Project Details

ROSES ID: NNH08ZDA001N
Selection Year: 2009
Program Element: Independent Investigation

Topic: Determine the possible role of galactic cosmic ray particles as a source for cloud condensation nuclei in the troposphere and lower stratosphere.

Project Title:
Formation of Coronal Flux Ropes and Onset of Coronal Mass Ejections

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Summary:
We propose to carry out 3D MHD simulations of the formation and eruption of magnetic flux ropes in the solar corona as a result of the following photospheric flux transport processes: (1) magnetic flux emergence, (2) shear and twisting motions, and (3) turbulent diffusion. Both analytic and numerical modeling in recent years have shown that a magnetic flux rope containing helical field lines is a promising candidate for the precursor structure for coronal mass ejections, and the eruption can result from an ideal MHD process of loss of stable equilibrium. We will model the formation and evolution of coronal flux rope structures for a wide range of CME source regions, from compact active region filaments to long quiescent filaments in decaying active regions. Through these simulations we will examine the conditions for an ejective eruption of the flux rope and the possible existence of a threshold in terms of the magnetic helcity for the onset of eruption given a normal flux distribution at the lower boundary. We will study the relative importance of the flux rope's self-helicity and the mutual helicity between the flux rope and the surrounding potential field in causing eruptions and explore the possibility where the helicity of the ejected flux rope is of the opposite sign of that of the pre-existing flux rope. Finally we will model specific observed events by carrying out realistic simulations for which the lower boundary driving conditions are derived from the observed vector magnetic field evolution on the photosphere. The resulting evolution of the coronal magnetic field from the simulations will be compared with multi-wavelength coronal observations. Such comparisons will provide crucial insight into the nature of the 3D coronal magnetic field evolution associated with eruptive flares and coronal mass ejections.

Publication References:

Summary: no summary

Reference: Fan, Y.; (2009), The Emergence of a Twisted Flux Tube into the Solar Atmosphere: Sunspot Rotations and the Formation of a Coronal Flux Rope, The Astrophysical Journal, Volume 697, Issue 2, pp. 1529-1542, doi: 10.1088/0004-637X/697/2/1529

Summary: no summary

Reference: Cottaar, M.; Fan, Y.; (2009), A Model of Coronal Streamers with Underlying Flux Ropes, The Astrophysical Journal, Volume 704, Issue 1, pp. 576-590 (2009), doi: 10.1088/0004-637X/704/1/576

Summary: no summary

Reference: Fan, Y.; (2010), On the Eruption of Coronal Flux Ropes, The Astrophysical Journal, Volume 719, Issue 1, pp. 728-736 (2010), doi: 10.1088/0004-637X/719/1/728

Summary: no summary

Reference: Fan, Y.; (2011), A Magnetohydrodynamic Model of the 2006 December 13 Eruptive Flare, The Astrophysical Journal, Volume 740, Issue 2, article id. 68, 13 pp. (2011), doi: 10.1088/0004-637X/740/2/68

Summary: no summary

Reference: Fan, Y.; (2012), Thermal Signatures of Tether-cutting Reconnections in Pre-eruption Coronal Flux Ropes: Hot Central Voids in Coronal Cavities, The Astrophysical Journal, Volume 758, Issue 1, article id. 60, 14 pp, doi: 10.1088/0004-637X/758/1/60

Summary: no summary

Reference: Chatterjee, Piyali; Fan, Yuhong; (2013), Simulation of Homologous and Cannibalistic Coronal Mass Ejections produced by the Emergence of a Twisted Flux Rope into the Solar Corona [Erratum: 2014ApJ...792L..24C], The Astrophysical Journal Letters, Volume 778, Issue 1, article id. L8, 5 pp. (2013), doi: 10.1088/2041-8205/778/1/L8

Summary: no summary

Reference: Chatterjee, Piyali; Fan, Yuhong; (2014), Erratum: "Simulation of Homologous and Cannibalistic Coronal Mass Ejections Produced by the Emergence of a Twisted Flux Rope into the Solar Corona" (2013, ApJL, 778, L8), The Astrophysical Journal Letters, Volume 792, Issue 1, article id. L24, 1 pp. (2014), doi: 10.1088/2041-8205/792/1/L24