Project Details

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Topic: Mechanism for solar wind heating and acceleration

Project Title:
Intermittent Heating of the Solar Wind in Coronal Holes

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Summary:
Much about the origin and nature of the solar wind, which is a key element of the Sun-Earth connection, depends on a detailed knowledge about the energy sources for the fast solar wind and the kinetic mechanisms responsible for its heating and acceleration in coronal holes. A broad consensus has emerged over the past decade attributing the solar wind heating to the cyclotron-resonant dissipation of ion cyclotron waves. Although a number of investigations of this mechanism have been carried out, two fundamental questions remain to be answered: What is the source and character of the necessary waves? and What is the detailed kinetic response of the ions? This proposal links small-scale magnetic reconnection events (microflares) at the coronal base to the generation of the fast solar wind. We explore the consequences of a new view that the microflares launch a highly intermittent electron heat flux up into the corona. These sporadic heat-flux bursts can excite highly-oblique ion cyclotron-resonant waves through a plasma microinstability and energize the ions. We have already developed a quantitative model of this process for the collision-dominated region near the base of the corona. The collisional relaxation of the proton distribution function in this region allowed us to simplify considerably the description of the solar wind evolution. With this model, we have shown that our mechanism is efficient enough to account for the initial acceleration of the fast solar wind. We now propose to extend our analysis to the rest of the solar corona. In the absence of collisions, a fully kinetic approach is required to describe the solar wind evolution. We will use both analytical and numerical techniques to develop and quantify this approach. When combined with our previous results, we will ultimately have a kinetic model that will work in the entire region of the solar wind acceleration. An essential goal of any coronal heating model is to explain the heating of the ions perpendicular to the magnetic field and the preferential heating of the heavy ions. For this purpose, we will incude O5+ and Mg9+ ions in our analysis. The theoretically predicted behavior of these ions will be verified with the help of the UVCS/ SOHO observational data. To test our theory, we will further derive the amplitudes of the density fluctuations associated with the heat-flux generated ion cyclotron waves and compare them with the interplanetary scintillation measurements. Studying the solar wind energization helps prevent the potential exposure of humans to harmful effects of the solar activity in the outer space. Thus, this work is important for the success of the future space exploration mapped out in the new national program of prolonged human activity on the Moon and on the roundtrip to Mars. By guiding and enhancing the observational capabilities of the NASA missions, this research will provide the information for policy formulation of federal agencies coordinating the national program of space exploration.

Publication References:

Summary: no summary

Reference: Markovskii, S. A.; (2007), The Effect of Proton Temperature Anisotropy on the Electron Heat Flux Dissipation in Solar Coronal Holes, The Astrophysical Journal, Volume 666, Issue 1, pp. 486-490, doi: 10.1086/520044