The temporal behaviour of MHD waves in a partially ionized prominence-like plasma: Effect of heating and cooling

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Abstract

Small amplitude oscillations in prominences are known from long time ago, and from a theoretical point of view, these oscillations have been interpreted in terms of standing or propagating linear magnetohydrodynamic (MHD) waves. In general, these oscillations have been studied by producing small perturbations in a background equilibrium with stationary physical properties. Taking into account that prominences are highly dynamic plasma structures, the assumption of an stationary equilibrium is not realistic, and any imbalance between prominence heating and cooling processes produces a temporal variation of prominence temperature.

On the other hand, prominence plasma is partially ionized, thus, when prominence plasma is heated the degree of ionization increases. On the contrary, when the prominence plasma cools down, recombination takes place decreasing the ionization degree. As a consequence, the temporal variation of the temperature and ionization degree modifies plasma parameters such as the mean atomic weight, resistivities, viscosity, thermal conduction coefficients, etc. In our calculations, and during the heating process, the plasma goes from almost fully neutral to almost fully ionized, while during the cooling process, the plasma goes from almost fully ionized to almost neutral, therefore, the full expression for the specific internal energy able to describe the behaviour of the plasma in those different situations must be considered.

In summary, our main aim here is to study how the temporal variation of temperature and plasma parameters modifies the temporal behaviour of MHD waves in a partially ionized prominence-like plasma. Furthermore, apart from considering a background whose temperature changes with time, perturbed optically thin radiation and thermal conduction as damping mechanisms for MHD waves are also considered, and we have sought for numerical solutions to the linear MHD wave equations when all the above mentioned physical processes are taken into account. This approach is new since earlier studies of MHD waves in a partially ionized prominence plasma have always assumed an stationary background with constant temperature and ionization degree.