Project Details

ROSES ID: NRA-NNH04ZSS001N
Selection Year: 2005
Program Element: Focused Science Topic

Topic: To determine the topology and evolution of the open magnetic field of the Sun connecting the photosphere through the corona to the heliosphere.

Project Title:
Towards a global 3D MHD solar wind model with realistic energy flux: tracing the turbulent energy flow from the photosphere to the corona and beyond

PI Name: Marco Velli
PI Email: Marco.Velli@jpl.nasa.gov
Affiliation: NASA JPL
Project Member(s):
-

Summary:
One of the key unsolved problems in our understanding how the solar corona and its embedded magnetic structure expands into interplanetary space is the role of waves and turbulence in the heating of the corona and accelerating the solar wind. We plan here to develop and use a combination of novel numerical techniques and analytical approximations to investigate the following fundamental questions: How is the spectrum of outwardly propagating turbulence observed in high speed solar wind streams generated, and is it the remnant of a basal flux heating the corona? What are the spectral characteristics and energy dissipation rates of waves and turbulence from the photosphere to the corona? and use the results as an input, using a tested global 3D MHD code BATS-R-US, to Construct a global 3D solar wind model with a realistic flux of turbulent energy. In previous work, many aspects of the above questions have been addressed by different researchers. In particular, linear, wkb analyses, and/or phenomenological nonlinear terms have been used to study the propagation of waves from the photosphere into the corona, using a variety of geometries for the magnetic field. The physics of this problem is complicated by the strong gradients in temperature and magnetic field across the transition region and the consequent coupling of the various wave modes. Here we will investigate the propagation of waves through the lower regions of solar atmosphere (from the photosphere, through the transition region and into the corona) using models of increasing complexity: from semi-analytical models, to shell-type models for nonlinear interactions, to direct numerical simulations. We plan to develop a new type of compressible MHD code coupling shock capturing schemes (Shu, 1997) to high order compact finite difference schemes (Lele, 1992, Pirozzoli, 2002), in order to follow the transport of a turbulence made up of Alfv n, fast and slow modes in 2 and 3 D while retaining shock capturing capability. We will obtain profiles of turbulent energy dissipation with height in the solar atmosphere in regions of different magnetic topology. We will then adapt an existing compressible 3D MHD code (BATS-R-US) to construct a global 3D solar wind model using results from the previous investigation to obtain a correct heating/turbulent pressure contribution to the global momentum equation as a function of height and magnetic field line topology. This research will be used as an input to a 3D MHD Global Modeling of the Sun-Earth Connection as a more realistic input driving the solar wind. It relates directly to one of the Focused Science Topics of the LWS TR&T program (e). In keeping with the goals of the LWS TR&T program, this research will increase our scientific understanding of the basic physical processes underlying the Sun-Earth connection and addresses all three SEC roadmap primary objectives. The team assembled, consisting of scientists from JPL and the University of Florence, has the necessary numerical, analytic and observational experience needed for the proposed work.

Publication References:

Summary: no summary

Reference: Rappazzo, A. F.; Dahlburg, R. B.; Einaudi, G.; Velli, M.; (2006), Nonlinear interactions in coronal heating, Advances in Space Research, Volume 37, Issue 7, p. 1335-1341, doi: 10.1016/j.asr.2005.12.015