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Solar Energetic Particle Events Observed at Widely Separate Heliographic Longitudes

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During solar cycle 24, thanks largely to the Solar Terrestrial Relations Observatory (STEREO), many solar energetic particle (SEP) events have been observed at widely separate heliographic longitudes, even including impulsive events. The particle intensity profiles sometimes show rather quick onsets after the solar event even if the measurements are made at a longitude generally considered to be poorly connected to the source region. Furthermore, we seldom find more than one eruption that could account for the observations of particles at separate locations. It is found that many of these wide-longitude SEP events accompany wave-like, large-scale coronal propagating fronts in Extreme-ultraviolet (EUV) images, usually referred to as EUV waves. They may represent the lower part of coronal shock waves at the coronal base, which are driven by fast coronal mass ejections (CMEs). In recent years, sophisticated geometrical models have been developed that integrate EUV waves into coronal shocks in 3D. Using such models, it has been shown that the estimated SEP release time is consistent with the time when the CME-driven shock wave comes into contact with the field line that is connected to the observer. However, many wide-longitude SEP events, observed at more than one heliographic longitude, do not appear to be explained in this scheme. In particular, we may need cross field diffusion when the SEP onset is slow and late. We discuss the uncertainties in interpreting existing data that prevent us from clearly understanding the temporal and spatial behaviors of SEP events during the onset phase.

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