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NON-SPECIALIST: Cosmic-ray modulation studies – why Parker needed Dirac and Kolmogorov

Friday, 15 July 2011 11:00 (30 minutes)

<p>In 1958, Eugene Parker predicted that the outer parts of the Sun's atmosphere, the solar corona, must be expanding in the form of a supersonic solar wind. This was confirmed by the Mariner 2 spacecraft in 1962. On 16 December 2004, the Voyager 1 spacecraft crossed the heliospheric termination shock, where the flow becomes subsonic, and began exploring the heliosheath. In August 2007, Voyager 2 also crossed the termination shock. The plasma properties of the heliosheath differ greatly from those of the heliosphere inside of the termination shock and particle transport beyond the termination shock is not yet fully understood. Different approximations of the cosmic-ray transport equation, originally derived by Parker in 1965, have been used for decades to study cosmic-ray modulation in the region inside of the termination shock, the focus of this presentation. Cosmic rays that reach Earth are subject to diffusion, convection, adiabatic energy changes, and gradient- and curvature drift due to the non-uniform heliospheric magnetic field. The consequence is that cosmic-ray intensities at Earth are lower than the interstellar value and is referred to as modulation. The turbulent heliospheric magnetic field is frozen into the supersonic solar wind. Inside of the termination shock the two hemispheres with oppositely directed magnetic field is separated by the so-called wavy neutral sheet, across which the magnetic field changes direction. We discuss how modulation studies have progressed from using simple spherically symmetric solutions of Parker's transport equation, to the current situation where in order to properly account for diffusion and drift, complex turbulence transport models are required as well as detailed knowledge of the form of turbulence energy spectra, the latter which include the so-called inertial range derived by Kolmogorov in 1941. Turning to plasma physics, we show that what appear to be two very different kinds of drift motion, along and away from the neutral sheet, actually follow from the standard expression for gradient- and curvature drift, provided that the particle distribution is nearly isotropic. In the course of this derivation one is confronted by a Dirac delta function that must be replaced by something physically acceptable without changing the physics involved. We also discuss why we can study the drift coefficient which determines drift velocity, while using a uniform background magnetic field that obviously does not cause large-scale drifts.

Level (Hons, MSc,
   PhD, other)?

other

Consider for a student
   award (Yes / No)?

No

Would you like to
 submit a short paper
 for the Conference
 Proceedings (Yes / No)?

No

Primary author: Prof. BURGER, Renier (North-West University)

Presenter: Prof. BURGER, Renier (North-West University)

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