EP 12: Sun and Heliosphere V

Time: Thursday 16:15–18:00 Location: ZHG101

Invited Talk EP 12.1 Thu 16:15 ZHG101

The Influence of Intermittent Turbulence on Solar Energetic Particle Transport: Modelling and Observations — •Frederic Effenberger — Ruhr-Universität Bochum

The detailed understanding and ultimately the ability to forecast solar energetic particle (SEP) events is critical in our efforts to mitigate space weather risks. I will discuss current issues in SEP modelling and observations, highlighting the capabilities under development at Ruhr-University Bochum. Of particular interest are coherent features in the solar wind turbulence that can influence particle transport behaviour. Synthetic fields to study particle transport are typically generated from superpositions of Fourier modes with a prescribed power spectrum and uncorrelated random phases, bringing the advantage of covering a wide range of turbulence scales at manageable computational effort. However, almost all of these models to date only account for second-order Gaussian statistics and thus fail to include intermittent features, as observed in more realistic but expensive direct magnetohydrodynamic simulations. We have developed novel methods to account for such shortcomings, including a minimal Lagrangian map approach. We investigate the particle transport properties by solving a large number of particle orbits in these synthetic turbulence realisations and specifically look for non-diffusive regimes and non-standard energy dependences resulting from the intermittency of the generated fields. Applications to SEP transport and acceleration and their connections to recent observations by Parker Solar Probe and Solar Orbiter will be discussed.

EP 12.2 Thu 16:45 ZHG101

Modeling superdiffusive Particle Motion with truncated Lévy Flights* — •Magdalena Litwin[1,2], Sophie Aerdker[1,2], Lukas Merten[1,2], 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

In the heliosphere, power-law profiles of high-energetic particles at shocks have been observed. These observations point to anomalous, non-Gaussian, transport behavior that might result from intermittent magnetic field structures. Previous studies showed that the power-law distributions can be described by a Lévy flight model. One limitation of such models is that the mean square displacement diverges. In Lévy walk models a spatio-temporal coupling leads to a finite mean-square displacement. We present a similar approach, a truncated Lévy flight model where the mean-square displacement is well-defined. The truncated Lévy flights are simulated with a modified version of the public software framework CRPropa 3.2. The resulting spatial distributions of the new model are compared to those obtained with non-truncated Lévy flight and Lévy walk models. First applications of particle transport at a shock are presented. *supported by SFB1491

EP 12.3 Thu 17:00 ZHG101

Superdiffusive acceleration at heliospheric shocks — •Horst Fichtner[1,2], Sophie Aerdker[1], Frederic Effenberger[1], Lukas Merten[1], and Dominik Walter[1] — [1]Institut fuer Theoretische Physik IV: Ruhr-Universitaet Bochum — [2]Research Department Plasmas with Complex Interactions, Ruhr-Universitaet Bochum

A classical paradigm for the acceleration of energetic particles is the diffusive shock acceleration. For many years this first-order Fermi process was the preferred one to explain the origin of Galactic cosmic rays and of various heliospheric populations, like anomalous cosmic rays or solar energetic particles. In recent years, the evidence has increased, that anomalous transport leading to superdiffusive shock acceleration appears to play a role in the energization of charged particles at shocks. Corresponding numerical simulations have to be based on the solution of fractional partial differential equations, either via finite difference methods or equivalent stochastic differential equations. In the talk both methods will be briefly described, their results for selected cases will compared, and open questions will be discussed. *supported by SFB1491

EP 12.4 Thu 17:15 ZHG101

Modulation of 1 GV protons - comparison of SOHO/EPHIN to AMS-02 fluxes — Bernd Heber[1], •Malte Hörlöck[1], Stefan Jensen[1], Patrick Kühl[1], Lisa Romaneehsen[1], and Holger Sierks[2] — [1]Christian-Albrechts-Universität Kiel, Kiel, D — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen, D

The Electron Proton Helium INstrument (EPHIN) aboard SOHO is designed to measure high-energy particles and is operating since 1995. It provides energy spectra of protons in the energy range from 4 to about 800 MeV. Above 50 MeV the $\frac{dE}{dx} - \frac{dE}{dx}$- and Bowtie-method is used to determine the energy dependent flux. To validate the measurements, we used published proton fluxes from 2011 to 2019 obtained by the Alpha Magnetic Spectrometer (AMS-02) which is a state-of-the-art particle physics detector designed to study cosmic rays and provides proton fluxes from ≈ 400 MeV to 100 GeV. Here we present the methods and their results that lead to an agreement with AMS-02 within 20% for protons with energies between 400 and 700 MeV. This work received funding from the BMWI (50OC2302,50OC2404) and the EU (101135044 - SPEARHEAD).

EP 12.5 Thu 17:30 ZHG101

Energy spectra of 300 keV to 1 MeV electrons from the SOHO Electron Proton Helium INstrument (EPHIN) — •Stefan Jensen[1], Bernd Heber[1], Alexander Kollhoff[1], Patrick Kühl[1], and Holger Sierks[2] — [1]Institut für Experimentelle und Angewandte Physik, Christian Albrechts-Universität zu Kiel, Germany — [2]Max Planck-Institut für Sonnensystemforschung, Göttingen, Germany

The origins of energetic electrons with energies ranging from a few tens of keV to tens of MeV in the inner heliosphere are manifold. They include Galactic Cosmic Rays, Jovian electrons as well as sporadic Solar Energetic Electron (SEE) events. Their energy spectra provide insights into the acceleration at the source and transport processes in the heliosphere. The SOlar and Heliospheric Observatory (SOHO) was launched December 1995 with the Electron Proton Helium INstrument (EPHIN) measuring electrons from 150 keV to several MeV. However, its measuring capability was reduced due to the failure of two detectors in 1997 and 2017, respectively. Thus from 2017 onwards only two electron channels, one in the range from 150 keV to one MeV and one broad channel that measures between 300 keV and 10 MeV. In this contribution we present a new data product for electron spectra based on the onboard histograms. This data product has the advantage of providing the total energy loss in the first two detectors with good statistics compromising energy resolution and counting statistics. Using the bow-tie method we were able to derive the flux in several energy channels between 300 keV and about 1 MeV. We present first results and compare them with instruments from other missions.

EP 12.6 Thu 17:45 ZHG101

Refining the GEANT4 model of EPHIN — •Malte Hörlöck[1], Bernd Heber[1], Stefan Jensen[1], Patrick Kühl[1], and Holger Sierks[2] — [1]Christian-Albrechts-Universität, Kiel — [2]Max-Planck-Institut für Sonnensystemforschung, Göttingen

The Electron Proton Helium INstrument (EPHIN) aboard SOHO is designed to measure electrons, protons and Helium. It is operating since 1995. GEANT4 simulations are extensively used to produce response functions needed to obtain primary quantities (like fluxes) from the quantities that EPHIN provides. Starting from an idealized model representing the nominal design of EPHIN and using calibration measurements performed at the Hahn-Meitner-Institut in Berlin, we demonstrate the development of a refined model including deadlayers, more precise detector dimensions and a model representing the SOHO spacecraft. This work received funding from the BMWI (50OC2302,50OC2404) and the EU (101135044 - SPEARHEAD).