Project Details

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Topic: Fast Reconnection Onset

Project Title:
Onset of Magnetic Reconnection and Solar Applications

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Summary:
Magnetic reconnection is a fundamental physical process that is at the heart of many important drivers of space weather. A crucial property of reconnection is its switch on nature. Reconnection must remain dormant to allow magnetic stresses to build, then suddenly activate to release the stored energy. If it were to occur too soon, phenomena like coronal mass ejections, solar flares, and magnetospheric substorms would be much weaker than observed, and nanoflares would be unable to heat the corona to its multi-million degree temperatures. Our overarching goals are to identify and understand (1) the onset conditions for fast reconnection and (2) the conditions necessary to sustain the reconnection to allow a large release of energy. We will concentrate on physical environments similar to those found on the Sun and other stars. Reconnection occurs at current sheets, and our specific objectives are to determine the dependence of reconnection on current sheet width, shear angle, length, and any other physical parameters that we may find to be important, including an investigation of the effects of line-tying and atmospheric stratification. We will study both equilibrium configurations and configurations that are evolving, e.g. in response to footpoint driving. An ultimate goal is to develop a numerical technique for incorporating these critical conditions into large-scale numerical simulations that are unable to resolve individual current sheets.
In some environments, such as the magnetosphere, reconnection onset appears to require that the thickness of the sheet be comparable to kinetic scales (ion gyroradius, ion skin depth). This is not the case in the solar corona. The tearing instability, which is how reconnection usually begins, is very fast even for sheets that are much fatter. Thus, a resistive MHD treatment is appropriate. We will use well-resolved numerical MHD simulations to study the linear onset and nonlinear growth of reconnection, expanding upon our recent initial results. As an observational test of our simulations, we will construct synthetic EUV spectral line profiles of very hot (> 5 MK) emission lines and compare them with data from EIS/Hinode, IRIS, and the EUNIS rocket. The shapes of the line profiles provide valuable information on spatially-unresolved flows and should reveal whether the reconnection is laminar, turbulent, or plasmoid dominated. In some cases there may be spatially-resolved signatures of reconnection (e.g., large plasmoids in eruptive flare current sheets). For these, we will compare with imaging observations such as those from AIA/SDO. We will also relate our results to general observational constraints, such as the famous Parker angle for coronal heating, which is the characteristic misalignment angle between adjacent magnetic strands in the tangled coronal magnetic field.
We will share our results and ideas freely with the entire Focused Science Team. It is highly likely that other team members will emphasize reconnection at kinetic scales. While solar reconnection is initiated by processes at fluid scales, the actual breaking of field lines occurs at kinetic scales. We treat this with electrical resistivity, but other kinetic effects are potentially important. Interacting closely with the team on this and other aspects of mutual interest is vital to progress. We will help other team members with comparisons to solar observations where appropriate.

Publication References:

no references