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How to simulate the propagation of solar energetic particles in the vicinity of a 3D heliospheric current sheet?

The interplanetary propagation of solar energetic particles (SEPs) can be influenced by large-scale interplanetary structures. The Heliospheric Current Sheet (HCS) is one such large scale structure that persists in the interplanetary solar wind background. Observations show that the time profile, onset time and other characteristics of the SEP flux change significantly after crossing the HCS. Numerical simulations show that SEPs experience significant drift effects near the HCS. They can drift to a longitude further away from the original one. SEPs flux are also impeded when traversing the HCS, and the fluence on the other side of the HCS decreases.

However, in most previous 3D numerical models of SEP interplanetary propagation, the role of the HCS has been overlooked. This affects the accuracy of the model in simulating SEP events.

Our study has used three-dimensional magnetohydrodynamics (MHD) method to simulate a structured solar wind background with HCS. The Focused Transport Equation (FTE) is used to describe the interplanetary propagation of SEPs. Since numerical dissipation leads to unphysical magnetic field reconnection near the HCS, we reshaped the magnetic field to artificially compress the HCS thickness. The drift velocity term has also been added to the SEP transport model. The hybrid model accounts for cross-field diffusion and includes stronger scattering effects near the HCS.

We have preliminarily simulated SEP propagation in a 3D solar wind background field with an HCS. It has been found that the magnetic field reshaping strongly affects the space-time distribution of SEPs, especially in the vicinity of the HCS. The distribution of the drift velocity is strongly affected by the particle pitch angle. The simulation reveals that the SEP drift velocity near the HCS is large comparing other mechanism (e.g. convection). Next, we will select some observational events to further validate and improve the model.

Collaboration(s)

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