RJPHY Research Journal of Physics

OPEN ACCESS

News & Comments

Simulating Three- Waves interaction in a Magnetic Loop

Sohaira Ahmad

In the solar atmosphere, coronal loops are closed magnetic field structures that are surrounded by intense plasma. Their length varies widely, from a few hundred kilometres to thousands of kilometres or even more. In many areas of the corona, especially the active zones where solar active events, such as flares, are hosted, loops play a crucial role. In coronal loops, non-thermal spectral line broadening has been noticed, which is most likely brought on by high-frequency Alfvén waves. Alfvén waves have the characteristic that their wave vector refracts in the direction of the lower values of the Alfvén speed and that their group velocity is oriented along the magnetic field.

The transport parameters of energetic charged particles, a crucial component of solar eruptions like solar flares and coronal mass ejections, are determined by MHD wave spectra in magnetized plasmas. To the lowest order, wave-wave interactions can be thought of as three-wave interactions under the mild turbulence approximation, in which two waves either combine to form a single wave or a single wave decay to form two waves. The impact of three-wave interactions on Alfvén waves propagating in coronal loops is taken into consideration in this research. It is investigated how they affect wave spectra, and spectra are used to calculate the transport characteristics of energetic particles in these loops.

The model of Chin and Wentzel, which has been expanded and applied to the case of two Alfvén waves and a sound wave by Vainio and Spanier, is used to investigate the three-wave interactions of two Alfvén waves and a magnetosonic wave. It is also used to calculate the cross-helicity of Alfvén waves downstream of a fast-mode shock.

For the sake of simplicity, the study only covers waves that travel parallel and anti-parallel to the magnetic field. In three-wave interactions, the conservation of angular momentum is identical to the conservation of polarization for Eigen modes travelling along the mean magnetic field, which is circularly polarized. The three-wave interactions that apply in these circumstances are an Alfvén wave coalescing into a sound wave, a counter-propagating Alfvén wave, and a sound wave into an Alfvén wave.

The wavelengths above 10 km and up to the proton cyclotron frequency were chosen to match the angular frequency range that will be studied. A coronal magnetic loop's wave conveyance was considered, along with the impact of three-wave interactions between the opposing Alfvén waves. The interaction of counter-propagating waves was shown to erode the spectrum of the wave mode emitted from the greater distance, leaving the wave field dominated by waves emitted from the closer footprint, for wave energy densities still in the weak-turbulence zone. The limitation to parallel-propagating waves was one of the modelling's main simplifications. Wave-wave interactions will result in the growth of the spectrum in the perpendicular direction, which may take over the parallel evolution modelled in the study.

Also note that the model predicts that sound waves will be emitted by the thermal plasma and will then absorb them, eroding the Alfvén wave spectra in the process. This would heat the loop and could perhaps trigger the acceleration of particles from the thermal tail. But this will be the focus of additional research.

JOURNAL REFERENCE

Nyberg S, Vainio R. Simulating Three-Wave Interactions and the Resulting Particle Transport Coefficients in a Magnetic Loop. Physics. 2022; 4(2):394-408.

KEYWORDS

Alfvén waves, wave–wave interactions, magnetic loops, solar corona, particle transport, numerical methods; modelling