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MHD Spectroscopy of the Solar Atmosphere

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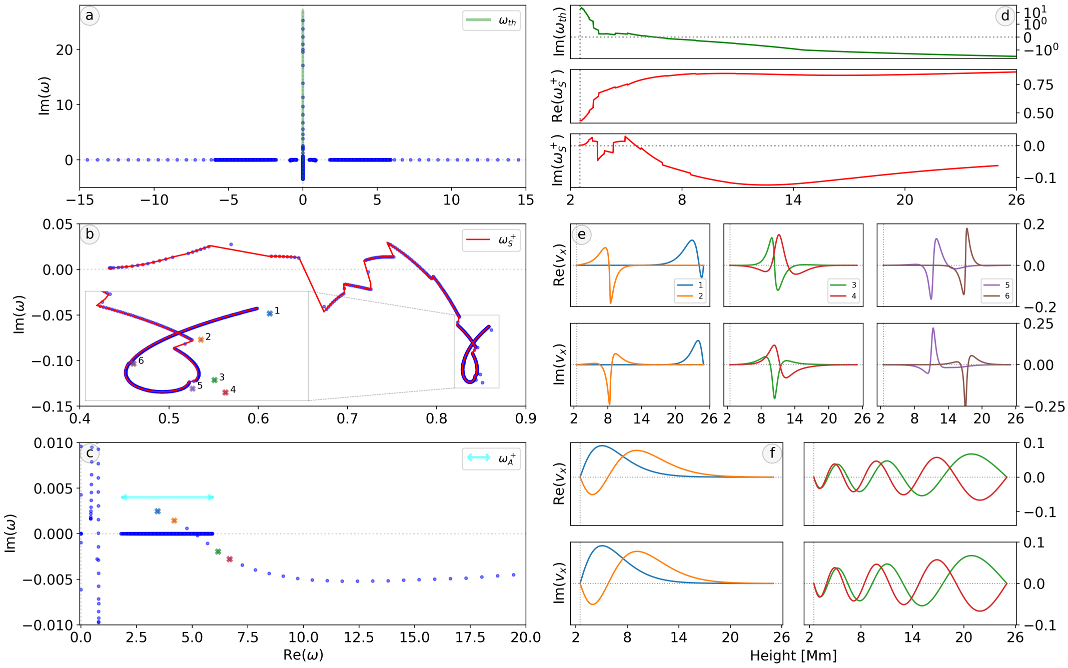

Here we present a detailed, high-resolution eigenspectrum analysis of the solar atmosphere using our recently developed Legolas code [1] to calculate full spectra and eigenfunctions of various equilibrium configurations, based on fully realistic solar atmospheric models including gravity, optically thin radiative losses and thermal conduction. These models treat a stratified, magnetized atmosphere with density and temperature profiles based on a widely used semi-empirical model [2]. Our focus mainly lies on thermal instabilities, along with a new outlook on the slow and thermal continua and their behavior in different chromospheric and coronal regions. We show that thermal instabilities are ubiquitously present in our solar atmospheric models, which implies a great variety of linear pathways to form condensations. Since these instabilities lie at the very basis of prominence formation and coronal rain [3, 4, 5], knowing all MHD modes of possibly coupled mode types in the magnetized solar atmosphere, and how they modify as a result of including relevant non-adiabatic effects, is thus a clear necessity. We demonstrate for the first time the intricate structure of the thermal, slow and Alfvén continua, and the way the many discrete modes organize in (coupled) thermal, slow, Alfvén and fast wave sequences. This essentially gives us a linear "preview" of how nonlinear simulations should develop as a result of (interacting) instabilities. An example is given in the figure above, which shows a part of the eigenspectrum with eigenfunctions of a solar coronal slab, indicating unstable thermal and slow continua as well as the possibility of having overstable fast modes in the Alfvén continuum range. Since many linear waves and instabilities can be at play and interact in realistic solar atmospheric evolutions, modern nonlinear simulations can benefit greatly from the full knowledge of all linear instabilities and eigenoscillations of a given configuration, while the MHD magnetothermal subspectrum is interesting in its own right for quantifying thermal instability.

References

[1] N. Claes, J. De Jonghe & R. Keppens, "*Legolas: a modern tool for magnetohydrodynamic spectroscopy*" (2020). The Astrophysical Journal Supplement Series, 251, 25.
[2] E. H. Avrett & R. Loeser, "*Models of the solar chromosphere and transition region from sumer and hrts observations*" (2008). The Astrophysical Journal Supplement Series, 175, 229.
[3] C. Xia & R. Keppens, "*Formation and plasma circulation of solar prominences*" (2016). The Astrophysical Journal, 832, 22.
[4] J. Jenkins & R. Keppens, "*Prominence formation by levitation-condensation at extreme resolutions*" (2021). Astronomy & Astrophysics, 646, A134.
[5] N. Claes, R. Keppens & C. Xia, "*Thermal instabilities: fragmentation and field misalignment of filament fine structure*" (2020). Astronomy & Astrophysics, 636, A112.