Project Details

ROSES ID: NNH19ZDA001N
Selection Year: 2019
Program Element: Focused Science Topic

Topic: Variable Radiation Environment in the Dynamical Solar and Heliospheric System

Project Title:
A Multi-spacecraft Approach to Understand the Spectral and Temporal Evolution in Large Solar Energetic Particle Events

PI Name: Mihir Desai
PI Email: desai@uleis.umd.edu
Affiliation: University of Maryland College Park
Project Member(s):
- Cohen, Christina M. S.;Co-I;California Institute of Technology
- Giacalone, Joe;Co-I;University Of Arizona
- Dayeh, Maher A;Co-I;Southwest Research Institute
- Ebert, Robert W;Co-I;Southwest Research Institute

Summary:
Current Understanding: Large gradual Solar Energetic Particle (SEP) events are thought to be produced by diffusive shock acceleration (DSA) processes at coronal and interplanetary (IP) shocks driven by fast coronal mass ejections (CMEs) as they plough through the solar corona and IP space. These SEPs are routinely transported to distant locations in the heliosphere, including near-Earth orbit. They are often associated with large increases in particulate radiation that can pose serious hazards to humans and technological assets in space. SEPs are thus a key driver of Space Weather and one major hurdle for human deep space exploration. The behavior of the energy spectra in SEP events is directly indicative of their intrinsic radiation threat and has been the subject of numerous studies. Studying SEP spectral properties; particularly understanding the physical mechanisms responsible for producing their variable spectral slopes and roll-over or break energies (Eo) is critical for developing a complete picture of DSA, how ICME shocks accelerate SEPs near the Sun and in IP space, and how SEPs are transported.
Objective: Our over-arching goal is to develop a physics-based understanding of the temporal and spectral properties of H Fe ions observed in large gradual solar energetic particle (SEP) events at 1 AU, and relate them to physical conditions (e.g. turbulence levels, shock properties, seed population) at their near-Sun source using existing theories, models, and available observations.
Science Questions: We achieve our objective by combining multi-spacecraft observations of >200 SEP events with targeted modeling of selected events to answer the following three questions:
SQ1. What physical processes determine the spectral shape of SEP events; acceleration or interplanetary transport?
SQ2. What are the relative contributions of acceleration and transport to SEP spectra during different interplanetary conditions?
SQ3. What do acceleration, transport signatures tell us about IP conditions, SEPs, & shock properties?
Methodology: To achieve our objective, we will perform the following prime tasks: (1) Survey SEPs detected at ACE, Wind, STEREO-A & -B, and PSP during 1998-present. (2) For each event, derive the associated shock, ICME, and SEP spectral and abundance properties. (3) Examine the H-Fe spectral Eo and their temporal behavior to identify the effects of acceleration and transport. (4). Perform extensive correlation analysis to reveal the processes that dominate SEP properties during different conditions (SQ1 closure). (5) Examine the spectral evolution of SEPs for different shock properties (geometry, strength, speed, pre-event conditions) to determine how the charge-to-mass dependence of Eo evolves throughout the event. (6). Perform detailed analysis on ~3 SEP events measured at multi-spacecraft to determine how the pre-event conditions and shock parameters affect the observed temporal and spectral profiles at 1 AU. Finally, we will model the 3 events using a physics-based model with constraining input from the observations. This will enable us to interpret the influence of different input parameters (SQ2, SQ3 closure).
Relevance and Contributions to the Focused Team Effort: Our project responds directly to the first Focused Science Topic (FST), The Variable Radiation Environment in the Dynamical Solar and Heliospheric System, by focusing on the production and acceleration mechanisms of SEPs, often associated with extreme particulate radiation. We contribute to the FST goals by providing physics-based understanding of acceleration and transport effects of SEPs, and critical modeling of SEP constraints. Our team has extensive experience in SEP analyses from multi-spacecraft and modeling SEP acceleration & transport effects. The project also responds to the first Strategic Science Area (SSA-0) determined by the LWS TR&T steering committee and to 2 key science goals of the 2012 Heliophysics Decadal survey (1&4).

Publication References:

no references