Project Details

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Program Element: Focused Science Topic

Topic: The Origin and Consequences of Suprathermal Particles that Seed Solar Energetic Particles

Project Title:
The Role of Magnetic Connectivity and SEP Event History in Determining Seed Populations and Large SEP Events

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Summary:
Forecasting large SEP events continues to be an outstanding challenge in solar and heliospheric physics. We do not directly observe the timing/location of particle acceleration regions, the transport of SEPs along magnetic field lines, or properties of the pre-event seed populations. Multipoint observations have shown that enhanced SEP fluxes can be detected at widely separated locations in the inner heliosphere, especially during active times, when multiple interplanetary shocks are present. Using data-driven modeling of shock evolution, we will determine the connectivity to the observing spacecraft and the spatial relationship between the shock(s) and observer(s). Results will be compared with multipoint measurements to determine the contribution of cross-field transport by evaluating how far away from the shock-connected regions SEPs are still detected.

Hypotheses for the origin of the seed populations associated with large SEP events include: (a) variations in the suprathermal tail of the nominal solar wind distribution at the Sun or in the heliosphere; (b) suprathermal ions from prior or current solar flares; and (c) previously shock-energized particles as a heliospheric source. We propose a combined data analysis and modeling approach to quantify the potential contribution of each of these by investigating the spatiotemporal extent and variability of:

1. SEP (shock) origin in the heliosphere: We will use Wang-Sheeley-Arge (WSA)-Enlil with SEPMOD to examine the field line connectivity and determine how much cross-field transport is necessary to explain the spatial extent of SEP events observed at multiple locations (e.g., L1, STA, PSP). Can the connectivity to CME-driven shock fronts explain the entire longitudinal extent of SEP events?

2. Magnetic geometry near the Sun: We will examine topological structures like pseudostreamers, S-web arcs, and narrow open-field channels into or near the flare site/CME source. Each of these regions has a large squashing factor, i.e., a small angular difference at 1Rs but a large angular difference at the source surface or 21.5Rs. As a result, any flare or CME dynamics could greatly enhance the longitudinal extent available to SEPs.

3. Pre-event conditions and remnant seed particles in the heliosphere: We will use WSA-Enlil+Cone with SEPMOD to investigate how often the observer field lines intersect multiple shocks. The modeled shock parameters will be used as input for detailed shock acceleration calculations with the resulting seed population(s) injected onto WSA-Enlil field lines. As the shock evolves, different field lines will encounter different suprathermal properties.

4. CME-driven shocks near the Sun: We will examine the shock structure in the low corona (