Project Details

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

Project Title:
Understanding the role of flare-accelerated suprathermal ions on spectral and abundance variations in large gradual solar energetic particle events

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Summary:
Science: The overarching objectives of this study are to (i) identify the pathways by which coronal mass ejection (CME)-driven shocks gain access to suprathermal ions from solar flares and (ii) determine how these suprathermal ions influence the energy spectral and abundance variations of H and heavy ions in large gradual solar energetic particle (SEP) events. To achieve these objectives, we answer the following three science questions:

Q1) What is the relative role of simultaneous versus preceding solar flare activity in driving the event-to-event spectral and abundance variations in large gradual SEP events?

Q2) How does the simultaneous activity in parent source regions or other sites in the corona affect the spectral and abundance variations in large gradual SEP events?

Q3) What is the relationship between remnant flare suprathermal ions and the spectral and abundance variations in large gradual SEP events?

Motivation: Large CME-driven shocks-associated gradual SEP events that are hazardous for human and robotic space exploration often exhibit extreme enhancements in the abundances of 3He and heavy-ion species. Since such enrichments are typical of the smaller impulsive flare-related SEP events, it is now accepted that flare suprathermal ions are an essential component of the seed population for CME-driven shocks. However, the mechanisms through which CME-shocks gain access to these flare suprathermals and produce large gradual SEP events remain largely unexplored. Two competing ideas are: 1) CME-driven shocks are launched into heliospheric reservoirs that are populated by residual material created during preceding flare activity the so-called remnant flare suprathermals, and 2) CME-driven shocks gain access to suprathermal material produced in the parent source region or by simultaneous flares from other sites in the corona.

Methodology: We bring closure to the proposed science questions using comprehensive in situ and remote-sensing analyses from five active Heliophysics missions, namely, ACE, SDO, STEREO, Wind at 1 au, and PSP at ~0.1 1.0 au. The remnant population is probed with the suprathermal ion measurements on azimuthally and radially separated ACE, STEREO, and PSP. Closer to the Sun, PSP can detect suprathermals from weaker flare-related events and simultaneously, the azimuthally separated spacecraft at 1 au can measure flare suprathermals distributed over a wide range of heliolongitudes. We determine residency times of flare suprathermals in the reservoir from prior occurrences of type-III radio bursts that are associated with impulsive SEP events. We investigate simultaneous activity in the parent flare using high-resolution observations on SDO. Rapidly changing structures with a size of ~1000 km can be resolved with SDO. These observations can reveal minor and short-lived jets that have been associated with solar sources of impulsive SEP events. Large-scale waves or shocks ejected from the parent source region can traverse jets at other sites in the corona. To examine the magnetic connection in the corona and to determine whether coronal structures are open or closed, we numerically model magnetic fields using PFSS (Potential Field Source Surface) and NLFF (Non-Linear Force Free) models.

Relevance: The proposed study is highly relevant to the scientific objectives of the Focused Science Topic (FST) #3: The Origin and Consequences of Suprathermal Particles that Seed Solar Energetic Particles. Specifically, it is relevant to two out of the three FST objectives: Understand the relative roles of solar flares and CMEs in producing large SEP events; Understand particle transport, mixing, and other effects that result in the observed variability in the properties of SEP events at 1 au. We contribute to the Focused Science Team s effort by providing new insights into the role of flare suprathermals on the spectral and abundance variations in large SEP events.

Publication References:

no references