Evidence from IRIS that Sunspot Large Penumbral Jets Spin

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Abstract

Recent observations from *Hinode* (SOT/FG) revealed the presence of large penumbral jets (widths ≥ 500 km, larger than normal penumbral microjets, which have widths < 400 km) repeatedly occurring at the same locations in a sunspot penumbra, at the tail of a filament or where the tails of several penumbral filaments apparently converge (Tiwari et al. 2016, ApJ). These locations were observed to have mixed-polarity flux in Stokes-V images from SOT/FG. Large penumbral jets displayed direct signatures in AIA 1600, 304, 171, and 193 channels; thus they were heated to at least transition region temperatures. Because large jets could not be detected in AIA 94 Å, whether they had any coronal-temperature plasma remains unclear. In the present work, for another sunspot, we use IRIS Mg II k 2796 Å slit jaw images and spectra and magnetograms from Hinode SOT/FG and SOT/SP to examine: whether penumbral jets spin, similar to spicules and coronal jets in the quiet Sun and coronal holes; whether they stem from mixed-polarity flux; and whether they produce discernible coronal emission, especially in AIA 94 Å images. The few large penumbral jets for which we have IRIS spectra show evidence of spin. If these have mixed-polarity at their base, then they might be driven the same way as coronal jets and CMEs.

Sunspot Large Penumbral Jets

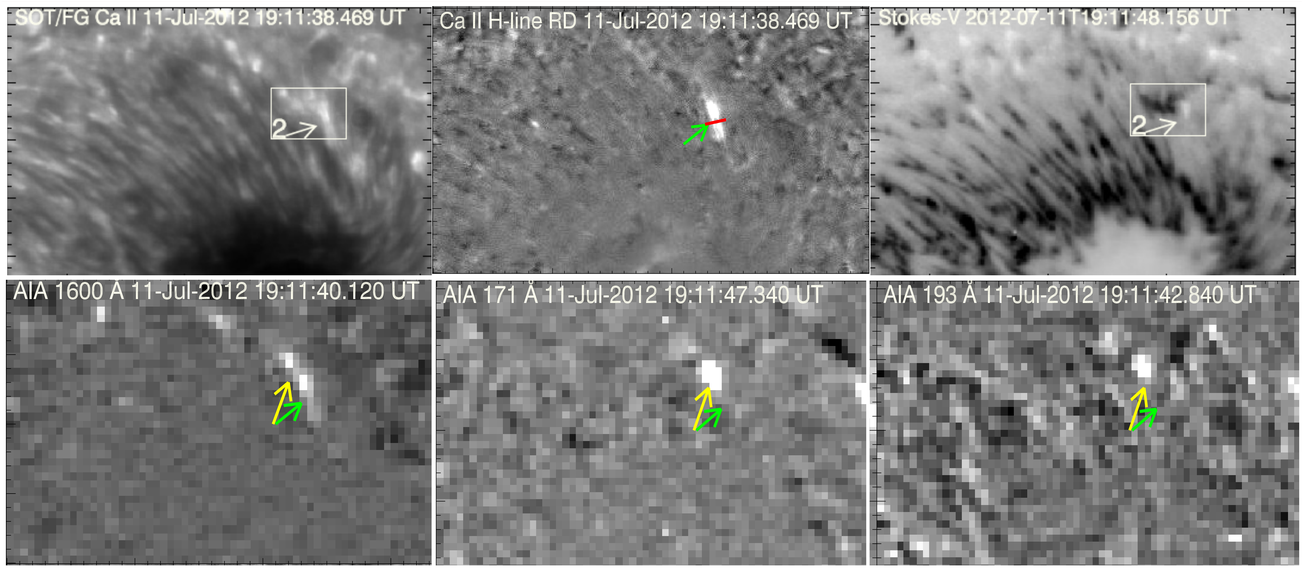


Fig. 1. A large penumbral jet, numbered "2" from Tiwari et al. 2016, ApJ. Stokes-V image shows a mixed polarity field at the base of the jet, where tails of several penumbral filaments appear to converge. The bottom panels show direct signature of this jet in AIA 1600, 171, and 193 Å images. Neither this one nor any other jet showed any signature in 94 Å (not shown here).

Twisting of Large Penumbral Jets

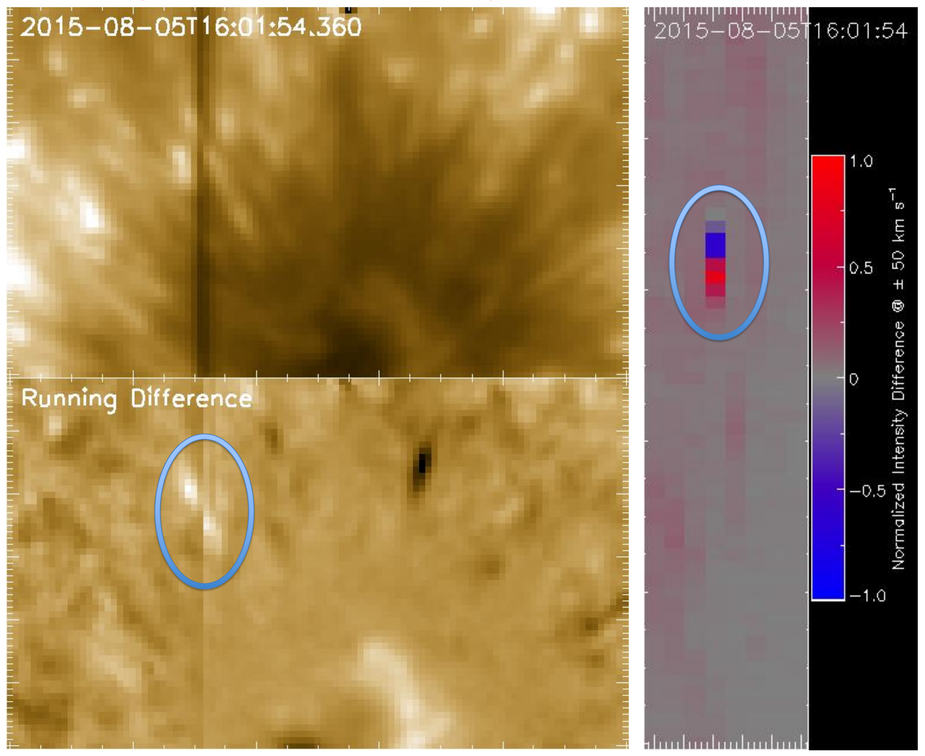


Fig. 3. An example large penumbral jet during its peak time, when the IRIS slit was placed across the middle of the jet. In the right panel a dopplergram is shown, clearly displaying a blue and red shifted region across the jet. Note that part of the jet is obscured by the slit. Of the 8-slit raster the fourth slit caught this event.

Schematic diagram depicting the formation mechanism of penumbral jets

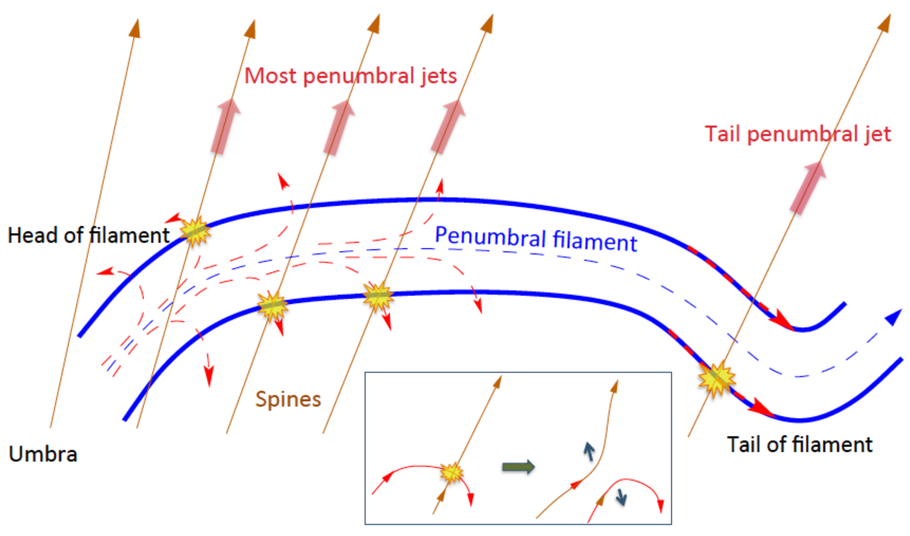
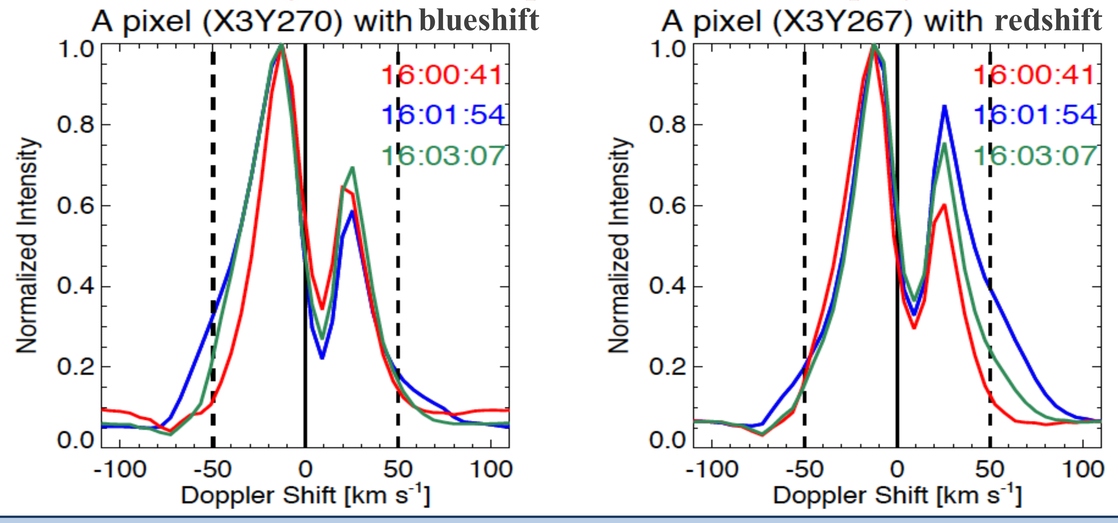


Fig. 2. Magnetic reconnection between spine field and tail field probably leads to the formation of large penumbral jets, as shown. Other smaller jets form by reconnection of the spine field with the opposite polarity field at the sides of penumbral filaments. All jets propagate along the spine field.

Mg II k 2796 line profiles for the example jet



Summary and Outlook: The slit should be placed across a jet during its peak time to see if it is twisting. We find at least four such examples in our 4h data. In each case we find blue and red shifts across the slit position of the jet, suggesting that large penumbral jets spin, similar to other coronal jets and CMEs. This, together with the fact that they have mixed polarity field at their base, indicates that large penumbral jets could form the same way as the coronal jets and CMEs. A more extensive study is underway.

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