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Acoustic/shock wave propagation in the gravitationally stratified partially ionised plasmas: the multi-dimensional effects

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Numerical and observational evidences both support that wave propagation and dissipation may be an important mechanism that contributes to the heating of the solar chromosphere. For instance, acoustic waves and the resulting shock waves in the gravitationally stratified solar atmosphere, may provide at least part of the energy to compensate the radiative energy losses in the chromosphere. However, high-frequency waves are difficult to observe because of the limited instrumental resolution, and in fact, numerical modelling also needs sufficient spatial and temporal resolution for high-frequency waves to avoid artificial numerical dissipation. Therefore, numerous one-dimensional numerical simulations have been performed without taking into account multi-dimensional effects, thus reducing the computational costs. We have used a neutral-ion two-fluid model to investigate high-frequency acoustic wave propagation in one-dimensional gravitationally stratified partially ionised plasmas, showing that sufficient energy can be transported from the bottom of the photosphere up to the chromosphere to compensate the radiative energy losses (Zhang et al. 2021). The model assumes an initial hydrostatic and ionisation equilibrium, and takes into account the effects of neutral-ion collisions, ionisation and recombination. In this work, we further quantify the multi-dimensional effects in modelling acoustic/shock wave propagation. More specifically, as our previous simulations show that the shock wave damping yields an important heating process, in two-dimensional simulations the formation of shocks may change since the energy spreads also in the horizontal direction as the waves propagate in the vertical direction.

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