STRATIFICATION EFFECT ON DAMPED OSCILLATIONS OF CORONAL MAGNETIC LOOPS

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Soon after transverse coronal loop oscillations were observed by TRACE spacecraft, they were interpreted as kink modes of magnetic tubes. It was also observed that these oscillations were strongly damped. Different damping mechanisms have been discussed. At present it seems that damping due to resonant absorption is in the best agreement with the observations. First models of resonantly damped loops treated the loops as straight magnetic tubes with the density varying only in the radial direction. Recently Andries et al. [A&A 2005, 430, 1109] studied numerically resonant damping of stratified magnetic loops where the density varies not only in the radial direction, but also along the loop. Their analysis is valid for arbitrary ratio of the loop radius to its length. However, it is well known that this ratio is very small, of the order of 0.01, so it can be used as a small parameter. This observation enabled us to develop an asymptotic theory of damped oscillations of stratified coronal loops analytically.

Similar to Andries et al. we assume that the density variation in the radial direction occurs only in a thin layer near the loop boundary. We also make an assumption of homogeneous stratification, which means that the ratio of densities outside and inside the loop is constant, and that the density dependence on the radial coordinate in the inhomogeneous layer can factored out. Then we show that the frequency of the loop oscillation is determined by the Sturm-Liouville problem for a second-order ordinary differential equation. We also calculate the oscillation decrement and show that it is given by exactly the same expression as in the case of a non-stratified loop. As as result, the ratio of decrement and oscillation frequency is independent of the stratification.

For a particular variation of the loop density, which can be considered as a reasonable model of stratification in real coronal loops, we manage to solve the Sturm-Liouville problem determining the oscillation frequency analytically and obtain an explicit expression for the frequencies of the fundamental mode and all overtones in terms of equilibrium quantities. We also give explicit expressions for the decrements of all modes. We calculate the ratio of frequencies of the first overtone and the fundamental harmonic and show that it depends on the ratio of densities at the loop apex and at the footpoints only. This implies that this ratio can be used in coronal seismology to obtain the ratio of the two densities from simultaneous observations of the fundamental mode and the first overtone of the transverse loop oscillations.