

EGU21-13091

<https://doi.org/10.5194/egusphere-egu21-13091>

EGU General Assembly 2021

© Author(s) 2022. This work is distributed under the Creative Commons Attribution 4.0 License.



Coronal loops in a box: 3D models of their internal structure, dynamics and heating

Cosima Breu, Hardi Peter, Robert Cameron, Sami Solanki, Pradeep Chitta, and Damien Przybylski
Max Planck Institute for Solar System Research, Sun and Heliosphere, Germany (breu@mps.mpg.de)

The corona of the Sun, and probably also of other stars, is built up by loops defined through the magnetic field. They vividly appear in solar observations in the extreme UV and X-rays. High-resolution observations show individual strands with diameters down to a few 100 km, and so far it remains open what defines these strands, in particular their width, and where the energy to heat them is generated.

The aim of our study is to understand how the magnetic field couples the different layers of the solar atmosphere, how the energy generated by magnetoconvection is transported into the upper atmosphere and dissipated, and how this process determines the scales of observed bright strands in the loop.

To this end, we conduct 3D resistive MHD simulations with the MURaM code. We include the effects of heat conduction, radiative transfer and optically thin radiative losses.

We study an isolated coronal loop that is rooted with both footpoints in a shallow convection zone layer. To properly resolve the internal structure of the loop while limiting the size of the computational box, the coronal loop is modelled as a straightened magnetic flux tube. By including part of the convection zone, we drive the evolution of the corona self-consistently by magnetoconvection.

We find that the energy injected into the loop is generated by internal coherent motions within strong magnetic elements.

The resulting Poynting flux is channelled into the loop in vortex tubes forming a magnetic connection between the photosphere and corona, where it is dissipated and heats the upper atmosphere.

The coronal emission as it would be observed in solar extreme UV or X-ray observations, e.g. with AIA or XRT, shows transient bright strands.

The widths of these strands are consistent with observations. From our model we find that the width of the strands is governed by the size of the individual photospheric magnetic field concentrations where the field lines through these strands are rooted. Essentially, each coronal strand is mainly rooted in a single magnetic patch in the photosphere, and the energy to heat the strand is generated by internal motions within this magnetic concentration.

With this model we can build a coherent picture of how energy and matter are transported into the upper solar atmosphere and how these processes structure the interior of coronal loops.