Project Details

ROSES ID: NNH08ZDA001N
Selection Year: 2009
Program Element: Focused Science Topic

Topic: Use Inner Heliospheric Observations to better constrain Coronal Mass Ejection (CME) and Solar Energetic Particle (SEP) Event models.

Project Title:
Simulating CME-Driven Shocks and SEP Acceleration

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Summary:
We propose to simulate and predict the propagation of CME-driven shocks in the solar corona, and calculate the acceleration of solar energetic particles at the shocks. We will perform these simulations in a realistic heliosphere using a global magnetohydrodynamic (MHD) model that allows us to perform event studies. The main focus of this study will be the structure and evolution of shocks as they propagate from the low corona to beyond 1 AU and how particles are accelerated at these shock fronts. We will validate our simulations by quantitative comparisons with both remote (coroagraph) observations and in situ observations throughout the heliosphere. The University of Michigan's BATSRUS code and SWMF framework will used to perform the proposed MHD simulations, while the FLAMPA code (Sokolov et al. 2004) will be used for particle calculations. This work builds upon our more recent simulation which demonstrated an unprecedented ability to model real CME events and quantitatively match coronagraph images, including identification of the CME driven shocks (Manchester et al. 2008). This proposal research proceeds as follows: (1) incorporate a realistic MHD model of the inner heliosphere based on the Wang-Sheeley-Argee empirical model, (2) validate coronal density with tomographic reconstructions of coronagaph images (3) investigate pre-eruption active regions and choosse CME initiation by flux rope, shear flows, or breakout mechanism, (4) validate the CME model by quantitative comparisons between synthetic white-light images and stereoscopic SECCHI observations and comparisons with in situ data from IMPACT, PASTIC, ACE, and Messenger (5) identify shock fronts and determine and (6) predict the spectra of particles accelerated at shock fronts. Understanding how CME structures evolve through the heliosphere will enhance the scientific return from numerous NASA instruments (particularly SECCHI and IMPACT) by predicting the white-light appearance of CMEs and predicting SEPs throughout the heliosphere. We will address many scientific issues such as (1) how shocks interact wit the solar wind at different heliocentric distances, (2) show distortions to the shock front affect particle acceleration, (3) what causes some CME to accelerate energetic particles towards Earth while others do not.

Publication References:

Summary: no summary

Reference: Manchester, W. B., IV; van der Holst, B.; Tóth, G.; Gombosi, T. I.; (2012), The Coupled Evolution of Electrons and Ions in Coronal Mass Ejection-driven shocks, The Astrophysical Journal, Volume 756, Issue 1, article id. 81, 12 pp, doi: 10.1088/0004-637X/756/1/81

Summary: no summary

Reference: Jin, M.; Manchester, W. B.; van der Holst, B.; Oran, R.; Sokolov, I.; Toth, G.; Liu, Y.; Sun, X. D.; Gombosi, T. I.; (2013), Numerical Simulations of Coronal Mass Ejection on 2011 March 7: One-temperature and Two-temperature Model Comparison, The Astrophysical Journal, Volume 773, Issue 1, article id. 50, 10 pp, doi: 10.1088/0004-637X/773/1/50