T 62: Cosmic Rays III

Time: Wednesday 16:15–18:15 Location: KS 00.006

T 62.1 Wed 16:15 KS 00.006

Time Dependant Modelling of Astrophysical and DM Secondary Signatures in Dwarf Galaxies — •Jannis Wagner[1,2], Julien Dörner[1,2], Athithya Aravinthan[1,2], Milena Brütting[1,2], and Julia Becker Tjus[1,2,3] — [1]Fakultät für Physik & Astronomie, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

Dwarf galaxies are increasingly gaining traction as targets of indirect searches for Dark Matter (DM) due to their high mass-to-light ratios and low star-formation rates. Searches mainly focus on gamma rays in the GeV-TeV range created through different annihilation channels of Weakly Interacting Massive Particles (WIMPs). These signals are distorted by radiative emission of astrophysical Cosmic Rays (CRs), which necessitates joint modelling. Furthermore, the galaxies' decline in star-formation rate and its feedback on the galactic magnetic field require a time-dependent modelling of the CR distribution. Such a modelling would allow for better gauging of the morphological impact of DM and thus support future observation attempts for evidence of DM or in setting stronger constraints on its characteristics.

In this work, we explore this coupled modelling using the Monte-Carlo framework CRPropa, including leptonic DM secondaries and astrophysical CR electrons. We present a comparison of the morphologies of the resulting signatures for basic models of source distribution and magnetic field evolution.

T 62.2 Wed 16:30 KS 00.006

Temporal and Geometrical Effects of the GMF on UHECRs — •Veronika Vašíčková, Leonel Morejon, and Karl-Heinz Kampert for the Pierre Auger-Collaboration — Wuppertal, Germany

To understand the origin of the Ultra-High-Energy Cosmic Rays (UHECRs), it is important to explain features of their spectrum, as well as their arrival directions. Currently, this is done with modelling approaches neglecting time evolution, especially in the galactic magnetic field (GMF). We study the influence of the GMF on the arrival direction of UHECRs and on the spectrum, with the emphasis on temporal and geometrical effects, investigating the rigidity-dependent residence time of extragalactic cosmic rays entering our Galaxy using CRPropa. We probe both constant and time-varying flux scenarios and find that UHECRs entering the Milky Way can experience delays of hundreds of kiloyears. This temporal effect modifies the spectrum, introducing features such as a rigidity-dependent enhancement of the flux, a suppression of particles between $10^{18} - 10^{19}$ V, or a natural softening of spectra with time. The comparatively short residence time of particles above a certain rigidity could explain the common maximum rigidity needed to describe the UHECR spectrum.

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T 62.3 Wed 16:45 KS 00.006

Study of Large scale Cosmic Ray Anisotropy with KASCADE and IceTop — •Joshua Turnwald, Donghwa Kang, and Andreas Haungs for the IceCube-Collaboration — Karlsruher Institut für Technologie (KIT)

We present a study of anisotropies in the arrival directions of cosmic rays using data from KASCADE (KArlsruhe Shower Core and Array DEtector) and IceTop, the surface component of the IceCube Neutrino Observatory. These two experiments, located in the Northern and Southern Hemispheres respectively, provide complementary coverage of the cosmic-ray sky. Our analysis focuses on large-scale anisotropies in the energy range from 100 TeV to about 50 PeV. The relative intensity of the anisotropy is determined using a maximum likelihood method. In this contribution, the results of the dipole amplitude and its systematic studies will be discussed.

T 62.4 Wed 17:00 KS 00.006

Investigation of the Diffusion Tensor for Different Turbulence Levels and Rigidities in the Resonant Scattering Regime — •Jan-Niklas Bohnensack[1] and Julia Becker Tjus[1,2,3] — [1]Theoretical Physics IV: Plasma-Astroparticle Physics, Faculty for Physics & Astronomy, Ruhr-Universityät Bochum, D-44780 Bochum, Germany; Supported by SFB1491 — [2]Ruhr Astroparticle And Plasma Physics Center (RAPP Center), Bochum, Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, SE-412 96 Gothenburg, Sweden

The quasi-linear theory (QLT) describes the interactions between charged particles and astrophysical plasmas in the limit of $b/B \ll 1$. The goal of the underlying thesis was to verify the QLT's prediction that for small turbulence levels b/B, where b is the turbulent magnetic field strength and B is the homogeneous magnetic field strength, the diffusion coefficient behaves like $\kappa \propto \rho^\gamma$ with $\gamma = 1/3$. To overcome those restrictions a code was developed in the underlying thesis to utilize methods of parallelization that calculate the running diffusion coefficient from particles propagated with CRPropa faster. The diffusion coefficients were generated for a range of reduced rigidities so that the particles scatter resonantly at any point in space for a given turbulence level. This talk shows new simulated data which better shows the behavior of the spacial diffusion coefficient against different turbulent levels and reduced rigidities. I will further give an outlook on how we will use the diffusion coefficients in future simulations and experiments (e.g. in laboratory plasmas or diffusive transport simulations).

T 62.5 Wed 17:15 KS 00.006

mw-atlas: Inferring the 3D Galactic cosmic ray density of our Milky Way — •Mareike Berkner[1], Torsten Ensslin[2], Hanieh Zandinejad[2], and Philipp Mertsch[1] — [1]RWTH Aachen University, Aachen, Germany — [2]Max-Planck-Institut für Astrophysik, Garching, Germany

Most models of the Galactic cosmic-ray (CR) distribution often rely on simplified source distributions and propagation scenarios. They consequently fail to capture the rich, non-axisymmetric structure of the Milky Way. The true, 3D distribution of CRs is however crucial in identifying CR sources and in understanding the feedback that CRs provide to the interstellar medium. In this contribution, we discuss methodological attempts for a data-driven reconstruction of the 3D CR density using Bayesian inference and Gaussian processes. Information of the CR density is provided by hadronic γ-rays, measured by Fermi-LAT. Morphological matching structure in the γ-ray sky with corresponding ones in spatially resolved gas maps allows reconstructing the smooth, spatially correlated CR density field, including a measure of its uncertainty. This 3D map can be directly compared to predictions from propagation models. This will enable new tests of CR transport scenarios, improve models of diffuse gamma-ray emission, and offer a starting point for integrating CR physics consistently into ISM analyses.

T 62.6 Wed 17:30 KS 00.006

Revised Diffusive Shock Acceleration with CRPropa3.2 for the description of cosmic ray spectra at supernova shocks — •Jakob Dörner[1], Sophie Aerdker[1,2], Lukas Merten[1,2], and Julia Tjus[1,2,3] — [1]Theoretical Physics IV: Plasma-Astroparticle Physics, Faculty for Physics & Astronomy, Ruhr University Bochum, Germany; Supported by SFB1491 — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center) — [3]Department of Space, Earth and Environment, Chalmers University of Technology, Gothenburg, Sweden

Supernova remnants (SNRs) play an important role in the acceleration of Galactic cosmic rays (CRs) that gain significant energy by repeatedly crossing the shock front. This acceleration process, known as diffusive shock acceleration (DSA), generally leads to a power-law spectral slope of E^{-2}. However, observations of nonthermal emission of SNRs imply CR energy distributions that are generally softer than E^{-2}, the DSA prediction. In contrast, non-linear theory of DSA would predict an even harder spectrum. Recent studies suggest that such soft spectra may arise from the additional drift of magnetic structures with respect to the thermal plasma downstream of the shock. We incorporate the effect of such drifts by changing the effective compression ratio of the shock in test particle simulations using the CRPropa framework, which solves the transport equation by utilizing stochastic differential equations. We obtain soft energy spectra, depending on the strength of the effective compression ratio, and concave energy spectra when the precursor is taken into account.

T 62.7 Wed 17:45 KS 00.006

Gamma-ray signatures from anisotropic cosmic ray transport in the Milky Way — •Julien Dörner[1,2], Jonas Hellrung[1,2], Julia Becker Tjus[1,2,3], and Horst Fichtner[1,2] — [1]Theoretical Physics IV, Plasma Astroparticle Physics, Faculty for Physics and Astronomy, Ruhr University Bochum, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Germany — [3]Department of Space, Earth and Environment, Chalmers University of Technology, 412 96 Gothenburg, Sweden

The magnetic field of the Milky Way is composed of a large-scale coherent background and a turbulent component. The spatial diffusion of cosmic rays (CRs) in this composed magnetic field configuration is expected to become anisotropic. The diffusion coefficient along the field line $\kappa_\parallel$ is greater than in the degenerated perpendicular directions $\kappa_\perp$.

In this work, we utilize the open-source framework CRPropa to investigate the anisotropic diffusion of CRs within the Milky Way. We phenomenologically vary the ratio $\epsilon = \kappa_\perp/\kappa_\parallel$, ranging from nearly parallel diffusion ($\epsilon = 10^{-3}$) to purely isotropic diffusion ($\epsilon = 1$). The source parameters are optimized to match the observed CR data at Earth. Afterwards, the line-of-sight integration framework HERMES is used to calculate the all-sky gamma-ray emission. Based on the resulting all-sky maps, the feasibility of gamma-ray observations to constrain not only the parameters of such anisotropic transport but also the structure of the Galactic magnetic field will be discussed.

T 62.8 Wed 18:00 KS 00.006

Forward Photon Measurement in Proton-Oxygen Run at the LHC with the LHCf Experiment — •Vlera Hajdini, Prof. Dr. Cigdem Issever, and Dr. Clara Leitgeb — Physics Insitute, Humboldt University of Berlin

The Large Hadron Collider forward (LHCf) experiment plays a fundamental role in Ultra High Energetic Cosmic Ray (UHECR) physics by providing tuning data for the hadronic interaction models used for Extensive Air Shower (EAS) simulations. LHCf measures neutral particles (γ, π^0, n) in the very forward region ($\eta > 8.4$) produced at the ATLAS interaction point (IP1), using two sampling calorimeters, Arm1 and Arm2, installed 140 m on both sides of the IP1.

In July 2025, LHCf participated in the first proton-Oxygen (p-O) collision run at the LHC, collecting data at $\sqrt{s_{NN}} = 9.6$ TeV. Forward particle production in p-O collisions is particularly relevant for UHECR studies, as it reproduces one of the projectile-target combinations characteristic of atmospheric interactions initiated by primary cosmic rays.

With a photon energy resolution of about 2% and a position resolution better than 40 μm, LHCf is well suited to investigate forward photon production with high precision. This contribution presents the current status of the photon analysis in p-O collisions.