Project Details

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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:
Simulation and Analytical Investigation of Waves Supported by Solar-Wind Tangential Discontinuities

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Summary:
In the solar wind, mulitple spacecraft have observed abrupt field rotations, called directional discontinuities. Surprisingly, single spacecraft misidentify many discontinuities as rotational ones with large finite normal magnetic field components. This suggests that the discontinuity is the result of the steepening of an Alfven wave. Timings from three or four spacecraft reveal that the discontinuity actually has a small magnetic field normal, more in agreement with a tangential discontinuity (TD) which has zero normal field component and can represent the boundary between magnetic flux tubes. The discrepancy at a single spacecraft is interpreted as a direct sign of the TDs supporting surface waves. Hollweg [1982] predicted the existence of linear noncompressive magnetohydrodynamic (MHD) surface wave solutions on solar-wind TDs where the magnetic field rotates across the layer. Because these waves are noncompressive, they would propagate undamped by collisionless resonant particle damping. Hollweg showed that such a wave on a TD causes the inferred normal component from a single spacecraft to appear large. Moreover, one class of these surface wave solutions travels near the average solar-wind magnetic field direction and could contributed to slab modes in the solar wind, which are an inferred population of solar-wind waves that propagate in this direction. Hollweg's analysis was limited to a cold plasma and linear MHD equations wherein the TDs are true discontinuities. In the solar wind, waves attain large relative amplitudes. We propose a three year investigation of the nonlinear behavior of finite amplitude surface waves, in a warm plasma, and on finite-width TDs. We plan to conduct numerical hybrid simulations with particle ions and fluid electrons of the surface waves on TDs. This work will be complemented with further analysis of MHD equations. We intend to determine whether or not nonlinear surface waves on TDs evolve to noncompressive waves which can travel far into the solar wind without collisionless damping. We will also examine how to identify discontinuities in the presence of waves, which is important in open magnetic field regions where waves from the Sun are very commonly present. The proper identification of a directional discontinuity as either rotational or tangential is often the difference between a type of wave structure or an actual boundary in the solar magnetic fields. We will also explore the possibility that some surface waves contribute to solar-wind slab modes.

Publication References:

no references