Project Details

ROSES ID: NNH20ZDA001N
Selection Year: 2020
Program Element: Focused Science Topic

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

Project Title:
Generation of Suprathermal Seed Particle Populations by Dynamic Small-scale Flux Ropes in the Vicinity of Traveling Shocks

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Summary:
1. Science Goals and Objectives. The main goals of this project are: (i) Investigation of the fundamental physics of how, and to what extent, dynamic small-scale magnetic flux ropes (SMFRs), observed to occur in the vicinity of shocks driven by coronal mass ejections (CMEs) and their interplanetary counterparts (ICMEs), produce suprathermal particle populations through efficient SMFR acceleration. (ii) Gain an understanding of how these populations act as seed particles for the diffusive shock acceleration (DSA) of solar energetic particles (SEPs) at CME/ICME-driven shocks between the solar corona and Earth orbit. This involves the following main science objectives: (1) Determination of the relative efficiency of various theoretically identified competing 1st and 2nd order Fermi acceleration SFMR mechanisms in producing suprathermal ion and electron populations. (2) Estimation of the probability of these suprathermal particle populations in forming a significant seed population for injection into DSA of SEPs at CME/ICME-driven shocks. (3) Study the existence of a competition between SMFR acceleration and DSA above a threshold energy which might modify the spectral features and time profiles of SEPs undergoing DSA. (4) Deduction of the background suprathermal spectrum in the corona.

2. Methodology. Transport theory based simulations of SMFR acceleration of suprathermals and DSA of SEPs near CME/ICME shocks, constrained by spacecraft data analysis results, will be performed for both ions and electrons between the solar corona and 1 AU. Existing focused and SMFR transport theories for suprathermal SMFR acceleration in the solar wind will be used to update available focused transport numerical models of energetic ion and electron transport and DSA at traveling shocks to include SMFR acceleration. Analysis of available data from ACE, Wind, STEREO A & B, Helios 1 & 2, and current and future data from the Parker Solar Probe will be used to estimate detailed SMFR characteristics with the aid of Grad-Shrafranov and wavelet data analysis methods and determine the associated SMFR accelerated energetic particle characteristics in the vicinity of CME/ICME-driven shocks to constrain simulations of SMFR acceleration. Data analysis will also address CME/ICME driven shock characteristics and relevant features of SEPs undergoing DSA at these shocks to constrain DSA simulations.

3. Relevance and Contribution to Team Effort. This project addresses Focused Science Topic (FST) 3: "The Origin and Consequences of Suprathermal Particles that Seed Solar Energetic Particles". Numerical focused transport models combining SMFR acceleration with DSA at CME/ICME-driven shocks will be developed. Simulations of SMFR acceleration to form suprathermal populations near CME/ICME driven shocks, DSA of SEPs, and injection of SMFR-accelerated into DSA of SEPs at these shocks, will be simulated for both ions and electrons between the solar corona and 1 AU. Conclusions about the dominant SMFR acceleration mechanisms for both ions and electrons, the injection efficiency of SMFR-accelerated suprathermals into DSA of SEPs, competition between SMFR acceleration and DSA above a threshold energy, and the background spectra of suprathermals in the corona will be drawn. This will be accomplished by validating the simulations with (i) observed time and spectral profiles of enhanced fluxes of suprathermals accelerated by SMFRs in the vicinity of CME/ICME-driven shocks and of SEPs undergoing DSA at these shocks, and (ii) with observed SMFR parameters estimated with the aid of Grad-Shrafranov and wavelet data analysis methods. Our theoretical, numerical, and data analysis results will be published in scientific journals.

Publication References:

Summary: Blah

Reference: Adhikari, L., Zank, G. P., Wang, B., Zhao, L.-L., Telloni, D., Pitna, A., Opher, M., Shrestha, B., McComas, D. J., and Nykyri, K., Theory and Transport of Nearly Incompressible Magnetohydrodynamic Turbulence: High Plasma Beta Regime, The Astrophysical Journal, 953, 44, 2023

- **Investigation Type:** Other Investigations
- Blah

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