EP 5: Astrophysics

Time: Wednesday 14:15–15:45 Location: ELP 1: HS 1.22

EP 5.1 Wed 14:15 ELP 1: HS 1.22

Astrophysical test of the equality of active and passive gravitational mass — •Claus Lämmerzahl and Eva Hackmann — ZARM, University of Bremen, Gemany

Each body possesses three types of a mass: the inertial mass, the passive gravitational mass (or weight), and the active gravitational mass (or gravitating mass). The equivalence of inertial and passive gravitational mass, also known as the Weak Equivalence Principle, has been confirmed at the level of 10^{-15} by the recent space mission MICROSCOPE.

The precision of tests of the equivalence of the active and passive gravitational mass scales with the strength of the gravitational field created by the participating masses. This makes laboratory tests very difficult yielding an estimate of the order 10^{-6}, only. On the other hand, one can show that gravitationally bound astrophysical masses with their strong gravitational fields are not suited for corresponding tests. The only viable situation for an astrophysical test is a solid body composed of different masses of different composition moving in a gravitational field of another body. Our Moon with non-concentric iron and aluminum dominated parts provides such an example.

In the presentation we will provide the theoretical background and describe our data analysis of more than 50 years of Lunar Laser Ranging. As a consequence, with Lunar Laser Ranging, any non-equivalence of the active and passive gravitational mass is now bound by $4 \cdot 10^{-14}$. In addition, new planned laboratory tests will be shortly described.

EP 5.2 Wed 14:30 ELP 1: HS 1.22

Lévy flight model for the superdiffusive transport and acceleration of particles at shocks* — •Sophie Aerdker[1,2], Lukas Merten[1,2], Frederic Effenberger[1,2], and Horst Fichtner[1,2] — [1]Theoretical Physics IV, Faculty of Physics and Astronomy, Ruhr University Bochum — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany

In the heliosphere, power laws in space and time profiles of energetic particles at shock fronts are observed. It has been proposed that they result from superdiffusive transport, which can be modelled by Lévy flights. Such anomalous, non-Gaussian, transport regimes may arise as a consequence of intermittent magnetic field structures.

Superdiffusive particle transport can be described by a space-fractional Fokker-Planck equation. Numerical solutions can be obtained by solving the corresponding Stochastic Differential Equations (SDEs). In contrast to Gaussian diffusion, where the SDE is driven by a normal distribution, for superdiffusion random numbers are drawn from a symmetric alpha-stable Lévy distribution.

We investigate particle transport and acceleration at a shock front and use the SDE approach to solve the space-fractional Fokker-Planck equation. With a modified version of CRPropa3.2 the time-dependent solutions of the number density and energy spectrum at the shock are obtained. Our simulations lead to results that are compatible with the expected power-law particle distribution upstream of a shock. We also find slightly flatter energy spectra at the shock, analogously to previous work on Lévy walks. *Supported by DFG (SFB1491)

EP 5.3 Wed 14:45 ELP 1: HS 1.22

MHD simulations of turbulent galactic outflows — •Jens Kleimann and Horst Fichtner — Theoretische Physik IV, Ruhr-Universität Bochum, Germany

Simulations of the wind-filled halos of starburst galaxies are performed in the framework of magnetohydrodynamics (MHD), suitably extended to track additional turbulence-related quantities. These quantities comprise the turbulent energy density, the cross-helicity, and the turbulent lengthscale. After a brief discussion of these extended equations and the employed numerical approach, I will present first simulation results, both for non-magnetized benchmark runs as well as for tests using the full system of equations. The dominant and unexpected feature of the former is a macroscopic flow instability near the rotational axis that prevents the outflow from reaching a steady state. Methods to determine the cause and nature of this instability are presented. The talk concludes with an analysis of the resulting turbulent properties, comparing them to the solutions found from similar work targeting the outer heliosphere.

EP 5.4 Wed 15:00 ELP 1: HS 1.22

ComPol - A Compton polarimeter in a Nanosat — •Matthias Meier[1,2], Ion Cojocari[3], Carlo Fiorini[4], Peter Hindenberger[1,2], Philippe Laurent[3], Martin Losekamm[1,2], Susanne Mertens[1,2], Jonas Schlegel[1,2], Lorenzo Toscano[4], and Michael Willers[1,2] — [1]Excellence Cluster ORIGINS, Garching, Germany — [2]Technical University of Munich, Munich, Germany — [3]Alternative Energies and Atomic Energy Commission, Paris, France — [4]Polytechnic University of Milan, Milan, Italy

It is hardly possible to resolve the geometry of astrophysical compact objects due to their small size. One way to indirectly learn about their structure are polarization measurements. Especially in the hard X-ray range polarization data is still partially missing. Therefore, the aim of the CubeSat mission ComPol is to fill this gap and to improve the physical model of the black hole binary system Cygnus X-1.

The detector system is composed of a Silicon drift detector (SDD) used as a scatterer and a CeBr3 calorimeter to capture the full Compton kinematics. From the measured interaction points and energies it is possible to perform an event-wise reconstruction and infer the polarization of the initial radiation.

The talk will give an overview of the scientific motivation, the underlying physics and the detector setup.

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EP 5.5 Wed 15:15 ELP 1: HS 1.22

Angular dependence of the muon neutrino flux — •Leonora Kardum, Karolin Hymon, Mirco Hünnefeld, Pascal Gutjahr, and Jean-Marco Alameddine — Technische Universität Dortmund

The IceCube Neutrino Observatory, a cubic kilometer detector nestled in the ice at the geographic South Pole, exhibits the capability to detect particles across a broad energy range, spanning from several GeV up to PeV. This enables precise measurements of the diffuse neutrino spectrum made from three components: astrophysical (originating from extraterrestrial sources), conventional (resulting from pion and kaon decays in atmospheric Cosmic Ray cascades), and the as-yet-undetected prompt component from the decay of charmed hadrons.

This work reveals the angular dependence and the all-component flux. The unfolding method, a composite model-independent technique, is employed to derive values from related quantities, eliminating the impact of assumptions made in the process. Specifically, we unfold the muon neutrino energy spectrum, incorporating a novel technique for rebinning the observable space to ensure adequate event numbers in the low statistic region at the highest energies.

Our presentation includes the unfolded energy and zenith angle spectrum reconstructed from IceCube data compared to model expectations and previous measurements, providing valuable insights into the accuracy of predicted angular dependencies in the atmospheric neutrino flux.

EP 5.6 Wed 15:30 ELP 1: HS 1.22

Trajectory-Dependent Photo Emission and Detection of Scintillation Light in a Bismut Germanium Oxide Scintillator Crystal — •Tom Ruge, Stephan Böttcher, and Ava Pohley — Christian-Albrechts-Universität zu Kiel IEAP - Extraterrestrische Physik

The Earth is continuously exposed to high-energy charged particles, so-called Galactic Cosmic Rays (GCRs). When these particles hit the Earth's atmosphere, they create a cascade of secondary particles. CHAOS (CHerenkov Atmospheric Observation System) is a particle telescope that is developed at the Department of Extraterrestrial Physics at Kiel University by a team of students to measure the different particle species of the primary GCRs. It consists of multiple solid-state detectors, a Cherenkov aerogel scintillator and a BGO scintillation calorimeter. The hexagonal BGO crystal with a side length of 52 mm and a thickness of 20 mm is one of the largest BGO crystals ever used for particle detection, which is why geometric effects within the BGO are more interesting than ever. When a charged particle interacts with the crystal, isotropic light is emitted that is measured by attached photodiodes. As part of my bachelor thesis, I am investigating in an experiment how much light is measured by the individual photodiodes, depending on where the particle has flown through the crystal. CHAOS is supposed to fly on a stratospheric balloon as part of the BEXUS (Balloon Experiments for University Students) program in fall 2024. This is why it is essential to investigate the properties of the used BGO. I will present my experiment and the findings.