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Constraining the location and frequency of the energy deposition in the solar corona with thermal non-equilibrium observations

C. Froment[1] and ISSI team 401 “Observed Multi-Scale Variability of Coronal Loops as a Probe of Coronal Heating”

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Solar coronal loops are the building blocks of the multi-million degree solar corona. However, it is still a matter of debate how the magnetic energy is dissipated to heat the coronal plasma. In order to properly differentiate between heating mechanisms, the location and frequency of the energy deposition, in particular, must be properly constrained.

We know from numerical simulations that a heating that is quasi-steady and concentrated toward the loop footpoints can lead to a state of thermal non-equilibrium (TNE) in which the plasma is undergoing evaporation and condensation cycles. Thermal instability is thought to be the main driver of the cooling phase of these cycles, leading to the formation of cool material in the hot solar corona, in the form of coronal condensations (0,1 MK - 0,01 MK). If such condensations, forming coronal rain showers and prominences, have been observed for decades, the observation of the cyclic behaviour characteristic of the TNE state is relatively new. Indeed, the discovery of ubiquitous long-period EUV pulsations in the solar corona and in particular in solar coronal loops, have brought a renewed attention on the importance of TNE cycles in the solar atmosphere.

Here I will summarise our most recent works related to this topic, focusing both on observations and simulations. First, I will present multi-instruments observations, capturing the extremes of the spatial and thermodynamic scales covered by TNE processes. This work is published in Froment et al. 2020.

Within the same coronal loop bundle, we captured long-period (6 hours) intensity pulsations (Fig. 1.) in the coronal channels of SDO/AIA and coronal rain in chromospheric wavelengths of the CRISP and CHROMIS instruments at the Swedish 1-m Solar Telescope (SST) – see Fig. 2. I will present the thermal analysis of the cycles as well as an extensive spectral characterization of the rain clumps that allow us to precisely measure the chromosphere-corona solar atmospheric mass and energy cycle during TNE.

Finally, I will also discuss comparisons between 3D hydrodynamical simulations and SDO data, emphasising on our current detection methods of this phenomena and on future developments. Such studies are critical to achieve better statistics of these events and eventually estimate their contribution to the circulation of mass and energy in the solar atmosphere.

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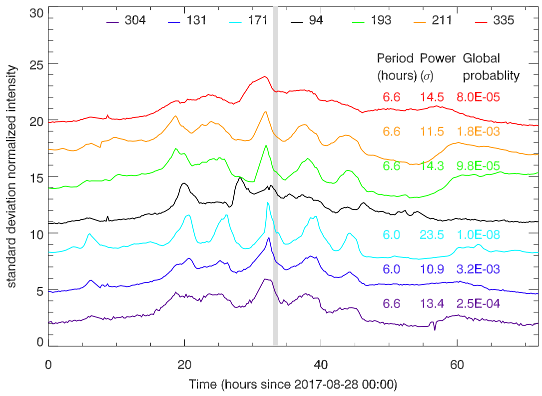

Fig. 1. Long-period intensity pulsations detected in a coronal loop bundle seen in Fig. 2. (EUV channels of SDO/AIA)

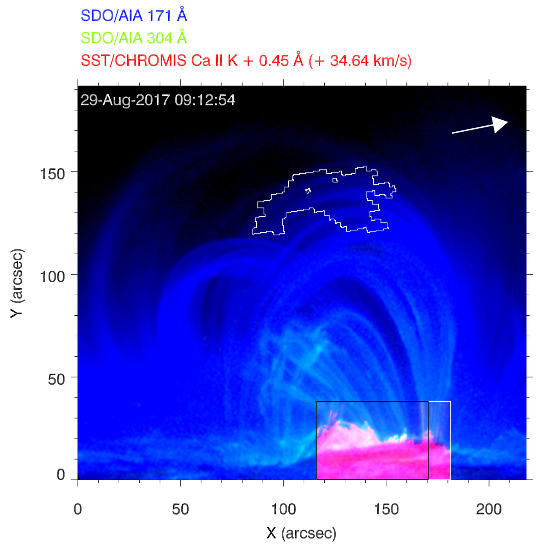

Fig. 2. Coronal loops observed with SDO and SST. The long-period intensity pulsations (Fig. 1) are detected in the white contour.

References

[1] Froment et al., A&A, 633, A11, 2020