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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. Then we show that the frequency of the loop oscillation is determined by the Sturm-Liouville problem for a second-order ordinary differential equation. For a particular variation of the loop density, which can be considered as a reasonable model of stratification in real coronal loops, we managed to solve this Sturm-Liouville problem analytically and derive an algebraic dispersion equation determining the frequency as a function of quantities defining the equilibrium state. The damping rate is given by a simple expression in term of the oscillation frequency and the equilibrium quantities. We also calculate the ratio of frequencies of the first overtone and the fundamental harmonic and use our results for interpretation of recent observations.