MHD SIMULATIONS OF UPFLOWS IN THE KIPPENHAHN-SCHLUETER PROMINENCE MODEL

Andrew Hillier, andrew@kwasan.kyoto-u.ac.jp
Kyoto University, Kyoto, Japan
Kazunari Shibata, shibata@kwasan.kyoto-u.ac.jp
Kyoto University, Kyoto, Japan
Hiroaki Isobe, isobe@eps.s.u-tokyo.ac.jp
University of Tokyo, Tokyo, Japan
Thomas Berger, berger@lmsal.com
Lockheed Martin Solar and Astrophysics Laboratory, Palo Alto, California, United States

The launch of SOT on the Hinode satellite, with its previously unprecedented high resolution, high cadence images of solar prominences, led to the discovery of small scale, highly dynamic flows in quiescent prominences. Berger et al. (2008) reported dark upflows that propagated from the base of the prominence through a height of approximately 10 Mm before ballooning into the familiar mushroom shape often associated with the Rayleigh-Taylor instability. Whether such phenomena can be driven by instabilities and, if so, how the instability evolve is yet to be fully investigated.

In this study, we use the Kippenhahn-Schlueter (K-S) prominence model as the base for 3D numerical MHD simulations. The K-S prominence model is linearly stable for ideal MHD perturbations, but can be made unstable through nonlinear perturbations, which we impose through inserting a low density (high temperature) tube through the centre of the prominence. Our simulations follow the linear and nonlinear evolution of upflows propagating from the hot tube through the K-S prominence model.

We excited Rayleigh-Taylor like modes inside the K-S model with a wave along the contact discontinuity created between the hot tube and the K-S prominence, and solved the perturbations of this system. For such a complex setting, the linear evolution of the instability has not been studied, and we found the growth rate to be \( \sim (\frac{\rho_- - \rho_+}{\rho_+ + \rho_-} - 0.05)^{0.22} \). The most unstable wavelength was \( \sim 100 \text{ km} \) which, through the inverse cascade process, created upflows of \( \sim 300 \text{ km} \). The rising plumes obtained a constant rise velocity in the nonlinear stage due to the creation of adverse magnetic and gas pressure gradients at the top of the plume.