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Nonlinear dynamics of the Parker scenario for coronal heating

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The Parker field line tangling problem for coronal heating is studied comprehensively via longtime high-resolution simulations of the dynamics of a coronal loop in cartesian geometry within the framework of reduced magnetohydrodynamics (RMHD).

At the boundaries we impose photospheric motions with scales of convective motions ($\sim 1{,}000$ km), and different timescales (time-independent, 5-8 minutes, and higher frequencies). Slow photospheric motions induce a Poynting flux that injects energy in the loop at the large scales. During the linear stage the magnetic field and the currents grow linearly in time, until they saturate by driving an anisotropic nonlinear turbulent cascade.

Although the efficient turbulent cascade prevents the magnetic field lines from becoming strongly entangled, current sheets are continuously formed and dissipated. We show that the current sheets are the result of the nonlinear cascade that transfer energy from the scale of convective motions down to the dissipative scales, where it is finally converted to heat and/or particle acceleration. We also show that these results remain substantially unaltered when considering a time-independent and a slow (5-8 minutes) photospheric forcing.

A picture is then realized, where both slightly entangled magnetic field lines and current sheets are present. Current sheets are the dissipative structure for this system, and the associated magnetic reconnection gives rise to impulsive "bursty" heating events. This picture is consistent with the slender loops observed recently by HINODE which, although apparently quiescent, present an X-ray emission and at the resolution scale

(~ 800 km) do not seem to reveal entangled features. We also show how the different regimes of MHD turbulence in the system influence the scaling laws for the small-scale energy deposition.