Study of thermal non-equilibrium in a 3D hydrodynamic simulation of an active region and comparision with EUV observables

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Résumé

One of the fundamentals questions in solar physics is, how the Sun's outermost layer, the solar corona, is heated to reach temperatures exceeding a million degrees? In order to adress this issue, we study a phenomenon that occurs in the corona due to a specific type of heating: thermal non-equilibrium (TNE). TNE is a common feature of active-region loops. TNE consists of
cyclic plasma evaporation and condensation driven by a highly stratified and quasi-steady heating.
Long-period (several-hours) EUV pulsations and coronal rain are two observables linked to these
periodic variations in coronal temperature and density. However, the bias of current Fourier-based
detections toward ideal cases hinders accurate evaluation of the coronal volume undergoing TNE
cycles, a key parameter for coronal heating models.
Based on a 3D hydrodynamic simulation (MAS) and synthetic observations of AR 11139, we aim to determine: (1) the fraction of the active-region volume subject to TNE cycles, and (2) the
proportion of these cycles that can be detected in synthetic EUV observations.
To address these questions, we adapt the method of Auch'ere et al. 2014 in order to detect 3D
temperature and density periodicities. We identify regions exhibiting TNE in the volume of the
active region and compare them with those of long-period EUV pulsations.
A significant part of the AR volume (between 30% and 50%) undergoes TNE cycles, mostly in
coronal loops. This result is most likely model-dependent, estimating the TNE volume in an active
region could therefore serve as a novel method to discriminate coronal heating models. However,

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not all the cycles are detected in the synthetic observations, especially when there are multiple
TNE cycles along the line-of-sight. We conclude that the current observational studies may greatly
underestimate the volume occupied by TNE.
We additionally detect TNE in open magnetic structures. This finding reinforces the hypothesis of Scott et al. (2024) that TNE can develop in open field regions and may inject material periodically into the solar wind.