Project Details

ROSES ID: NNH09ZDA001N
Selection Year: 2010
Program Element: Focused Science Topic

Topic: Predict the Onset and Space Weather Impacts of Fast CMEs/Eruptive Flares

Project Title:
Modeling Dynamical Flux Emergence as the Driver of Coronal Mass Ejections

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Summary:
Coronal mass ejections (CMEs) are eruptions of solar plasma and magnetic field from the solar corona into interplanetary space. The collision of Earth-directed CMEs with the Earth's space environment is a primary source of magnetospheric substorm activity, which creates hazards for radio communications and Earth-orbiting spacecraft. There are a number of competing theoretical models for erupting CME magnetic structures, many of which rely on the emergence of magnetic fields from the solar convection zone into the corona to drive or destabilize the CME. However, rather than dynamically emerging this field, most rely on the specification of kinematic photospheric boundary conditions to mimic flux emergence. The goal of this proposal is to perform a fundamental test of whether CME initiation can be driven by self-consistent, dynamical flux emergence. We will primarily focus on the breakout CME model and the flux rope loss of equilibrium and torus instability models. We will study how flux emergence from the high beta convection zone into the low beta corona affects such CME-prone coronal fields. We will then develop a model for driving coronal simulations with observational data input at a high beta photospheric boundary. In collaboration with our Focused Science Topic teammates, we will simulate the evolution of CME producing regions, testing whether such data driven simulations can reproduce observed eruptions.

Our simulations will be run with the NRL-developed 3D magnetohydrodynamic code ARMS. This code has been used to study CME initiation via kinematic boundary driving, and to study dynamical flux emergence into a field free

corona. For our proposed work we will combine these two simulation capabilities together to study the initiation of CME eruptions via flux emergence into a pre-existing coronal field. The simulation results will be compared against photospheric vector magnetic field observations of flux emergence, EUV and X-ray observations of coronal magnetic field structures, and coronagraph observations of CME eruptions. This program is aimed at improving our understanding of how CMEs are driven and destabilized, thus enhancing NASA's ability to develop predictive tools for CMEs and their space weather consequences.

Publication References:

Summary: no summary

Reference: Leake, James E.; Linton, Mark G.; Antiochos, Spiro K.; (2010), Tests of Dynamical Flux Emergence as a Mechanism for Coronal Mass Ejection Initiation, The Astrophysical Journal, Volume 722, Issue 1, pp. 550-565, doi: 10.1088/0004-637X/722/1/550

Summary: no summary

Reference: Leake, James E.; Linton, Mark G.; (2013), Effect of Ion-Neutral Collisions in Simulations of Emerging Active Regions, The Astrophysical Journal, Volume 764, Issue 1, article id. 54, 15 pp, doi: 10.1088/0004-637X/764/1/54