Propagation of Torsional Alfven Waves from the Photosphere to the Corona: Reflection, Transmission, and Heating in Expanding Flux Tubes

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Abstract

It has been proposed that Alfven waves play an important role in the energy propagation through the solar atmospheric plasma and its heating. Here we theoretically investigate the propagation of torsional Alfven waves in magnetic flux tubes expanding from the photosphere up to the low corona and explore the reflection, transmission, and dissipation of wave energy. We use a realistic variation of the plasma properties and the magnetic field strength with height. Dissipation by ion-neutral collisions in the chromosphere is included using a multifluid partially ionized plasma model. Considering the stationary state, we assume that the waves are driven below the photosphere and propagate to the corona, while they are partially reflected and damped in the chromosphere and transition region. The results reveal the existence of three different propagation regimes depending on the wave frequency: low frequencies are reflected back to the photosphere, intermediate frequencies are transmitted to the corona, and high frequencies are completely damped in the chromosphere. The frequency of maximum transmissivity depends on the magnetic field expansion rate and the atmospheric model, but is typically in the range of 0.04-0.3 Hz. Magnetic field expansion favors the transmission of waves to the corona and lowers the reflectivity of the chromosphere and transition region compared to the case with a straight field. As a consequence, the chromospheric heating due to ion-neutral dissipation systematically decreases when the expansion rate of the magnetic flux tube increases.