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The Crucial Role of Perpendicular diffusion in the Longitude Distribution of > 10 MeV Solar Energetic Protons

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The composition of gradual solar proton events is believed to include both solar components originating near the Sun and interplanetary components associated with interplanetary shock, and interplanetary shock is critical in supplying particles to regions not magnetically connected to the solar source region. In this work, we calculate the ratios of the peak intensities for four energy channels (13-16 MeV, 20-25 MeV, 32-40 MeV, and 40-64 MeV) and compare the ratios observed by multiple spacecraft at different locations. We often find that the ratios of peak intensities observed at different locations do not vary with energy in the same event. In other words, the ratios of the peak intensities for the various energy channels remain constant regardless of the spacecraft's location. This phenomenon suggests that, in many gradual events, energetic particles observed at different locations are predominantly composed of solar components that undergo perpendicular diffusion in the vicinity of the Sun and in interplanetary space. The main factor that enables energetic particles to be detected in regions without magnetic connection to the solar source region is perpendicular diffusion, rather than the acceleration of interplanetary shock.

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