

The automatic detection and origin of magnetic twisted flux tubes in the lower solar atmosphere

Twisted magnetic flux tubes are essential structures that can be found in the solar atmosphere. They are believed to be driven by photospheric motions and have been linked to essential atmospheric processes such as plasma heating, jets, and eruptive phenomena. Until recently there were no methodologies available for their automatic detection. The automatic detection of these structures is essential for constructing large and reliable databases for the statistical analysis of their morphology and properties. In this presentation, we will address this issue by defining a twisted magnetic flux tube to be a magnetic vortex. For that, we will introduce a formal definition based on a recently developed magnetic coherent structure detection technique, i.e. the Integrated Averaged Current Deviation (IACD) method. We will apply this magnetic vortex identification methodology to a simulated solar plage region obtained from the MURaM code and demonstrate that these magnetic structures, last on average, around a minute and locally concentrate the vertical magnetic field and current density. Based on their magnetic to kinetic energy ratio, our results indicate the existence of two types of magnetic vortices. For the magnetic vortices dominated by magnetic energy, we find that the magnetic field is mostly oriented perpendicular to the solar surface. In contrast, for the second type of magnetic vortices dominated by kinetic energy, there is a wider variety of shapes, sizes and orientation of the magnetic field. Regarding their origin, we found that magnetic vortices may appear if two conditions i.e. (i) shear flow and (ii) plasma- $\beta > 1$ are simultaneously satisfied. More surprisingly, our results show that the presence of rotational motion is not actually a necessary condition for the formation of magnetic vortices.