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ORIGINAL ARTICLE

Resonantly damped oscillations of elliptically shaped stratified emerging coronal loops

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Abstract The effects of both elliptical shape and stage of emergence of the coronal loop on the resonant absorption of standing kink oscillations are studied. To do so, a typical coronal loop is modeled as a zero-beta longitudinally stratified cylindrical magnetic flux tube. We developed the connection formulae for the resonant absorption of standing transversal oscillations of a coronal loop with an elliptical shape, at various stages of its emergence. Using the connection formulae, the dispersion relation is derived and solved numerically to obtain the frequencies and damping rates of the fundamental and first-overtone kink modes. Our numerical results show that both the elliptical shape and stage of emergence of the loop alter the frequencies and damping rates of the tube as well as the ratio of frequencies of the fundamental and its first-overtone modes. However, the ratio of the oscillation frequency to the damping rate is not affected by the tube shape and stage of its emergence and also is independent of the density stratification parameter.

Keywords Sun: corona · Sun: magnetic fields · Sun: oscillations

1 Introduction

Solar corona and its extraordinary high temperature has been the topic of various debates and studies from several decades ago. The origin and the source of coronal continual heating and high temperature have been related to coronal loops. The claim that the coronal loops and their behaviors such as their damping oscillations may be one of the main reasons of coronal heating, has been investigated through several studies so far.

Transverse oscillations of coronal loops have been observed by the Transition Region And Coronal Explorer (TRACE) for several years (see e.g. Aschwanden et al. 1999; Schrijver and Brown 2000). Nakariakov et al. (1999) interpreted these oscillations as fast kink modes with the period ranging from 2.3 to 10.8 min and decay time from 3.2 to 20.8 min. The observed values of the periods and decay times make it possible to obtain indirect information on the conditions of the plasma and magnetic field in coronal loops.

Ofman and Aschwanden (2002) used the data deduced by Aschwanden et al. (2002) to investigate the oscillations of 11 coronal loops. They argued that the observed TRACE loops consist of multiple unresolved thin loop threads which produce inhomogeneous internal structure of the observed loop. They adopted 1-dimensional Cartesian slabs of plasma with the magnetic field lines in the z-direction and the direction of the inhomogeneity along the x-axis normal to the magnetic surfaces, as a simple model for the oscillating loops. They found that the dependence of the decay time on both the length and the width of the loop is in excellent agreement with the power law damping predicted by phase mixing.

The property of resonant absorption as a non-thermal mechanism makes it possible to describe the heating of magnetic loops in solar corona as well as rapid decaying of magnetohydrodynamics (MHD) waves even in weakly dissipative plasmas (see e.g. Ionson 1978; Poedts et al. 1989; Ofman et al. 1994; Erdélyi and Goossens 1994, 1995; Tirry

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