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Effects of various velocity drivers on MHD wave propagation in the partially ionized solar atmosphere from 2D multi-fluid simulations

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Partial ionization effects related to electron-neutral and ion-neutral interactions play an important role in the weakly ionized solar chromosphere, where the number density of neutrals vastly exceeds the number density of protons. The interactions between the magnetized plasma and the neutral particles can significantly change the resistivity of the plasma and lead to additional heating. Such multi-species interactions cannot be described within the simple MHD single fluid models and the non-equilibrium partial ionization effects cannot be properly captured even when generalized MHD models including Ambipolar diffusion terms are taken into account. A more detailed approach to describe these processes in the solar chromosphere is to use multi-fluid numerical simulations where the neutrals and the plasma species are described as separate fluids, coupled through the chemical reactions, additional currents, friction and resistivity terms. In this study we have elaborate on our previous results and perform 2D two-fluid simulations with an electron-proton fluid and a separate neutral fluid using an improved model where the density and temperature dependence of the plasma viscosities and heat conduction for the neutrals is assumed. Previously we have investigated the chromospheric propagation of fast and slow waves generated by a fixed photospheric foot-point velocity driver. In this study we have varied the velocity driver's frequency and location. We have also distinguished between the types of drivers which excite pure slow/Alfvén waves or a mixture of slow and fast waves. Finally, we have studied the non-uniform heating caused by the waves.