EP 4: Sun and Heliosphere II

Time: Wednesday 10:30–12:30 Location: H-HS VIII

Invited Talk EP 4.1 Wed 10:30 H-HS VIII

Linking Solar Eruptions and Energetic Particles through Observations and Modeling — •Frederic Effenberger — Helmholtz Centre, GFZ German Centre for Geosciences, Potsdam, Germany

The relation between different energetic particle populations accelerated in the solar atmosphere and detected in interplanetary space is not well established. Observational studies during the last years demonstrated the still poorly understood existence of a connection between solar flare signatures of accelerated particles at the Sun and the corresponding solar energetic particles (SEPs) detected at 1 AU. It is thus important to make progress towards answering the question: Under which circumstances do these two observations point to the same population of accelerated particles? Here, we will discuss recent progress concerned with this issue. We illustrate the potential for observations and simultaneous modeling of the escaping and precipitating electron populations to constrain the plasma properties of the flaring region and interplanetary medium. In particular, with the recently launched Parker Solar Probe and Solar Orbiter missions, which will explore the Sun from a close distance and with unprecedented detail, new insights into these questions can be expected. We emphasize the importance of such studies for the fundamental understanding of physical processes in space plasmas and for our space weather forecasting capabilities.

EP 4.2 Wed 11:00 H-HS VIII

Helicity Shedding by Flux Rope Eruption — •Bernhard Kliem and Norbert Seehafer — Universität Potsdam, Institut für Physik und Astronomie

It has been suggested that coronal mass ejections (CMEs) remove the magnetic helicity of active regions from the Sun. Such removal is often regarded to be necessary due to the hemispheric sign preference of the helicity, which inhibits a complete annihilation by magnetic reconnection between volumes of opposite helicity. We have monitored the relative magnetic helicity contained in the coronal volume of erupting magnetic flux ropes. The torus instability, or a combination of helical kink and torus instability, leads to eruption and ejection of the flux rope, which is a model for CMEs. It is found that the fraction of helicity ejected depends strongly on the characteristics of the initial force-free equilibrium of the flux rope. For a rather strongly twisted, initially kink-unstable flux rope of 2.5 field line turns, which has a relatively large fraction of self-helicity, not only the normalized total initial helicity (< 0.1) but also the ejected helicity (about 30 per cent) are relatively small. For a weakly twisted (solely torus-unstable) flux rope, which has a relatively large fraction of mutual helicity, up to 2/3 of the much higher initial helicity (0.2–0.3) are shed. This supports the conjecture hat helicity shedding by CMEs is an important aspect of the solar magnetism.

EP 4.3 Wed 11:15 H-HS VIII

Estimating uncertainties for Solar Energetic Particle anisotropies — •Maximilian Brüdern, Nina Dresing, Bernd Heber, Lars Berger, Alexander Kollhoff, and Patrick Kühl — IEAP Christian Albrechts Universität zu Kiel

Solar Energetic Particles (SEPs) can routinely be observed at 1 AU depending on their origin at the Sun and their transport through the interplanetary medium. Their energy is mostly determined close to the Sun. As SEPs propagate outward along the Interplanetary Magnetic Field (IMF) the pitch-angle with respect to the local field is systematically focused due to the radial decreasing IMF. While stochastic changes are induced by scattering at fluctuations of the IMF. Often the first order anisotropy of SEPs is calculated to disentangle imprints of source and transport. Strong anisotropies indicate periods of weak pitch-angle scattering. Although many modeling and observational studies are based on the anisotropy, its uncertainty is often neglected which could result in inaccurate conclusions. Therefore, we propose a new method based on a bootstrap approach where we consider (1) directional instrument responses, (2) the variation of the magnetic field, and (3) the stochastic nature of detection. Here, we present our procedure and final results for different SEP events using measured data of the IMF and particle fluxes by the Solar Electron and Proton Telescope (SEPT) on board of each STEREO spacecraft. The SEPT provides four viewing directions with a view cone of 0.66 sr each on a three axis stabilized spacecraft. In future we plan to apply our method to the Electron and Proton Telescope (EPT) on board Solar Orbiter.

EP 4.4 Wed 11:30 H-HS VIII

Charged particle transport in MHD simulations — •Felix Spanier[1,2] and Alex Ivascenko[2] — [1]Institut für Theoretische Astrophysik, Universität Heidelberg — [2]Centre for Space Research, North-West University, Potchefstroom, South Africa

Transport and acceleration of charged particles in turbulent media is a topic of great interest in space physics and interstellar astrophysics. These processes are dominated by the scattering of particles off magnetic irregularities. These irregularities are often described as plasma waves.

We report on incompressible MHD simulations combined with charged test particle simulations using the GISMO code. Here we describe a new method to derive the diffusion coefficients $D_{\mu\mu}$ and $D_{\perp}$ from these numerical experiments which is applicable even in the case of strong turbulence where quasi-linear theory is no longer valid. Results for these parameters are presented where a special emphasis is on the transport characteristics at $\mu = 0$.

EP 4.5 Wed 11:45 H-HS VIII

Scattering of the electron strahl in the solar wind — •Daniel Verscharen[1,2], Benjamin Chandran[2,3], Seong-Yeop Jeong[1], Chadi Salem[4], Marc Pulupa[4], and Stuart Bale[4,5,6] — [1]Mullard Space Science Laboratory, University College London, UK — [2]Space Science Center, University of New Hampshire, USA — [3]Department of Physics and Astronomy, University of New Hampshire, USA — [4]Space Sciences Laboratory, University of California, Berkeley, USA — [5]Physics Department, University of California, Berkeley, USA — [6]The Blackett Laboratory, Imperial College London, UK

We investigate the scattering of strahl electrons by microinstabilities as a mechanism for creating the electron halo in the solar wind. We develop a mathematical framework for the description of electron-driven microinstabilities and discuss the associated physical mechanisms. We find that an instability of the oblique fast-magnetosonic/whistler (FM/W) mode is the best candidate for a microinstability that scatters strahl electrons into the halo. We derive approximate analytic expressions for the FM/W instability threshold in two different β_c regimes, where β_c is the ratio of the core electrons' thermal pressure to the magnetic pressure, and confirm the accuracy of these thresholds through comparison with numerical solutions to the hot-plasma dispersion relation. The comparison of our theoretical results with data from the *Wind* spacecraft confirms the relevance of the oblique FM/W instability for the solar wind. We make predictions for the electron strahl close to the Sun, which will be tested by measurements from *Parker Solar Probe* and *Solar Orbiter*.

EP 4.6 Wed 12:00 H-HS VIII

Nonlinear diffusion of energetic particles — •Dominik Walter — Ruhr-Universität Bochum

In recent years the nonlinearity of the cosmic ray transport in various astrophysical environments has been emphasized. While nonlinearity is mostly often described by mutually coupled equations for the dynamics of the thermal plasma and the cosmic ray transport or for the transport of the plasma waves and the cosmic rays, we study the case of a single but nonlinear advection-diffusion equation. The latter can be approximatively solved analytically or semi-analytically, which has the advantage that these solutions are easy to use and, thus, can facilitate a quantitative comparison to data. We present a variety of possible solution strategies, ranging from exact solutions for a diffusion-only equation, to integral mehtods and finally an expanding strategy, that solves the problem using fundamental solutions. For the latter case we will also look at a radially symmetric model.

EP 4.7 Wed 12:15 H-HS VIII

The kappa-cook book — •Klaus Scherer, Horst Fichtner, Marian Lazar, and Edin Husidic — Ruhr Universität Bochum, Institute for Theoretical Physics IV

Recently the standard kappa-distribution (SKD) was extended by the regularized kappa distribution (RKD), to avoid some of the problems of the SKD. Here we present a generalization of the kappa distribu-

tions and discuss the applicability of the various cases to data. We compare some of the different kappa distribution commonly used in literature. We show that for kappa values larger than three all of these distributions lead to very similar results, but for lower kappa values one has to use the regularized types to avoid unphysical behavior, for example too high contributions from superluminal particles.