Project Details

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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:
Spatial Distribution of Flare-Accelerated Particles and Their Role as Seed Particles for SEPs

PI Name: Dale E. Gary
PI Email: dgary@njit.edu
Affiliation: New Jersey Institute of Technology
Project Member(s):
- Fleishman, Gregory D;Co-I;New Jersey Institute Of Technology
- Jing, Ju;Co-I;New Jersey Institute Of Technology
- Park, Jinhye;Collaborator;Kyung Hee University Research and University-Industry Corporation
- Moon, Yong-Jae;Collaborator;Kyung Hee University Research and University-Industry Corporation
- Nita, Gelu M;Co-I;New Jersey Institute Of Technology
- Xu, Yan;Co-I;New Jersey Institute Of Technology
- Wang, Haimin;Co-I;New Jersey Institute Of Technology

Summary:
Solar Energetic Particle (SEP) events are known to be associated with Coronal Mass Ejections (CMEs), with the high-energy particles likely to be accelerated by CME-associated shock waves en route to Earth. However, current theories of shock acceleration do not allow acceleration directly from the thermal pool, but rather require the pre-existence of a population of non-thermal 'seed' particles. The fact that SEPs are well associated with large solar flares suggests that particles accelerated during the flare might provide such seed particles. However, most of our knowledge of flare-accelerated particles comes from hard X-rays, high-frequency microwaves, or indirect evidence such as heating by downward-directed particles. These emissions are heavily weighted to the high-density, high-magnetic-field, lower-altitude parts of the flaring region far from the CME front. Recently, a new data stream has become available, multi-frequency microwave imaging from the Expanded Owens Valley Solar Array (EOVSA), which can directly image and obtain particle energy diagnostics of the relatively low-density, low-magnetic field, high-altitude parts of the eruption, thus linking flare-accelerated particles with the larger eruption and CME. Here we propose to combine the EOVSA microwave imaging and diagnostics with observations from solar space missions, including RHESSI, SOHO, STEREO-A, SDO, Hinode, and IRIS, as well as ground-based observations from Big Bear Solar Observatory (BBSO) to further explore this linkage and improve our understanding of the origin of seed particles in relation to SEP events.

The science goals and objectives of the proposal are: (i) to obtain flare-accelerated particle diagnostics at high altitudes using microwave imaging spectroscopy of dozens of flares already observed by the new EOVSA; (ii) to use NASA spacecraft and ground-based data to dynamically relate these spatially-resolved diagnostics to both the lower atmosphere and the wider eruption and CME.

Methodology. We propose to use the new data stream from EOVSA, which provides a new capability to obtain multi-frequency (2.5-18 GHz) radio images at 1-s cadence, with spatial resolution about 3" at 18 GHz. The data provide never-before-available diagnostics of energetic particles and coronal magnetic fields throughout the region linking flares to the associated eruption and CME. We will also use BBSO, SDO and Hinode data of jointly observed events to determine (1) properties of magnetic reconnection rates calculated from ribbon separation, (2) magnetic free energy in the hosting active region (AR), (3) magnetic decay index and twist in ARs with identified flux ropes. Our collaborators at Kyung Hee University will provide 3D parameters of associated CMEs and properties of EUV waves, using tools they have developed. We will apply these techniques to SEP events associated with AR 12673, and to similar events without SEPs to identify the necessary and sufficient conditions for effective seeding in these events.

Proposed Contributions: This Targeted Investigation is relevant to the Focused Science Topic "Toward a systems approach to energetic particle acceleration and transport on the Sun and in the heliosphere," for which EOVSA's unique sensitivity to high-energy particles and their transport provides the missing link between the flare (and host AR) and the ensuing eruption and CME. An understanding of this link is essential to prediction of which events will be accompanied by SEP events. The proposal will contribute to the FST effort by (1) using our team's expertise in analyzing SDO/AIA/HMI data and deriving key data products as described above for magnetic properties of source ARs and flares, (2) using our team's expertise in analyzing microwave and hard X-ray data for direct imaging and diagnostics of emission from energetic particles over a large region, and (3) using our team's expertise in characterizing CMEs and EUV waves.

Publication References:

no references