T 103: Cosmic rays IV

Time: Friday 11:00–13:00 Location: L-3.002

T 103.1 Fri 11:00 L-3.002

Connection between turbulence and diffusive Cosmic Ray transport in the ISM — •Julien Dörner, Patrick Reichherzer, and Julia Tjus — RAPP-Center at Ruhr-University Bochum, Theoretische Physik IV, Bochum, Germany

The propagation of Cosmic Rays can be described by diffusive motion in most astrophysical environments. In the diffusion approach a proper modeling of the diffusion tensor is necessary. It has recently been shown that the energy dependence of the parallel component of the diffusion tensor is a function of the turbulence level, i.e. $\kappa \propto E^{\gamma(\delta B/B)}$. In this talk, we will discuss these insights in the astrophysical context. We focus on the impact of $\delta B/B-$dependent diffusion on the signatures of cosmic-ray propagation in the Galactic Interstellar Medium and the interpretation of recent gamma-ray measurements by Fermi.

T 103.2 Fri 11:15 L-3.002

Propagation in the Galactic magnetic field: Effects on the spectrum, composition and anisotropy of Galactic and extragalactic cosmic rays * — •Alex Kääpä for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

In the energy range signifying the transition from Galactic to extragalactic cosmic rays (GCRs and EGCRs), current cosmic ray source and propagation models fail to describe the observed flux above PeV energies. This calls for modifications to such models, the nature of which may be found in the study of the Galactic magnetic field (GMF), as it exhibits a range of effects on the propagation of cosmic rays. At the lowest rigidities, near the end of the diffusive regime, GCRs are trapped in, and EGCRs are effectively shielded from the Galaxy. At intermediate rigidities, the EGCRs that reach the Galaxy and GCRs are concentrated in the Galactic plane. At highest rigidities, particles are hardly affected by the GMF.

In this talk, I will present the consequences of these propagation effects on the spectrum, composition and anisotropy of both GCRs and EGCRs with special focus on how this may help elucidate the missing predicted flux in the transition region.

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T 103.3 Fri 11:30 L-3.002

Deepening the understanding of cosmic-ray diffusion — •Patrick Reichherzer[1,2,3], Julia Tjus[1,2], Ellen Zweibel[4], Lukas Merten[5], and M.J. Pueschel[6] — [1]Ruhr-University Bochum, Theoretical Physics IV — [2]Ruhr Astroparticle and Plasma Physics (RAPP) Center — [3]Irfu,CEA Paris-Saclay — [4]Department of Astronomy & Physics, University of Wisconsin-Madison — [5]Institute for Astro-& Particle Physics, University of Innsbruck — [6]Institute for Fusion Studies, University of Texas at Austin

Understanding the transport of energetic cosmic rays belongs to the most challenging topics in astrophysics. The complicated evolution of the cosmic-ray distribution can be modeled mathematically by a diffusive process in the limit of large times. Consequently, diffusion is of fundamental importance in the transport of cosmic rays through turbulence.

We demonstrate the reduction of numerical artifacts for the calculation of the diffusion coefficient D by providing important conditions for physical and numerical input parameters. We characterize the rigidity regimes of D for arbitrary rigidities and guide fields, which we derive as a function of physical and numerical parameters. We show that at turbulence levels b/B above 5% of the total magnetic field, the approximation of an energy dependence E^(1/3) as predicted for a Kolmogorov spectrum within Quasi-Linear Theory does not hold. Consequently, a proper description of cosmic-ray propagation can only be achieved by using a b/B-dependent diffusion coefficient and can contribute to solving the Galactic cosmic-ray gradient problem.

T 103.4 Fri 11:45 L-3.002

Investigation of a Combined Fit Method to Identify a Nearby Cosmic Ray Source — Teresa Bister, Martin Erdmann, •Josina Schulte, and Marcus Wirtz — III. Physikalisches Institut A, RWTH Aachen

The origin of ultra high energy cosmic rays is still unknown and every progress to constrain the physical parameters of the acceleration process at the origin site will help to identify suitable cosmic ray source candidates. The application of a combined fit method to the energy spectrum and shower depth distribution measured by the Pierre Auger Observatory already unveiled information on the spectral index, original elemental composition as well as the maximum cosmic-ray rigidity at the sources. Now, the hypothesis of identical, homogeneously distributed sources is extended by a nearby source with a distance d and a signal fraction f_s using CRPropa 3 simulations to explore the astrophysical scenario in even more detail. In this talk, results of the combined fit method using the extended hypothesis applied on simulated data are presented. In order to develop a reliable analysis, the dependency of the fit results on a wide range of the astrophysical parameters is investigated.

T 103.5 Fri 12:00 L-3.002

Predicting the UHE photon flux from GZK-interactions of hadronic cosmic rays using CRPropa 3 — •Anna Bobrikova, Marcus Niechciol, Markus Risse, and Philip Ruehl for the Pierre Auger-Collaboration — University of Siegen

Measurements of the ultra high energetic cosmic ray (UHECR) spectrum taken by the Pierre Auger Observatory indicate an energy cut-off at about 50 EeV. The origin of this cut-off is still unclear. Possible explanations are the GZK-process (UHE proton interacting with the photons of the cosmic microwave background), photodisintegration interactions of UHE nuclei, or the maximum acceleration energy of the sources themselves. Indirect evidence for the GZK-effect could be provided by the search for UHE photons. Such photons would be produced if hadronic cosmic rays with energies above the cut-off energy interact via the GZK-process. In order to interpret the experimental upper limits on the flux of the UHE photons, theoretical predictions are needed. Predictions of the photon flux above 1 EeV as expected from the GZK-process have been derived in the past. The constantly growing amount of data collected at Auger along with refined analysis methods make it possible to search for photons with energies down to 2×10^{17} eV. For the study presented in this contribution, the CRPropa 3 framework is used to simulate the propagation and interaction of primary hadronic cosmic rays and their secondaries on their way from their sources to the earth to obtain predictions for the UHE photon flux below 1 EeV. Funded by BMBF Verbundforschung Astroteilchenphysik.

T 103.6 Fri 12:15 L-3.002

Search for Cosmic Ray Sources Using Graph Convolutional Neural Networks — Teresa Bister, Martin Erdmann, Jonas Glombitza, •Niklas Langner, Josina Schulte, and Marcus Wirtz — III. Physikalisches Institut A, RWTH Aachen

Convolutional neural networks (CNNs) are a promising tool in the search for nearby sources of ultra-high energy cosmic rays (UHECRs). Here, CNNs are used to identify patterns in the arrival directions and energies of UHECRs created by their deflection in the Galactic magnetic field. We investigate graph CNNs, which operate on a graph constructed from the UHECR-features, efficiently utilizing both arrival directions and energies of the UHECRs. First, simple toy simulations of single multiplets consisting of a signal pattern on top of an isotropic background are analyzed as a function of the number of injected UHECRs from a source. Second, astrophysical simulations of many sources taking into account the attenuation in photon fields during the propagation in the extragalactic universe are used to evaluate the sensitivity of the graph networks for varying source densities.

T 103.7 Fri 12:30 L-3.002

Testing The Pierre Auger Observatory Starburst Galaxy and Active Galactic Nuclei Correlation Anisotropy Result with CRPropa Simulations — •Wilson Namasaka — Bergische Universtät Wuppertal - Germany, Gaußstr. 20, 42119 Wuppertal

Intermediate scale anisotropies in the distribution of UHECR arrival directions can be associated with two prominent classes of extragalactic gamma-ray sources detected by Fermi-LAT. In a most recent study, a correlation between the arrival direction of cosmic rays at energies above 38 EeV for starburst galaxies (SBG) and 39 EeV for active galactic nuclei (AGN) was reported by the Pierre Auger Collaboration with a significance of 4.5σ and 3.1σ respectively. In the study, the observed gamma-ray Luminosity was used as a proxy for cosmic ray Luminosity. The predicted cosmic ray excess maps were created using an angular smearing parameter to fit the observed arrival direction distribution via an optimization scan. In this research, we investigate the viability of this angular smearing using CRPropa simulation to test whether the results of the Pierre Auger Observatory can be reproduced by the deflections expected due to magnetic fields. We have selected the five strongest gamma-ray sources in both the Fermi-LAT AGN and SBG catalogs, and match our CR arrival intensity to the 1.4 GHz emission Luminosity for each of these sources. Simulations of the flux from these sources including extragalactic and galactic fields will be discussed. Furthermore, the results of search radius from both catalogs will be presented in this talk.

T 103.8 Fri 12:45 L-3.002

Fitting cosmic ray charges to cluster in accordance with an extragalactic source model — •Teresa Bister, Martin Erdmann, and Marcus Wirtz — III. Physikalisches Institut A, RWTH Aachen University

One of the main aims of astroparticle physics nowadays is to identify the sources of ultrahigh energy cosmic rays. This quest is particularly challenging as it requires knowledge of the galactic magnetic field as well as information about each cosmic ray's individual energy and charge. The latter cannot be measured directly at the highest energies by air shower experiments. Therefore this analysis presents a novel approach to fit all individual charges simultaneously by deep learning techniques. The fit uses different origin models as well as measurements of the energy and the shower depth in the atmosphere. The expected sensitivity is evaluated on simulated astrophysical scenarios and it is verified that this technique can differentiate between isotropic scenarios and cosmic rays originating in starburst galaxies.