Project Details

ROSES ID: NNH14ZDA001N
Selection Year: 2014
Program Element: Focused Science Topic

Topic: Prediction of the Interplanetary Magnetic Field Vector Bz at 1AU

Project Title:
Evolution of the magnetic field in solar transients between the upper corona and 1 AU

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Summary:
We propose to investigate the evolution of the interplanetary magnetic field (IMF) in solar transients between the upper corona and 1 AU by a combination of numerical simulations and the analysis of remote-sensing observations and in situ measurements. Coronal mass ejections (CMEs) are the major source of long-duration steady southward Bz, which are the main cause of geomagnetic storms. With recent developments using solar as well as coronagraphic observations, it may be possible to determine the orientation of the magnetic field inside a CME in the corona. However, recent studies have shown that some CMEs rotate as they propagate, modifying the direction of their magnetic field. In fact, a recognized issue in the field of heliophysics is that in situ modeling is often at variance with remote-sensing observations of transients, especially for the CME size and orientation. Other studies have revealed how CME-CME interaction can result in reconnection of the poloidal field of a CME. Last, other sources of steady magnetic fields, such as small transients (STs) have been investigated, but their exact importance to understand and predict the IMF at 1 AU has not yet been determined.

Our objective is to understand how the orientation and magnitude of the magnetic field inside CMEs and STs vary during their heliospheric propagation. To do so, we will address the following science questions:

1- What are the causes of CME heliospheric rotation? How frequent is it and at what distance does it typically stop?

2- How much does the magnetic field inside CMEs and STs decrease during their propagation due to the expansion of the transients?

3- How does the interaction of a CME with other CMEs or with CIRs affect its internal magnetic field?

4- What are other sources of steady periods of southward Bz and can they be predicted from coronagraphic and heliospheric imaging?

To answer these questions, we will conduct self-consistent 3-D MHD simulations in idealized settings as well as simulations of selected real events. We will also analyze in situ measurements of CME-CME interaction and STs for solar cycles 23 and 24, as well as measurements when two or more spacecraft were in conjunction with different analysis techniques. Last, we will analyze remote-sensing observations of solar transients by SECCHI coronagraphs and heliospheric imagers and by LASCO.

This proposal aims at addressing part of the call of Prediction of the Interplanetary Magnetic Field Vector Bz at 1 AU of LWS. Our investigation will focus on "observational and modeling investigations relating to identification of characteristics in the inner heliosphere that affect the magnetic field topology" and "investigations of CMEs to include the embedded magnetic field vector".

We propose to contribute to the team efforts in a number of different ways: (i) we will provide our simulations results for possible ``blind'' analysis to the rest of the team and (ii) we will provide the link between solar and coronal investigations and in situ measurements by performing numerical simulations of particular events of interest and by studying the causes of the discrepancies between analyses based on in situ measurements and those based on remote-sensing observations.

Publication References:

Summary: no summary

Reference: Lugaz, N.; Farrugia, C. J.; Winslow, R. M.; Al-Haddad, N.; Kilpua, E. K. J.; Riley, P.; (2016), Factors affecting the geoeffectiveness of shocks and sheaths at 1 AU, Journal of Geophysical Research: Space Physics, Volume 121, Issue 11, pp. 10,861-10,879, doi: 10.1002/2016JA023100