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ORIGINAL ARTICLE

Transverse oscillations in solar spicules induced by propagating Alfvénic pulses

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Abstract The excitation of Alfvénic waves in solar spicules by localized Alfvénic pulses is investigated. A set of incompressible MHD equations in the two-dimensional x–z plane with steady flows and sheared magnetic fields is solved. Stratification due to gravity and transition region between chromosphere and corona is taken into account. An initially localized Alfvénic pulse launched below the transition region can penetrate from transition region into the corona. We show that the period of the transversal oscillations is in agreement with those observed in spicules. Moreover, it is found that the excited Alfvénic waves spread during propagation along the spicule length, and suffer efficient damping of the oscillations amplitude. The damping time of the transverse oscillations increased with decreasing k_b values.

Keywords Sun: spicules · Alfvénic pulses

1 Introduction

Spicules are among the most fundamental components of the solar chromosphere. They are seen in chromospheric spectral lines at the solar limb at speeds of about 20–25 $\mathrm{km\,s^{-1}}$ propagating from the chromosphere into the solar corona (Zaqarashvili and Erdélyi 2009). Their diameter and length vary from spicule to spicule, having values from 400 km to 1500 km and from 5000 km to 9000 km, respectively. Their typical lifetime is 5–15 min. The typical electron density at heights where the spicules are observed is approximately 3.5×10^{16}–$2 \times 10^{17}\ \mathrm{m^{-3}}$, and their temperatures are estimated as 5000–8000 K (Beckers 1968; Sterling 2000). Kukhianidze et al. (2006), Zaqarashvili et al. (2007), by analyzing the height series of $H\alpha$ spectra in solar limb spicules, observed their transverse oscillations with an estimated period of 20–55 and 75–110 s. More recently, Ebadi et al. (2012a), based on *Hinode*/SOT observations, estimated the oscillation period of the spicule axis to be around 180 s.

Despite the large body of theoretical and observational work devoted to the spicules, their ejection mechanism has not become clear yet. In other words, observations with high spatial resolutions are needed to distinguish their origin. Alfvén waves are usual candidates for energy transport from the lower layers of the solar atmosphere to the corona (De Pontieu et al. 2007; Tsiklauri et al. 2002). Hollweg (1982) showed that the Alfvén waves may be nonlinearly coupled to fast magnetoacoustic shocks, which may lead to spicule formation. Cargill et al. (1997) performed numerical simulations of the propagation of Alfvénic pulses in two-dimensional magnetic field geometries. They concluded that for an Alfvénic pulse the time at which different parts of the pulse emerge into the corona depends on the plasma density and magnetic field properties. Moreover, they discussed that this mechanism can lead to the interpretation of a spicule ejection as forced through the transition region. Kudoh and Shibata (1999) used the random nonlinear Alfvénic pulses and concluded that the transition

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