Magnetic braids in eruptions of a spiral structure on the Sun

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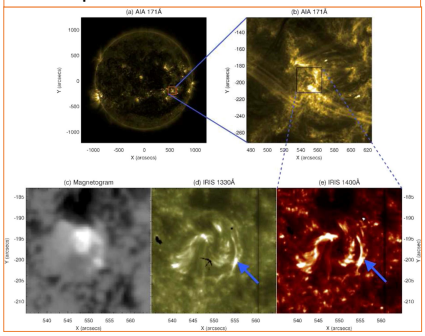
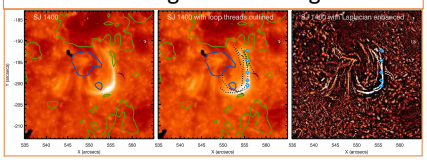
Context

- Magnetic reconnection is one of the keys to understand coronal heating and solar eruption.
- Magnetic braids are one of the preferred topologies that generate the magnetic reconnection required to power the corona (Parker 1983a, 1988 ; Schrijver 2007) .
- Magnetic braids are difficult to observed depending on the degree and pattern of the field line tangling within the loops (Pontin et al. 2017).
- Here we report on high-resolution IRIS observations that show evidence of magnetic braids associated with an eruption of a spiral structure in the solar transition region.

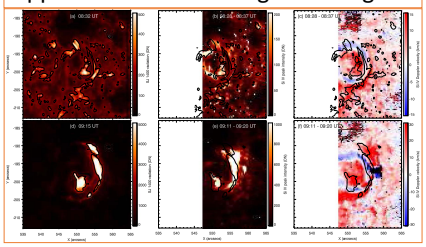
The structure of the event in IRIS SJ images and HMI magnetogram. The blue arrows point at the eruptive portion of the structures.



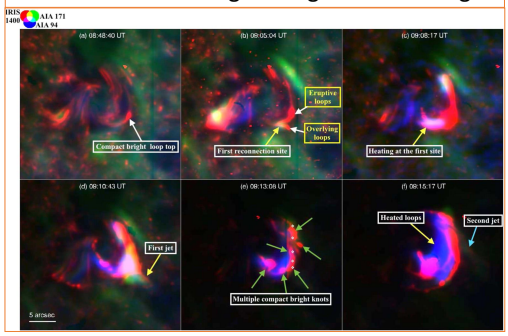
Multiple loop threads are seemingly bundled each other in the eruptive region—providing enough loop threads for magnetic braiding.



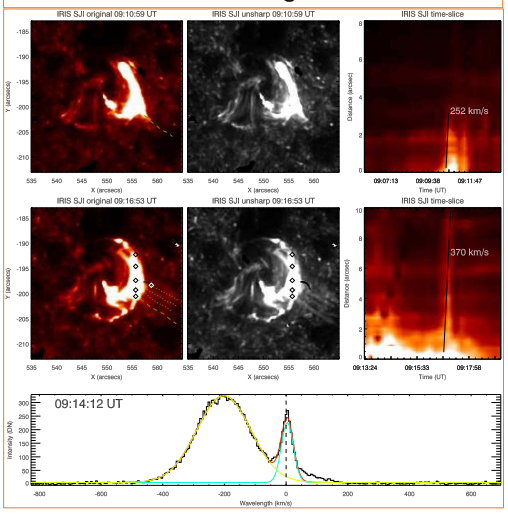
Doppler maps (Si IV) confirm multiple loops crossing each other with opposite velocities along their lengths.



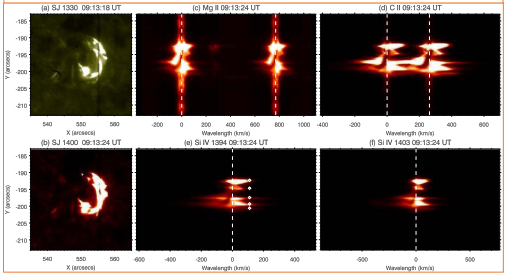
Evidence of magnetic braiding (1): localised compact bright knots (panel e) — heat locally at locations with higher degree of braiding.



Evidence of magnetic braiding (2): well separated multiple threads of jets ejecting from the compact bright knots — magnetic reconnection in magnetic braids.

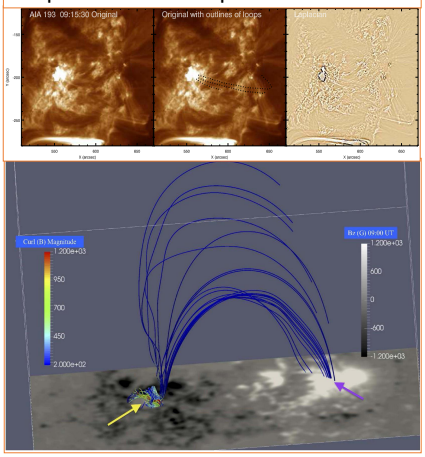


Evidence of magnetic braiding (3): well separated explosive events corresponding to the footpoints of jets and the bright knots — further evidence for magnetic reconnection.

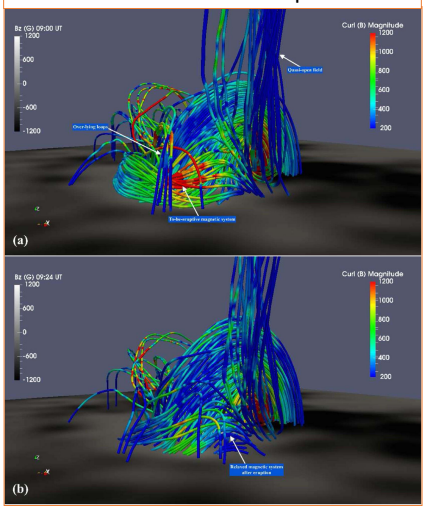


The full story including animations of the eruption could be found in a published paper: ApJ, 2018, 854, 80.

Non-linear force-free (NLFF) magnetic fields of the region comparing to the AIA observations. The yellow arrow points to the eruptive structure.



NLFF magnetic fields of the region before and after the eruption: strong curl value before eruption indicates high degree of complexity that will released after the eruption.



Conclusion

- With high resolution observations of IRIS and SDO, we observed evidence of magnetic braids in eruption of a spiral structure in the solar atmosphere. The evidence includes:
- multiple loop threads bundled at the eruptive area—providing basic conditions for magnetic braiding.
- localised bright knots—well isolated heating events that agree with the picture of magnetic braiding.
- well separated jet threads and explosive events that both are consistent with the bright knot.
- complexity of magnetic field and relaxes after eruption, demonstrated by NLFF fields.

IRIS-9, Göttingen, 25-29 June 2018

Poster

3. Magnetic coupling and mass flux through the atmosphere

Magnetic braids in eruptions of a spiral structure in the solar atmosphere

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We report on high-resolution imaging and spectral observations of eruptions of a spiral structure in the transition region, which were taken with the Interface Region Imaging Spectrometer (IRIS), the Atmospheric Imaging Assembly (AIA) and the Helioseismic and Magnetic Imager (HMI). The eruption coincided with the appearance of two series of jets, with velocities comparable to the Alfvén speeds in their footpoints. Several pieces of evidence of magnetic braiding in the eruption are revealed, including localized bright knots, multiple well-separated jet threads, transition region explosive events and the fact that all these three are falling into the same locations within the eruptive structures. Through analysis of the extrapolated three-dimensional magnetic field in the region, we found that the eruptive spiral structure corresponded well to locations of twisted magnetic flux tubes with varying curl values along their lengths. The eruption occurred where strong parallel currents, high squashing factors, and large twist numbers were obtained. The electron number density of the eruptive structure is found to be $\sim 3 \times 10^{12}\,\mathrm{cm}^{-3}$, indicating that significant amount of mass could be pumped into the corona by the jets. Following the eruption, the extrapolations revealed a set of seemingly relaxed loops, which were visible in the AIA 94 Å channel indicating temperatures of around 6.3 MK. With these observations, we suggest that magnetic braiding could be part of the mechanisms explaining the formation of solar eruption and the mass and energy supplement to the corona.