国立天文台天文シミュレーションプロジェクト成果報告書

Simulations of the Magnetic Rayleigh-Taylor Instablity in Quiescent Prominences

Andrew Hillier (Kyoto University)

利用カテゴリ XT4MD ・ SX9MD

The launch of the Hinode satellite allowed for high spatial and temporal cadence observations of the quiescent prominences in the seeing free environment of space. These observations reveal that on small scales, prominences are highly dynamic phenomena. The most striking of these observations show dark plumes that propagate through the prominence material.

The dark plumes (presented in Berger et al. 2010) form at the boundary between the prominence and large bubbles that emerge from beneath the prominence. These can be seen in panels (a) and (b) of Figure 1. The bubble that forms below the prominence have density less than 20% of the prominence. Panel (a) of Figure 1 shows how the boundary between the light fluid of the bubble and the dense material of the prominence being supported above goes unstable. This process, where flows aligned with gravity, releasing gravitational potential energy, can be seen as analogous the magnetic Rayleigh-Taylor instability.

The simulations performed are 3D simulations of the magnetic Rayleigh-Taylor instability in the Kippenhahn-Schlüter prominence model. Figure 1 panels (c) and (d) shows a 2D slice, taking through the centre of the prominence. The colour shows the mass density, where the dense prominence material is above the light material of the bubble. The formation of plumes is created by the interchange of magnetic field lines resulting in the magnetic Rayleigh-Taylor instability in the system. The simulated plumes rise at a velocity of $7\,\mathrm{km\,s^{-1}}$ which is a factor of 3 smaller than the observed velocities.

In this simulation, the most important results relates to the nonlinearity of the system. The small plumes that can be seen in Figure panel (c) evolve into the much larger ($\sim \times 10$) plumes in panel (d). This is due to a nonlinear inverse cascade in the system, where small plumes interact with each other, creating much larger structures in the system. Therefore the observed plumes cannot be treated with simple linear analysis, but must be viewed as the result of nonlinear interaction between much smaller structures.

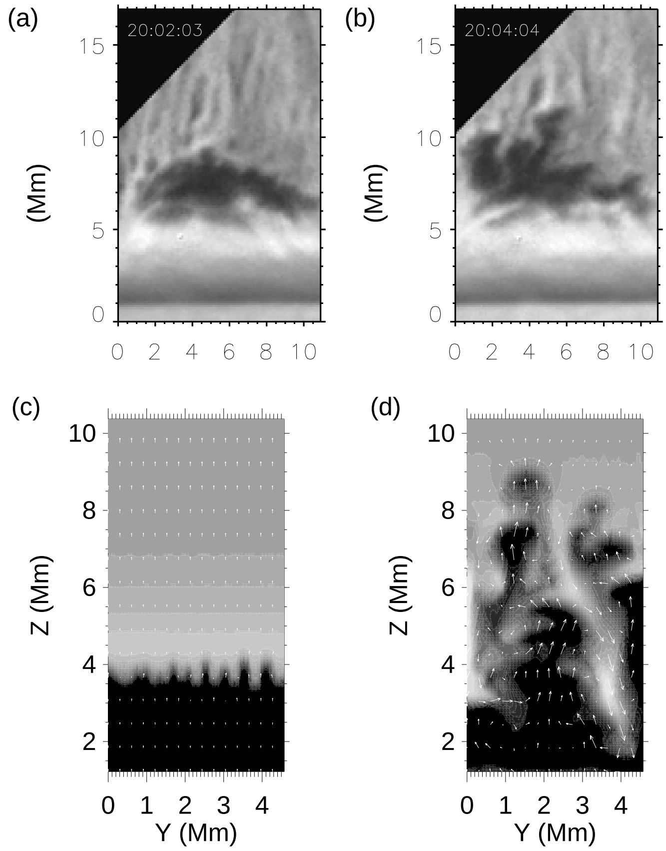

図 1: Panels a and b are observations showing the formation of dark plumes propagating from a bubble that forms below a quiescent prominence observed at 8-Aug-2007 20:01 UT taken in the 656.3 nm Hα spectral line. Panels c and d show the simulated evolution of upflows at $t = 719$ and 2453 s (normalized units $t = 15.3$ and 52.2) taken in the $x = 0$ plane.