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Coronal heating by Alfvén waves

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The coronal heating in the sun is an old problem [1,2,3]. The high temperature of the corona is a generic phenomenon which can occur in other stars in the galaxy. Since the early days that the sun's corona was found to have millions degree of temperature, magneto-hydrodynamic (MHD) waves were suspected as the underlying mechanism of the coronal heating. Alfvén first suggested Joule heating by the MHD wave, which was later dubbed as the Alfvén wave, may provide the heating partially [4], but immediately it was realized that such MHD waves cannot damp for solar plasma parameters [5]. Thus, search for the heating mechanism has been naturally extended to various other mechanisms such as the kinetic effects [6], nonlinear waves as well as direct current heating and recently, magnetic reconnection [7]. From the perspective of wave heating, Alfvén waves have enough energy to heat the corona, and are still of interest [8.9]. In the wave heating approach, finding a proper dissipation mechanism is a critical issue [10].

Alfvén waves in the sun are driven by the Sun's surface motion. The Sun's surface has a granular structure and thus from the birth the Alfvén wave in the corona could have a finite horizontal length scale. Early theories, however, have overlooked this potentially important additional length scale and focused on the physics in the propagating direction. Another confusion in the dissipation of the Alfvén wave in the coronal regime came from the viscosity. Braginskii's form [11,12] and the fluid form have been used in a mixed manner, but as Braginskii pointed out in his articles, the classical form is valid only in limited circumstances [11]. In a highly nonlinear or turbulent plasma, the use of fluid viscosity may have a practical validity as evidenced in many realistic MHD simulations.

In this talk I will discuss using a recent simulation result [13], which demonstrates that if the horizontal length scale and the fluid viscosity are incorporated, Alfvén waves can effectively dissipate in the lower region of the corona [13].

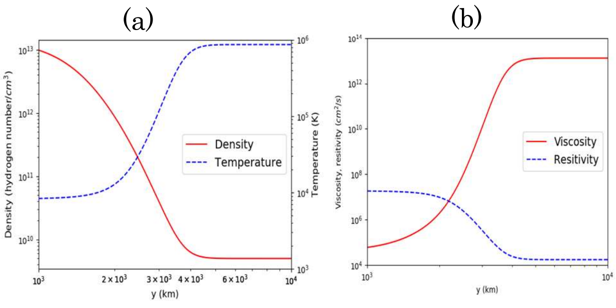

Fig. 1. (a) Model density and temperature profiles. (b) Viscosity and resistivity used in simulations.

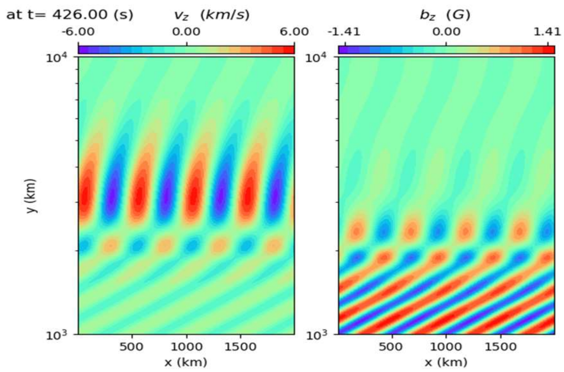

Fig. 2. Velocity and magnetic components of Alfvén waves.

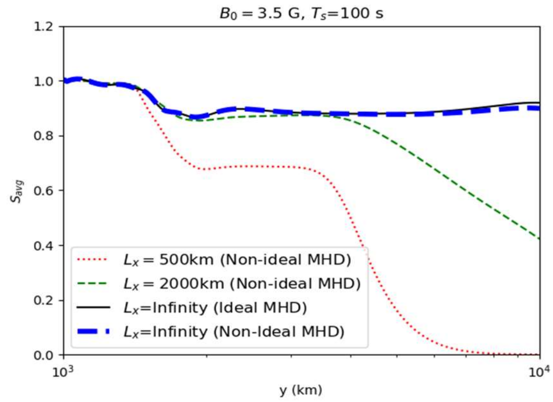

Fig. 3. Averaged Poynting fluxes vs. height.

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