Fine Strand-Like Structure in the Solar Corona from Magnetohydrodynamic Transverse Oscillations

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The organisation of fine-scale structure in the coronal high-Reynolds environment is a major unknown in solar physics. One of the leading theories for explaining the heating of the solar corona consists on the ubiquitous existence of small-scale locations where efficient energy release through magnetic reconnection takes place, a scenario leading to the concept of nanoflares [1]. According to that theory, coronal loops, closed magnetic flux tubes permeating the solar corona, are expected to have a braided field substructure, which would favour the occurrence of magnetic reconnection and therefore nanoflares. Due to the strongly anisotropic thermal conduction in the corona, nanoflares are expected to produce strand-like structure. The existence of strands as substructure of larger coronal structure such as loops has therefore been considered as strong evidence for a leading role of reconnection in the heating of the corona [2].

Transverse MHD waves are now known to be ubiquitous in the solar atmosphere [3-6]. Such waves are characterised by periods of a few minutes, amplitudes of a few km/s and show generally strong damping, which is usually explained through resonant absorption, a process of energy conversion from the transverse motion to local Alfvén waves at the boundary of the flux tube [7-9]. In this Letter [10] we have suggested an alternative mechanism for generation of strand-like structure in EUV lines by establishing a link with the ubiquitous small amplitude transverse MHD oscillations observed in the corona. Through three-dimensional MHD simulations combined with proper forward modelling we have shown that small amplitude transverse MHD waves can lead in a few periods time to strand-like structure in loops in EUV intensity images. Low amplitude transverse MHD oscillations matching those presently observed in the corona lead to Kelvin-Helmholtz instabilities (KHI) that deform the cross-sectional area of loops [11-13]. Azimuthal flows at the boundary of the flux tube are enhanced by resonant absorption, thereby facilitating the onset of the instability. A coupling takes place in which the KHI extracts the energy from the resonance and dumps it into heat through the generation of vortices and current sheets. Strands result as a complex combination of the vortices and the line-of-sight angle, and can be observed for spatial resolutions of a tenth of loop radius. Transverse MHD waves may therefore play an important role in the heating and morphology of the solar corona.

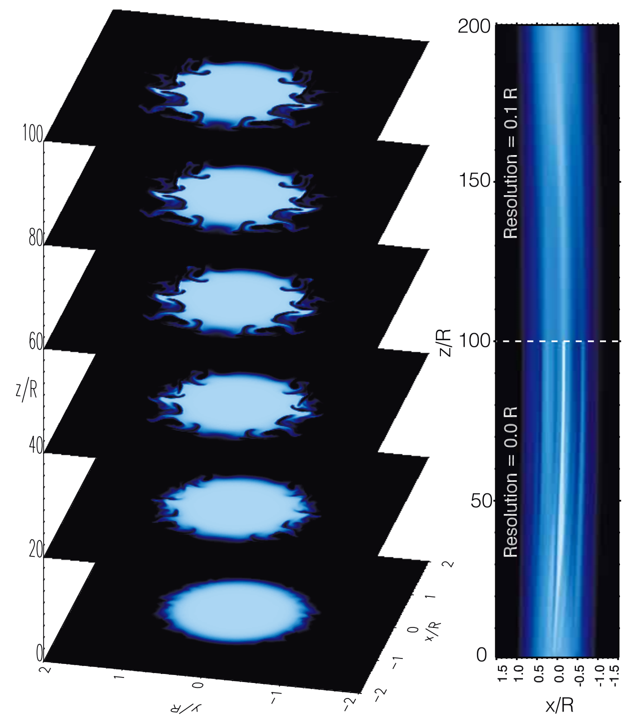

Figure 1: Left: Snapshot of the emission line flux of Fe IX 171.073 Å for several cross-sections along half a coronal loop subject to a transverse MHD wave. Right: KHI vortices produced by the wave appear as strand-like structure in intensity. The lower half of the loop shows the full numerical resolution, while the upper half corresponds to a spatial resolution of 10 % the loop radius R.

References

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