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Non-linear propagation of MHD kink waves to the solar chromosphere. How close we are to solve the coronal heating problem

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Small-scale magnetic field concentrations (magnetic elements) are believed to contribute to the energy budget of the upper layers of the Sun's atmosphere, as they are observed to support a large number of magneto-hydrodynamic (MHD) modes.
In recent years, kink waves in magnetic elements were observed at different heights in the solar atmosphere, from the photosphere to the corona.
However, the propagation of these waves has not been fully evaluated. We analysed high-quality, long duration spectropolarimetric data of a photospheric quiet Sun region observed near the disk centre with the spectropolarimeter CRISP at the Swedish Solar Telescope (SST).
We complemented these data with simultaneous and co-spatial broadband chromospheric observations of the same region.
Our findings reveal a clear upward propagation of kink waves with frequency above 2.6 mHz. Moreover, the signature of a non-linear propagation process is also observed. By comparing photospheric to chromospheric power spectra, no signature of an energy dissipation is found at least at the atmospheric heights at which the data analysed originate.
This implies that most of the energy carried by the kink waves (within the frequency range under study < 17 mHz) flows to upper layers in the Sun's atmosphere.
We discuss these results and their implications for the chromospheric and coronal heating problem.

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