

On the role of transition region on the Alfvén wave phase mixing in solar spicules

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Abstract Alfvénic waves are thought to play an important role in coronal heating and solar wind acceleration. Here we investigate the dissipation of standing Alfvén waves due to phase mixing at the presence of steady flow and sheared magnetic field in the stratified atmosphere of solar spicules. The transition region between chromosphere and corona has also been considered. The initial flow is assumed to be directed along spicule axis, and the equilibrium magnetic field is taken 2-dimensional and divergence-free. It is determined that in contrast to propagating Alfvén waves, standing Alfvén waves dissipate in time rather than in space. Density gradients and sheared magnetic fields can enhance damping due to phase mixing. Damping times deduced from our numerical calculations are in good agreement with spicule lifetimes. Since spicules are short living and transient structures, such a fast dissipation mechanism is needed to transport their energy to the corona.

Keywords Sun: spicules · Alfvén waves: phase mixing · Transition region

1 Introduction

The heating mechanism of the solar corona is one of the most mysterious issue in astrophysics (Aschwanden 2004).

In the corona, the temperature rises to a few million degrees. To maintain such a high temperature in the corona in spite of cooling by heat conduction and radiative losses, a continuous supply of thermal energy is necessary. X-ray observations from space experiments (e.g. skylab) have shown that the corona is not uniform and consists of many bright loops. Two promising models for coronal heating (Erdélyi and Ballai 2007) are: heating by small scale flares triggered by magnetic reconnection, and heating by the dissipation of Alfvén waves that propagate in the magnetic flux tubes (Alfvén 1947; Hollweg 1973, 1986; McKenzie et al. 1995). However, there are other types of waves such as acoustic, slow-mode and fast-mode waves which are strongly damped or reflected at the steep density and temperature gradients of chromosphere and transition region. As an origin of Alfvén waves, Kudoh and Shibata (1999) considered a photospheric random motion propagating along an open magnetic flux tube in the solar atmosphere, and performed MHD simulations for solar spicule formation and the coronal heating. They have shown that Alfvén waves transport sufficient energy flux into the corona. De Pontieu et al. (2007) estimated the energy flux carried by transversal oscillations generated by spicules and compared by the result of Kudoh and Shibata (1999). They indicated that the calculated energy flux is enough to heat the quiet corona and to accelerate the high-speed solar wind. There are many proposed mechanisms for the dissipation of Alfvén waves. Interaction of Magnetohydrodynamic (MHD) waves with inhomogeneous plasmas in which has density gradients in both x- and z-directions, can leads to a number of very interesting physical phenomena, such as mode coupling (Moriyasu et al. 2004), resonant absorption (Ionson 1978; Ruderman et al. 1997), magnetohydrodynamic (MHD) turbulence (Matthaeus et al. 1999), and phase mixing (Heyvaerts and Priest 1983). These phenomena can affect the

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