Project Details

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Program Element: Focused Science Topic

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

Project Title:
Integrated Model for the Solar Energetic Particles, Galactic Cosmic Rays, and Alfven Wave Turbulence in the Inner Heliosphere

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Summary:
The aim of the proposed investigation is to characterize the radiation environment due to solar energetic particles (SEPs) and galactic cosmic rays (GCRs), and the variability of this environment affected by the Sun. The two principle science objectives of this study are 1) quantification of the relationship between extreme SEP events and Forbush decrease, and anisotropy of the CGRs observed at Earth, and 2) identification of the mechanism of SEP acceleration and their energy spectrum and anisotropy.

In this investigation, we will analyze energetic proton spacecraft observations, and use them for the model validation. Modeling that will be performed as a part of the study includes three major components: 1) kinetic modeling of SEPs in the inner heliosphere accounting for their stochastic acceleration, 2) kinetic modeling of GCRs starting at 5 AU as they propagate toward the inner heliosphere, and 3) MHD modeling of solar wind including the quantification of turbulence. The novel feature of our approach is concurrent modeling of the turbulent solar wind, SEPs, and GCRs in the same simulation.

To address the diffuse shock acceleration driven by the Coronal Mass Ejection (CME), we will employ the Eruptive Event Generator using the Gibson-Low flux rope (EEGGL) to simulate the CME and accompanying shock.

To model the SEP transport through a wide range of heliocentric distances from 1 Rs to about 5 AU. We will use the Field-Line-Advection Model for Solar Particle Acceleration (M-FLAMPA) model, recently implemented to work with multiple lines.

The realistic three-dimensional magnetic field governing the particle motion will be simulated using the Alfven Wave turbulence based Solar atmosphere Model (AWSOM) with the capability of faster than Real-time simulation (AWSOM-R). In the latter, the Alfven wave turbulence both heats the solar corona and powers and accelerates the fast and slow solar wind. Following a system approach, we will employ the turbulence as simulated in the AWSOM-R as the agent controlling the energetic particle transport and determining the particle spatial diffusion coefficient or pitch-angle scattering.

With an assumed (or based on observations) spectra of GCRs at 5AU, we will study their transport to the inner heliosphere as well as the SEP population propagating from the Sun. The highest-energy particle trajectories will be traced with the Adaptive Mesh Particle Simulator (AMPS) code available at the University of Michigan. Electric and magnetic fields that are needed for calculating these trajectories, as well as the level of turbulence, will be derived from the expanded AWSOM model.

The model of the SEP fluxes and spectra will be validated against the spacecraft observations (ACE, STEREO, and GOES).

The proposed project will contribute to the Focused Team Effort by characterizing the radiation environment due to SEPs and GCRs in the heliosphere up to 5 AU. One of the outcomes of the project will be improved the models of the solar wind, SEPs, and GCRs models that were developed and maintained by the proposing team. That serves improving the numerical models of cosmic ray modulation in the heliosphere, high-energy particles from major solar eruptions, and the Forbush decrease by extreme CME events, which is a measure of success of FST #1. All the relevant models are available to the heliophysics community via the Community Coordinated Modeling Center (CCMC). Therefore, this work will have a broader impact that goes beyond the science goals of this investigation by providing better modeling tools to the heliophysics community.

The proposed work will also directly contribute to Understanding the influence of major solar eruption events on the high energy radiation environment near-Earth and interplanetary space, and Studies of the temporal and spectral properties of large SEP events that are the science goals of FST #1.

Publication References:

no references