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ORIGINAL ARTICLE

# Observation of standing kink waves in solar spicules

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**Abstract** We analyze the time series of Ca II H-line obtained from *Hinode*/SOT on the solar limb. The time-distance analysis shows that the axis of spicule undergos quasi-periodic transverse displacement at different heights from the photosphere. The mean period of transverse displacement is ∼180 s and the mean amplitude is 1 arc sec. Then, we solve the dispersion relation of magnetic tube waves and plot the dispersion curves with upward steady flows. The theoretical analysis shows that the observed oscillation may correspond to the fundamental harmonic of standing kink waves.

**Keywords** Sun: spicules · MHD waves: dispersion relation · Kink modes

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## 1 Introduction

Observation of oscillations in solar spicules may be used as an indirect evidence of energy transport from the photosphere towards the corona. Transverse motion of spicule axis can be observed by both, spectroscopic and imaging observations. The periodic Doppler shift of spectral lines have been observed from ground based coronagraphs (Nikolsky and Sazanov 1967; Kukhianidze et al. 2006; Zaqarashvili et al. 2007). But Doppler shift oscillations with period of ∼5 min also have been observed on the SOlar and Heliospheric Observatory (*SOHO*) by Xia et al. (2005). Direct periodic displacement of spicule axes have been found by imaging observations on Optical Solar Telescope (SOT) on *Hinode* (De Pontieu et al. 2007; Kim et al. 2008; He et al. 2009). The torsional Alfvén waves were reported recently in the context of a flux tube connecting the photosphere and the chromosphere as periodic variation of spectral line width (Jess et al. 2009).

The observed transverse oscillations of spicule axes were interpreted by kink (Nikolsky and Sazanov 1967; Kukhianidze et al. 2006; Zaqarashvili et al. 2007; Kim et al. 2008) and Alfvén (De Pontieu et al. 2007) waves. All spicule oscillations events are summarized in a recent review by Zaqarashvili and Erdélyi (2009). They suggested that the observed oscillation periods can be formally divided in two groups: those with shorter periods ($<$2 min) and those with longer periods ($\geqslant$2 min) (Zaqarashvili and Erdélyi 2009). The most frequently observed oscillations lie in the period ranges of 3–7 min and 50–110 s.

Spicule seismology, which means the determination of spicule properties from observed oscillations and was originally suggested by Zaqarashvili et al. (2007), has been significantly developed during last years (Ajabshirizadeh et al. 2009; Verth et al. 2011; Tavabi et al. 2011).