T 73: Cosmic Ray 4

Time: Wednesday 16:15–18:15 Location: T-H32

T 73.1 Wed 16:15 T-H32

Probing magnetic fields in the Galactic halo and studing their effects on arrival direction of cosmic rays — •Vasundhara Shaw, Andrew Taylor, and Arjen Van Vliet — Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany

The Galactic halo in the past was less explored than other regions of the Galaxy. However, in the last decade, this has started to change with the observation of the Fermi bubbles and the latest eROSITA bubbles, we know that there is much to unravel in this region.

These large extended Galactic halo bubbles can play a key role in the magnetic field structure of the Galaxy. The magnetic fields for the bubble region have so far been largely masked out in the models however, the strength and geometry of magnetic fields in this region can be fundamental not only in understanding the Galactic magnetic fields but also the deflection of extra-Galactic cosmic rays.

In this talk, I will try to motivate the reason behind our toy model magnetic field for the Galactic halo and highlight how it compares with radio observation data. The second part of this talk will focus on the effect arrival directions of cosmic rays from our toy model and compare it with other existing magnetic field models.

T 73.2 Wed 16:30 T-H32

Incorporating the Galactic magnetic field into the propagation effects of cosmic rays in the transition region* — •Alex Kääpä — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

In the energy range signifying the transition from Galactic to extragalactic cosmic rays (GCRs and EGCRs), propagation in the Galactic magnetic field (GMF) changes from diffusive to ballistic. This leads to a range of observable effects vital to understanding the respective contributions of GCRs and EGCRs to the total flux. GCRs more readily leak out of the Galaxy with increasing energy and, hence, the flux arriving at Earth is suppressed. EGCRs experience two competing effects, shielding from as well as confinement in the Galactic plane, both of which weaken with energy. These effects have been re-confirmed to cancel exactly in the case of isotropic injection. Flux modifications can occur in the case of an anisotropic EGCR flux into the Galaxy. Their nature depends both on the type and direction of the anisotropy.

In this talk, we present the propagation effects that the GMF imposes on the flux of GCRs and EGCRs. We incorporate these into minimal, experimentally and theoretically motivated injection spectra of GCRs and EGCRs. With this incorporation, we seek to retrieve a more realistic picture of the expected flux arriving at Earth, and to better estimate the nature and degree of possible additional contributions to the injected flux.

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T 73.3 Wed 16:45 T-H32

Influence of diffusive cosmic-ray transport on multi-messenger observables — •Patrick Reichherzer[1,2,3], Julia Becker Tjus[1,2], Lukas Merten[1,2], Leander Schlegel[1,2], Julien Dörner[1,2], M.J. Pueschel[4,5], and Ellen Zweibel[6] — [1]Theoretical Physics IV: Plasma-Astroparticle Physics, Faculty for Physics & Astronomy, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Ruhr Astroparticle And Plasma Physics Center (RAPP Center), Bochum, Germany — [3]University Paris-Saclay, France — [4]Dutch Institute for Fundamental Energy Research, 5612 AJ Eindhoven, The Netherlands — [5]Eindhoven University of Technology, 5600 MB Eindhoven, The Netherlands — [6]Department of Astronomy, University of Wisconsin-Madison, Madison, WI 53706, U.S.A.

Cosmic-ray transport in astrophysical environments is often dominated by diffusion in a magnetic field with a turbulent component. The diffusion properties of charged particles directly influence observable properties, such as the spectrum of cosmic rays and their secondaries produced in interactions. In many diffusion scenarios, the simplified assumption of fully resonant Kolmogorov diffusion in the quasi-linear limit results in a parallel diffusion coefficient $D \propto E^{1/3}$. A quantitative investigation of the scattering regimes, however, shows that the diffusion coefficient tensor can deviate significantly from this behaviour. In this talk, the complex dependencies of charged particle diffusion on the turbulence level of the magnetic field are presented. Examples of how this affects observational signatures will be shown in the context of galaxies or the transient sky, i.e., flaring Blazars.

T 73.4 Wed 17:00 T-H32

Perception of arrival direction maps of cosmic rays — •Edyvania Emily Pereira Martins[1], Markus Roth[2], and Darko Veberič[2] — [1]Institut für Experimentelle Teilchenphysik - Karlsruher Instituts für Technologie, Karlsruhe, Germany — [2]Institut für Astroteilchenphysik - Karlsruher Instituts für Technologie, Karlsruhe, Germany

The processing of visual information in the human brain is guided by identifying colors and patterns formed by same-color areas. In cosmic-ray research, two main interests are to relate detected events to their sources and to identify excess regions in the sky. In this pursuit, maps of arrival directions are a commonly used tool. Depending on the choice of the smoothing applied to the maps, the plotting can render different locations of the perceived flux-excess regions on the map, represented in a different color to the flux-deficit regions. In addition, the most commonly used smoothing fabricates structures that are not real nor significant, and can lead to misinterpretation. An alternative to the standard, top-hat smoothing is presented, which facilitates the interpretation of data.

T 73.5 Wed 17:15 T-H32

Self-confinement of low-energy cosmic rays around supernova remnants — •Hanno Jacobs, Philipp Mertsch, and Vo-Hong Minh Phan — TTK RWTH Aachen

Supernova Remnants have long been considered as promising candidate sources for cosmic rays. However, modelling the transport around these sources is difficult due to its nonlinear nature. The strong overdensity in the near source region leads to the production of plasma turbulence, upon which the particles scatter. To calculate this mechanism, called self-confinement, requires the numerical solution of two coupled differential equations describing the transport of particles and waves. Here, this formalism is extended to energies below 10 GeV, where energy losses become relevant. Particles around 100 MeV are found to be confined for in between 300 kyr and 1 Myr, depending on the interstellar medium. The diffusion coefficient is initially suppressed by up to two orders of magnitude. Interestingly, the spectrum outside the supernova flattens below 1 GeV at later times, similar to the spectral behaviour observed by Voyager. Furthermore, the grammage accumulated in the near source region is found to be non-negligible, which could be important for precision fitting cosmic ray spectra.

T 73.6 Wed 17:30 T-H32

No longer ballistic, not yet diffusive–the formation of cosmic ray small-scale anisotropies — •Marco Kuhlen, Vo Hong Minh Phan, and Philipp Mertsch — TTK Institut, RWTH Aachen

In the standard picture of cosmic ray transport the propagation of charged cosmic rays through turbulent magnetic fields is described as a random walk with cosmic rays scattering on magnetic field turbulence. This is in good agreement with the highly isotropic arrival directions as this diffusion process effectively isotropizes the cosmic ray distribution. However, high-statistics observatories like IceCube and HAWC have observed significant deviations from isotropy down to very small angular scales. This is in strong tension with this standard picture of cosmic ray propagation. By relaxing one of the assumptions of quasi-linear theory and explicitly considering the correlations between the fluxes of cosmic rays from different directions, we show that power on small angular scales is a generic feature of particle propagation through turbulent magnetic fields. We present a first analytical calculation of the angular power spectrum assuming a physically motivated model of the magnetic field turbulence and find good agreement with numerical simulations. We argue that in the future, the measurement of small-scale anisotropies will provide a new window to testing magnetic turbulence in the interstellar medium.

T 73.7 Wed 17:45 T-H32

Non-thermal ion acceleration at highly oblique non-relativistic shocks — •Naveen Kumar and Brian Reville — Max-Planck Institute for Nuclear Physics Heidelberg, Germany

Non-thermal acceleration of particles (both electrons and ions) at

an oblique, non-relativistic shock is demonstrated by using one-dimensional large-scale particle-in-cell simulations. Our results show the generation of non-thermal ions at highly oblique shocks with acceleration efficiencies of $\sim 5\%$ measured at the end of simulation runs. These results have important implications for understanding the non-thermal radiation generation at astrophysical sites such as supernova remnants.

T 73.8 Wed 18:00 T-H32

Can superbubbles accelerate PeV protons? — •Thibault Vieu and Brian Reville — Max-Planck-Institut für Kernphysik, Postfach 10 39 80, 69029 Heidelberg, Germany

The local cosmic-ray spectrum and recent gamma-ray observations suggest the existence of Galactic sources able to accelerate protons up to at least several PeV. These sources are still to be identified. Standard scenarios of particle acceleration at isolated supernova remnants struggle to reach PeV bands. However, most massive stars are not isolated but clustered. Clustered stars heat their surrounding medium, which inflates a cavity called a superbubble. In the superbubble, the stellar feedback creates multiple shocks, a turbulent environment, and amplifies the magnetic fields. These are ideal conditions for particle acceleration and superbubbles have long been thought to accelerate PeV protons. While it is indeed expected that an extended and strongly turbulent source could accelerate protons up to tens of PeV, it is yet unclear how the different acceleration processes can act collectively in superbubbles.

In this work we estimate the maximum energy of protons accelerated in superbubbles, considering various detailed scenarios. We derive under which circumstances PeV protons are expected. The forward shock of the superbubble barely accelerates particles up to 100 TeV. Supernova remnants expanding in the interior, or the collective wind termination shock which forms around a compact cluster, barely accelerate PeV protons. We show that protons of several PeV are only expected within loose and extended stellar clusters.