Project Details

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Project Title:
A New Kinetic Model for Coronal Heating and Generation of the Fast Solar Wind by Ion-Cyclotron Resonance

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Summary:
The solar wind directly controls the properties of the Earth's plasma environment, as well as fundamentally mediating all the energetic plasma disturbances, from coronal mass ejections to cosmic rays, which affect our life and society. The heating and acceleration of the ions in coronal holes, which produces the basic fast solar wind, has been the subject of intense investigation for many years. The process which seems most likely to explain this heating is the cyclotron-resonant dissipation of ion-cyclotron waves. Many theoretical models incorporating this mechanism have been able to reproduce the fluid properties of the fast wind, but very little of this work has considered the detailed kinetics of this resonant interaction.
Recently, we presented a new analytical description of the kinetic response of collisionless coronal ions to the resonant cyclotron interaction. This 'kinetic shell' picture uses the reasonable assumption that the resonant response of the ions occurs much faster than the non-resonant processes in the corona. Our initial investigations of this assumption were very encouraging, and lead to a number of promising suggestions for modeling the generation and kinetic evolution of the fast solar wind.
Here, we propose a three-year project to develop a comprehensive quantitative model of the generation of the fast solar wind, using this kinetic shell formalism. We will undertake a series of well-defined steps to extend our initial calculations, adding in stages the effects of inward-propagating waves, dispersion, and heavy ions. Qualitative analysis has already shown that this model can produce a realistic fast wind with a minimum of free parameters, as well as detailed new explanations for the presence of the secondary proton beam and the preferential heating of heavy ions.
Ultimately, this model will provide rigorous tests of the resonant cyclotron heating mechanism, and will serve as a valuable operational tool to guide future observations. This understanding of the kinetic origins of the solar wind is a necessary foundation on which to build models and predictions of more complicated behavior of the heliospheric medium.

Publication References:

Summary: no summary

Reference: Isenberg, Philip A.; Lee, Martin A.; Hollweg, Joseph V.; (2001), The kinetic shell model of coronal heating and acceleration by ion cyclotron waves: 1. Outward propagating waves, Journal of Geophysical Research, Volume 106, Issue A4, p. 5649-5660, doi: 10.1029/2000JA000099

Summary: no summary

Reference: Isenberg, Philip A.; (2001), The kinetic shell model of coronal heating and acceleration by ion cyclotron waves: 2. Inward and outward propagating waves, Journal of Geophysical Research, Volume 106, Issue A12, p. 29249-29260, doi: 10.1029/2001JA000176

Summary: no summary

Reference: Hollweg, Joseph V.; Isenberg, Philip A.; (2002), Generation of the fast solar wind: A review with emphasis on the resonant cyclotron interaction, Journal of Geophysical Research (Space Physics), Volume 107, Issue A7, CiteID 1147, doi: 10.1029/2001JA000270