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Chromospheric heating and flux emergence in coronal hole simulations

Various dynamical processes occur in the solar atmosphere, significantly contributing to its thermal balance. Observations and simulations have particularly highlighted the importance of waves and magnetic reconnection in the chromosphere, which provide the necessary energy to counterbalance radiative cooling. However, the relative contributions of different processes in various solar regions (e.g., coronal holes) remains questioned (Carlsson et al. 2019).

Numerical simulations have notably demonstrated that the braiding of magnetic field lines by photospheric convection can sustain a million-degree corona via Poynting flux injection through the chromosphere (Gudiksen and Nordlund 2005, Finley et al. 2022). Nevertheless, initial magnetic field configurations in these models are not constrained yet, so the impact of flux emergence and subsequent energy injected by magneto-convection is still open for investigation.

We present a parametric study using the Bifrost code (Gudiksen et al. 2011), focusing on coronal holes simulations. By varying the upwardly advected magnetic field at the bottom boundary, we simulate different idealized configurations of flux emergence. Our findings indicate that the coronal temperature achieved after flux emergence is not a monotonic function of the injected magnetic field amplitude. Indeed, increasing the upward transport of magnetized material both triggers heating phenomena and enhanced radiative cooling. To start investigating this subtle equilibrium, we quantify the power contributed by shocks and magnetic reconnection to the chromosphere and find that they actually represent a majority of the heating balance. Additionally, we discuss the resulting changes in those contributions and in the mass loading, as a function of the emergence configuration.

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