansys and Garfield++

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Micro-Pattern Gas Detectors (MPGDs) represent a category of gaseous ionization detectors based on microelectronics and filled with gases. After a high-energy particle interacts with the gas medium, ions and electrons are produced, which are subsequently accelerated in opposite directions due to the applied electric field. Deflected electrons trigger further ionization to create electron-ion pairs through an avalanche process. These particles can be detected with very high precision at the readout. The Gas Electron Multiplier (GEM) is one type of MPGD constructed with a polyimide film caldded copper on both surfaces under a high voltage difference. Microscopic holes in the foil facilitate electron avalanche. However, the current geometry of the GEM detector used in various experiments is suboptimal for the gain and performance. In this study, we have modified the geometry of the GEM detector to enhance the gain, reduce ion backflow, and enhance the performance of the detector. We are proposing a new geometry of the GEM detector foil for higher gain, better performance, and durability. For this study, the geometry has been constructed in ANSYS, and further studies have been performed using Garfield^{++}.

Field of contribution:

Experiment

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Coupled Dark Energy Models and CPL Parameterization to Explain the Chosen Equations of State

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Equation of State of the coupled dark energy can be expressed in terms of the ration of total pressure to the vacuum energy density. Here in this article the stability of the saddle points are produced for different types of functions which can be considered to produce the quintessence models. Chosen functions are further tested with CPL parameterization to fit them for dark energy models.

Field of contribution:

Theory

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Studying net-proton number cumulants in a modified van der Waals hadron resonance gas model

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The ideal hadron resonance gas (HRG) model, which considers a system of non-interacting point size hadrons and resonances, is successful in explaining the particle ratios observed in high-energy heavy ion collisions. It also agrees with thermodynamic results from lattice QCD (lQCD) calculations up to a temperature of $T \sim 150$ MeV. However, the model fails to explain the higher-order conserved charge fluctuation calculations from lQCD results as well as from experiments. The conserved charge fluctuations are, however, sensitive to the second-order phase transition. Therefore, it is an important parameter to study the possible critical point in the QCD phase diagram. The inclusion of van der Waals (VDW) interaction extends the applicability of the hadron gas model to high temperature (T) and baryochemical potential (μ_B) region. However, it still remains far from explaining the experimental data on higher-order fluctuations. To further improve the model, we argue that the VDW parameters a and b must be taken into consideration. We employ a χ^2 minimization technique to fit thermodynamic quantities obtained in our model to lQCD results at different μ_B/T values to obtain different a and b values for each case of μ_B/T. This allows us to parameterized the VDW parameters as a function of T and μ_B. Hence, we construct a modified VDWHRG (MVDWHRG) model where the parameters are no longer constants and vary as a function of T and μ_B. We use a simple parametrization to relate T and μ_B as a function of the centre of mass energy ($\sqrt{s_{NN}}$). We then calculate the net-proton number cumulants as a function of energy in the ideal HRG, VDWHRG as well as in the modified VDWHRG and compare the results with experimental data. We observe that our results from MVDWHRG are in reasonable agreement with the experimental data.

Field of contribution:

Phenomenology

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Study on $B_c \to J/\psi(\eta_c)$ and $B_c \to \chi_{c0,1}(h_c)$ semileptonic channels in modified perturbative-QCD framework

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This study investigates the decay modes of the B_c meson, focussing on semileptonic decays into S and P wave charmonia. The primary objective is to extract the shape parameter of the B_c meson distribution amplitude through a data-driven approach, utilizing $B_c \to \eta_c, J/\psi$ form factors in modified perturbative QCD framework. Further, by employing heavy quark spin symmetry, shape of $B_c \to \eta_c$ form factor is derived from existing lattice results of $B_c \to J/\psi$ form factors, giving a model-independent prediction of LFUV observable $R(\eta_c) = 0.304(36)$, which we have found to be in good agreement with previous results. Additionally, we have extracted the decay constants of P wave charmonium states, χ_{c0}, χ_{c1} and h_c through their radiative decay modes, providing a data-driven alternative to existing model dependent values, enabling us to use them as inputs to predict the $B_c \to P$ wave form factors at $q^2 = 0$ within the modified perturbative QCD framework. Subsequently, utilizing the shapes of the $B_c \to \eta_c$ and J/ψ form factors, we have obtained q^2 distribution of the $B_c \to \chi_{c0}, \chi_{c1}$ and h_c form factors through pole expansion parametrization, using which we obtain predictions of LFUV observables $R(\chi_{c0}) = 0.195(4)$, $R(\chi_{c1}) = 0.129(7)$ and $R(h_c) = 0.109(4)$.

Field of contribution:

Phenomenology

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Forces in non-Hermitian system

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We review the well-known Hellmann Feynman Theorem 1, originally developed for Hermitian systems to facilitate the calculation of forces among the molecules. Our work extends this foundational theorem to the domain of non-Hermitian quantum mechanics, in particular the PT symmetric non-Hermitian quantum physics 2. We derive a modified form of the HFT which holds good for both PT broken, unbroken phases and even at the exceptional point of the theory. Several examples for both discrete [3] as well as continuum systems [4] have been considered to test our result. We further consider an example of non-PT symmetric non-Hermitian system to show the validity of the modified theorem [5]. Moreover, we also demonstrate that the modified theory can give rise to a potential numerical advantage for computing the expectation value of many- body operators for interacting many-body Hamiltonian. Finally, we also derive a generalized Virial theorem for non-Hermitian systems using the modified HFT, which potentially can be tested in experiments. Our results will open up then new window to calculate various physical quantities, particularly in the field of molecular dynamics, using HFT in non-Hermitian systems directly.

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Field of contribution:

Theory

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Correlation Studies in O+O Collisions at $\sqrt{s_{\mathbf{NN}}} = 200$ GeV using AMPT Model

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Comprehensive understanding of the origins of collectivity in small collision systems has recently become a prominent research topic of growing interest given the plethora of measurements taken at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC) over the years. The ^{16}O+^{16}O collision system is unique since it not only complements the flow measurements in other small systems at both RHIC and LHC but also allows one to study observables carrying the signatures of nucleon-nucleon correlations predicted by effective field theories. In this work, we present a systematic study of azimuthal correlations in O+O collisions at $\sqrt{s_{\text{NN}}} = 200$ GeV considering both spherical and clustered nuclear geometries. We have simulated events using the A Multi-Phase Transport (AMPT) model to investigate centrality dependence of the geometric response to initial spatial anisotropy described by eccentricity coefficients (ε_n) as well as anisotropic flow coefficients (v_n). The clustered geometry is found to exhibit distinctive features compared to the spherical configuration. In addition to this, we compare our findings with recent STAR flow measurements for central O+O collisions.

Field of contribution:

Phenomenology

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Thermodynamic curvature of charged Gauss-Bonnet black holes with AdS2 horizons

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In this paper, we study the phase structure and thermodynamic curvature of charged topological Gauss-Bonnet black holes in d-dimensional anti-de Sitter spacetime. By calculating the scalar curvature of the Ruppeiner geometry and analyzing its behaviour near the phase transition, we can gain empirical insights of the microstructure characteristics of the system based on the sign and magnitude of thermodynamic curvature. At low temperature, we compute thermodynamic curvature for charged Gauss-Bonnet black holes with AdS_2 near horizon geometry, and containing a zero temperature horizon radius r_h, in a spacetime which asymptotically approaches AdS_d . Both attraction and repulsion-dominated regions arise, generally governed by the black hole's electric charge, Gauss-Bonnet coupling, and horizon radius. The curvature is computed through a semi-classical analysis, as well as with quantum fluctuations included.

Field of contribution:

Theory

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Production of "techni di-jets" comprising the composite particles.

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We investigate the phenomenology of the electroweak gauge bosons W^+, W^-, Z^0, and the Higgs boson as composite states of new fermions governed by strong dynamics. To produce these composite particles, we propose a model in which production occurs through the Drell-Yan process, $q\,\bar{q} \to q_{TC}\,\bar{q}_{TC}$, where q_{TC} denotes a technicolor quark forming a doublet under a flavour group $SU(2)$. The technicolor sector connects to the Standard Model (SM) sector via γ^*/Z^0, preserving the electroweak gauge group, and is charged under the new strong gauge group $SU(N)_{TC}$, while the incoming SM quarks are singlets under $SU(N)_{TC}$. In our model, proton-proton (pp) collisions occur at center-of-mass energy $\sqrt{s} = 100$ TeV.

The technicolor quarks undergo fragmentation, producing additional technicolor quarks, which, through hadronization, form hadrons at a composite scale $\Lambda \approx 1$ TeV. These hadrons include technicolor mesons, such as pions and eta (Π^+, Π^-, Π^0, and η), bound states of technicolor quarks. These technicolor mesons are analogous to the electroweak gauge bosons W^+, W^-, Z^0, and the Higgs boson.

To illustrate the process, we draw an analogy with QCD, comparing it to the process $e^+e^- \to q\,\bar{q}$, where q represents SM quarks. In this analogy, the incoming leptons are singlets under the color gauge group $SU(3)_c$, while outgoing SM quarks are charged under $SU(3)_c$, with both initial and final particles preserving the electroweak gauge group $SU(2)_L \otimes U(1)_Y$. Following hadronization, the final-state hadrons are produced at the QCD scale $\Lambda \approx 1$ GeV.

Since these technicolor mesons are invisible, we model their decay back to the SM particles and reconstruct the fast jets from the final-state particles at the detector level. We observe a dijet-like situation similar to the QCD dijets and study the signatures of the final-state particles. Our model aims to probe the potential existence of composite states at high energies, motivated by the search for new dynamics beyond the Standard Model and insights into electroweak symmetry breaking mechanisms. This work is useful for exploring physics at the 100 TeV collider, composite models, and related phenomena.

Field of contribution:

Phenomenology

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Longitudinal polarization asymmetry of Ξ_b decays with the effect of non-universal Z' boson

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Rare baryonic decays induced by flavour changing neutral current (FCNC) have been of immense interest in recent years because of their sensitivities towards new physics (NP) beyond the standard model (SM). The exploration had been triggered with the observation of $b \rightarrow sll$ transition at the Fermilab 1 and the LHCb 2. Theoretically these decays are also studied at different NP models [3-5]. Inspired by these results obtained for baryonic decays [3-7], we are interested to study the polarization asymmetry for Ξ_b baryon with the effect of NP. Various theoretical studies of branching fractions for $b \rightarrow sll$ decays in the standard model (SM) [8] proclaim the possibility of observation of these decays at the LHC. In this work, we will mainly concentrate on longitudinal polarization asymmetries for muonic, electronic and taunic channels in family non-universal Z' model [9, 10]. Asymmetry parameters characterize the angular dependence of differential decay width with polarized and unpolarized heavy baryons. We will investigate the observables with the contribution of Z' boson. The phenomenology of Z' is one of the important sectors to the accelerators. Due to its heavy mass, it may be used to calibrate the upcoming runs of the experiments. Here, we will introduce the NP couplings nd use their constrained values. We will show the variation of the observables throughout the whole allowed kinematic region. These results for b decays will help the experimental community to observe the decays in colliders and will unlock a new horizon to the theoretical community to probe NP with heavy baryons.

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Field of contribution:

Phenomenology

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Study of LFV Baryonic Decays with the effect of Non-universal Z' boson

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The study on lepton flavour violating (LFV) decays in the framework of the non-universal Z' model delves into several fascinating aspects of particle physics. Focusing on the $\Sigma_b \to \Sigma l_1 l_2$ decays, which are induced by the quark-level transition $b \to s l_1 l_2$, is especially relevant given the existing experimental constraints on LFV processes. The lepton flavour violating decays are suppressed in the Standard Model (SM) as their expected branching fractions at the SM are very lower than the current experimental findings. The branching fractions of these transitions are calculated in the SM. In reference 1, we can observe that the branching ratios for $B^0 \to^{\pm}$ and $B_s \to^{\pm}$ decays are of the order of 10^{-54} whereas experimentally they are constrained at the order of 10^{-5} by BaBar and LHCb with 90% and 95% confidence level respectively [2, 3]. The LFV transitions and other anomalies of b hadron sector are explained by various theoretical considerations proposing various theoretical models [4, 5]. Although the accelerators have provided the experimental bounds, there are no experimental evidence till now. The colliders are trying to see the LFV decays nowadays so that the anomaly can be explained successfully. In this work we will study several observables of LFV decays $\Sigma_b \to \Sigma l_1 l_2$ induced by the quark level transition $b \to s l_1 l_2$ with the contribution of non-universal Z' boson where l_1 and l_2 are charged leptons of different flavours. We will constrain the NP couplings using several experimental upper limits. We have already explored the LFV λ_b decays [6]. Here, we will explore the LFV Σ_b decays and get a comparative study of the lepton flavour violation in the baryonic sector in different NP theories. It is expected that the study would be very interesting and that might emboss the footprints of NP more aesthetically.

Acknowledgement:
S. Biswas thanks Saha Institute of Nuclear Physics for providing fellowship for research. I would like to thank Dr. Tinku Sinha Sarkar and Dr. Debasish Das, SINP Kolkata for useful discussions.

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Field of contribution:

Phenomenology

467

Prospects of Dynamic Radius Jet Clustering Algorithm at the LHC

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The emergence of jets, bunches of collimated hadrons, in high-energy colliders is a prevalent phenomenon. In the current LHC context, along with traditional narrow QCD jets, the study of fat jets, which may appear as a result of the decay of a heavy particle, has become an essential part of collider studies. Current jet clustering algorithms, namely kt-type sequential recombination algorithms, use fixed radius parameters for the formation of jets from the hadrons of an event in a collider. The appearance of differently-sized jets in a single event from such algorithms is, therefore, impossible to achieve. In our work, we made an attempt to form differently-sized jets via the dynamic radius chosen during the evolution of each jet. Instead of keeping the constant radius parameter of the standard kt-type sequential recombination algorithms, we allowed the radius to vary dynamically based on the local kinematics and distribution in the eta-phi plane around each evolving jet. In this

talk, I will discuss our methodology of the dynamic radius jet algorithm. I will then present the usefulness of the algorithm at the 13 TeV LHC through some example processes from SM and BSM scenarios.

Field of contribution:

Phenomenology

468

Tetraquarks in meson-meson picture using variational approach

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The present study investigates the low-lying doubly-charm tetraquark states in the meson-meson interaction picture. The masses of charm mesons are calculated within the Cornell potential framework, including the spin-spin interaction and using Gaussian wavefunctions that include a variational parameter. Monte Carlo sampling is employed to determine the potential parameters, incorporating the masses of the quarks and the strong coupling constant. Subsequently, these meson masses are minimized with respect to the variational parameter for each state, providing optimized values of the masses of charm mesons. These calculated masses are then used to model the formation of tetraquark states. In this approach, meson-meson interactions are considered with the same potential parameters as those for individual mesons. This study contributes to understanding exotic hadronic states, specifically doubly-charm tetraquarks, and provides insights into the dynamics of multiquark interactions within a unified potential model.

Field of contribution:

Phenomenology

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Phase Transition in Neutron Star Cores

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The region of QCD phase diagram characterized with low temperature and high baryonic density is been speculated to be found in the cores of neutron stars which are prone to phase transitions. In my present work, the transition between the chiral and diquark condensate is being studied while reproducing some numerical results. The thermodynamic grand potential of system is minimized with respect to the order parameters m and Δ to get the form of the gap equations. Using Numerical

Techniques, we analyse these gap equations to study the strong competition between chiral and diquark condensate in the 2 Flavour Superconducting Phase.

Field of contribution:

Theory

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Probing BSM Physics through High-Mass Diphoton Signatures with the CMS experiment

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The search for new physics beyond the Standard Model (BSM) continues to be a central pursuit in contemporary particle physics, driving the exploration of new particles and interactions. In this talk, we present the results from a comprehensive search for BSM particles in 'high-mass diphoton events', a distinctive signature predicted by several SM extensions, including Supersymmetry, extra spatial dimensions, and non-minimal Higgs sectors.
We investigate both spin-0 and spin-2 particles in resonant as well as non-resonant scenarios, leveraging the datasets of proton-proton collisions at $\sqrt{s}$ = 13/13.6 TeV from LHC Run II/III, recorded by the CMS detector. Constraints are placed on the production of heavy Higgs bosons and the continuum clockwork mechanism. Notably, we establish the most stringent limits to date on models with ADD extra dimensions and RS gravitons, excluding coupling parameters greater than 0.1.
This presentation will highlight salient results from Run II, while also outlining the ongoing efforts using the latest Run III data. We will discuss the analysis methodology, with particular emphasis on the complementary approaches used to model signals/backgrounds, and the use of advanced multivariate techniques to enhance photon identification, etc. These strategies have significantly increased the sensitivity to potential BSM signals, paving the way for future advancements.

Field of contribution:

Experiment

471

Quantum Entropies for a non-Hermitian two level system coupled to bosonic oscillators and PT phase transition

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The study of non-Hermitian systems is spreading very rapidly over the various branches of physics. We consider a spin-1/2 particle in an external magnetic field coupled to bosonic oscillators via non-hermitian interactions to study the various information theoretic measures. The present system is not PT symmetric but Pseudo-hermitian with respect to two different operators, parity (P) and σ_z. We show that this system can be reduced to smaller invariant subspaces with k (=1,3,5 $\cdots$) number of states. Each subspace possess a second order exceptional point (EP) and we observe complex to

real phase transition at EP. We further calculate the density matrix of the system in these invariant subspaces and hence calculate the quantum entropies such as von Neumann entropy and Rényi entropy. We study how these quantum entropies changes with strength of the non-Hermiticity. We observe that both of these entropies remain real in some region of the unbroken phase and become complex in other regions, for each subspace.

Field of contribution:

Theory

472

Boosting Signal Detection in Rare Higgs Decay to Zγ at √s = 13 Tev

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Higgs Boson is characterized by $J^{\pi} = 0^{+}$ and fundamentally forms the cosmos by interacting with other particles to impart mass in standard model. This study is focused on Zγ channel of Higgs with branching ratio of $\beta(H \to Z\gamma) = (1.57 \pm 0.09) \times 10^{-3}$. Feynman diagram for Z$\gamma$ channel is similar to $\gamma\gamma$ channel, and loop diagrams in this process are particularly sensitive to BSM physics. Analysis $H \to Z\gamma \to \mu^{+}\mu^{-}\gamma$ or $e^{+}e^{-}\gamma$ done using collision data generated from proton-proton interactions using PYTHIA-8 at $\sqrt{s}$ = 13 TeV. Detection of heavy resonance signals in heavy-ion physics is challenging due to complex background noise and pile-up in dense media also current Higgs detection methods are sub-optimal. This study addresses these issues by applying an angular correlation approach and will help in enhancing Higgs signal-to-background ratio in both heavy-ion and proton-proton experiments. Higgs mass is reconstructed by employing selection criteria focused on certain kinematic variables at various stages and signal-to-background ratio computed. Further analysis involves examining relation between P_Z vs $\theta_{\ell^{+}\ell^{-}}$ and P_H vs $\theta_{Z\gamma}$ - refers to 1^{st} and 2^{nd} angular correlation respectively. Both up to 1σ were applied which enhanced the signal-to-background ratio up to several orders of magnitude. Similar approach have been applied to complex decays of the particle to enhance signal-to-background ratio. Studies on acceptance and efficiency have also been conducted to integrate them into the cross-section calculation.

Field of contribution:

Experiment

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Lattice QCD study of doubly heavy bottom tetraquarks

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Baryons and mesons (collectively referred to as hadrons) have been
understood as quark-gluon composite states bound by Quantum ChromoDynamics (QCD), the theory of strong interactions. The conventional understanding is that baryons are made of three quarks

and mesons are composed of a quark-antiquark pair. QCD also supports the existence of more complex hadrons, made of more than three quarks. Only recently collider experiments such as at LHCb and Belle have reported these unexpected states, referred to as exotic hadrons, that are compelling candidates for such complex hadrons. The discoveries of several such exotic states dubbed X, Y, Z, and Tcc(3875) in the heavy quark flavor sector have sparked enormous interest in the community. Understanding the binding mechanism of these exotic hadrons can play a crucial role in comprehending the non-perturbative nature of QCD dynamics.

In this talk, I will discuss state-of-the-art lattice QCD investigations
of two-meson interactions involving at least one bottom meson, relevant for heavy tetraquark channels. The computations were conducted on
state-of-the-art MILC ensembles.

Field of contribution:

Phenomenology

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Information Scrambling with Higher-Form Fields

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The late time behaviour of OTOCs involving generic non-conserved local operators show exponential decay in chaotic many body systems. However, it has been recently observed that for certain holographic theories, the OTOC involving the $U(1)$ conserved current for a gauge field instead varies diffusively at late times. The present work generalizes this observation to conserved currents corresponding to higher-form symmetries that belong to a wider class of symmetries known as generalized symmetries. We started by computing the late time behaviour of OTOCs involving $U(1)$ current operators in five dimensional AdS-Schwarzschild black hole geometry for the 2-form antisymmetric B-fields. The bulk solution for the B-field exhibits logarithmic divergences near the asymptotic AdS boundary which can be regularized by introducing a double trace deformation in the boundary CFT. Finally, we consider the more general case with antisymmetric p-form fields in arbitrary dimensions. In the scattering approach, the boundary OTOC can be written as an inner product between asymptotic 'in' and 'out' states which in our case is equivalent to computing the inner product between two bulk fields with and without a shockwave background. We observe that the late time OTOCs have power law tails which seems to be a universal feature of the higher−form fields with $U(1)$ charge conservation.

Field of contribution:

Theory

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Search for charged lepton flavor violation in the tau sector

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Charge lepton flavor violation in the tau sector, an unambiguous signature of New Physics, has been searched in many channels by multiple collaborations, including BaBar, Belle, Belle II, LHCb, ATLAS and CMS. Current experimental status and future improvements are discussed. Combined upper limits as compiled by the Tau subgroup of the Heavy Flavor Averaging group are presented, for channels where multiple searches provide significant contributions. Future discovery potential of several new physics models with charged lepton flavor violation as its experimental signature are presented, along with constraints on Wilson coefficients on different lepton flavor violating operators in an effective field theory approach.

Field of contribution:

Experiment

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Development, Fabrication, Assembly, and Testing of the HGCAL Backend System for the CMS Experiment

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Co-authors: Chetan Mandloi [1]; Gagan Mohanty [1]; Kameswara Rao Kodali [1]; Shashi Dugad [1]

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Our group at TIFR is participating in the development, fabrication, and assembly of backend carrier boards based on the AdvancedTCA form factor for trigger electronics of the CMS high-granularity calorimeter (HGCAL). Specifically, we are developing a general-purpose 'Serenity'board that will be compatible with most subdetectors, including HGCAL, for the Phase-2 Upgrade of the CMS experiment at CERN. Its data engine uses optical or electrical SAMTEC Firefly connectors to deliver high data throughput of up to 10 TBps per carrier board, with a processing time of 5 μs for each collision. Approximately 250 field-programmable gate arrays mounted on Serenity boards will perform this processing at various stages. We recently fabricated and assembled Serenity pilot boards and subsequent pre-series boards in India, followed by their extensive electrical tests at TIFR and CERN. This talk will cover efforts related to the CMS backend system carried out by TIFR.

Field of contribution:

Experiment

477

First Level Calorimeter Trigger Hardware and firmware development for the CMS Experiment at HL-LHC

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Hardware and firmware development work at TIFR for CMS L1 Trigger

Field of contribution:

Experiment

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Material Identification and Binary Classification of High-Z Materials in Cosmic Muon Imaging using PRM and Deep CNN

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Muon Scattering Tomography (MST) is an effective technique for identifying special nuclear materials (SNM) in cargo transporting across borders, posing a significant threat to homeland security. Images of SNM and other materials in cargo can be produced on the basis of scattering suffered by cosmic mons while passing through the objects. The magnitude of scattering is known to be dependent upon the atomic number and density of the object material for a given muon momentum. The production of such images can be accomplished by tracking incoming and outgoing muons with position sensitive detectors followed by reconstruction of the respective trajectories and calculation of the scattering angle using suitable algorithms. Further, the images are analyzed for discrimination of materials and their identification.
In the present work, an image processing protocol is proposed with the help of simulated images for a prototype MST setup which is currently under construction. The images were produced from analyzing scattering angles within the target material using the Point of Closest Approach (PoCA) algorithm and further processed with a Pattern Recognition Method (PRM). Kernel shapes used in the PRM were varied to improve the model's ability to define boundaries. Following this, Deep Convolutional Neural Network (DCNN) was employed to classify different materials. The model was trained using histogram images generated from the density of PoCA points and the scattering angles of muons in various materials, like Aluminium (Al), Iron (Fe), Lead (Pb), Uranium (U) etc. as simulated with GEANT4. Different filters including the same kernels used in PRM have been implemented to optimise the model. Several other parameters were also optimised, and the Receiver Operating Characteristic (ROC) curve was generated to compare performance across models. The highest Area Under the Curve (AUC) observed was 0.9921, with an overall model accuracy of 95% for classification between Uranium and Lead.

Field of contribution:

Experiment

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{Medium effects of charged-hadron production in $p+Pb$ and $Pb+Pb$ collisions at $\sqrt{s_{\rm NN}} = 5.02$ using modified Tsallis distribution

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The transverse momentum (p_T) spectra of charged hadrons in $p+p$, $p+Pb$ and $Pb+Pb$ collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV are presented here within the rapidity
range of $-2.5 < y < 2.0$. We study the medium effects, which is produced by heavy ion collisions, on the behaviour of charged hadrons, by using a phenomenological fit function. These effects are attributed to two main factors:
the transverse collective flow and the the energy loss of charged hadrons due to multiple scatterings. We observe the transverse
collective flow at low and intermediate p_T region and the energy loss at high p_T region.
Here we take all the published data from the ATLAS collaboration.

Field of contribution:

Phenomenology

480

Analyzing the 21-cm signal brightness temperature in the Universe with inhomogeneities

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We explore the 21-cm signal in our Universe containing inhomogeneous matter distribution at considerably large scales. Employing Buchert's averaging procedure in the context of a model of space-time with multiple inhomogeneous domains, we evaluate the effect of our model parameters on the observable 21-cm signal brightness temperature. Our model parameters are constrained through the Markov Chain Monte Carlo method using the Union 2.1 supernova Ia observational data. We find that a significant dip in the brightness temperature compared to the ΛCDM prediction could arise as an effect of the inhomogeneities present in the Universe.

Field of contribution:

Theory

481

New Physics effects in the semileptonic $B_c^+ \to B_d \mu^+ \nu_\mu$ decay

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The analysis of the $B_c^+ \to B_d \mu^+ \nu_\mu$ transitions in mesonic decays for the search of new physics in the presence of right-handed neutrinos would be an interesting aspect of the phenomenological study. We have followed the effective field theory approach for the low-energy effective Hamiltonian comprising the dimension-six operators. The new physics operators are constrained by using the available measurements of mesonic charm decay transitions, and the Wilson coefficients are determined through a χ^2 fit using the Miniut package. We make the predictions of differential branching fraction and angular asymmetries for the mode to explore the effect of the new physics on the mesonic decay through right-handed neutrinos to motivate future measurements.

Field of contribution:

Phenomenology

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Exotic Tccus tetraquark from numerical simulations of QCD

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The recent discovery of the exotic Tcc tetraquark by the LHCb collaboration has garnered significant interest in the particle physics community. Building on this discovery, our research investigates the potential existence of another exotic tetraquark, Tccus, which could be within the reach of LHCb, if it exists. Using lattice QCD, a first-principles approach, we simulate scattering of charm $D^{(*)}$ and charm-strange $D_s^{(*)}$ mesons. Finite volume energy spectra, determined using variational procedures, are utilized to extract the coupled channel $DD_s^* - D_s D^*$ scattering amplitudes. Pole singularities in the resultant amplitudes across the complex energy plane are extracted and studied in conjunction with the known hadronic features in the experimental cross sections and/or with potentially yet-to-be-discovered tetraquark candidates.

Field of contribution:

Theory

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Anomalies in Neutrino Physics and steps towards their resolution

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A very significant collective effort over the next decade will be devoted to resolving and understanding four short-baseline anomalies in the neutrino sector. These are a) the reactor anomaly, b) the Gallium source anomaly, the excess of electron-like events in the c) MiniBooNE detector and d) in the LSND detector. Their importance lies in their potential to lead us to new physics beyond the Standard model. A number of theoretical proposals for new physics will be extensively tested in the process by a robust experimental program. We will review the current situation vis a vis both theory and experiment, highlighting the important new physics proposals as well as their tests via current and upcoming experiments.

Field of contribution:

Phenomenology

484

The Amaterasu and other Extremely High Energy Cosmic Ray events

Author: Raj Gandhi[None]

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The Telescope Array Collaboration recently reported the detection of a cosmic-ray particle, "Amaterasu,"with an extremely high energy of 2.4 × 10ˆ20 eV. No powerful enough candidate sources are located within the region consistent with its propagation horizon and arrival direction, raising question about its origin. This puzzling feature has led to proposals of past astrophysical transient sources, ultra-heavy cosmic rays, Lorentz invariance violation, and superheavy dark matter as possible explanations for its observation. Prior to the the Amaterasu event, an even more energetic event, Fly's Eye event (E = (3.2 x 10ˆ20 eV was observed in 1995. Two other extremely energetic events, within one standard deviation of the Amaterasu particle, have also been previously reported by the Pierre Auger Collaboration. We will review the current situation vis a vis these extremely energetic events and their potential for revealing new physics.

Field of contribution:

Phenomenology

485

Computing unified atomic mass unit and Avogadro number with various nuclear binding energy formulae and strong and electroweak mass formula

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In this paper, we make an attempt to estimate the famous Avogadro number with programming logics written in Python associated with advanced nuclear binding energy formulae and our proposed strong and electroweak mass formula pertaining to 4G model of final unification. Average rest mass of nucleon, nuclear binding energy per nucleon and electron rest mass seem to play a vital role in estimating the unified atomic mass unit and Avogadro number. Interesting point to be noted is that, Avogadro number seems to be the inverse of the Unified atomic mass unit. With further study, it seems possible to estimate the unified atomic mass unit and Avogadro number accurately. Our interesting observation is that, short range strong nuclear force seems to have a vital role in deciding the accuracy of Avogadro number. For that purpose one may consider AI techniques along with newly observed atomic nuclides and their nuclear binding energies. For Z=6 to 118 and A_low=2Z and A_upper=3.5Z, estimated average value of Avogadro number is $N_{Average} \cong 6.01938 \times 10^{26}$. Considering the saturation of nuclear binding energy, at Z=26, $N_{Z=26} \cong (6.02229 \text{ to } 6.02285) \times 10^{26}$. At academic level, our proposal can be given a chance as a case study. It is planned to develop a web application for this purpose

Field of contribution:

Theory

486

Multipartite dark matter in a leptophilic gauge theory

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The classical conservation of the lepton number is an accidental symmetry present in the Standard Model (SM). Thus, we consider here a scenario where the SM is extended with a U(1) gauge group, promoting the lepton number to a local symmetry. The gauge anomaly cancellations necessitate the extension of the particle spectrum with several beyond the SM (BSM) particle fields. The extended lepton gauge group breaks around the TeV scale via spontaneous symmetry breaking, and a Z_2 symmetry remains, which ensures the stability of the light Z_2 odd BSM particles. Interestingly, the particle spectrum of the model has two distinct dark sectors, with one having a Dirac-type DM and the other one containing a Majorana-type DM, thus resulting in a multipartite dark matter scenario. We have explored the available parameter space consistent with the observed dark matter relic density and direct detection measurements for both of the DM particles. Having a Majorana dark matter, we have also studied for the gamma line signatures to constrain the parameter space from the indirect dark matter detection experiments like FermiLAT and CTA.

Field of contribution:

Phenomenology

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Charge and heat transport phenomena in a weakly magnetized hot QCD medium within the Bhatnagar-Gross-Krook model

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We have calculated the charge and heat transport coefficients of a hot QCD medium by solving the relativistic Boltzmann transport equation in the Bhatnagar-Gross-Krook (BGK) model with a modified collision integral
in the weak magnetic field regime. The modified collision integral with the instantaneous particle number conservation enhances charge and heat transport phenomena, as evidenced by the increased values of the transport coefficients, such as the electrical conductivity, the Hall conductivity, the thermal conductivity and the Hall-type thermal conductivity, in comparison to the relaxation collision integral. We have also carried out a comparative analysis of the aforementioned transport coefficients in both weak and strong magnetic fields, indicating a significant reduction in the weak magnetic field case within the BGK model. Additionally, some observables associated with the aforementioned transport coefficients, such as the Knudsen number describing the validity of the local equilibrium property of the medium and the Lorenz number elucidating the correlation between the heat flow and the charge flow through the Wiedemann-Franz law, are explored in the presence of both weak magnetic field and finite chemical potential. We have observed from the behavior of the Knudsen number that the medium at finite chemical potential remains in the local equilibrium in the weak magnetic field regime. Further, the Lorenz number exhibits a rising trend at low temperatures, showing a violation of the Wiedemann-Franz law, whereas at high temperatures, it gets saturated for a weakly magnetized hot QCD medium at finite density. Since the Lorenz number stays greater than unity, it
suggests that the thermal conductivity dominates over the electrical conductivity in the aforesaid regime.

Field of contribution:

Phenomenology

488

The Type-I 2HDM: Distinctive Signals and the Road to Discovery

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In the Type-I 2HDM, all the five new physical Higgs states can be fairly light, (100) GeV or less, without conflicting with current data from the direct Higgs boson searches and the B-physics measurements. In this talk, I will discuss how the new neutral and the charged Higgs bosons of the model can be simultaneously observable, resulting from the electro-weak (EW) production. Since the parameter space configurations where this is achievable are precluded in the other, more extensively pursued, 2HDM Types, experimental validation of our findings would be a clear indication that the true underlying Higgs sector in nature is the Type-I 2HDM.

Field of contribution:

Phenomenology

489

Analysis of the cell pattern for partial modules

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In the High Luminosity phase of the LHC, the High Granularity Calorimeter (HGCAL) are the planned replacement end-cap calorimeters to handle the increased radiation levels. HGCAL is a sampling calorimeter that uses silicon and plastic scintillators as active material. The talk goes over the intricacies of HGCAL geometry and their implementations in CMS Software Framework. The shape and dimensions of the cells in silicon wafers has been updated and validated to reflect the design. To improve the reconstruction, methods to extract the area and center of gravity for the cells in full and partial silicon wafers have been implemented and validated.

Field of contribution:

490

Estimating the Newtonian gravitational constant with Fermi's weak coupling constant via 4G model of final unification

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In our recent publications pertaining to 4G model of final unification, we have proposed three assumptions. First assumption is: There exists a weak fermion of rest energy $M_{wf}c^2 \cong 584.725$ GeV. Second assumption is: There exists a nuclear charge of magnitude $e_n \cong 2.9464e$. Third assumption is: For the weak, nuclear and electromagnetic interactions, there exists three large gravitational coupling constants, $G_w \cong 2.909745 \times 10^{22}\ m^3kg^{-1}sec^{-2}$, $G_n \cong 3.329561 \times 10^{28}\ m^3kg^{-1}sec^{-2}$ and $G_e \cong 2.374335 \times 10^{37}\ m^3kg^{-1}sec^{-2}$ respectively. Objective: To estimate the magnitude of the Newtonian gravitational constant G_N with Fermi's weak coupling constant G_F via 4G model of final unification. Method: With reference to the proposed weak fermion and proton, it seems possible to fit the Fermi's weak coupling constant, $G_F \cong \hbar c \left(\frac{2G_w M_{wf}}{c^2}\right)^2 \cong \left[\left(G_e^2 G_N\right)^{\frac{1}{3}} m_p^2\right] \left(\frac{2G_n m_p}{c^2}\right)^2$. Conclusion: There is a scope for the combined study of weak, electromagnetic, nuclear and gravitational interactions at fundamental level. Proceeding further, Newtonian gravitational constant can be estimated from atomic and nuclear physical constants and the estimated value can be considered as a reference for ongoing and future experimental results.

Field of contribution:

Theory

491

Boosting galactic dark matter with relic supernova neutrinos

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Diffuse neutrinos from past supernovae in the Universe present us with a unique opportunity to test dark matter (DM) interactions. These neutrinos can scatter and boost the DM particles in the Milky Way halo to relativistic energies allowing us to detect them in terrestrial laboratories. In this talk, I will discuss how the consideration of energy-dependent cross-sections for DM interactions can significantly affect constraints previously derived under the assumption of constant cross-sections, modifying them by multiple orders of magnitude. I will focus on generic models of DM-neutrino and electron interactions, mediated by a vector or a scalar boson, and discuss new limits obtained on DM-neutrino and electron interactions for DM with masses in the range $\sim (0.1, 10^4)$ MeV, using recent data from XENONnT, LUX-ZEPLIN, and PandaX-4T direct detection experiments.

Field of contribution:

492

Transverse single spin asymmetries in back-to-back photon + jet production

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We study the transverse single spin asymmetries (TSSAs) in back-to-back photon + jet production in scattering of unpolarized beams of protons off a transversely polarized proton target, with the aim of using these as a probe of the Gluon Sivers Function (GSF). We provide estimates within the region where the imbalance
$\vec{q}_\perp \equiv \vec{p}_{\gamma\perp} + \vec{p}_{J\perp}$
between the transverse momenta of the photon and the jet is much smaller than the average of the transverse momenta
$\vec{p}_\perp \equiv \frac{lvert\vec{p}_{\gamma\perp} - \vec{p}_{J\perp}rvert}{2}$,
i.e., the back-to-back region. The presence of these two scales in the process makes it particularly suitable for applying transverse momentum dependent (TMD) factorization, in contrast to conventional single-scale processes that rely on the generalized parton model approach where the factorization in terms of transverse momentum dependent parton distribution functions is assumed without formal proofs. We present our preliminary results for the transverse single spin asymmetry for this process in the context of the RHIC and NICA experiments.

Field of contribution:

Phenomenology

494

IDEA Preshower detector simulation for future circular collider

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The Future Circular Collider (FCC) study is developing designs for high-performance particle colliders to potentially follow the Large Hadron Collider (LHC) at CERN after its High-Luminosity phase. The plans include a 90.7 km tunnel at an average depth of 200 m, with eight surface sites supporting up to four experiments. The IDEA (Innovative Detector for Electron–positron Accelerator) has been selected for the FCC due to its innovative design, featuring a central tracker enclosed in a superconducting solenoidal magnet, a Preshower detector, a dual readout calorimeter etc. In the IDEA detector, the μRWELL technology; a single-amplification stage resistive Micro Pattern Gaseous Detector (MPGD), based Pre-shower and muon detectors are integrated with modular design of active tile area 50 × 50 cm2 and pitch width of 400μm. The $H \longrightarrow \gamma\gamma$ decay is a favorable channel to detect H which is the primary function of the electromagnetic calorimeter (ECAL). However, false signals from the short-lived neutral π0 decay into low-energy photons can be misidentified as an H signal when the π0 decays into two closely spaced, low-energy photons that together register as high energy in the ECAL. This challenge can be addressed by incorporating a fine-granular Pre-shower, capable of distinguishing between two very close, low-energy photons, thereby minimizing uncertainties in Higgs physics. The endcap and barrel Pre-shower are placed before the ECAL to overcome this deceptive signal problem. This presentation covers the current status of the Preshower's uni-layer barrel design with 32 sides and the endcap implementation for the IDEA detector, using DD4hep within the k4geo framework, which is standardized for all future Higgs factories. It also suggests future directions for developing Preshower detector geometry.

Field of contribution:

Experiment

495

Nonclassical Nature of Coherent Squeezed Vacuum State in the Oscillating FRW Universe

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The inflationary era is mostly related to the classical gravity in the Friedmann–Robertson–Walker (FRW) universe. In this study, we explore the behavior of a nonclassical scalar field in the context of the Friedmann-Robertson-Walker (FRW) universe. We represented the massive inflaton field in the semi-classical gravity using a coherent squeezed vacuum state. This state provides insight into quantum fluctuations, which play a critical role in the early universe, influencing cosmic inflation, structure formation, and the evolution of the universe. Mandel's Q parameter is useful for examining the nonclassical nature of the inflaton field. Hence, we investigated Mandel's Q parameter in the cosmological reference with related cosmological parameters for coherent squeezed vacuum state.

Field of contribution:

Theory

496

Boosting Beyond Standard Model Searches: ML-enhanced Nested Sampling for Rapid Parameter Estimation

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Exploring parameter spaces in Beyond Standard Model (BSM) scenarios, especially in high-dimensional cases, is computationally prohibitive and inefficient with conventional sampling due to the curse of dimensionality. In this study, we implement a Machine Learning (ML)-assisted Nested Sampling (NS) approach to estimate the posterior distribution of the Type-II Seesaw Model. We use a generative framework, namely, Real-valued Non-Volume Preserving (Real NVP) normalizing flows as our ML framework. We use the predictions of such a simulator to guide the iterations of the NS, with much fewer likelihood evaluations, while another pre-trained classifier effectively selects valid points of the parameter space. The predicted points with both correct and incorrect predictions are saved with the actual observable/likelihood values and are used to periodically re-train the simulator, thereby refining sampling accuracy. This approach achieves convergence with a tolerance of ~0.001 in a matter of days, significantly accelerating convergence relative to traditional sampling methods, which require several weeks.

Field of contribution:

Phenomenology

497

Simulation of Secondary Shower Production from Cosmic Muons Using a Triangular Scintillator Detector Setup in GEANT4

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This paper explores the production and detection of secondary particle showers produced by cosmic muons interacting with a lead absorber in a triangular scintillator detector setup. We used the GEANT4 simulation framework to model three scintillator detectors arranged to capture secondary particles produced by muons traversing a layer of lead. The configuration of the detector consists of arranging two parallel scintillator plates side by side (B and C) below a lead absorber. There is, finally, a third scintillator plate (A) which is placed above the layer of lead. This arrangement has the potential of counting primary muons, together with the secondary particles (gamma rays and electrons) which would be produced from interactions of muons with lead. We employed the Cosmic-ray Shower Library (CRY) as particle source and the FTFP_BERT physics list to simulate accurately the complex interactions and showers in the detector system.

During the simulation run, we processed a total of 129,600 muons (equivalent to an exposure of one week) to study the generation of secondary particles by varying lead thicknesses and how the detector responds. The detector coincidence mode was set at ABC, recording a count only when all three detectors fired simultaneously. Such a criterion ensures counting of only those events which had secondary particle production to trigger all detectors. The results indicated that with initial increase in lead absorber thickness, count rate increased due to more frequent generation of secondary showers. However, beyond a certain lead thickness, the count rate began to decrease. This decrease can be explained by noting the fact that at those greater thicknesses, the lead layer absorbed a larger number of secondaries before they could reach detectors, thus leading to fewer coincidence detections. Such threshold thickness values corresponding to other available absorber materials have been identified for possible experimental validation.

This preliminary analysis of the numerical simulations shows the promise of the proposed detector configuration to effectively observe secondary showers resulting from interaction of cosmic ray muons with intervening media. These results can be useful for further experiments involving different materials of varying thicknesses.

Field of contribution:

498

Equivalence of two component spinor mechanism and four component spinor mechanism in top quark pair production

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In this article, we calculate the S-matrix elements for the process $e^+e^- \rightarrow t\bar{t}$ mediated by Standard Model photon, Z boson and an additional $Z^{'}$ boson indicating the contribution from new physics. We calculate the amplitude square using two component spinor formalism and four component spinor formalism and show the equivalance of the results using the two formalisms. We also establish the relations between the couplings of $Z^{'}$ boson to fermions in the two component spinor formalism and four component spinor formalism.

Field of contribution:

500

Identification of Nuclear waste using Muon Scattering Tomography

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Imaging methods based on the absorption or scattering of atmospheric muons, collectively called "muon tomography"have many potential applications. Study of identification of Nuclear waste using multiple Coulomb scattering of cosmic ray muons is presented. Scattering angles for different radioactive materials used as fuel in nuclear reactors in India.
How can Cosmic ray muons be used to identify high Z-materials using muon scattering tomography? To solve the problem, dimension of fuel assembly of Advanced Heavy Water Reactor(AHWR) is used for Geant4 simulation and scattering angle is calculated for materials that are used for its fuel assembly.
The geometry of the muon detector is simulated using GEANT4 contains three plastic scintillators on top and bottom of a nuclear waste material cubic box shielded by concrete and stainless steel in cylindrical geometry. Recognition of the incoming vector is the difference between the hit locations in the second top detector layer and the third top detector, while the subtraction from the hit position in the second bottom scintillator yields the latter vector 1. Identification of material depends upon the muon scattering angle with the matter. ThO2 rods with enriched U233 and Pu244 are inserted in the cylinder whose outermost layer is made of stainless steel which is useful for AWHR designed in BARC, Mumbai 2.
Scattering angles are tabulated compared with A.I. Topuz data for nuclear waste materials. As for U233 scattering angles is calculated 169.037 63.498 at 1.25 GeV energy which is compared with the scattering angle of reference data 168.248 92.783. Energy range of cosmic ray muons that are used in simulation is 8 bins partitioned by 1.25 GeV to 4.75 GeV energy with a step of 0.5 GeV for Cs133, U233, and Th232 that are released as nuclear waste from nuclear reactors.
References:
1 Topuz, A. Ilker, Madis Kiisk, and Andrea Giammanco. "Non-destructive interrogation of nuclear waste barrels through muon tomography: A Monte Carlo study based on dual-parameter analysis via GEANT4 simulations." Journal of Instrumentation 17.12 (2022): P12005.
2 Garg, Kajal, and Sonali Bhatnagar. "Identification of nuclear wastage with the help of scintillation detectors." Pramana 95.1 (2021): 12.

Field of contribution:

Experiment

501

Polyakov loop potential at rich baryonic matter

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We calculated the Polyakov loop potential with chemical potential. The potential is calculated for a matter of both quark and hadrons and the quark matter at rich baryonic matter. It is identified from the calculation that there is a stability in the Polyakov potential with the chemical potential for different fields. From the quark and hadronic matter but the quark matter there is no such stability of the potential with the baryonic matter. It indicates that there will be possibility of finding the equation of state in this region of quark and hadronic phase.

Field of contribution:

Phenomenology

502

Precise measurements of the mass and decay width with singly reconstructed top quark at CMS experiment

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We present precise measurements of the mass and decay width of the top quark in the t-channel, the dominant production mode for single top quarks at the LHC. The final state includes a top quark and a light quark, resulting in at least two jets, one of which originates from the hadronization of a b-quark, along with an isolated high-momentum lepton (electron or muon) and significant missing transverse momentum from the escaping neutrino in the W boson decay. The analysis uses proton-proton collision data collected by the CMS experiment during 2016–2018. Standard Model backgrounds are studied in complementary regions, and a Deep Neural Network is employed to distinguish signal from background. Additionally, we estimate the expected sensitivity on the top quark mass and width through a simultaneous fit of both parameters.

Field of contribution:

Experiment

503

Precise probing of the dark sector at the LHC and its synergy with evolution mechanism in the early universe

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Despite compelling evidence from numerous astrophysical and cosmological observations, dark matter (DM) remains an enigma, lacking much insight into its fundamental properties and evolution in the early universe.

In this talk, we discuss how different DM scenarios, constructed with a minimalistic setup, can be probed at the collider, especially in the context of the Large Hadron Collider (LHC) with precision search.

It is fascinating to note the synergy between different DM candidates, such as WIMP and FIMP. Understanding their evolution mechanisms alongside the appropriate search strategies can significantly enhance the exploration of their unique signatures at colliders. Our investigations incorporate one-loop QCD corrections for the production processes and also leverage an advanced multivariate analysis, employing a boosted decision tree to optimise our search strategy, enhancing signal and background discrimination.

Field of contribution:

Phenomenology

504

Texture zeros in lepton mass matrices and its phenomenological implications in left-right symmetric model using $D_4 \times Z_2$ symmetry

Author: Happy Borgohain[1]

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We studied the possibility of texture zero in the lepton mass matrices in the framework of minimal left right symmetric model using the dihedral D_4 symmetry and Z_2 symmetry. This leads to interesting correlations between the neutrino parameters. From phenomenological point of view, we consider the observables like neutrinoless double beta decay (NDBD) and charged lepton flavor violation (LFV) within this framework. The study is carried out for both normal and inverted hierarchy keeping in mind the recent global fit neutrino data. We have varied the mass of the right handed gauge boson within the accessible collider limits and see its phenomenological implications.

Field of contribution:

Phenomenology

505

Quark Diagram Analysis of Bottom Meson Decays Emitting Pseudoscalar(P) and Tensor(T)Mesons

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Abstract Submission

Field of contribution:

506

Distinguishing between Dirac and Majorana neutrinos using temporal correlations

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In the context of two flavour neutrino oscillations, it is understood that the 2×2 mixing matrix is parameterized by one angle and a Majorana phase. However, this phase does not impact the oscillation probabilities in vacuum or in matter with constant density. Interestingly, the Majorana phase becomes relevant when we describe neutrino oscillations along with neutrino decay. This is due to the fact that effective Hamiltonian has Hermitian and anti-Hermitian components which cannot be simultaneously diagonalized (resulting in decay eigenstates being different from the mass eigenstates). We consider the PT symmetric non-Hermitian Hamiltonian describing two flavour neutrino case and study the violation of Leggett-Garg Inequalities (LGI) in this context for the first time. We demonstrate that temporal correlations in the form of LGI allow us to probe whether neutrinos are Dirac or Majorana. We elucidate the role played by the mixing and decay parameters on the extent of violation of LGI. We emphasize that for optimized choice of parameters, the difference in K4 (K3) for Dirac and Majorana case is ~15% (~10%).

Field of contribution:

Phenomenology

507

Exploring Constraints on Dark hypercharge Models with Light vector Mediator from COHERENT, TEXONO, and Dark Matter Direct Detection Experiments

Authors: ANIRBAN MAJUMDAR[1]; Dimitrios K. Papoulias[2]; HEMANT KUMAR PRAJAPATI[1]; Rahul Srivastava[3]

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Data from Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) and Elastic Neutrino-Electron Scattering (EνES) are utilized to constrain "chiral" $U(1)_X$ gauge models featuring a light vector mediator. These models represent a unique class of new symmetries known as Dark Hypercharge Symmetries, where the Z' boson couples to all Standard Model fermions at tree level. The $U(1)_X$ charges are assigned based on anomaly cancellation requirements, allowing significant variation in the relative charges of leptons and quarks across different solutions. This leads to distinct phenomenological signatures for each model, which can be tested and constrained through various experiments. In this work, we analyze recent COHERENT experiment data along with Dark Matter direct detection results from XENONnT, LUX-ZEPLIN, and PandaX-4T, placing new constraints on three benchmark models. We further include constraints from TEXONO data and discuss the potential for improvement with next-generation DM direct detection experiments, particularly the upcoming DARWIN experiment.

Field of contribution:

Phenomenology

508

Improved Impact Ionization Modelling for Thin Non-Irradiated Low Gain Avalanche Detectors

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The present and future detector systems in High Energy Physics (HEP) require fast timing, improved spatial measurements and good signal-to-noise ratio (SNR). This prompted the development of Low Gain Avalanche Detectors (LGADs) as an attractive alternative for replacing traditional silicon sensors for 4D tracking purposes. As fast timing necessitates thin sensors, the use of thin LGADs for timing applications is beneficial as they can provide a higher SNR due to their internal charge multiplication. However, these sensors have poor spatial resolution due to the design limitations imposed by the complex structural patterning required to produce adjacent pixels. For that reason, different technologies of LGADs with different gain layer profiles are under development with the aim to improve their capabilities. Since the optimization of these sensors is still in early stages, the investigation into their response continues to be an ongoing process.

To predict and optimize the LGAD performance, Technology Computer-Aided Design (TCAD) simulations are helpful in analyzing the generated and collected charge. Recent studies using common TCAD tools have shown discrepancies between simulated and observed charge collection in thin LGADs from major manufacturers for given design parameters. This emphasizes the need to refine impact ionization model parameters which are responsible for internal charge multiplication. Further, the thin sensors in contrast to the thicker versions have higher bulk field, higher drift velocity of signal charge carriers and reduced trapping effects due to lower drift length and time. This motivates the present study to optimize the various model parameters specifically for thin LGADs.

The present simulation studies focus on the parameterization of impact ionization models for thin non-irradiated LGADs to obtain the optimized sets of values for model parameters in Silvaco. As per the availability of the measurement results, we used deep and shallow junction thin LGADs with the p-well doping profiles derived from experimental CV characteristics. Further, it is observed that the optimized values of model-parameters obtained in the present work using Silvaco produce different results as compared to the previous optimization performed using other TCAD frameworks. This is in accordance with the prior studies related to the comparison between modelling in different TCAD tools that emphasize the inherent differences in different TCAD frameworks in respect of simulation models and parameters. Enhanced ionization models for LGADs represent an initial step toward optimizing these sensors under irradiation and developing designs that address their limitations.

Field of contribution:

Experiment

509

Study of higher-order cumulants of net-charge, net-hadron, net-kaon and net-proton production in pp collisions at $\sqrt{s} = 13$ TeV using Pythia8 and Herwig

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The study of higher-order cumulants of conserved quantities—such as net-charge, net-baryon, and net-strangeness distributions—is a valuable approach for determining freeze-out parameters and exploring phase transitions in heavy-ion collisions at LHC energies. Recent studies hint at the formation of Quark-Gluon Plasma (QGP) in smaller systems, such as proton-proton (pp) collisions, which further motivates this investigation.

In this contribution, the first Monte Carlo analysis of higher-order cumulants and their ratios for net-charge, net-hadron, net-kaon, net-baryon, and net-proton distributions in pp collisions at $\sqrt{s} =$ 13 TeV is studied by utilizing pQCD-based models such as Pythia8 and Herwig. This includes an examination of different particle production mechanisms and their influence on cumulant values. The results provide a foundational simulation baseline for upcoming LHC measurements, offering insights into the interplay between small system behavior and heavy-ion collisions.

Field of contribution:

Phenomenology

510

Insights into CP Violation through Majorana Phases of Neutrinos

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This is my abstract.

Field of contribution:

Phenomenology

511

Advancing Low-Gain Avalanche Diodes (LGAD) into Ultra-fast Silicon Detectors for Future Nuclear and Particle Physics Experiments

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Future collider experiments require tracking detectors with better time and spatial resolution than current technologies. Low Gain Avalanche Diodes (LGADs) offer a viable solution, providing time resolution < 20 ps and spatial resolution $\sim 50\ \mu$m using pixel segmentation. At HL-LHC, with an average of 1.6 collisions/mm, LGADs significantly improve fake jet rejection and jet-tagging efficiency. This study investigates the correlation of various detector designs and irradiation parameters with the signal output from LGAD electronics. Using the WeightField2 simulation package, we examine the impact of bias voltage, Gain Implant (G.I.) concentration, and sensor thickness on signal optimization, specifically for n-in-p monolithic LGADs with p-doped Si and SiC bulk. We determine the optimal sensor bulk width and compare results for both materials under HL-LHC conditions (-15°C), accounting for radiation damage and lattice defects. Our findings identify LGAD designs with time resolution ~ 20 ps and provide criteria for optimal signal output.

Field of contribution:

Experiment

512

Study of Inclusive Decay $\bar{D}^0 \to K_S X$ in Belle and Belle II Experiments

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Study of Inclusive Decay $\bar{D}^0 \to K_S X$

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We investigate the inclusive decay mode $\bar{D}^0 \to K_S X$, where X represents any particle that satisfies the decay condition. Within the Belle collaboration, we utilize the $\Upsilon(4S)$ resonance to produce B^+B^- pairs. Following hadron B-tagging, the B^- is reconstructed using the FEI algorithm, with the B^+ serving as the signal side. On the signal side, we identify the decay $B^+ \to \bar{D}^0\pi^+$. Subsequently, the number of K_S mesons in the $\bar{D}^0$ region is determined using the sPlot technique.

We present preliminary results from a Monte Carlo (MC) study focused on the signal and background of this decay mode, as well as on extracting the branching fraction for $\bar{D}^0 \to K_S X$.

Keywords: Inclusive decay, FEI algorithm, sPlot, Monte Carlo, branching fraction

Field of contribution:

Experiment

513

Light scalars at low energies: some exact results from QCD-like theories

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In this talk, I will present some exact results in supersymmetric QCD involving a light neutral chiral superfield. Using symmetry arguments, I will derive the exact low-energy superpotential, which describes the interactions between mesons and the additional scalar and pseudoscalar components of the neutral chiral superfield. The low-energy effective scalar potential will be determined under anomaly-mediated supersymmetry breaking. I will demonstrate that the pseudoscalar component can act as an axion, rotating the θ angle and predict its mass, while the scalar component functions as a dilaton. Extending these results to non-supersymmetric QCD, I will derive couplings between the mesons and a Higgs-mixed scalar by matching the chiral Lagrangian with the theory above the confinement scale, and constrain these interactions from Kaon decay.

Field of contribution:

Phenomenology

514

Exploring dark matter-baryon interactions from the survival of neutron star

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Neutron stars (NS), characterized by strong gravity and extreme density, provide a lucrative place to explore the properties of dark matter (DM) particles. We investigate the DM capture inside the neutron star and report that the DM capture rate enhanced for velocity and momentum-dependent DM-baryon interactions. The accreted DM particles get thermalized, form a gravitationally bound core, and eventually lead to a black hole formation inside the NS. After accreting the surrounding material, the black hole can destroy the host neutron star. Utilizing the existing pulsar data J0437-4715 and J2124-3858, we derive the stringent constraints on the DM-nucleon scattering cross-section across a broad range of DM masses.

Field of contribution:

Theory

515

Impact of sea quarks on transition quadrupole moment of baryons

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Electromagnetic properties serves as a powerful tool for unraveling the internal composition of hadrons, emphasizing the crucial role of sea quarks and gluons in shaping their dynamics. In the present work, we investigated the transition quadrupole moment ($\Delta^0 \rightarrow N$) using the statistical framework, incorporating the detailed balanced principle. The expansion of hadrons modeled in terms of various quark gluon Fock states as $|q\bar{q}g\rangle$, $|q\bar{q}gg\rangle$, $|q\bar{q}q\bar{q}\rangle$, $|ggg\rangle$. Each Fock state has associated probabilities in flavor, color and spin space. These probabilities are derived in terms of statistical coefficients based on appropriate multiplicities of Fock states. To better visualize sea, the individual contribution of scalar (spin-0), vector (spin-1) $\&$ tensor (spin-2) sea is calculated. We also addressed the SU(3) flavor symmetry breaking in sea by introducing a suppression factor $(1 - C_l)^{n-1}$ due to heavy mass of strange quark. This factor limits the generation of strange $q\bar{q}$ condensates and change the probabilities of Fock states, hence influence the value of transition quadrupole moment. Our computed results highlights the significance of both strange ($s\bar{s}$) and non-strange sea ($u\bar{u}, d\bar{d}$) in determining the decuplet (spin-$\frac{3}{2}^+$) $\rightarrow$ octet (spin-$\frac{1}{2}^+$) transition quadrupole moment. These results may provide useful information for upcoming experimental studies.

Field of contribution:

Theory

516

GEM Signal Readout PCBs and their Manufacturing, Validation, and Properties for High Eta Muon upgrade in CMS

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The High-Luminosity upgrade of the Large Hadron Collider (HL-LHC) introduces new challenges for experiments like CMS by substantially increasing the collision rate. This intensified luminosity will particularly affect the forward regions of the CMS detector, where particle flux will be most intense. To meet this challenge, CMS is deploying new Gas Electron Multiplier (GEM) stations—GE1/1, GE2/1, and ME0—in its forward muon system to enhance tracking and triggering capabilities in these highrate environments. The GEM stations require highly advanced, two-layer printed circuit boards (PCBs) for efficient signal readout and processing, which are specifically designed for the demands of HL-LHC. This report details the PCB-based readout system and validates its readiness for HL-LHC conditions. The GEM detector is essential to the CMS muon system, with the first station, GE1/1, already installed during the second long shutdown (LS2) to cover the pseudorapidity range from 1.55 to 2.18. Production is ongoing for two additional stations: GE2/1, which will span the range from 1.6 to 2.4, and ME0, covering 2.0 to 2.8. Operating in high-radiation environments presents unique challenges, particularly for signal readout systems like PCBs. To address these, the readout materials are specifically tailored for the Phase 2 upgrade of the CMS GEM detectors, with radiation-hardened substrates to minimize contamination and ensure signal fidelity in high-radiation zones. The fabrication of the PCBs involves advanced techniques to meet the precision demands of HL-LHC. Processes such as CNC drilling ensure the accuracy and uniformity of boreholes, and electroless copper plating reinforces the copper layers. Techniques including outer layer photo printing, microetching for surface treatment, and resist stripping ensure micron-level precision and high-density signal tracks, optimizing overall detector performance. To extend PCB lifespan, chromite passivation is applied after component assembly. Rigorous validation procedures are essential to guarantee PCB reliability under the extreme conditions of the CMS experiment. Mechanical and dimensional inspections, electrical testing, structural analysis, and signal integrity assessments identify potential manufacturing defects and inconsistencies. A thermal stress test evaluates the resistance of the PCB's base material and copper layers to temperature fluctuations, ensuring long-term stability and functionality. This summary focuses on the properties, fabrication processes, and performance validation of PCBs designed for high-flux radiation environments in the CMS GEM detectors, ensuring readiness for the HL-LHC era.

Field of contribution:

Experiment

517

High Eta Muon upgrade in the CMS experiment and operation of the GE1/1 detectors

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The High-Luminosity Upgrade of the Large Hadron Collider (HL-LHC) aims to boost luminosity to approximately in the range of 5 x 10^{34} cm^{-2} s^{-1} to 7 x 10^{34} cm^{-2} s^{-1}, significantly increasing the discovery potential of its detector system. In the CMS detector, particularly in the muon spectrometer, upgrades are essential to manage the higher Level-1 muon trigger rates and to sustain the overall performance of the endcap muon system. To meet this challenge, gaseous detectors based on triple-Gas Electron Multiplier (GEM) technology will be installed in the innermost region of the CMS muon spectrometer, where particle fluxes will be most intense. The triple-GEM technology, selected for its radiation hardness and high spatial resolution, will extend the acceptance and maintain the performance of the CMS muon spectrometer under the demanding HL-LHC conditions. The first station, GE1/1, was installed during Long Shutdown 2 (LS2) and has been fully operational since the start of Run 3 in 2022. Integrated into CMS's data acquisition and online data quality monitoring systems, GE1/1 adds two additional muon hit measurements in the pseudorapidity region from 1.55 to 2.18, enhancing muon tracking and triggering capabilities. This improvement allows the muon trigger rate to be managed without raising the threshold on muon transverse momentum. The chambers in GE1/1 operate with high stability, achieving efficiency levels over 95%. Experience with the first large-area GEM station, GE1/1, has provided valuable insights for further advancements in detector and electronics design. Based on these insights, several significant improvements have been made to extend the detector lifespan, minimize discharge spread, and mitigate crosstalk during operation. The success of GE1/1 has established a foundation for designing and implementing the next GEM stations, GE2/1 and ME0. In this abstract, we present an overview of the GE1/1 operation, summarize key lessons learnt, and highlight the impact these insights will have on the development of future GEM stations in the CMS muon system.

Field of contribution:

519

Preheating in the Universe: Einstein-Jordan frame correspondance

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Cosmological observations indicate that the Universe underwent an inflationary phase in the very early stages of evolution, which lead to its supercooled state. Then, to again heat up the Universe and generate particles, there was a phase of preheating and/or reheating, the exact description of which depends on the particle physics model and the interaction Lagrangian. In contrast to this, the preheating phase can also be explained as an effect of modified gravity, by coupling the matter fields non-minimally to the gravity sector. In this study, we build a relationship between the Einstein and Jordan frame Lagrangian, in order to explain the parametric resonance effect needed for preheating. We consider different forms of potential with a parametric resonance term in the Einstein Frame and its correspondance to a non-trivial f(R) and conformal-like coupling in the Jordan Frame. This study is a first step towards building an important relationship between the two frames that will allow further investigations on the production of primordial gravitational waves and black holes during preheating

Field of contribution:

Theory

520

Constraining the neutron star equation of state by including the isoscalar-vector and isovector-vector coupling using the Bayesian approach

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We constrain the nuclear matter equation of state by including the isoscalar-vector and isovector-vector coupling using the Bayesian approach. We use the recent observation GW190814 (R. Abbott et al 2020 ApJL 896 L44) for the compact star of mass 2.6 $M_\odot$ along with the nuclear saturation properties for finite and infinite nuclear matter at saturation properties at saturation and supra-saturation. Here we see that the cross coupling between isocalar-vector and isovector-vector is more effective to reach such high mass of compact star. We use FSUGold and IU-FSU parameters as the references. Finally, we discuss the effects of such coupling on the non-radial oscillations of neutron stars.

Field of contribution:

521

Inclusive-jet photoproduction with Pythia for Electron-Ion Collider

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Inclusive-jet photoproduction at HERA has shown to be a favorable ground for verifying perturbative QCD with the obtained jet cross-section. Monte-carlo event generator PYTHIA8 is used to compare the data of ZEUS collaboration aiming for high precision measurements of α_s at HERA. Inclusive-jet photoproduction in the reaction $e^+ + p \to e^+ + jet + X$ with beam energies E_p = 920 GeV, E_e = 27.5 GeV and centre-of-mass energy $\sqrt{s}$ = 318 GeV is analyzed using different parton distribution function (PDFs) and jet reconstruction algorithm such as, k_T, anti-k_T and SIScone. A better fit for parton content of photon is required for precision phenomenology at Electron-Ion collider, the successor of HERA that will be colliding spin polarized electrons and ions at energy scales from 29-141 GeV. The framework developed from the validated results is used in making prediction for differential cross-section at EIC with different centre-of-mass energies (44.7, 63.2, and 141.4 GeV) at low and high photon virtualities. This study further aims to explore the multi-parton interaction from hadronic fluctuation of the exchanged photon.

Field of contribution:

Phenomenology

522

Isospin-Dependent Inverse Potentials for Elastic Pion-Nucleon Scattering in the S11 and S31 Channels

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Background: The study of pion-nucleon scattering is essential in particle and nuclear physics due to the complexities introduced by strong interactions and isospin-dependent dynamics. The analysis of pion-nucleon scattering provides insights into resonance behavior and the underlying forces between pions and nucleons.
Purpose: In this work, we construct inverse potentials for pion-nucleon scattering by choosing a piece-wise smooth Morse function as a reference, focusing on single channel scattering processes. Our study specifically targets the S11 (isospin T = ½) and S31 (isospin T = 3/2) states to capture the isospin-dependence in the scattering interaction.
Methodology: The phase equations for ⊠ = 0 channel are solved using the fifth-order Runge-Kutta method, enabling the calculation of scattering phase shifts across a range of energies up to 310 MeV. Model parameters of the reference function were optimized by minimizing the mean squared error (MSE) between the computed and expected scattering phase shifts, providing an accurate description of the pion-nucleon interaction for both isospin states.
Results: The inverse potentials for pion-nucleon scattering, were successfully constructed with MSE equal to 0.12 and 0.0004 for S31 and S11 respectively. For the S11 state, the inverse potential analysis reveals a strong attractive potential with a depth of Vd = −384.86 at a short range of rd = 0 .55 fm. This state also exhibits a moderate Coulomb barrier of VCB=9.85 at a distance of rCB = 1.59 fm, reflecting the repulsive effect of the pion's charge at close proximity to the nucleon. In contrast, for the S31 state, we observe a significantly shallower potential depth of Vd = −121.818 MeV, extended to rd = 0.78 fm, indicating a weaker but more extended interaction range. The Coulomb barrier for this state is minimal at VCB = 0.0003 MeV and rCB = 5.56 fm, suggesting a reduced repulsive influence in this isospin channel. These results underscore the isospin-dependent nature of the pion-nucleon interaction, highlighting distinct scattering behaviors in the S11 and S31 channels.

Conclusion: The constructed inverse potentials accurately describe the isospin-dependent dynamics of pion-nucleon scattering in the S11 and S31 channels, as reflected in the low MSE values of 0.0004 and 0.123, respectively. These results offer valuable insights into the strength and range variations of pion-nucleon interactions across different isospin states, supporting further exploration of resonance and scattering phenomena in particle physics.

Field of contribution:

Theory

523

CMS Muon System Upgrade Featuring the ME0 Module with GEM Technology for Enhanced Forward Detection in the High-Luminosity LHC

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The High-Luminosity Large Hadron Collider (HL-LHC) upgrade will substantially increase the instantaneous luminosity, achieving values between 5 × 10ˆ34 cm^{-2} s^{-1} and 7 × 10ˆ34 cm^{-2} s^{-1}, approximately seven times the nominal level. This upgrade intensifies the particle flux, creating significant challenges for the forward sections of the Compact Muon Solenoid (CMS) detector. In response, new Gas Electron Multiplier (GEM) stations, GE2/1 and ME0, will be installed within the CMS muon system to strengthen its forward capabilities. These stations will enhance the tracking and triggering efficiency in regions with high particle flux.

The ME0 station is a pivotal addition to CMS, extending the detector's pseudorapidity coverage to the range $2.03 < |\eta| < 2.80$. This expansion takes advantage of CMS's improved inner tracking capabilities, optimizing muon identification efficiency within this extended range, especially in the extreme forward region where particle flux is highest. Built on the successful performance of GEM technology in GE1/1, ME0 is designed to meet the demanding HL-LHC environment, featuring high spatial resolution, rapid rate handling, and strong radiation resistance.

This presentation offers an overview of the CMS muon system upgrade with GEM technology, focusing on the ME0 upgrade. It covers the design, chamber production, and validation processes essential to this enhancement.

Field of contribution:

Experiment

524

Electromagnetic signals within viscous Gubser flow

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We investigate thermal dilepton production in heavy-ion collisions using relativistic second-order Israel-Stewart hydrodynamics with Gubser solutions. The Gubser flow considers both the transverse expansion of the medium along with longitudinal boost invariance. We study in detail the temperature and shear stress evolutions of hot QCD medium by varying the associated parameter q of the Gubser model. The dilepton production is calculated in the presence of Chapman-Enskog like viscous correction to the particle distribution function. Varying the parameter q, we find enhanced dilepton production at small q values. We also extract effective temperature of hot QCD medium from the transverse mass spectra for different q values.

Field of contribution:

Theory

525

Non-Radial Oscillations of Dark Matter Admixed Strange Quark Stars

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We investigate the non-radial fundamental f-mode oscillations of dark matter (DM) admixed strange quark stars (DMSQSs) using an equation of state (EoS) that accounts for feebly interacting DM in strange quark stars (SQSs). By varying EoS parameters, we examine the structural properties (mass, radius, and tidal deformability) of DMSQSs in light of astrophysical constraints. Our analysis reveals the impact of DM on f-mode spectra within the Cowling approximation, yielding frequencies as a function of mass, compactness, and star composition. Notably, this study pioneers the examination of non-radial f-mode oscillations in DMSQSs. We also obtain that the mass-scaled angular frequency of DMSQSs varies universally with the compactness.

Field of contribution:

Theory

526

Probing deep interiors of Earth using atmospheric neutrino oscillations

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Information about the interior of Earth is traditionally obtained through indirect probes such as seismic and gravitational measurements. Atmospheric neutrinos serve as an independent tool for probing the deep interiors of Earth using weak interactions, offering insights complementary to those obtained from other studies. As multi-GeV neutrinos pass through Earth, they experience Earth matter effects that depend on both neutrino energy and the electron density distribution along their path, making them ideally suited for exploring the inner structure of Earth. In this talk, we present the expected sensitivity of an atmospheric neutrino experiment, such as an iron calorimeter detector (ICAL), to simultaneously constrain the core radius and density jumps inside Earth. Our analysis uses a five-layered density model of Earth, where layer densities and the core radius are modified to explore the parameter space, ensuring that the mass and moment of inertia of Earth are conserved and the hydrostatic equilibrium condition is satisfied. Additionally, we show that the capability of the ICAL detector to distinguish neutrinos from antineutrinos is crucial for effectively constraining the parameter space.

Field of contribution:

Phenomenology

527

Compton Polarimetry for 11 GeV electron beam during the MOLLER Experiment at Jefferson Laboratory

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The recent 12 GeV energy upgrade at the Thomas Jefferson National Accelerator Facility in Virginia has opened many new experimental possibilities including need for advancements in beam polarization measurement techniques. We will present some results from the preliminary analysis framework developed using GEANT4 for the Compton data analysis along with other novel ideas being attempted. We are also carrying out systematic studies on the polarization measurement through the setup and will share the preliminary studies and development. This Compton Polarimeter is integral to the MOLLER (Measurement of Lepton-Lepton Electroweak Reaction) experiment at JLab that seeks to measure the parity-violating asymmetry in electron-electron scattering with unprecedented precision, targeting a high-precision (2.4%) determination of the weak charge of the electron. Polarimetry is the biggest contributor in the error budget of this precision measurement. The design for this Compton polarimeter incorporates a magnetic chicane that bends the main electron beam into a laser-locked cavity where some electrons get Compton scattered with the photons of green laser. These backscattered photons are to be measured in a scintillator based photon detector and the thus scattered electrons are registered in a novel diamond pixel-based electron detectors. GEANT4 and Modelsim simulations will optimize detector response, timing, and noise reduction. This work builds on techniques from the Qweak experiment and introduces novel components for achieving new standards in precision polarimetry, essential for probing electroweak physics.

Field of contribution:

Experiment

528

Characterization study of CsI(Tl, Eu) Crystal.

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Thallium-doped CsI scintillators are well-regarded for their high light output (˜64,000 photons/MeV), relatively fast decay time, and responsiveness to various types of radiation, making them strong candidates for applications in medical imaging, security scanning, high-energy physics, and other radiation detection fields. However, a limitation of CsI(Tl) is its long afterglow, which reduces effectiveness in fast radiographic and radionuclide imaging. This afterglow can lead to pulse pileup in high count-rate situations, diminished energy resolution in nuclear imaging, and artifacts in computed tomography. This study aims to reduce the afterglow effect in CsI(Tl) crystals by introducing Europium as a codopant. We present findings from characterizing and evaluating CsI(Tl, Eu) for energy resolution, threshold, trigger efficiency, and afterglow time range in this symposium.

Field of contribution:

Experiment

530

Exploring Flavor Dependent Long-Range Interactions in Atmospheric Neutrino Oscillation at IceCube DeepCore

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The IceCube experiment is a cubic kilometer neutrino observatory at the South Pole which uses an array of Digital Optical Modules (DOMs) deep inside the ice to detect the neutrinos. IceCube has a denser geometry of DOMs at its bottom central region known as DeepCore which enables it to detect GeV energy atmospheric neutrinos. DeepCore provides a unique avenue to explore various tiny Beyond the Standard Model (BSM) physics scenarios with its high statistics data. In this work, we consider a minimal anomaly free extension of the Standard Model by an additional lepton-number symmetry ($L_e - L_\mu$ or $L_e - L_\tau$) which can introduce a very light gauge boson mediating flavor-dependent neutral current long-range interaction. This new interaction may lead to significant modifications in neutrino oscillation probabilities which can be observed in the atmospheric neutrino oscillations data at DeepCore. In this talk, we present the sensitivity of the IceCube DeepCore to put constraints on this flavor-dependent long-range interaction potential with a runtime of 9.3 years.

Field of contribution:

Experiment

531

Using angular observables to probe primary operators at colliders

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The precise measurements of interactions of the Higgs boson with the particles of the Standard Model (SM), especially electroweak gauge bosons, at the LHC, serve as indirect probes of heavy new physics. To facilitate this, we consider a theoretical framework based on amplitude approach in which the most general amplitude for a process can be factorized into a set of primaries, which are finite in number, with each multiplied by a series in Mandelstam variables, called descendants. A connection between this amplitude expansion with the partial wave expansion is established by identifying the primaries as the minimum-J amplitudes. Considering the Higgsstrahlung process : $f\bar{f} \longrightarrow Z(ll)h(b\bar{b})$, a set of independent primary amplitudes linked to the independent helicity combinations are identified by considering contributions from both 3-point and 4-point couplings. These primary operators do not always appear at the leading order in the EFT expansion (for e.g. not at dimension 6 for SMEFT), but they do provide the leading contribution to particular experimental observables. Finally, we propose observables, called angular moments, as coefficients of independent differential distributions in three different angular variables at the level of Z-decay products. These observables are useful to probe the partial wave amplitudes corresponding to the independent helicity combinations that receives dominant contribution from the primary amplitudes. This will help to maximally constrain all the effective couplings associated with the different vertex structures relevant for our process.

Field of contribution:

Phenomenology

532

Comparative Analysis of Cosmic Ray Intensity Variations Across Different Latitudes using DEASA

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On Earth, the flux of cosmic rays measured at ground level fluctuates, primarily influenced by two main factors: solar activity in space and atmospheric effects which influence the daily variations of the count rate of particle detectors. However, the effects of temperature, humidity, electric field, and gravity are negligible in comparison to the effect of pressure; and the correction for the pressure is necessary 1.

This study focuses on the relationship of pressure corrected cosmic ray intensity (CRI) modulation through Dayalbagh Educational Air Shower Array (DEASA) and neutron monitors (NM) at different latitudes such as DEASA in India is operated at latitude 22.17 N with cutoff rigidity 14.35 GV which near to tropic of cancer a mid - latitude, Oulu NM in Finland operated at high latitude of 65 N with lower cutoff rigidity of 0.8 GV, and the Don Inthanon NM in Thailand at lower latitude 18 N with high cutoff rigidity of 16.8 GV respectively [2,3].

To remove atmospheric pressure dependence from raw secondary cosmic ray data for the duration of 2020 -2022. The linear regression analysis was applied to observed DEASA raw CRI fluctuations (%) with relative pressure to derive a pressure coefficient of -0.36/mbar in 2020, and -0.50 /mbar in 2022 respectively. Pressure-corrected DEASA CRI were then compared to the neutron monitor data, revealing a degree of correlation -0.23 ± 0.10 with the Oulu NM and -0.55 ± 0.07 with the Don Inthanon NM, suggesting latitude-dependent responses to cosmic ray modulation. The high /

low amplitudes in CRI have been investigated during 2020-22 using the neutron monitor data for different latitudes. Finally the harmonics of daily variations in CRI for different latitudes will be presented.
This comparative analysis highlights the influence of latitude, cutoff rigidity, and atmospheric pressure on CRI. The results advance our understanding of CRs behavior across varying latitudes and provide insights into solar modulation effects, enhancing the accuracy of CR Intensity. This work has implications for space weather prediction and contributes to broader studies in high-energy astrophysics[4].

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Field of contribution:

Experiment

533

study the p_T spectra of light-flavor hadrons in different charged-particle multiplicities for p + p collisions at √s = 7 TeV.

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study the p_T spectra of light-flavor hadrons in different charged-particle multiplicities for $p + p$ collisions at $\sqrt{s} = 7$ TeV

we present the published data of ALICE at the mid-rapidity region to study the p_T spectra of light-flavor hadrons in different charged-particle multiplicities ($\frac{dN_{ch}}{d\eta}$) for $p + p$ collisions at $\sqrt{s} = 7$ TeV.
We parametrize the p_T spectra of different hadrons such as pion ($\pi^+ + \pi^-$), kaon ($K^+ + K^-$), K_S^0, K^{*0} ($K^{*0} + \bar{K^{*0}}$), ϕ, proton (p + $\bar{p}$), lambda ($\Lambda + \bar{\Lambda}$), cascade ($\Xi^- + \bar{\Xi}^+$) and omega ($\Omega^- + \bar{\Omega}^+$) using Tsallis distribution.
We perform this analysis by considering both differential and single freeze-out scenarios.
In a differential freeze-out scenario, we notice that, the Tsallis parameter n increases with multiplicity for most of the particles. This implies that the multi-partonic interactions increase the multiplicities in $p + p$ collisions, bringing the system towards thermal equilibrium.
The value of parameter T increases with the mass of the hadrons and increases with the multiplicity. This supports the differential freeze-out scenario and suggests that massive particles freeze-out earlier from the system.
In the case of a single freeze-out scenario, the value of the parameter n has a little variation with multiplicity and the parameter T increases with multiplicity. This implies that the degree of thermalization remains similar for the events of different multiplicity classes.

Field of contribution:

Phenomenology

534

Reconstruction of Cherenkov ring from the first test beam data of dRICH detector of the Electron-Ion Collider (EIC) experiment

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Understanding the internal structure of the nucleons and the fundamental interactions that govern the particle behavior such as mass, spin, and distribution of momentum among quarks and gluons is crucial to reveal a clearer picture of the Standard Model of Particle Physics. To probe these, an Electron-Ion Collider (EIC) experiment will be built, which will unlock the secrets of the strong force in nature, by colliding electron-proton and electron-ion at Brookhaven National Laboratory (USA). To identify various particles (such as protons, kaons, and pions) created in high energy collisions at EIC; accurate Particle Identification (PID) is pivotal. To achieve precise PID across a broad range of momenta, a dual-radiator Ring Imaging Cherenkov (dRICH) detector will be employed in the EIC.

As the Part of R&D for dRICH; in October 2023, a test beam was performed at CERN to validate the performance of various components of the detector. In the test beam, a polarized beam of $\pi-$ (pions) with collision energy of 10GeV was projected. PID was done using a dual-radiator Ring Imaging Cherenkov detector with Aerogel (n = 1.02) and C2F6 (n=1.0008) acting as the two radiators.

This work presents a comprehensive analysis of the Cherenkov ring detected by the dRICH detector within the test beam setup with a primary objective to study the ring parameters, the background noise/dark count rate, and the intensity of photons that are striking individual SiPMs. The estimated parameters are validated for accuracy and reliability by employing various fitting techniques.

Field of contribution:

Experiment

535

Enhancing Dark Matter Phenomenology with Vector-Like Quarks in the IDM

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The Inert Doublet Model (IDM) is among the most extensively studied frameworks for addressing the mystery of dark matter (DM). We considered here an interesting aspect of compressed spectrum scenario and its implications for DM phenomenology and collider probes. In this context, I will discuss the role of an additional vector-like quark (VLQ) which improves the DM scenario and gives interesting signatures at present and future collider experiments.

Field of contribution:

Phenomenology

536

Explaining the Filamentary Structure Connecting the Radio Lobes of the Galaxy ESO 137–006

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Filamentary structures in radio galaxies have been known for a few decades. Over the past few years, owing to the high resolution and sensitive images of the radio sky with telescopes such as the LOFAR and the MeerKAT, the number of radio galaxies found to harbor such structures has increased manyfold. ESO 137−006 (coordinates 16:15:03.8 −60:54:26; J2000) is a luminous radio galaxy as seen by Meerkat ($L_{1.4\,GHz} \simeq 2 \times 10^{32}$\, erg\,cm^{-2}\,Hz^{-1}; Sun 2009), lying at the center of the merging Norma galaxy cluster. This galaxy has been observed through X-ray telescope XMM-Newton with its EPN and EMOS modules.

An ellipsoidal shockwave generated at the center of a galaxy and moving orthogonal to the plane of the galaxy evolves to produce bubble-like structures over timescales of Millions of years and as it gets older, the collimated synchrotron threads (CSTs) may take its visible form as the remnant of the bubble. I have simulated the shockfront using blast wave equations and have given feasible explanations for this. The total synchrotron radiation behind the shock and ratio of the magnetic to the cosmic electron energy density is also calculated. An azimuthal profile is extracted using binned sectors in annulus form crossing the thread location of ESO 137-006 galaxy. The corresponding X-ray and radio photon counts are calculated from different regions and a count rate profile is made. A detailed explanation will be presented at the oral presentation.

Field of contribution:

Theory

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Dark Energy Stars and Gravitationally Sensitive Oscillations

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We investigate the fundamental oscillation modes of anisotropic dark energy stars using the Chaplygin prescription, incorporating anisotropic effects via the Bowers-Liang model. We study the global properties of anisotropic dark energy stars by solving stellar structure equations, and also compare the obtained mass-radius profiles with observational data from gravitational wave events and millisecond pulsars. We employ the well known Cowling approximation to compute the prominent non-radial f-modes for different values of anisotropy parameters that ranges from -2 to $+2$. We report that f-mode spectra of anisotropic dark energy stars are distinct from those of neutron stars and quark stars. We strongly believe that this distinct nature of the spectra would result in easy identification in the near future. Moreover, the tidal deformability characteristics of anisotropic dark energy stars have also been investigated.

Field of contribution:

Theory

538

Effect of light right-handed neutrinos on $\Upsilon(1S) \to B_{(c)}\tau\bar{\nu}_\tau$ decay mode in the effective field theory framework

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Driven by the persistent anomalies observed in the $b \to (u,c)\tau\bar{\nu}_\tau$ decays, we investigate these transitions within the framework of effective field theory, incorporating possible contributions from light right-handed neutrinos. By performing a global fit to the available experimental data, including measurements of $R_{D^{(*)}}$, $R_{J/\psi}$, R_π, $P_\tau^{D^*}$ the branching ratio for $B_c \to \tau\bar{\nu}_\tau$, and $B \to \pi\tau\bar{\nu}_\tau$, we determine the allowed ranges for the Wilson coefficients associated with various new physics scenarios. We then explore the impact of the constrained new parameters, specifically those arising from light right-handed neutrinos, on the semileptonic decay $\Upsilon(1S) \to B_{(c)}\tau\bar{\nu}_\tau$. Furthermore, we examine the existence of lepton non-universality in these decay modes.

Field of contribution:

Phenomenology

539

Dark Z and dark photon effects on $B_c \to D_s^{(*)}\mu^+\mu^-(\nu_\ell\bar{\nu}_\ell)$ decay modes

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We explore the role of dark matter in connection with flavor physics by using the dark force carriers, dark Z and dark photon. We perform a global fit to the new parameters using existing data on

$b \to s\mu^+\mu^-$ transitions. With these constrained parameters, we examine the improvements in the branching ratios and angular observables of the semileptonic $B_c \to D_s^{(*)}\mu^+\mu^-(\nu_\ell\bar{\nu}_\ell)$ decay modes relative to Standard Model predictions.

Field of contribution:

Phenomenology

540

Experimental Cosmic Ray studies through the Portable Muon Telescope.

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To analyze atmospheric pressure effects on muon flux intensity related to meteorological factors over long periods provide valuable insights into the dynamics of space weather and climate change. This study analyzes the relationship between muon flux and atmospheric conditions, specifically pressure, using data recorded since 2015 with portable detectors. Data have been collected from two configurations of muon detectors. The first configuration includes two plastic scintillators—one coupled with wavelength-shifting fibers and the other with a light guide—measuring 23.5 cm x 24 cm x 2 cm and 32 cm x 10 cm x 2 cm, respectively. In the second setup, both detectors are plastic scintillators with wavelength-shifting fibers, each measuring 23.5 cm x 24 cm x 2 cm. Both configurations have been oriented vertically for data collection. The solid angle between two detectors in the first assembly is 0.06 sr, and for the second assembly of muon detectors is 0.15 sr. The distance between the detectors is 15 cm in each of the set up2.
This experiment has been conducted at Dayalbagh Educational Institute in Agra, where muon flux data were collected from the first setup in 2019, before Covid and from the second in 2022 post Covid. To assess correlations, the same two month comparison has been made between muon count rates and atmospheric pressure , from 2019 and 2022.
The analysis reveals a significant negative correlation between atmospheric pressure and muon flux. In 2019, the raw data indicated a pressure coefficient of -0.02/mbar and a correlation coefficient of -0.50 ± 0.11. applying correct data, the correlation coefficient improved to -0.36 ± 0.13. Similarly, in 2022, raw data presented a pressure coefficient of -0.14/mbar and a correlation coefficient of -0.49 ± 0.11. After data corrections, the correlation strengthened significantly, reaching -0.96 ± 0.01. In 2019, the initial raw data indicated a pressure coefficient of -0.02/mbar and a correlation coefficient of -0.50. After applying data corrections, the correlation coefficient improved to -0.36 ± 0.13. Similarly, in 2022, raw data presented a pressure coefficient of -0.14/mbar and a correlation coefficient of -0.49 ± 0.11. After data corrections, the correlation strengthened significantly, reaching -0.96 ± 0.01.
The measured value of relative Muon flux intensity for the two months in the year 2019 range from -11 to 58, while 2022 data vary from -7.5 to 12.5. Can this fall in the muon flux intensity be due to the minimum solar activity in 2019 for the solar cycle 25 ? This lockdown has a significant effect on the atmospheric conditions in terms of the air pollution.
These findings suggest that pressure-corrected muon flux data are essential for accurate measurements and highlight potential implications for solar modulation, which influences cosmic ray intensity, particularly during periods of increased solar activity. This approach enriches the understanding of cosmic ray behavior, atmospheric effects, and their implications for climate studies[3].
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Field of contribution:

Experiment

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Investigation of Event Shape Variables as Discriminators of Jet Topology in High-Energy pp Collisions at different energies

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In proton-proton (pp) interactions at high energies, the shape of an event—defined by the distribution of particle momenta—is an effective tool for probing the underlying event topology. This study looks at event shape observables, namely transverse sphericity, sphericity, aplanerity etc. to see how they vary with the jet production. We use PYTHIA simulations to assess pp collision data at center-of-mass energies of 7 TeV, 13.6 TeV, and 27 TeV. This study intends to provide insight into the efficacy of transverse sphericity, sphericity and aplanerity as a discriminator in different energy regimes, with implications for jet topology studies in future high energy experiments.

Field of contribution:

542

A modular perspective to the jet suppression from a small to large radius in very high transverse momentum jets.

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In this work, we extend the scope of the JETSCAPE framework to cover the jet radius parameter (R) dependence of the jet nuclear modification factor, R_{AA}, for broader area jet cones, going all the way up to R = 1.0 . The primary focus of this work has been the in-depth analysis of the high-p_T inclusive jets up to 1 TeV (to probe the quark-gluon plasma medium at much shorter distance scales) and the quenching effects observed in the quark-gluon plasma formed in the Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV for the most-central (0-10%) collisions. The nuclear modification factor is calculated for inclusive jets via coupling of the MATTER module (which simulates the high virtuality phase of the parton evolution) with the LBT module (which simulates the low virtuality phase of the parton evolution). These calculations are then compared with the experimental results collected from the ATLAS and the CMS detectors in the jet transverse momentum (p_T) ranging up to 1 TeV . The predictions made by the JETSCAPE are consistent in the high p_T range as well as for extreme jet cone sizes, with the deviations staying within 10-20%. Our major focus is on calculating the double ratio ($R^{\mathrm{R}}_{\mathrm{AA}}/R^{\mathrm{R=small}}_{\mathrm{AA}}$) as a function of jet radius and jet-p_T, where the observations are well described by the JETSCAPE framework which is based on the hydrodynamic multi-stage evolution of the parton shower.

Field of contribution:

Experiment

543

Volume effect on the QCD phase diagram and the first order line

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As various ongoing and upcoming experiments explore the QCD critical point, it is important to theoretically study various factors that become significant in such searches. In particular, the size of the system created in such experiments is not too large compared to the strong interaction scale. It is important to explore the effect of the finite system size on the phase diagram.

Using an effective model of QCD we will explore the effect of the finite system size on the phase diagram, in particular on the critical point and the associated first order line, and the baryon number susceptibilities. Our study uses the MIT boundary condition: the importance of an appropriate boundary condition in finite volume studies will be discussed. The kinetics at the first order line will also be briefly discussed.

Field of contribution:

Theory

544

Measurement of the WW production cross-section at 13.6TeV with the CMS experiment

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We will present the recent measurements of opposite-sign WW production cross-section in proton-proton collisions at a center-of-mass energy of 13.6 TeV. The data used were collected by the CMS experiment in 2022 during Run3 of the LHC, corresponding to an integrated luminosity of 34.8 fb-1. The events were selected using leptonic decay channel by requiring one electron and one muon of opposite charge, and for the first time in proton-proton collisions, WW events with zero, one, and at least two jets were studied simultaneously and compared with theoretical predictions. Both inclusive cross-section measurement and, differential cross-section measurement as a function of the jet multiplicity in the event will be presented.

Field of contribution:

Experiment

545

Leptoquark influenced non-standard interactions at DUNE

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Co-authors: AJAY KUMAR YADAV [1]; Jogesh Rout [2]

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Neutrino experiments currently prioritize precise measurements of every oscillation parameter. Foreseeing data from long-baseline neutrino experiments, we impose constraints on leptoquark couplings derived from decays such as $\pi^0 \to l_l^{\pm} l_j^{\mp}$ and $\tau^- \to l(\pi^0, \rho^0, \omega)$, where $l = e, \mu$. These couplings potentially induce significant non-standard interactions (NSI), which experiments like DUNE can elucidate. Utilizing the constrained NSI parameters, we explore the sensitivity to standard unknowns in the neutrino sector at DUNE. We distinguish intrinsic CP-violation effects from extrinsic CP-violation effects, as matter effects brings extrinsic CP-violation into intrinsic CP-violation, further complicated by the presence of NSI.

Field of contribution:

Phenomenology

546

Field induced phase transition and Entropy growth in Schwinger pair production by Sauter felds

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Particle–antiparticle pair creation from a vacuum under the action of a strong electromagnetic (EM) field is one of the most profound phenomena in quantum electrodynamics (QED). This phenomenon of pair creation can be seen as a field-induced phase transition (FIPT) [1,5]. This occurs because the vacuum state evolves over time due to the non-stationary Hamiltonian [7], leading to spontaneous symmetry breaking under time reversal. As a result, electron-positron pairs are generated, acting as massive analogues of Goldstone bosons [2,3].To measure this symmetry breaking, we define a complex order parameter, Φ(p, t), given by Φ(p, t) = 2⟨0in|a† p(t)b† −p(t)|0in⟩ =|Φ(p, t)| exp(iψ(p, t)), where a† p(t) and b† −p(t) are operators that create particles and antiparticles with momentum ±p in a time-dependent basis [1,4-6]. FIPT has been explored in oscillating electric fields with a Gaussian profile and Sauter pulse profile [4-5]. The modulus of the order parameter, |Φ(p, t)|, evolves through three stages: the quasi-electron-positron plasma (QEPP) stage, the transient stage, and the residual electron-positron plasma (REPP) stage[4,6]. However, the evolution of the complex order parameter in a sequence of Sauter pulses with time delay T remains unstudied.

In this work, we employ the quasi-particle representation of quantum kinetic theory (QKE) to investigate the evolution of the vacuum state in a time-dependent electric field [1,8-10]. We examine the modified evolution stages of the order parameter, which transitions from quasielectron-positron plasma oscillations to the residual electron-positron plasma stage via the highly non-linear transient region[8,9].
Additionally, we study the evolution of entropy for a sequence of laser pulses with time delay, revealing that entropy density evolution aligns with the modulus of the order parameter in the quasi-particle stage of the single-particle distribution function's dynamical evolution.This correspondence implies a non-monotonic increase in entropy as vacuum breakdown occurs. Instantaneous entropy increases or decreases reflect the interplay between polarizing and depolarizing effects given by the real and imaginary components of the order parameter, governing the dynamics of pair production and annihilation. The monotonic increase in entropy
beyond the transient region is attributed to the dephasing in the particle-antiparticle correlation function.
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Field of contribution:

Phenomenology

547

Heavy Baryons in Hypercentral Constituent Quark Model: A comprehensive review

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We have witnessed several experimental identifications of the heavy hadrons in the past few years. Several experimental facilities have observed many excited states of singly, doubly, and triply heavy baryons. The incredible experimental progress sparked theoretical investigations into the physics of heavy baryons. Theoretical research primarily focuses on understanding heavy baryons' mass, electromagnetic characteristics, and weak decay. Understanding the flavor structure and dynamics of these baryons depends on these investigations. We can establish baryon spectroscopy and provide a solid foundation for further research on the heavy quark symmetry by comprehending the nature of heavy baryons and looking for the missing heavy resonances. We give an overview of heavy baryon resonances found to date in this article. We employ the Hypercentral Constituent Quark Model (hCQM) to demonstrate an interaction between constituent quarks, and screening potential has been considered as confining potential with color-coulomb potential. The whole mass spectra of heavy baryons have been generated in our previous work.

Field of contribution:

Phenomenology

548

Simulating Blast Wave Scenarios in Astrophysical Phenomena & Multiwavelength Analysis of Threads in ESO 137-006 Galaxy

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Shockwave generation in Supernova explosions or in Active Galactic Nuclei (AGN) various jet activities or in gamma ray bursts are common phenomena and the shockfront originates from the central galaxy and moving orthogonal to the plane of the galaxy. As time evolves depending on the velocity of the shock, input energy and ambient medium density it retains its shape and forms gigantic bubbles, similar to ones seen in our own Milky Way galaxy. For AGN it forms a cocoon with the plasma material due to the forward and sideways velocity of jet propagation. We try to simulate the shape of the shockfront from various initial surfaces over timescale of millions of years. Eventually this bubble in AGN could form filaments or threads visible in different clusters. We explore this for a Radio galaxy where threads are connected with the radio lobes and have performed its associated multiwavelength analysis. The simulation and analysis results will be discussed in detail in the poster.

Field of contribution:

Theory

549

Applications of Newly Discovered Orthogonal Polynomials in Quantum Theory

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In quantum theory, the solutions of most of the solvable systems are related to the well-known classical orthogonal polynomials namely the Hermite orthogonal polynomials, Laguerre orthogonal polynomials or the Jacobi orthogonal polynomials etc. In this work, listed all the newly discovered orthogonal polynomials (also known as exceptional orthogonal polynomials) with their important properties and discuss their applications in searching of new solvable systems. We further show that the solutions of these solvable potentials can also be written explicitly in terms these exceptional orthogonal polynomials.

Field of contribution:

Theory

550

Anisotropy in Pantheon+ supernovae

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We employ Maximum Likelihood Estimators to examine the Pantheon+ catalogue of Type Ia supernovae for large scale anisotropies in the expansion rate of the Universe. The analyses are carried out in the heliocentric frame, the CMB frame, as well as the Local Group frame. In all frames, the Hubble expansion rate in the redshift range $0.023 < z < 0.15$ is found to have a statistically significant dipolar variation exceeding 1.5 km s^−1 Mpc^−1, i.e. bigger than the claimed 1% uncertainty in the SH0ES measurement of the Hubble parameter H0. The deceleration parameter too has a redshift-dependent dipolar modulation at > 5σ significance, consistent with previous findings using the SDSSII/SNLS3 Joint Lightcurve Analysis catalogue. The inferred cosmic acceleration cannot therefore be due to a Cosmological Constant, but is probably an apparent (general relativistic) effect due to the anomalous bulk flow in our local Universe.

Field of contribution:

551

Entropy growth in Schwinger pair production as field induced phase transition of vacuum state

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Particle–antiparticle pair creation from a vacuum under the action of a strong electromagnetic(EM) field is one of the most profound phenomena in quantum electrodynamics (QED). The phenomenon of pair creation can be seen as a field-induced phase transition (FIPT) [1,5]. This occurs because the vacuum state evolves over time due to the non-stationary Hamiltonian [7], leading to spontaneous symmetry breaking under time reversal. As a result, electron-positron pairs are generated, acting as massive analogs of Goldstone bosons [2,3].To measure this symmetry breaking, we define a complex order parameter, Φ(p, t), given by Φ(p, t) = 2⟨0in|a† p(t)b† −p(t)|0in⟩ = |Φ(p, t)| exp(iψ(p, t)), where a† p(t) and b† −p(t) are operators that create particles and antiparticles with momentum ±p in a time-dependent basis [1,4-6].FIPT has been explored in oscillating electric fields with a Gaussian profile and Sauter pulse profile [4-5]. The modulus of the order parameter, |Φ(p, t)|, evolves through three stages: the quasi-electron-positron plasma (QEPP) stage, the transient stage, and the residual electron-positron plasma (REPP) stage[4,6]. However, the evolution of the complex order parameter in a sequence of Sauter pulses with time delay T remains unstudied.
In this work, we employ the quasi-particle representation of quantum kinetic theory (QKE) to investigate the evolution of the vacuum state in a time-dependent electric field [1,8-10]. Using the mean-field approximation—neglecting collisions and back-reaction on the external field—we examine the

modified evolution stages of the order parameter, which transitions from quasielectron-positron plasma oscillations to the residual electron-positron plasma stage via the highly non-linear transient region[8,9].
Additionally, we study the evolution of entropy for a sequence of laser pulses with time delay, revealing that entropy density evolution aligns with the modulus of the order parameter in the quasiparticle stage of the single-particle distribution function's dynamical evolution. This correspondence implies a non-monotonic increase in entropy as vacuum breakdown occurs. Instantaneous entropy increases or decreases reflect the interplay between polarizing and depolarizing effects given by the real and imaginary components of the order parameter, governing the dynamics of pair production and annihilation. The monotonic increase in entropy beyond the transient region is attributed to the dephasing in the particle-antiparticle correlation function.

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