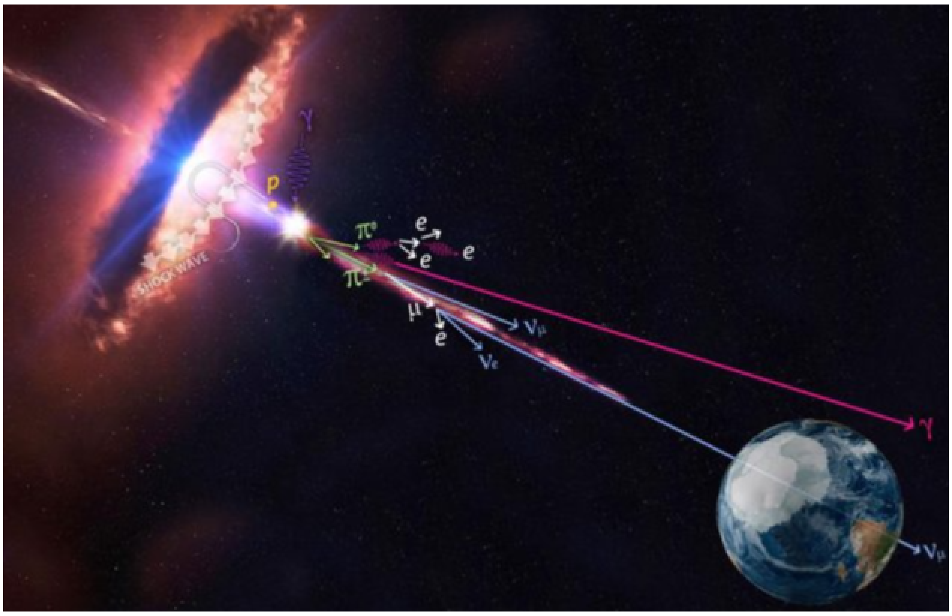
11th International Workshop on Very High Energy Particle Astronomy (VHEPA 2024)



Report of Contributions

https://indico.icrr.u-tokyo.ac.jp/e/1024

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

Constraints on VHE gamma-ray emission of Flat Spectrum Radio Quasars with the MAGIC telescopes

Blazars are a class of active galactic nuclei (AGN) where the relativistic jet is pointed towards the observer. They are powerful sources of non-thermal radiation from radio to Very high energy(VHE) gamma-rays. Flat Spectrum Radio Quasars (FSRQs) are a subclass of blazars where there are broad absorption or emission lines present in the optical spectra.
The observed properties of FSRQs are strongly affected by the magnetic field in the accretion disk which changes the UV emission of Broad Line Region (BLR) and infrared emission from the Dusty Torus.
While many (774 as reported in 4FGL-DR2 catalogue) FSRQs have been detected at high energies(E>100 MeV), only a few (9 as of now) could be detected at very-high energies (> 100 GeV)
In this work, we present observations of nine FSRQs performed by MAGIC between 2008 and 2020 with a total observation time being 174 hours. For two of the sources, CTA102 and B2 2234+28A, we include observations from the Fermi-LAT, Swift-UVOT, Swift-XRT and KVA (Kungliga Vetenskapsakademien). The multi-wavelength spectra for these sources show hints of additional absorption. We also modelled the broadband emission of the sources to look for signatures of absorption of VHE gamma-ray emission in the BLR region.

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

Tensor Perturbations and Primordial Gravitational Waves in the Brane-Antibrane Inflation Model

We study the production of gravitational radiation during the inflationary era. We leverage the fact that tensor perturbations correspond to two propagating degrees of freedom, known as graviton polarizations. Unlike electromagnetic radiation, which reaches transparency at the decoupling scale, the Universe becomes transparent to gravitational radiation at energy scales just below the Planck scale. This transparency allows us to probe the early universe through graviton spectra computation. We detail our calculations of the graviton spectra, and use it to examine the behavior of gravitational waves during inflation. We study the Brane-Antibrane inflation model and derive the characteristics of primordial gravitational waves. We present its role in the early universe conceptualized as a brane and factorized as $M_4 \times CY_6$, where M_4 is four-dimensional Minkowski space and CY_6 is a six-dimensional Calabi-Yau manifold.

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

Study of an unusual ultra-long GRB 220627A

The ultra-relativistic, highly collimated jets generated by Gamma-Ray Bursts (GRBs) provide crucial insights into particle emission. These jets also reveal the physical mechanisms driving the rapid release of high-energy gamma-ray photons. This presentation will discuss time-resolved and flux-resolved spectroscopy for the ultra-long GRB 220627A. The analysis spans a duration exceeding 1200 seconds using Fermi telescope data. Two prompt emission episodes observed by Fermi-GBM, separated by more than 500 s, were analyzed. Due to its unique characteristics, GRB 220627A serves as an excellent source for studying particle emission processes, small-scale variability, and central engine properties. To investigate gravitational lensing, the time bins of the first episode were correlated with those of the second episode. A coherent relationship was observed between flux and photon spectral distribution. This relationship was modeled using power law and exponentially cut-off power law models for both episodes. The hardness ratio was inconsistent across both episodes. LAT detected high-energy gamma-ray photons only for up to 700 seconds, thus ruling out gravitational lensing. These results suggest that GRB 220627A is an ultra-long GRB with two episodes rather than a lensed GRB. Our findings from spectral analysis reveal characteristics most consistent with those of an ultra-long GRB. Parameters such as isotropic energy, jet velocity, and burst duration align with the established limits for a blue supergiant progenitor, as the literature describes.

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

Two decades of studies of cosmic-ray arrival directions at the Pierre Auger Observatory

We report the latest results from the Pierre Auger Observatory on the determination of the anisotropies in the arrival direction distribution of ultra-high-energy cosmic rays. We present large angular scale analyses, including the tridimensional dipole measurements above 4 EeV and its equatorial component above 0.03 EeV, as well as some indications of intermediate angular scale anisotropies at the highest energies, above 32 EeV. We also discuss the spectrum and mass composition estimator measurements, which together with the anisotropies, play a key role in the efforts to understand the origin of ultra-high energy cosmic rays.

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

Searching for Ultra-High Energy Neutrinos with ARA and PUEO Experiments

The Askaryan Radio Array (ARA) is an in-ice ultra high energy (UHE, >10 PeV) neutrino experiment at the South Pole that aims to detect UHE-neutrino induced radio emission in ice. ARA consists of five independent stations each consisting of a cubical lattice of in-ice antenna clusters with side length of ˜10 m buried at about 200 m below the ice surface. All five independent ARA stations have collectively accumulated about 310 TB of data over the last decade. The fifth station of ARA (A5) is special as this station has an additional central string, the phased array (PA), which provides an interferometric trigger that enables ARA to trigger on weak signals that are otherwise buried in noise. Leveraging the low threshold phased array trigger, ARA was the first radio neutrino experiment to demonstrate significant improvement in sensitivity to weak signals. In this talk, I will present initial results from a neutrino search on A5 combining information from both the traditional station antennas and the phased array antennas. We will show the improved vertex reconstruction achieved with this approach, and leveraging this improvement, we expect to enhance the analysis efficiency beyond what has been achieved previously by ARA. This analysis is the paradigmatic representation of future neutrino searches with the next generation of in-ice neutrino experiments. I will also present the current state of the first array-wide diffuse neutrino search using data from all five independent stations of ARA. We anticipate that this analysis will result in the first UHE neutrino observation or world-leading limits from a radio neutrino detector below 100 EeV. Additionally, this analysis will demonstrate the feasibility for multi-station in-ice radio arrays to successfully conduct an array-wide neutrino search, paving the way for future, large detector arrays such as RNO-G and IceCube-Gen2 Radio.
In this talk, I will also discuss the science goals, recent developments, and timeline of the Payload for Ultrahigh Energy Observations (PUEO) experiment. PUEO is NASA's upcoming balloon-borne experiment that aims to study the ultra-high energy neutrino regime by utilizing the Askaryan effect to observe neutrino interactions in the Antarctic ice. PUEO is the successor of the successful Antarctic Impulsive Transient Antenna (ANITA) mission and boasts an improved design that can achieve world-leading sensitivity to the ultrahigh-energy neutrino flux above 1 EeV.

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

VHE galactic sources

The development and improvement of the Imaging Air Cherenkov Technique (IACT) has opened a new window to the Universe: the very-high-energy gamma-ray regime (VHE; E> 100 GeV). We currently know more than 300 sources that emit this kind of radiation, all of them with violent environments that allow for extreme particle acceleration and, hence, gamma-ray production. In this contribution, we will explore the Galactic VHE sky, reviewing the state-of-the-art of persistent, variable and transient sources.

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

Suppression of Cosmic Ray Flux in f(Q) Theories of Gravity

We examine the impact of turbulent magnetic field diffusion on the ultra-high energy cosmic ray (UHECR) spectrum from a cosmological perspective. Specifically, we explore the effect of magnetic diffusion within the framework of one of the modified symmetric teleparallel gravity, known as $f(Q)$ gravity. In this modified alternative theory of gravity (MATG), the non-metricity scalar Q and its arbitrary function replace the torsion scalar of standard teleparallel gravity. This $f(Q)$ gravity theory has been employed to study various cosmological phenomena, including dark energy and has shown promise in addressing various issues of modern astrophysics and cosmology. Using this MATG, we calculate the suppression in the UHECR flux for various sources, considering both non-evolution (NE) and cosmic star formation rate (SFR) scenarios. Additionally, we explore a mixed composition scenario involving nuclei up to iron (Fe). We also provide a parameterisation of the proton suppression factor and mixed compositions within this $f(Q)$ framework. A comparative analysis with the standard ΛCDM model demonstrates that the $f(Q)$ model predicts a greater suppression of flux, highlighting the significant influence of MATG on the suppression factor.

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Contribution ID: **10** Type: **not specified**

Recent studies on the energy spectrum and the composition of galactic cosmic rays with HAWC

The HAWC observatory is an air-shower Cherenkov detector installed at high altitudes (4100 m a.s.l.) with the mission of studying the universe at TeV energies by means of the gamma and cosmic rays that are received from the sky. The analyses of the hadronic-induced events at HAWC have allowed to investigate the sky maps, energy spectrum and the composition of cosmic rays at energies from TeV's to 1 PeV with high precision and statistics. From these studies, HAWC has measured the all-particle energy spectrum of cosmic rays just below the knee down up to the energy region dominated by direct experiments and has observed a cut-off in the total spectrum at tens of TeV's. Furthermore, it has estimated the energy spectrum for H+He nuclei, which has led to the observation of a softening at around 24 TeV. Unfolding studies in this energy region with HAWC have shown that such structure is due to the presence of individual cut-offs in the spectra of H and He, which were observed for the first time by direct experiments. In addition, HAWC results have also indicated the existence of a cut-off in the heavy component of cosmic rays between 100 and 300 TeV and hardenings in the spectra of the light cosmic ray nuclei at around 100 TeV. In this talk, we will present a review of the main results of HAWC on the spectrum and composition of cosmic rays. Finally, we will compare the findings with data from direct and indirect experiments.

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

The Impact of Neutrino Astronomy on Understanding Cosmic Rays

High-energy cosmic rays are a significant aspect of the high-energy universe, but their origins and acceleration mechanisms are not fully understood. Neutrinos, generated through interactions of these cosmic rays, provide a unique means to study these energetic particles and their sources. This presentation focuses on how observations of neutrinos can inform our understanding of cosmic ray acceleration and propagation.

We will review the relationship between cosmic rays and neutrinos, including theoretical models that predict neutrino fluxes resulting from cosmic ray interactions in various astrophysical environments. Recent data from neutrino observatories will be discussed, along with analyses showing how these observations contribute to our understanding of cosmic ray sources and acceleration mechanisms. Additionally, the presentation will explore the potential for future research to address outstanding questions in cosmic ray physics.

By examining the interplay between neutrinos and cosmic rays, we aim to enhance our knowledge of high-energy astrophysical processes and improve our understanding of the most energetic particles in the universe.

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

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

Gamma Ray Astronomy at PeV Energies-Phase 3 (GRAPES-3) is a cosmic ray experiment located in Ooty, Tamil Nadu, featuring an array of extensive air shower detectors and a muon telescope. The primary objectives of GRAPES-3 are to precisely measure the cosmic ray energy spectrum, study its nuclear composition, and explore multi-TeV γ-ray astronomy. A key aspect of these studies is understanding muon multiplicity and kinetic energy, which are crucial for accurate cosmic ray composition analysis. In this contribution, we will present a comparative analysis of high-energy hadronic interaction models by examining cosmic ray muons produced in TeV to PeV monoenergetic showers using CORSIKA (Version 7.7550) simulations. We evaluate the performance and differences of three hadronic interaction models: QGSJET II-04, EPOS LHC, and SIBYLL 2.3d. The analysis emphasizes the discrepancies and consistencies among these models, with a focus on the multiplicity and energy distributions of cosmic ray muons with GRAPES-3 conditions with several primaries.

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Contribution ID: **13** Type: **not specified**

Electric Field Simulation of the GRAPES-3 Proportional Counter

The GRAPES-3 experiment in Ooty, Tamil Nadu, operates the world's largest muon telescope, which consists 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 6m x 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 center of the counter in the transverse plane, along with the longitudinal variation of the electric field strength. Additionally, 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. These analyses provide critical insights into the operational characteristics of the PRCs, influencing their efficiency and accuracy in detecting and measuring cosmic ray particles.

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Contribution ID: **14** Type: **not specified**

Particle Lateral Densities from TeV - PeV Cosmic Ray Showers at the GRAPES-3 Experiment

Upon the interaction of primary cosmic rays with atmospheric nuclei, an Extensive Air Shower (EAS) is produced, generating secondary particles that offer an indirect method to study cosmic rays. The muonic component of these showers is crucial for understanding the mass composition of the primary cosmic rays. However, at higher energies, significant discrepancies persist between simulated and experimental data, underscoring the need to refine current hadronic interaction models. The GRAPES-3 Muon Telescope (G3MT) in Ooty, Tamil Nadu, a 560 m^2 ground-based detector, utilizes nearly 4000 gaseous proportional counters to sample muons from air showers. A similar, larger telescope with a 70% increased field of view is under construction. In this contribution, we will present a comparative analysis of high-energy hadronic interaction models (EPOS-LHC, QGSJET II-04, and SIBYLL 2.3d) using the CORSIKA simulation package to examine muon and electron production across various parameters, focusing on the lateral distributions of muons and electrons in cosmic ray showers. We investigate monoenergetic vertical showers within the TeV - PeV energy range by using GRAPES-3 parameters, analyzing primaries such as protons, helium, nitrogen, and iron. Key parameters like particle densities, shower size, and shower age derived from lateral distributions are evaluated to deepen our understanding of EAS.

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

Spectral and Temporal Analysis of BHXB GX 339-4 using the AstroSat data during its 2021 outburst

Using AstroSat observations, we present spectral and temporal studies of the outburst of the black hole X-ray binary (BHXB) GX 339-4 that occurred during January-April 2021. We have also used X-ray data from Maxi and Swift. We have studied the rising phase of this outburst and its evolution in detail. In the power density spectrum (PDS). We found that quasi-periodic oscillation (QPO) increases from 0.1 Hz in the hard state to 6 Hz in the soft intermediate state (SIMS) as the outburst evolves.
Additionally, harmonic and sub-harmonic features are noted in a few observations, primarily in SIMS. Using disk, comptonization, and relativistic reflection models, we fit the combined SXT and LAXPC energy spectra in the energy range 0.7–25.0 keV. We will present how the evolution of an outburst affects spectral parameters like gamma, absorption column density (nH), inner radius of the accretion disk (Rin), and Mdot.

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Contribution ID: **16** Type: **not specified**

Determining muon multiplicity at the GRAPES-3 experiment using pulse width for measuremets near the cosmic ray knee

It has long been observed that extensive air showers (EAS) produced by heavier mass primary cosmic rays (PCR) contained more muons than those created by lighter ones. As a result, muon multiplicities in EAS have been used as an indicator for estimating the PCR composition. This points towards the importance of an accurate determination of the muon multiplicity in an EAS. 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, counting hits in the proportional counters has been used for the PCR composition studies. Here, we present a new method to calculate the number of muons in an EAS based on the energy deposited by particles in the proportional counters which is stored as pulse width, recorded beside the hit information. The preliminary simulation results of the analysis show that the dynamic range of detecting muons is increased by two orders of magnitude. Such an increase in the dynamic range is important to determine the PCR composition accurately beyond the Knee region (\sim3 PeV) of the cosmic ray spectrum.

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