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Simulation of Solar Energetic Particles Propagation under Stream Interaction Regions

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Stream interaction regions (SIRs) are formed when fast and tenuous streams originating from coronal holes overtake slow and dense ones ahead.

In this work, we developed a coupled model composed of a data-driven analytical background model providing solar wind configuration and a particle transport model represented by the focused transport equation (FTE), to examine two SIR-associated energetic particle events.

One event was observed by the Solar-Terrestrial Relations Observatory-A (STEREO-A) from 21 to 24 August 2016. The background model driven by spacecraft observation near 1AU provides the solar wind density, velocity, and magnetic field as functions of r and φ, which is simple but can present a more complete description of the solar wind. We simulated proton transport in the SIR region of interest in order to obtain the evolution of proton fluxes and derive the spectra. We find that the simulation is well correlated with the observation. And we suggest that instead of being accelerated by distant shocks, a local mechanism similar to diffusive shock acceleration (DSA) acting in the compression region could explain the flux enhancements of 1.8-10.0MeV nucleon-1 protons [1].

The other energetic proton events, associated with a stream interaction region (SIR), were observed by twin Solar-Terrestrial Relations Observatory (STEREO) and WIND spacecrafts from 2007 September 19 to 25. Different from other spacecraft observations, the in-situ data from STEREO-B show significant increase and rapid decay of particle intensity in the compound stream region after the SIR passing over the spacecraft. By using the coupled model, our results reproduce the evolution features of proton intensity and energy spectrum from the observation of STEREO-B and confirm the additional energetic particle event is closely related to the previous SIR event. We highlight the variation in particle distribution as a function of radial distance within the SIR. The magnetic field configuration in the compound stream region observed by STEREO-B provides a more direct connection to the source particle region, which presents a view to explain the differences between the energetic proton observations of the three spacecraft [2].

References

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[2] Xinyi Tao, Fang Shen, and Xi Luo. Modeling Energetic Proton Transport from a Stream Interaction Region to Compound Streams, 2025, *Astrophys. J.*, 978 143.