Project Details

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Selection Year: 2017
Program Element: Focused Science Topic

Topic: Toward a Systems Approach to Energetic Particle Acceleration and Transport on the Sun and in the Heliosphere

Project Title:
Linking Energetic Storm Particles to their Upstream Physical Conditions and Shock Properties

PI Name: Maher A Dayeh
PI Email: maher.aldayeh@swri.edu
Affiliation: Southwest Research Institute
Project Member(s):
- Kostan, Travis;Co-I;Southwest Research Institute
- Burns, Cheryl;Collaborator;Self
- Ebert, Robert W;Co-I;Southwest Research Institute
- Gonzales, Edith M;Collaborator;Self
- Hebert, Vanessa;Collaborator;Self
- Desai, Mihir I;Co-I;Southwest Research Institute
- Li, Gang;Co-I;University Of Alabama, Huntsville
- Berger, Laura L;Collaborator;Self

Summary:
Current Understanding: Enhancements of >0.1 MeV/nucleon ions near 1 AU in association with the passage of an interplanetary (IP) coronal mass ejection (ICME) are often referred to as energetic storm particle (ESP) events. The primary candidate of producing these enhancements is diffusive shock acceleration (DSA). ESPs can produce significant increases in the near-Earth particulate radiation and pose severe hazards to astronauts and hardware in space. Physical parameters thought to affect ESP production include IP shock properties (e.g., speed, strength, obliquity) and upstream conditions ahead of the propagating shock (e.g., turbulence, seed populations, SW and IMF conditions). While several observational studies and theories have attempted to link ESP production to these drivers, reliable prediction of ESP properties (e.g. intensities, spectra, abundances), including their event-to-event variability, has so far proven elusive, indicating an incomplete understanding of how ICME-driven IP shocks accelerate ESPs.

Goal and Science Questions: Our overarching goal is to identify the dominant upstream and shock parameters that influence ESP properties and lead to their event-to-event variability, thereby advancing current understanding of ICME-driven shock particle acceleration. We will also determine whether these drivers can be used to predict ESP properties at 1 AU. We will achieve this goal by answering the following three science questions:

Q1. What is the relationship between upstream conditions, ESP properties, and IP shock properties at 1 AU?

Q2. How do upstream conditions and IP shock properties affect ESP production and properties?

Q3. Can upstream conditions and IP shock properties be used to predict ESP properties at 1 AU?

Methodology: We use energetic H-Fe ion, plasma and magnetic field measurements from ACE, Wind, and STEREO-A&B during solar cycles 23 and 24. Using specific criteria, we will identify all shocks and ESP events measured at 1 AU. For each ESP and when available, we will derive a matrix of parameters describing the upstream conditions, IP shock, and ESP. Statistical and correlation studies will follow to pinpoint the dominant drivers that influence ESP properties (Q1). Once the Upstream-Shock-ESP linkage is determined, we will utilize the Particle Acceleration and Transport in the Inner Heliosphere (PATH) model to explore the influence of these dominant drivers on ESP properties. PATH model inputs, constrained by observations, will be varied systematically to isolate the influence of each potential driver on ESP intensities, spectra and abundances (Q2). Using the parameter matrix derived in Q1, we will utilize Machine Learning algorithms to determine if and how upstream and shock parameters can be used to predict ESP properties (Q3). The relationships uncovered in these analyses are expected to lead to a more complete understanding of ICME-driven particle acceleration at 1 AU.

Relevance to NASA and LWS: Our project responds directly to the second Focused Science Topic (FST) and to two LWS Program Science goals, as indicated in the special FST contributions elsewhere in this proposal. Results are also relevant to two science goals of the 2012 Solar and Space Physics Decadal Survey, and to a key strategic goal of NASA " s Heliophysics Division, i.e., understand the Sun and its interactions with the Earth and the solar system, including space weather

Publication References:

no references