Project Details

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Topic: Determine the mechanisms that heat and accelerate the solar wind

Project Title:
Heating the Corona and the Solar Wind by Magnetic Reconnection

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Summary:
Understanding the heating of the corona and the solar wind is a primary objective of the LWS TR&T program. We propose to investigate the role of magnetic reconnection as a fundamental heating mechanism of the global corona and the solar wind. Magnetic reconnection and solar wind acceleration and heating are identified, respectively, as Research Focus Area F1 and F2.3 in the most recent Sun-Solar System Connection Roadmap (May, 2005). Both of these areas are objectives of several ongoing and future missions including SOHO, TRACE, RHESSI, RAM, Solar Probe, SDO, Solar-B, Solar Orbiter, SPI, STEREO and Doppler.

The heating of the solar corona and the solar wind occurs continually, in regions of closed as well as open field lines (coronal holes), in the quiet as well as the active Sun. The magnetic carpet, which covers the entire surface of the Sun, holds the key to our understanding of this heating. It is estimated that 95% of the photospheric magnetic flux closes within the magnetic carpet in low-lying loops. There is significant observational evidence that strong coronal heating in active regions have much in common with the quasi-steady heating in quiet regions and coronal holes, and that the latter may occur due to scaled-down versions of explosive reconnection events in bipolar configurations in the network. We propose to use analytical techniques and time-dependent simulations based on resistive and Hall MHD equations to investigate the role of collisional as well as collisionless current sheets and reconnection in heating the corona and the solar wind. We will undertake the following tasks:

(1) Coronal Heating Driven by Explosive Reconnection in Sheared Network Bipoles. We will begin with a simple 2.5D bipole configuration in which reconnection is driven by photospheric footpoint shear, and investigate current sheet formation and magnetic reconnection in resistive and Hall MHD regimes. We will follow up with configurations of increasing complexity leading up to the tectonics model which includes a myriad of bipoles with multiple separatrices, and quantify the amount of heating as a function of the dissipation mechanism.

(2) Reconnection and Thin Current Sheets in 3D Line-Tied Geometries With and Without Nulls. We will consider 3D magnetic geometries of line-tied fields, both with and without nulls, and quantify their contributions to coronal heating. We will build on our recent rigorous results on the Parker model of tangential discontinuities, which is a prime example of a model without nulls, and explore connections with quasi-separatrix layer (QSL) models. We will also consider the build-up of current sheets and fast reconnection in models with nulls and null-null lines by a combination of exact analytical models and 3D simulations.

(3) Generation of Alfv n Waves by Photospheric Reconnection. We will investigate the possibility of generating Alfv n waves in regions containing open field lines by photospheric reconnection in low-lying loops. In turn, these waves can produce producing an enhanced flow of wave energy into the solar wind. With this quantitative analysis, we will determine whether the energy flux in these waves is sufficient to explain the observed long-period power and can drive heating and solar wind acceleration in coronal holes.

(4) Energetics, Scaling Laws for Heating, and Observational Tests. We will attempt to answer the following questions: What fraction of the magnetic free energy in a given network configuration is dissipated as heat by resistive and collisionless reconnection mechanisms? How does the heating scale as a function of the plasma parameters and system size? What are the corresponding scaling properties for Alfv n wave heating produced by photospheric reconnection? Are nanoflares and microflares, reflected in EUV emission, sufficient to account for coronal heating in regions of closed as well as open field lines?

Publication References:

no references