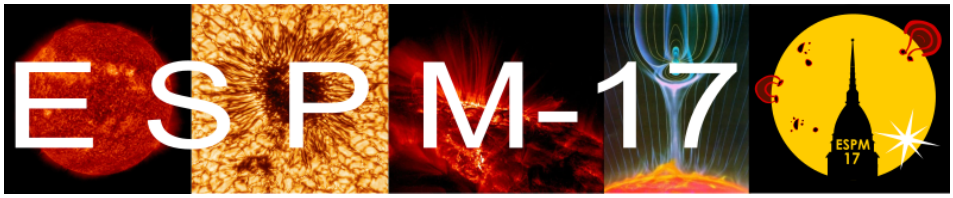

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Vortex Flows in the Solar Atmosphere: Detection and Heating Mechanisms in 3D MHD Numerical Simulations

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Vortex flows are structures associated with the rotation of the plasma and/or the magnetic field that are present throughout the solar atmosphere, which have been detected in both numerical simulations and observations. In recent years, their study has become increasingly important, as they are present on a wide variety of temporal and spatial scales and can connect several layers of the solar atmosphere. In this way, it has been proposed as one of the possible mechanisms responsible for the energy transport and heating of the chromosphere and solar corona.

In this work we performed an automatic detection of these structures in 3D MHD numerical simulations using the MANCHA3D code. The code incorporate non-ideal MHD effects and simulations are available in three magnetic fields configurations at different spatial resolutions. To detect vortex structures we proposed to use the novel SWIRL code (Canivete Cuissa & Steiner (2022)), which combines mathematical criteria based on the velocity gradient tensor to identify such structures with an advanced clustering algorithm. By applying this code, we have been able to determine multiple structures associated with small and large scale vortices that extend in height in our simulations. Prior to the detection, simulations have been filtered in order to remove the continuous oscillation caused by the presence of p-modes. We focus our study on the temperature distribution and heating mechanisms (ambipolar diffusion and viscous and ohmic dissipation) that take place in the detected vortices, and how they change as the magnetic field and spatial resolution are modified.

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