

Huang, Xia, Nelson, Liu, Wiegelmann, et al. 2018, ApJ, 854, 80

# Magnetic braids in eruptions of a spiral structure on the Sun

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Huang (Shandong University), Nelson (Sheffield University), Liu (Sheffield University & Uni. of Sci. and Tech. China), Wiegelmann (MPS), Tian (Peking University), Klimchuk (GSFC), Chen & Li (Shandong University)



Poster

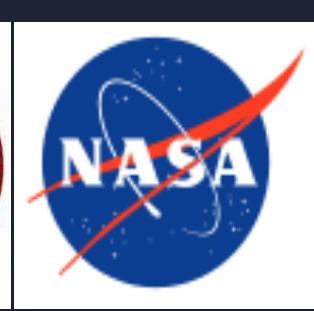
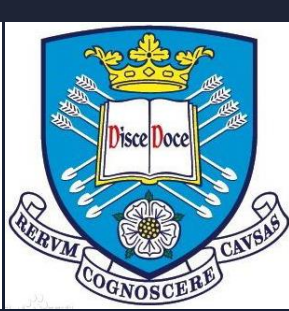
## 3. Magnetic coupling and mass flux through the atmosphere

**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  $\sim 3 \times 10^{12} \text{ cm}^{-3}$ , 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.



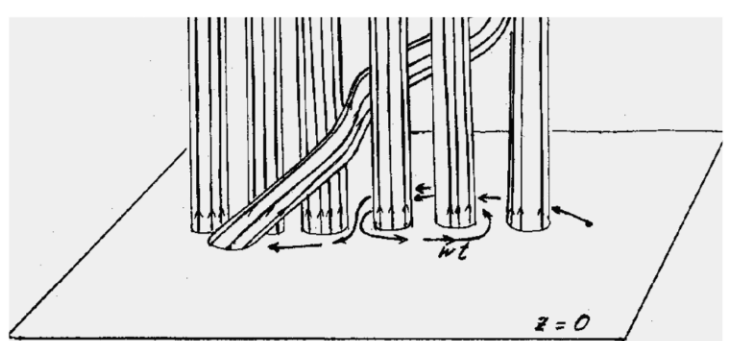
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ing of the flux tubes that make up the continuum field over a bipolar active region  
ing its neighbors as a consequence of the random walk of the footpoints at  $z =$

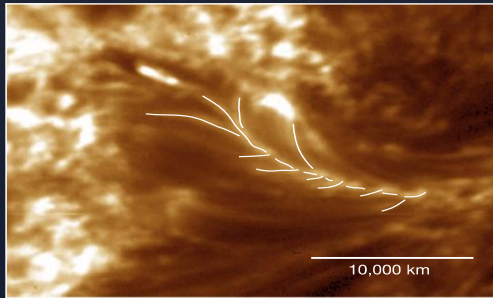
energy input in the corona can  
as of the magnetic stresses at  
fluid motions are driving the  
extending vertically from the  
where it is fixed at  $z = L$ , as  
evident that a net horizontal  
(along some random path) of  
length  $L$  and strength  $B$  produces

the magnetic field in which  
follows that the characteris  
 $B/(4\pi\rho)^{1/2}$  is large compared  
hence large compared to  
manipulate the field. Specifica  
the corona, where  $N = 2 \times 10^9$   
 $10^6$  K, and  $B = 10^2$  gauss,  $t$   
 $\text{km s}^{-1}$  and the sound speed

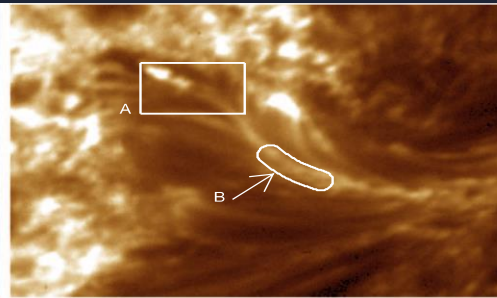
**Magnetic braiding:**  
when twisted flux tubes  
are bundled together,  
they are subjected to  
neutral point  
reconnection and **can**  
**produce the active corona**  
**of the Sun.** —(Parker 1988)



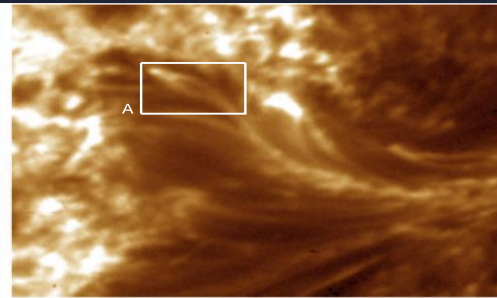
a Hi-C 193 Å: 18:53:28



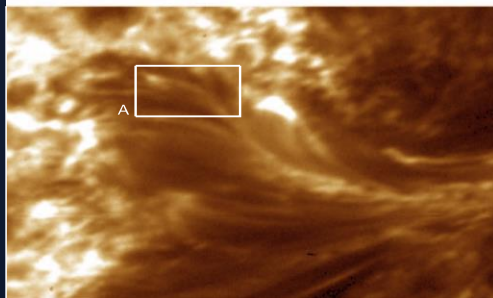
b Hi-C 193 Å: 18:53:45



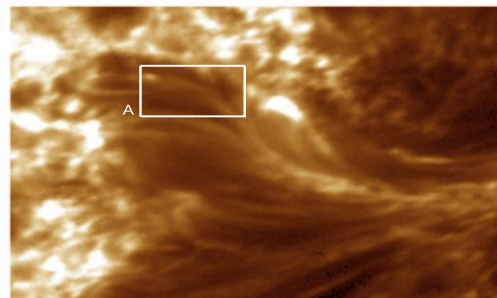
c Hi-C 193 Å: 18:54:13



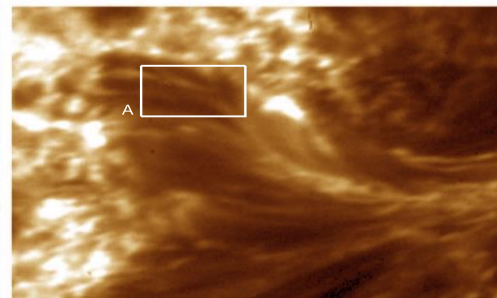
d Hi-C 193 Å: 18:54:41



e Hi-C 193 Å: 18:55:08



f Hi-C 193 Å: 18:55:36

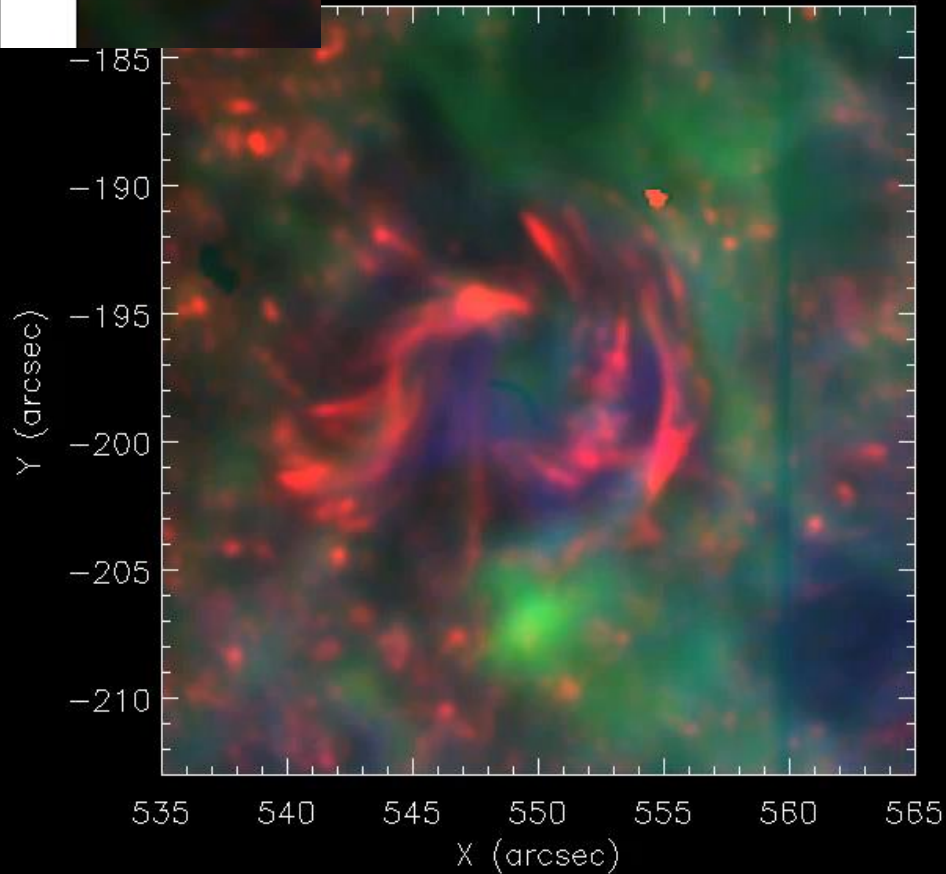


# Observational evidence

Observational evidence of magnetic braiding is difficult to be observed, and **the only** convincing **evidence** so far **is** provided by **Hi-C observations of dynamics in the seemingly-braiding loop threads** (Cirtain et al. 2013).

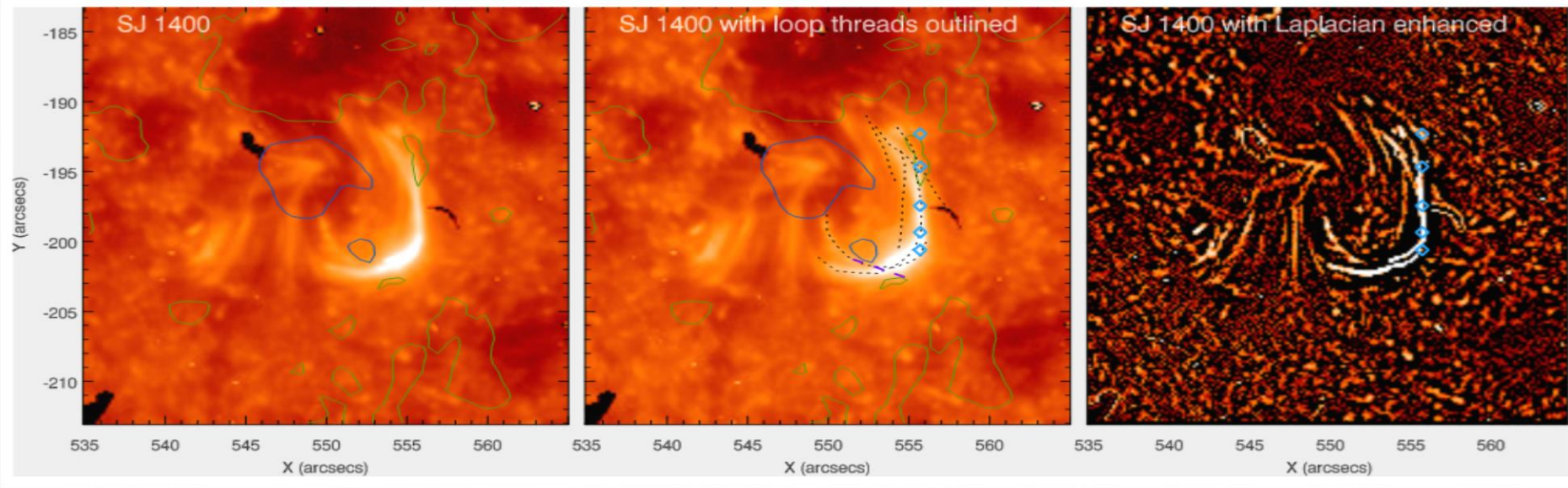


08:40:03 UT



Here, we present  
evidence of  
magnetic braiding  
from IRIS and SDO  
observations of an  
eruption of a spiral  
structure in the solar  
atmosphere.

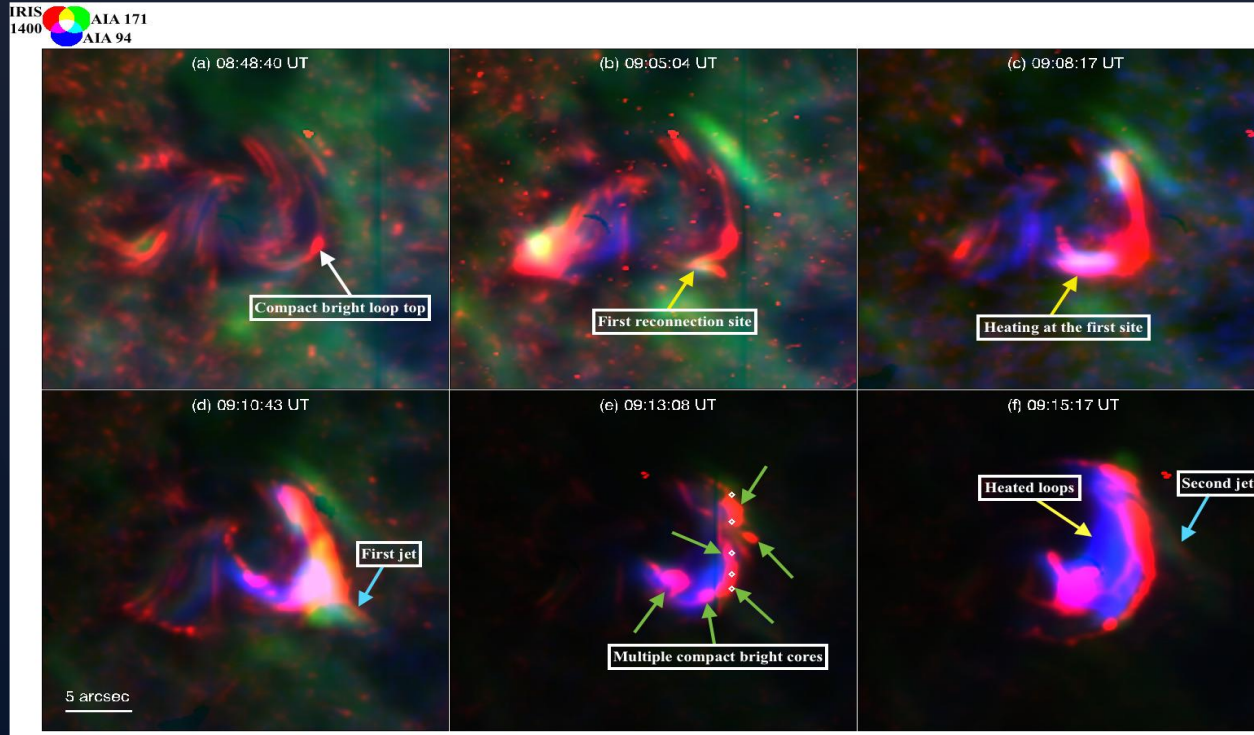




Multiple loop threads are seemingly crossing each other at the locations of eruption—  
providing a field geometry for possible braiding.



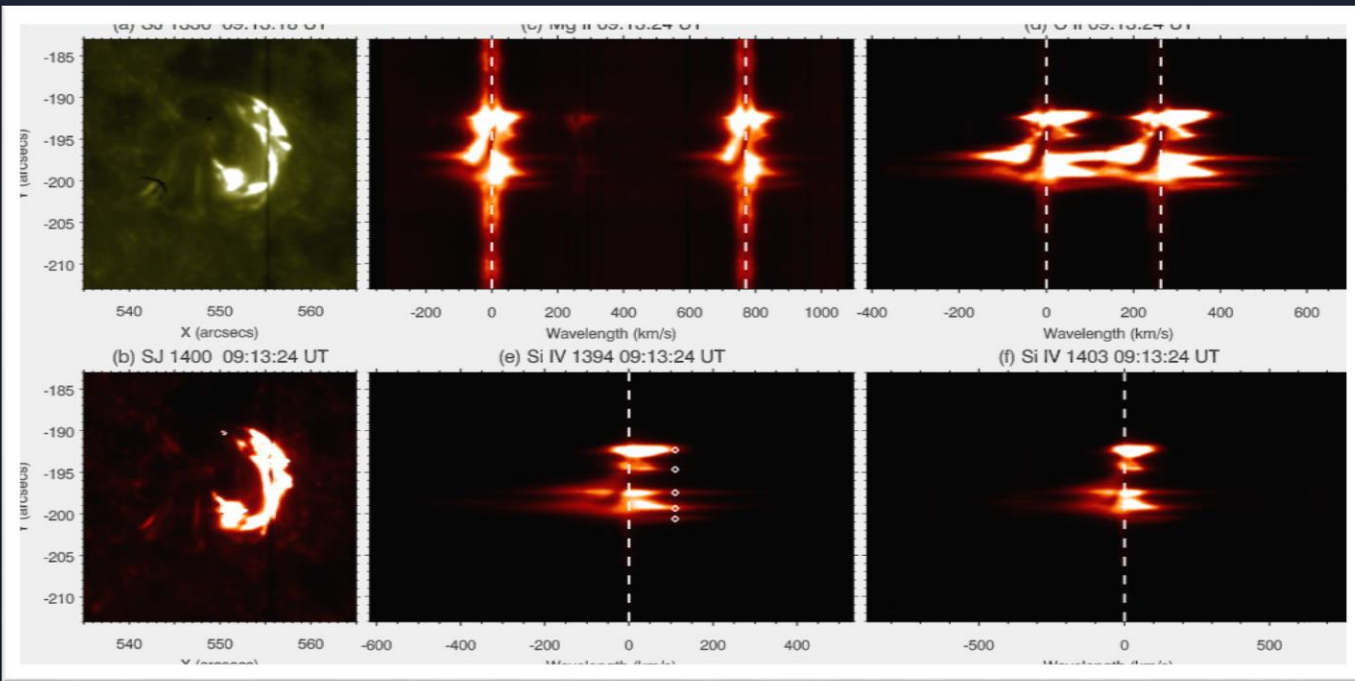
Compact bright knots: indication of localised heating events that magnetic braiding could provide.



Relaxed and heated loops: indication of untwining of loop threads via processes of energy release.

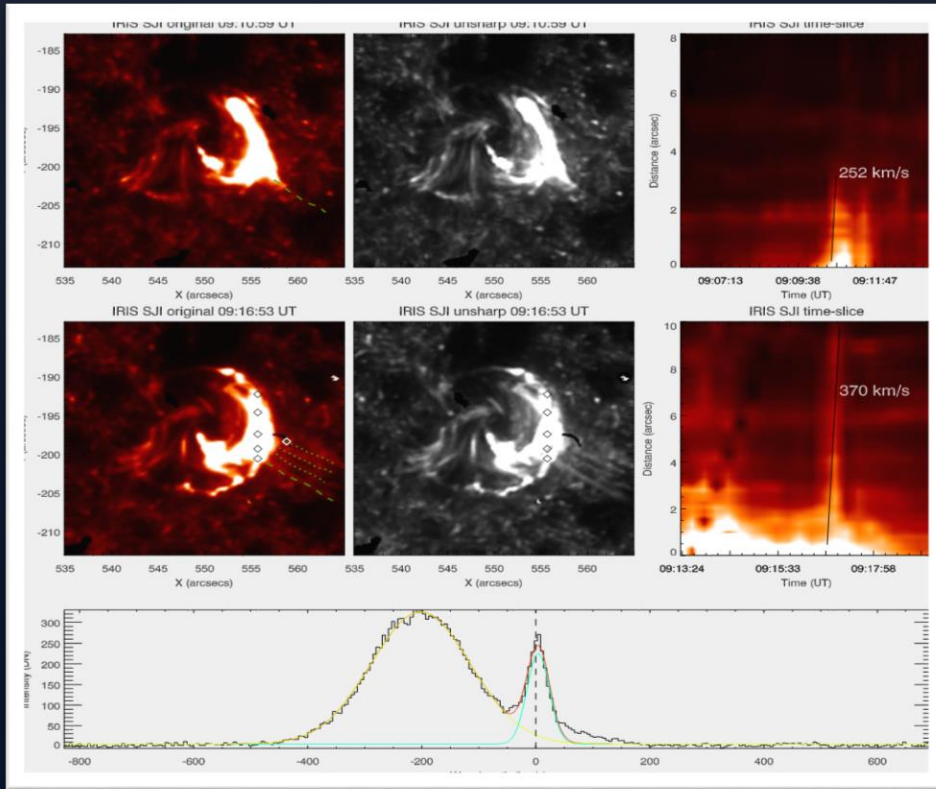






Extremely broadened spectral profiles (i.e. **transition region explosive events, diamonds in the image**) at the location where compact bright knots are observed: **hints of magnetic reconnection in the braiding positions.**





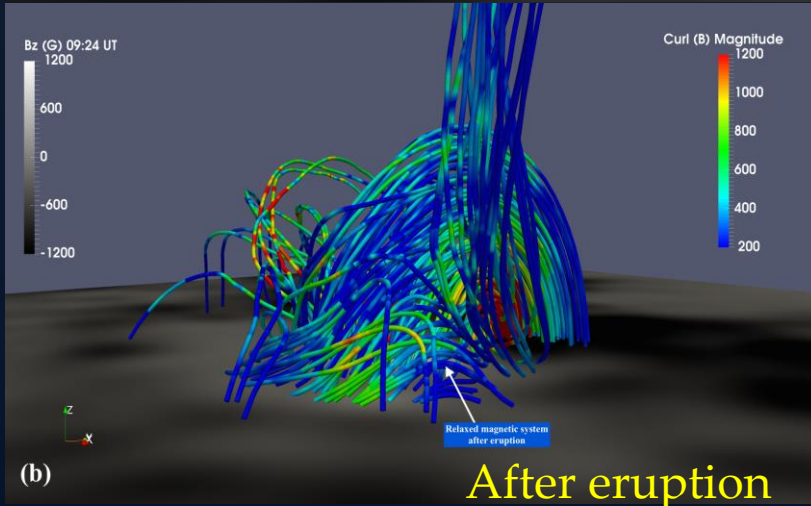
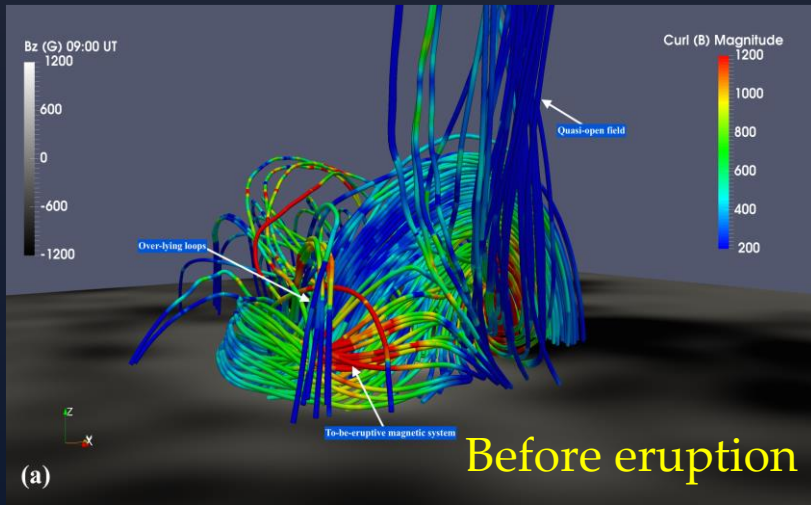
High speed ( $\sim$ Alfven speed) jets with multiple threads in jets originating from the bright knots: indication of magnetic reconnection.

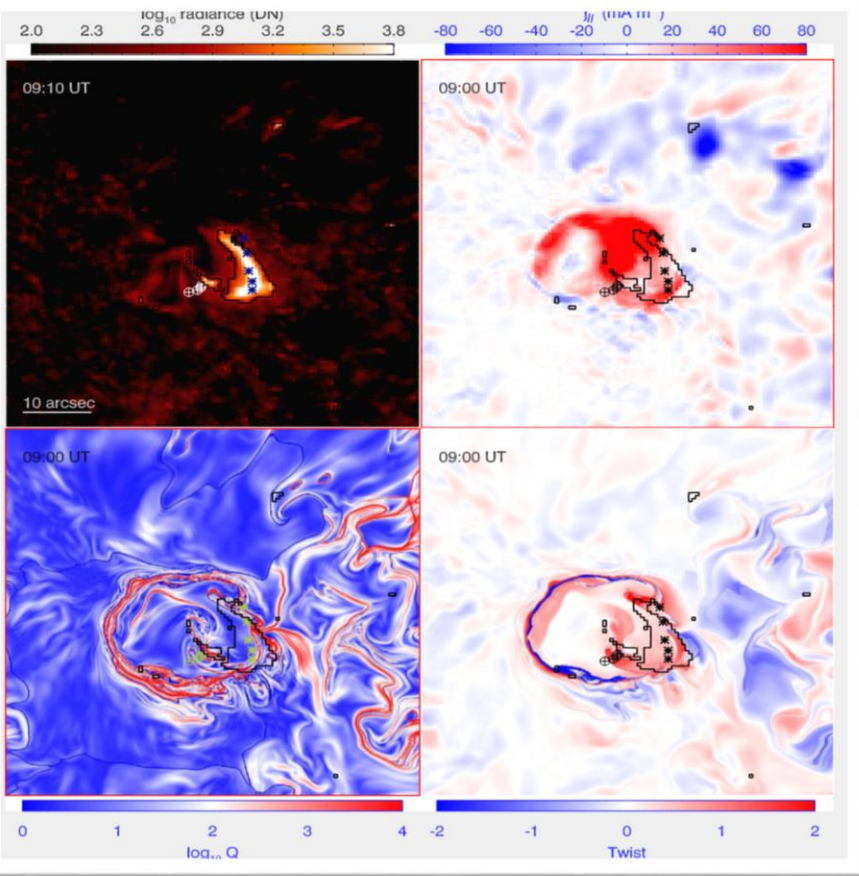


# Non-linear force free fields

Before eruption: Variable curl values along the eruptive loop systems gives evidence of magnetic braiding geometry.

After eruption: Releases of magnetic curl provides evidence of untwined loop threads.





Parallel current, squashing factor (Q) and twist numbers of the region based on the extrapolated magnetic field.

- strong and opposite direction of parallel current;
- high Q values and twist number

**Agree with reconnection in magnetic braids.**



# One sentence as summary

With IRIS and SDO, we observed evidence of magnetic braids in a spiral structure in the solar atmosphere.

The full story is referred to a poster at the poster area and a published paper

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