Prominence Tornadoes: Yes or No?

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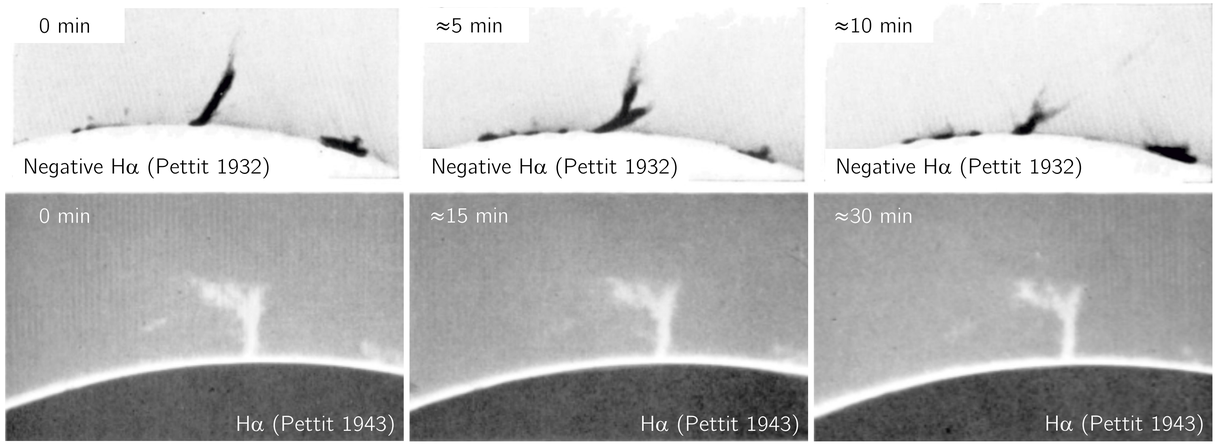
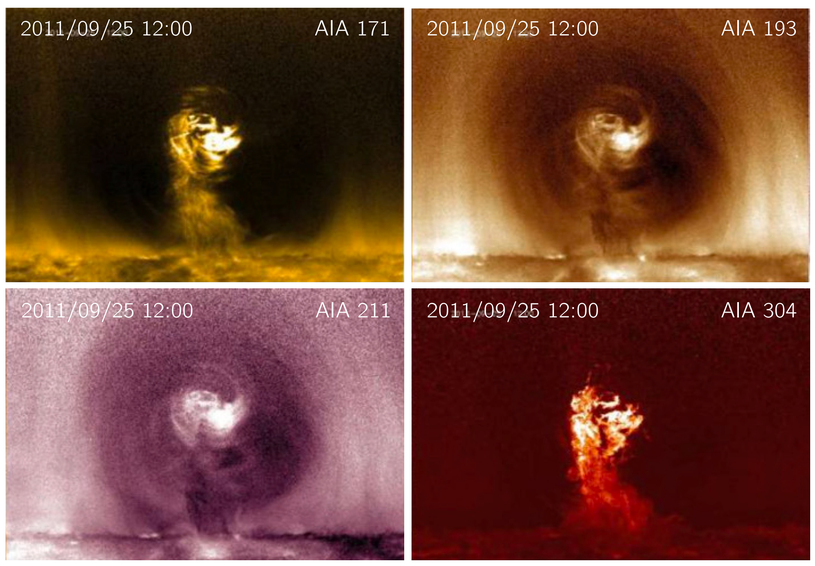
Solar prominences are dynamic and highly structured 3D solar phenomena that we can observe only in 2D projections. In this work we discuss the physical nature of the type of prominences called prominence tornadoes. These appear as vertical structures that would be generally identified as prominence feet or barbs if it were not for the fact that in movies they seem to show rotational motions around the vertical (or horizontal) axis. This apparent rotation has been corroborated by measurements of Doppler shifts showing the characteristic change of a sign of the line-of-sight velocity at both sides of the axis of rotation. As presented, there might be little doubt that what one sees is indeed a vertical column of plasma continually rotating around its axis, justifying the name given to it by its analogy with the terrestrial atmospheric phenomenon. However, this analogy collides with the usual paradigm of the stable and long-lived horizontal magnetic field topology where the cool plasma of prominences is thought to be located in the magnetic dips.

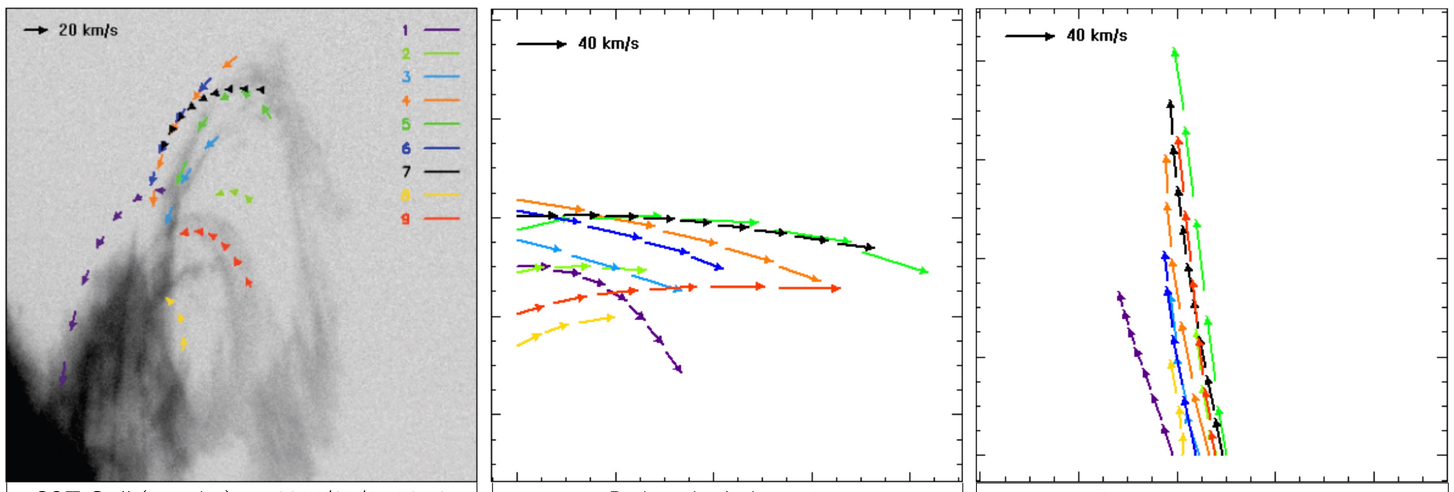


Hα observations of tornado-class prominences defined by Pettit (1932).

Yes



No

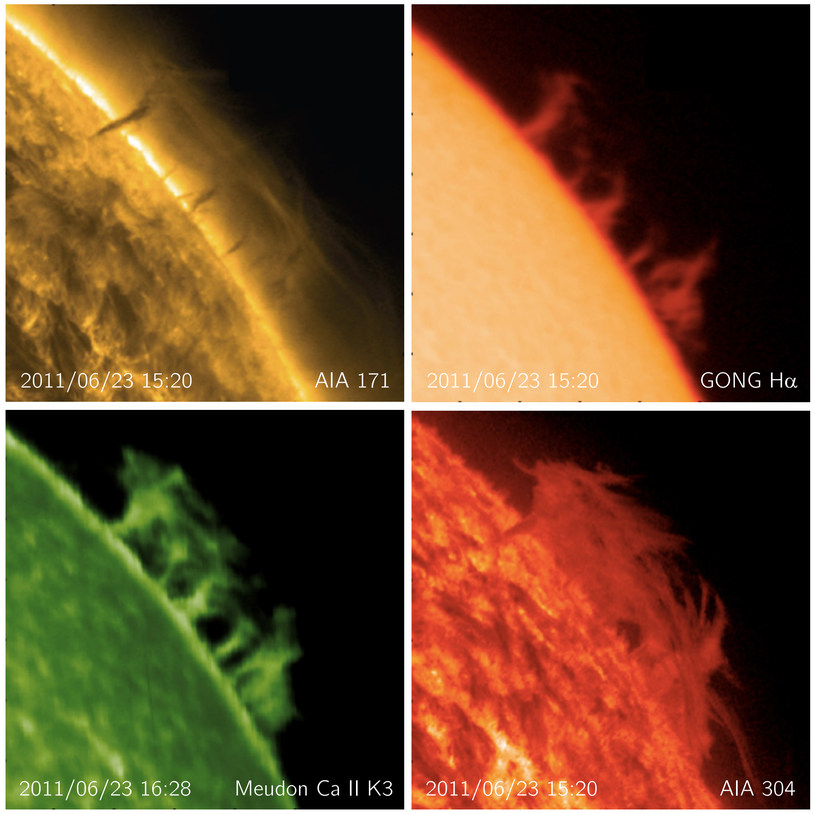


SOT Ca II (negative) 2014/07/15 10:50
x-y plane

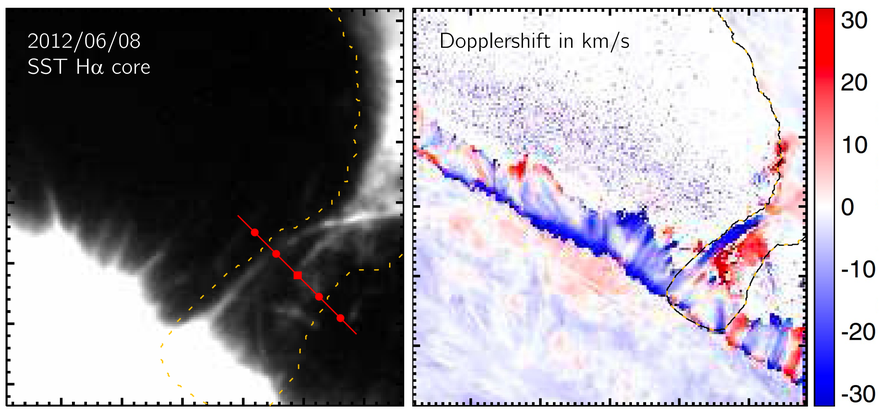
Projected velocity vectors
z-y plane

Projected velocity vectors
x-z plane

Prominence tornado with helical motions around the horizontal axis of a flux rope. Adapted from Li et al. (2012).

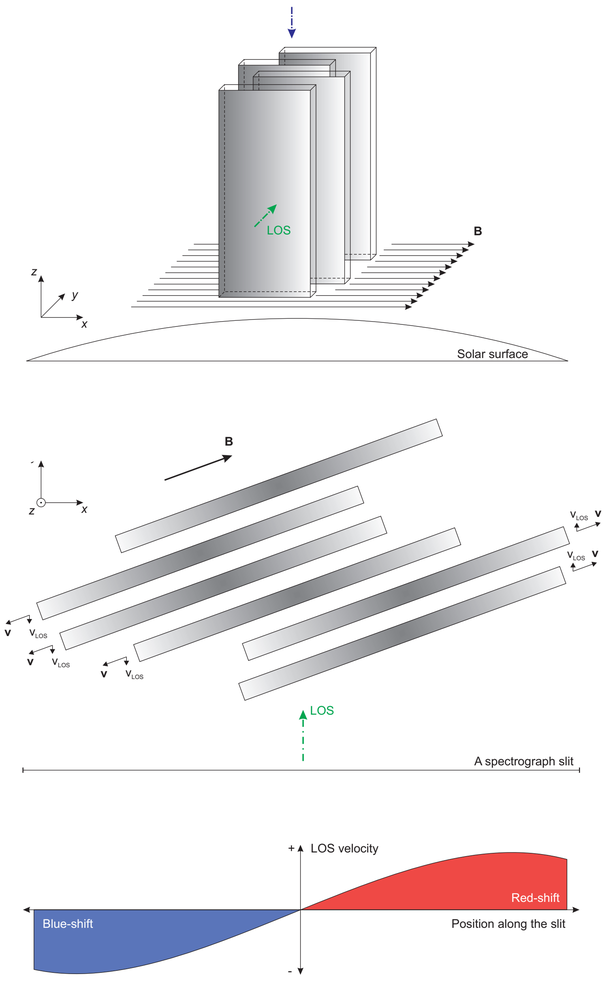


Multi-wavelength view of a quiescent prominence. The dark column-like features (prominence tornadoes) visible in AIA 171 correspond to the bright prominence legs or barbs visible in Hα and Ca II K3. Adapted from Su et al. (2012).

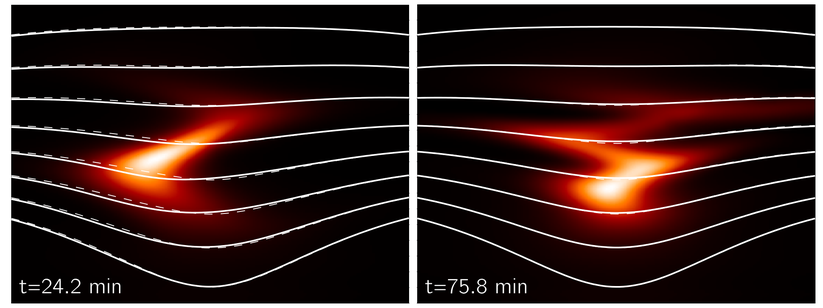


LOS velocities derived from Hα Dopplershifts show a pattern indicative of a rotation of the prominence leg around a vertical axis. Dopplershifts are based on the best-scan snapshot. Adapted from Wedemeyer et al. (2013).

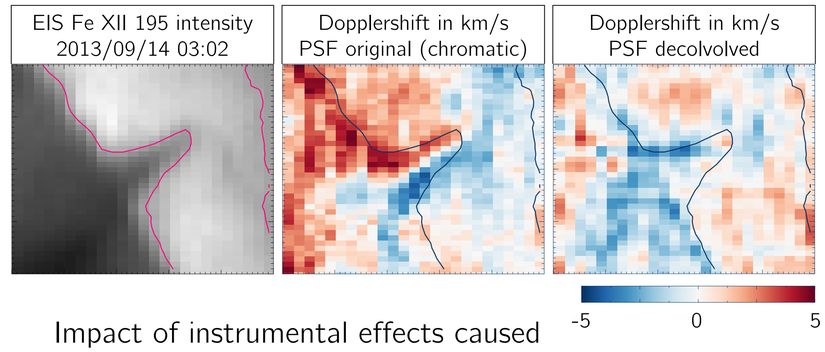
Reconstructed 3D trajectories of dynamic prominence fine structures. In the observations (x-y plane) we can see apparent helical movements but the restored velocity vectors show almost horizontal motions predominantly along the z-axis. Adapted from Schmieder et al. (2017b).



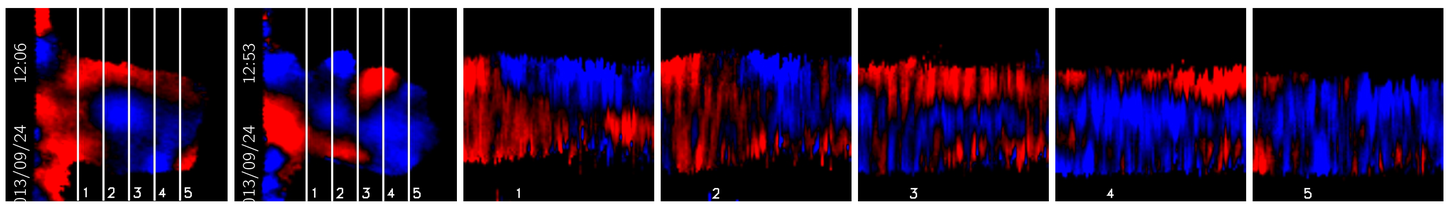
Stochastically moving prominence fine structures often produce rotation-like Dopplershift patterns.



Large-amplitude prominence oscillations – pendulum model. Oscillations of prominences and their fine structures may create an illusion of rotation. Adapted from Luna et al. (2016).



Impact of instrumental effects caused by the chromatic PSF of Hinode/EIS on the derived Dopplershift patterns (e.g. Warren et al. 2018).



Evolution of Hα Dopplershift patterns in a quiescent prominence observed with Meudon MSDP. We show time-distance diagrams at the marked slit positions. Adapted from Schmieder et al. (2017a)

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