Fan-shaped jet close to a light bridge

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Abstract

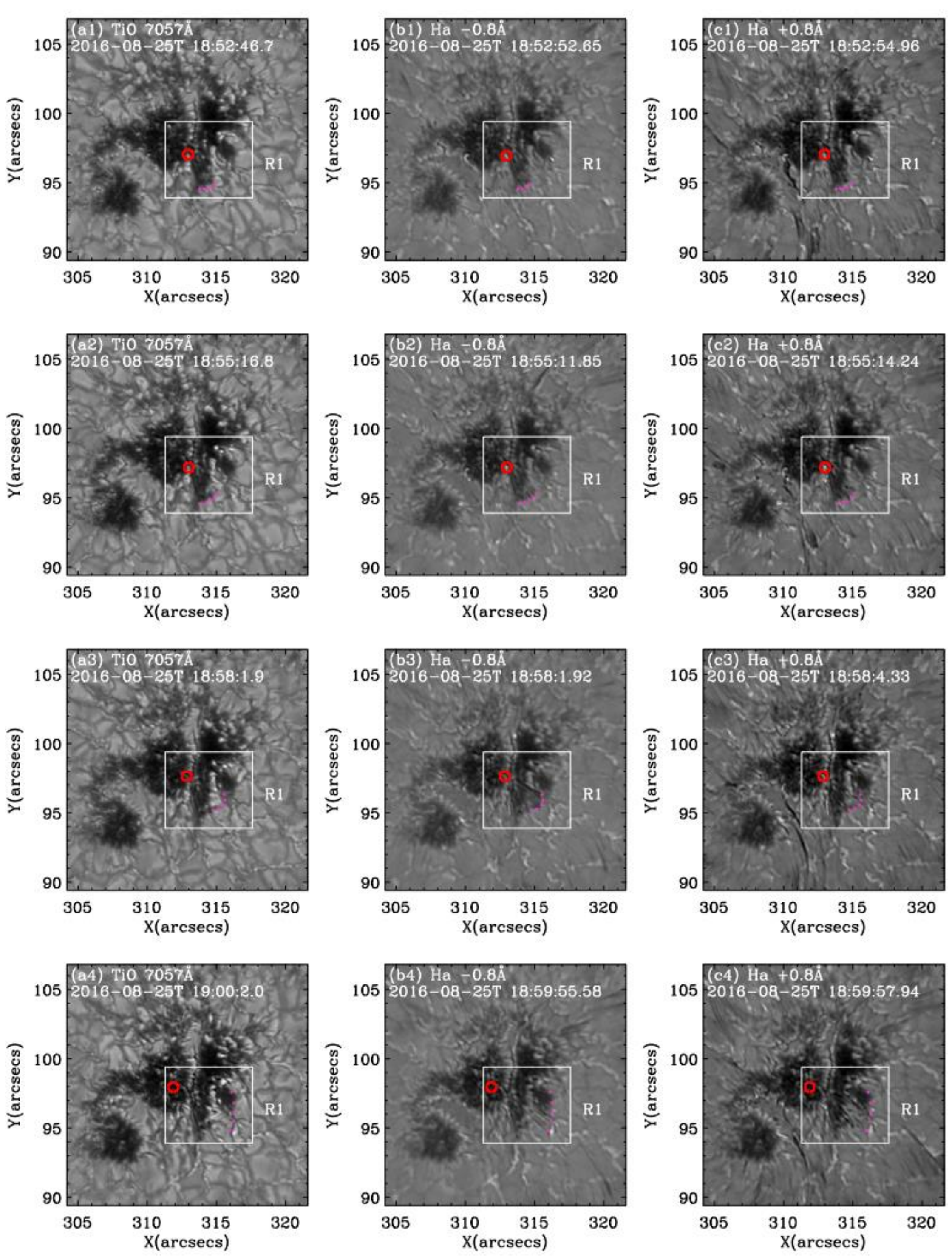
Aims. On the Sun, jets in light bridges (LBs) are frequently observed with high-resolution instruments. The respective roles played by convection and the magnetic field in triggering such jets are not yet clear.

Methods. We report a small fan-shaped jet along a LB observed by the 1.6m Goode Solar Telescope (GST) with the TiO Broadband Filter Imager (BFI), the Visible Imaging Spectrometer (VIS) in Hα, and the Near-InfraRed Imaging Spectropolarimeter (NIRIS), along with the Stokes parameters. The high spatial and temporal resolution of those instruments allowed us to analyze the features identified during the jet event. By constructing the Hα Dopplergrams, we found that the plasma is first moving upward, whereas during the second phase of the jet, the plasma is flowing back. Working with time slice diagrams, we investigated the propagation-projected speed of the fan and its bright base.

Results. The fan-shaped jet developed within a few minutes, with diverging beams. At its base, a bright point was slipping along the LB and ultimately invaded the umbra of the sunspot. The Hα profiles of the bright points enhanced the intensity in the wings, similarly to the case of Ellerman bombs. Co-temporally, the extreme ultraviolet (EUV) brightenings developed at the front of the dark material jet and moved at the same speed as the fan, leading us to propose that the fan-shaped jet material compressed and heated the ambient plasma at its extremities in the corona.

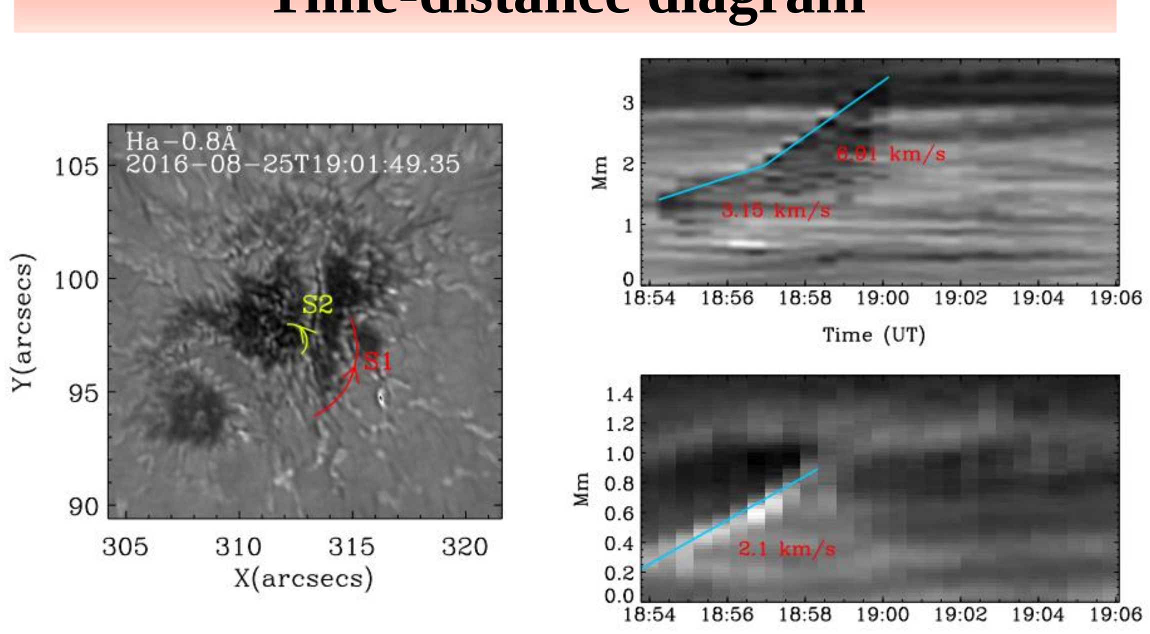
Conclusions. Our multi-wavelength analysis indicates that the fan-shaped jet could result from magnetic reconnection across the highly diverging field low in the chromosphere, leading to an apparent slipping motion of the jet material along the LB. However, we did not find any opposite magnetic polarity at the jet base, as would typically be expected in such a configuration. We therefore discuss other plausible physical mechanisms, based on waves and convection, that may have triggered the event.

GST



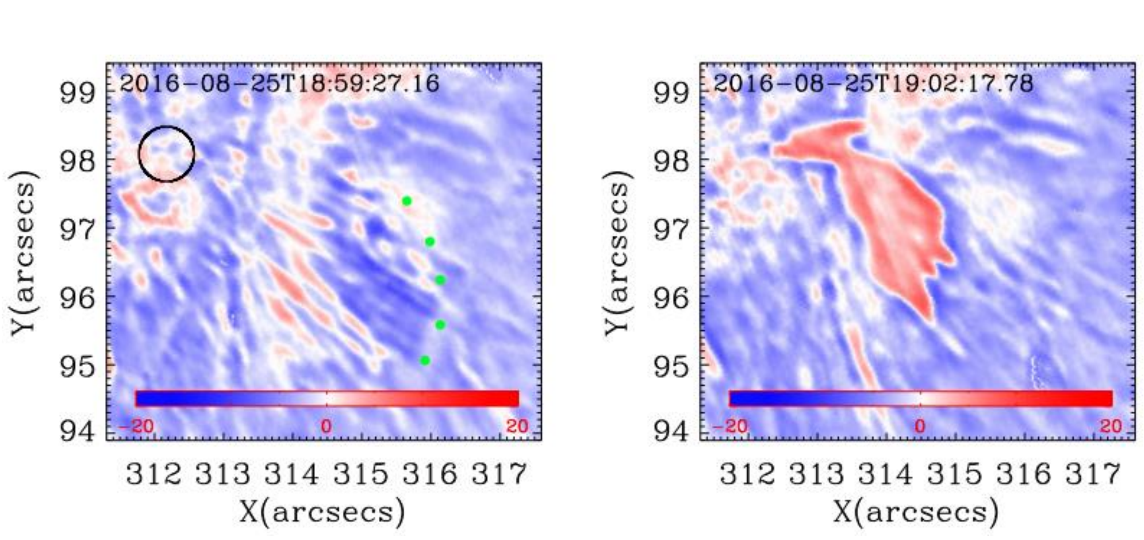
The fan-shaped jet observed in absorption in the Hα +/- 0.8 Å shows a diverging shape.

Time-distance diagram

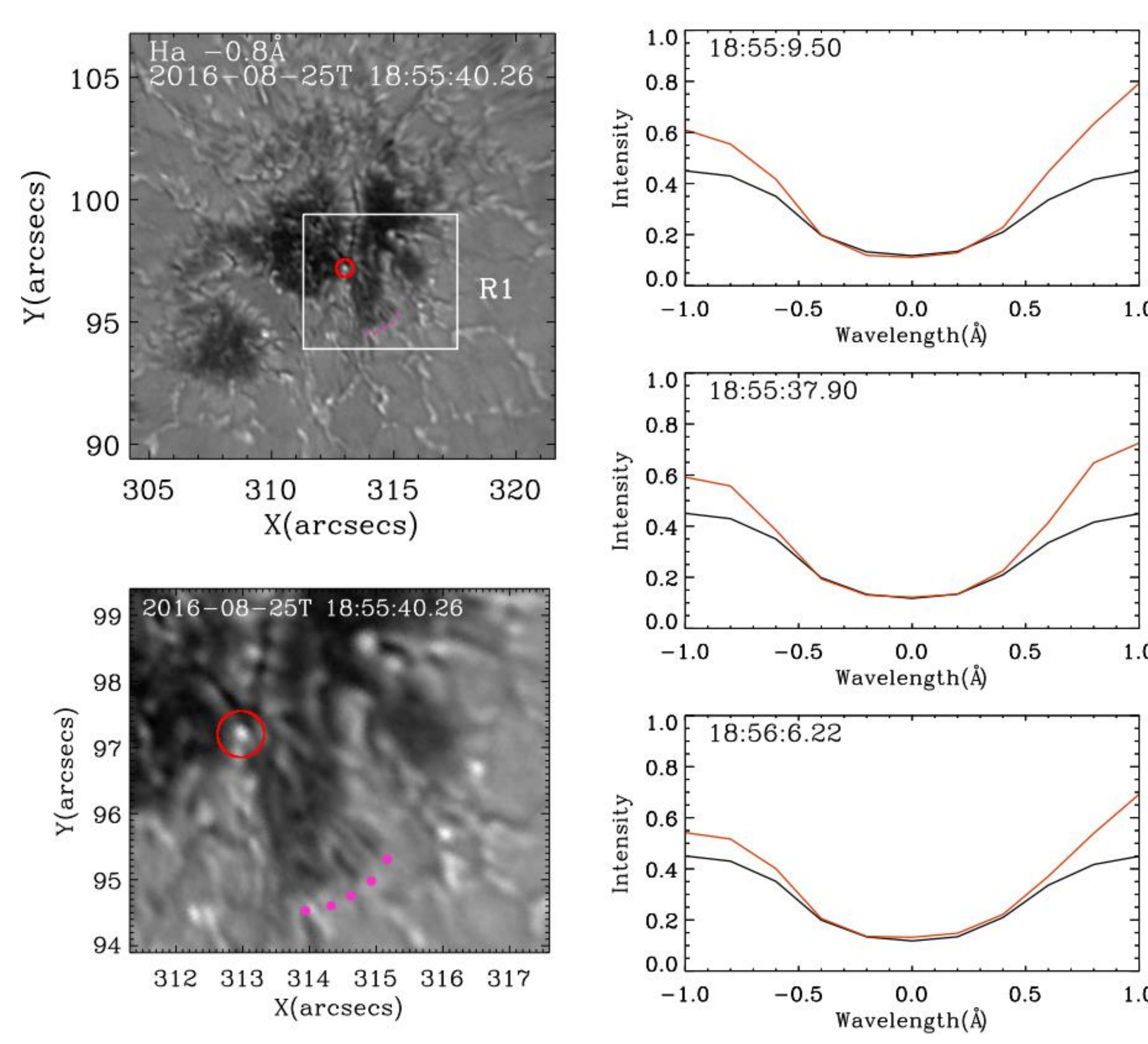


In the first phase, it exhibits a sweeping motion from the south to the north of the sunspot with an approximate velocity of $3.15 - 6.91$ km s^{-1} and in the the second phase, the jet material is flowing back toward the photosphere. The computed Doppler diagram of the jet confirms these upflows and downflows

Doppler velocity

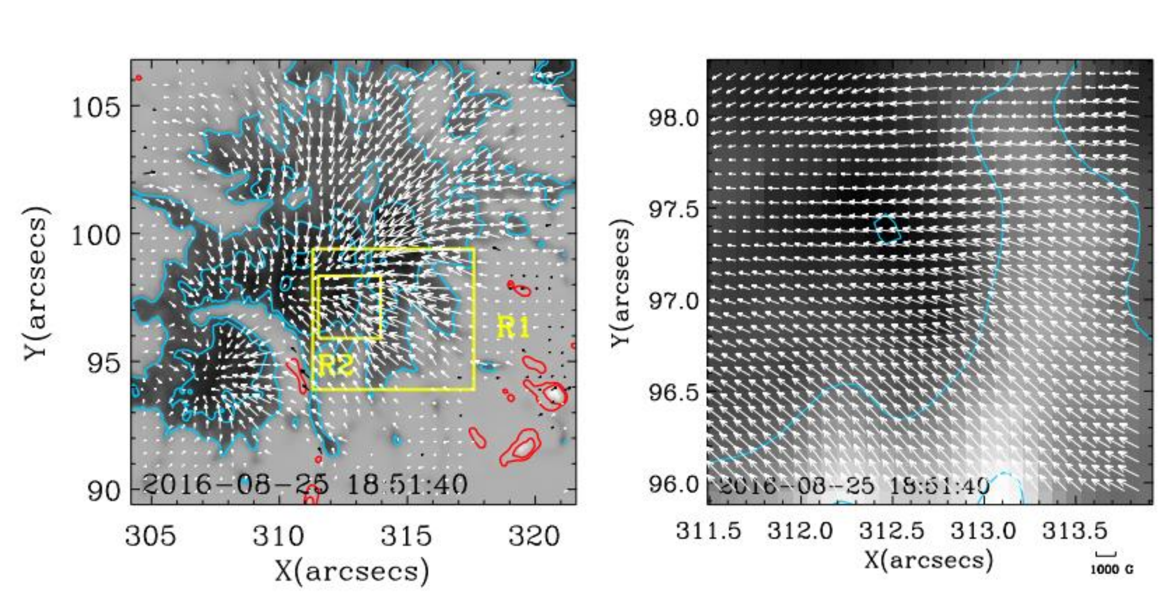


Ellerman bomb



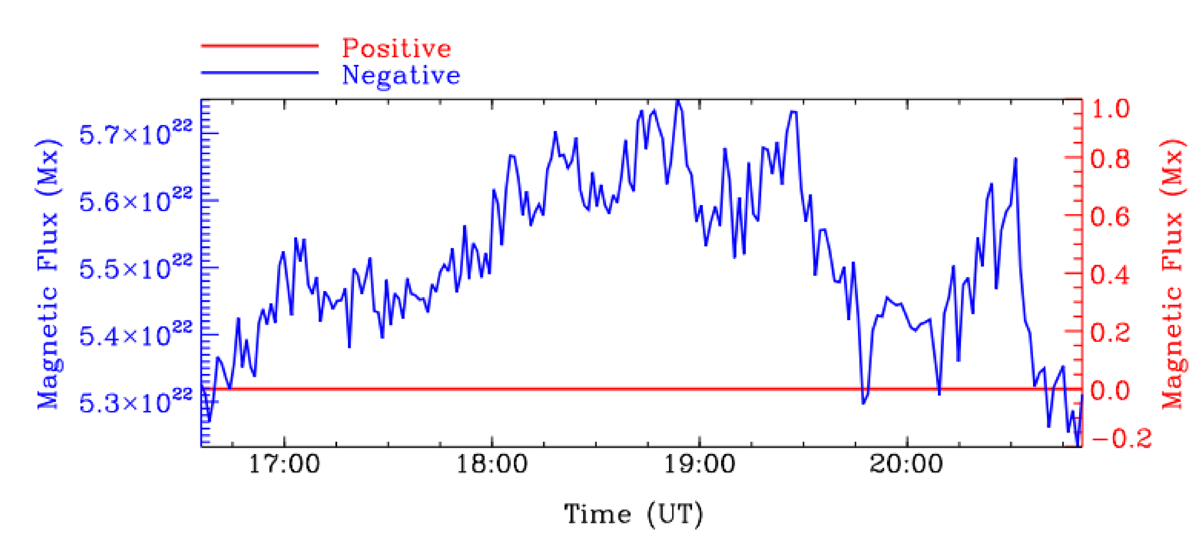
- We also identified a bright point in the Hα blue wing located in the LB that is spatially consistent with the footpoint of the fan-shaped jet. This bright point is moving along the LB axis with an estimated speed of 2. 1km s^{-1}.
- We normalized the intensity and exposure time of the Hα 11 wavelength images. The Hα profiles in the bright points corresponding to the jet footpoints are presented at three different times at 18:55:09, 18:55:57, 18:56:06 UT.
- They show a clear enhancement of intensity in the Hα line wings and no obvious signature in the Hα line core. These profiles are consistent with Ellerman bomb (EB) Hα line. This suggests that this bright point may result from magnetic reconnection.

Vector magnetic field



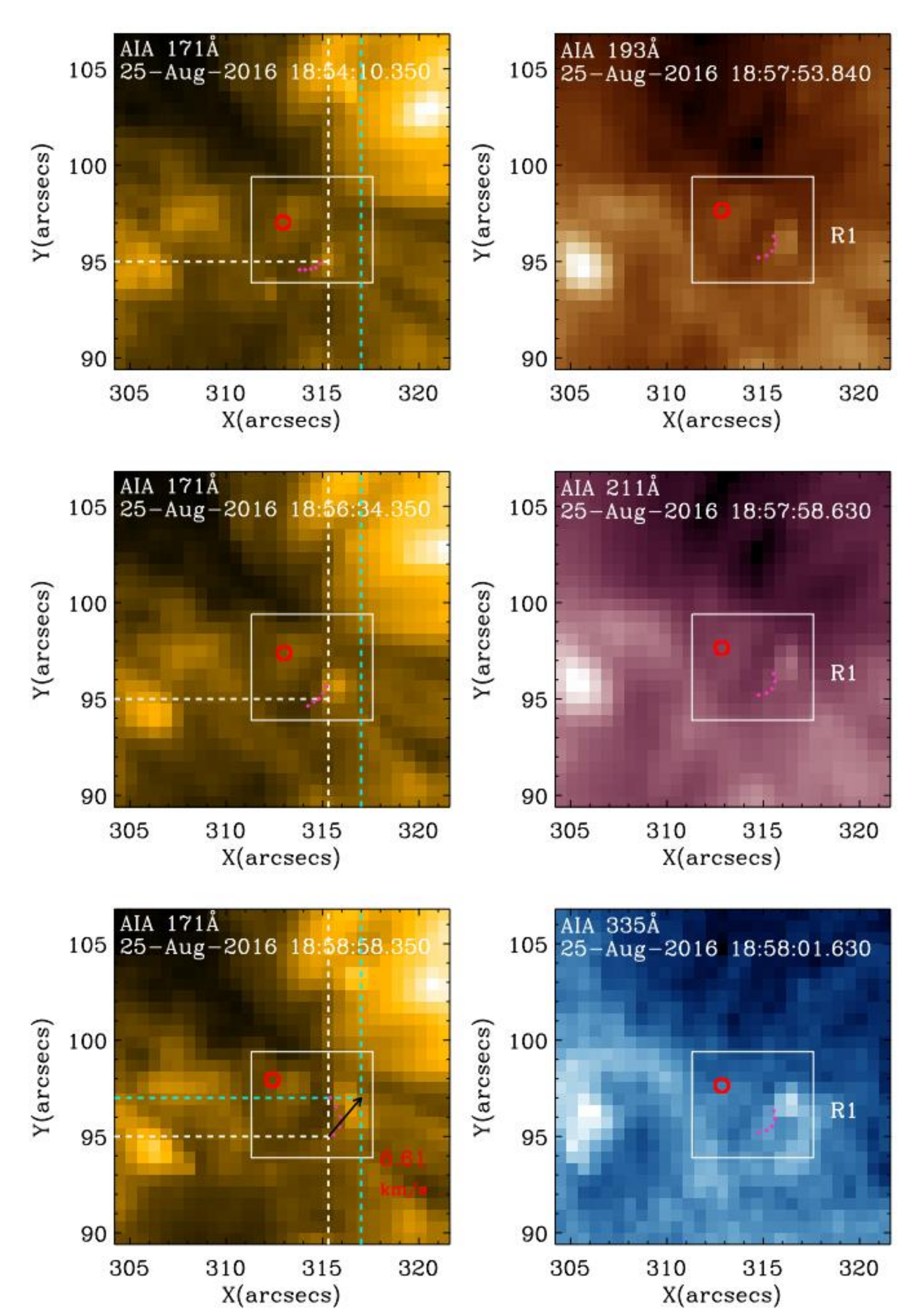
- In analyzing the NIRIS vector magnetogram, we found that the magnetic field associated with the fan-shaped jet strongly diverges starting at the jet footpoint up to its front.
- We observe a change in direction versus the x axis of the horizontal component evolving from a south-west to north-eastward orientation to a west-eastward orientation in the northern part.
- This change in the horizontal magnetic field direction is kept as we go further away from the fan-shaped jet footpoint toward the west (see the right side of the R1 box). This change in orientation in the field is consistent with the diverging shape of the dark structures forming the fan-shaped jet observed in the Hα -0.8 Å.

Magnetic flux



By computing the magnetic flux in the region R2, we found no emergence of new positive magnetic flux. Pixel by pixel, we analyzed the Stokes profiles to detect a third lobe but we could not identify such a pattern in the profiles, as done in the work by Bai et al. (2019). The difference of resolution of NIRIS compared to VIS is only a factor 2.8 and this cannot explain the non-visibility of an opposite polarity either.

Brightenings



From the AIA observations, during the first phase of the jet, we observe a multi-thermal structure located at the front of the Hα jet and moving in time with it from south to north with an estimated speed of 6.6 km s^{-1}. This indicates that hot material up to 10^6 K is present at the fan-shaped jet front.