Onset of the Magnetic Explosion in On-disk Solar Coronal Jets

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Abstract

In our recent studies of ~10 quiet region and ~13 coronal hole coronal jets, we found that flux cancelation is the fundamental process in the buildup and triggering of the minifilament eruption that drives the production of the jet. Here, we investigate the onset and growth of the ten on-disk quiet region jets, using EUV images (304, 171, 193, and 94 Å) from SDO/AIA and magnetograms from SDO/HMI. We find that: (i) in all ten events the minifilament starts to rise at or before the onset of the signature of internal or external reconnection; (ii) in two out of ten jets brightening from the external reconnection starts at the same time as the slow rise of the minifilament and (iii) in six out of ten jets brightening from the internal reconnection starts before the start of the brightening from external reconnection. These observations show that the magnetic explosion in coronal jets begins in the same way as the magnetic explosion in filament eruptions that make solar flares and coronal mass ejections (CMEs). Our results indicate (1) that coronal jets are miniature versions of CME-producing eruptions and flux cancelation is the fundamental process that builds and triggers both the small-scale and the large-scale eruptions, and (2) that, contrary to the view of Moore et al (2018), the current sheet at which the external reconnection occurs in coronal jets usually starts to form at or after the onset of (and as a result of) the slow rise of the minifilament flux-rope eruption, and so is seldom of appreciable size before the onset of the slow rise of the minifilament flux-rope eruption.

Evolution of a Pre-Jet Minifilament

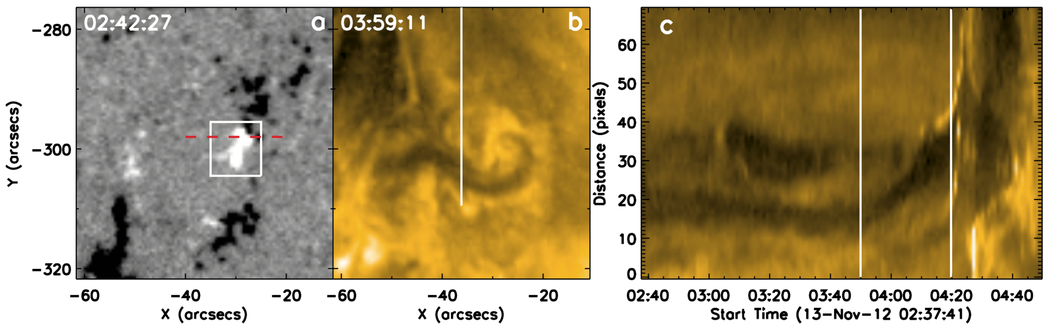

Fig.1. Quiet region pre-jet minifilament observed on 2012 November 13: (a) shows the photospheric magnetic field of pre-jet minifilament. The boxed region shows the area measured for the magnetic flux-time plot in Fig 2(a) and the red dashed line shows the east-west cut for the time-distance map of Fig. 2(b). Panel (b) shows the 171 Å AIA intensity image of the pre-jet minifilament; the white line shows the location of time-distance map shown in (c). Panel (c) shows the time-distance image along the white line of (b). The left and right vertical line in (c) mark the start and end time of the slow-rise of the minifilament (MF), respectively.

Magnetic Field Evolution

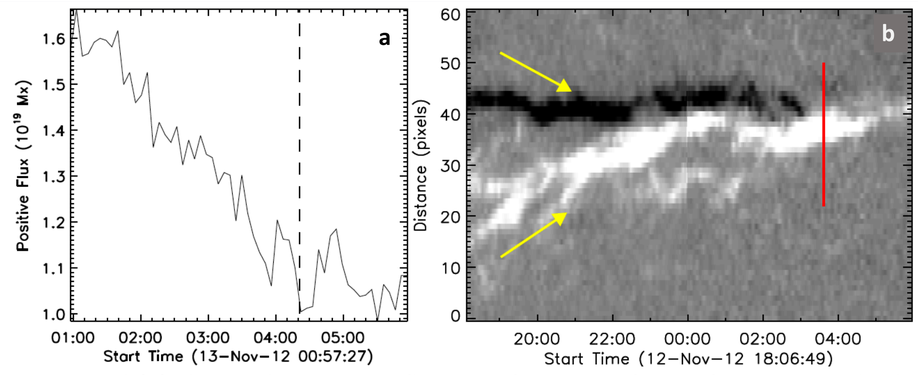

Fig 2. Panel (a) shows the positive flux as a function of time from inside the box of Fig. 1(a). The dashed line shows the jet onset time. Panel (b) shows the time-distance map of magnetic flux along the red dashed line of Fig 1(a). The arrows point to the flux patches that converged and canceled over 12 hours before and during jet eruption. The red line shows the jet eruption time (03:33 UT; Panesar et al 2016).

Onset of the Magnetic Explosion

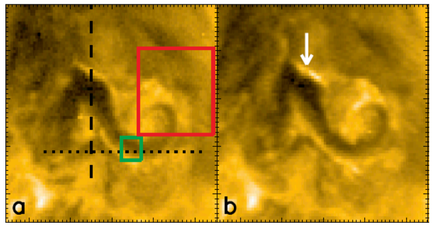

Fig.3. (a) The green and red boxed region shows the area used for measuring intensity in Fig. 4a and 4c, respectively. The dotted and dashed lines mark the positions of time-distance images shown in Fig. 4b and Fig 4d, respectively. The white arrow in (b) points to the breakout current sheet.

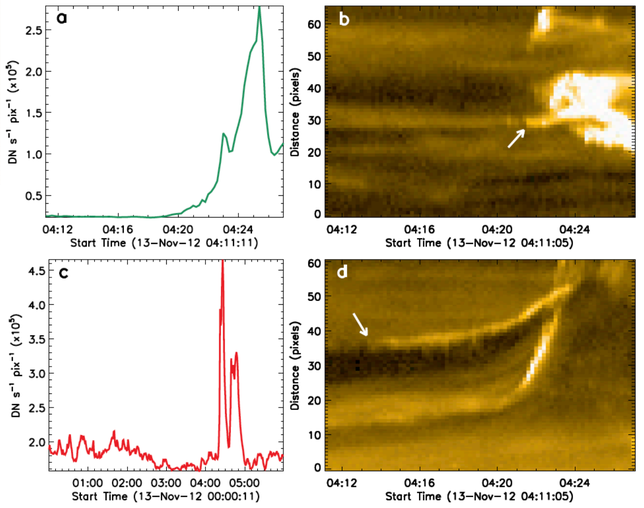

Fig.4. Panels (a-b) show the onset of the JBP that appears at the neutral line (04:21:49; white arrow in (b)) early in the fast-rise phase. Panel (c) shows the onset of external brightenings that appears, at 03:50:35 UT, at majority-polarity flux patch. The white arrow in (d) points to the current sheet brightening that appears between the explosive magnetic arcade and the ambient far-reaching field. Current sheet forms, at 04:14:47, 23 minutes after both the onset of the external reconnection and the start of the MF slow-rise.

Discussion and Interpretation

- In each of our ten jets, the MF starts to rise before or at the onset of the signature of internal or external reconnection. This result is consistent with one of the results of Moore et al. (2018).
- In one out of ten jets brightening from the internal reconnection starts at the same time of the start of MF rise.
- In two out of ten jets, the minifilament starts rising simultaneously with the onset of external reconnection.
- In six out of ten jets, brightening from the internal reconnection starts before the start of the brightening from external reconnection. In contrast, Moore et al. (2018) found that the internal reconnection, under the erupting flux rope, starts after the start of the external reconnection in (85%) X-ray polar coronal hole jets.
- In seven out of ten jets, the jet spire starts both after the onset of the signature of internal or external reconnection and the minifilament rise. In jet J3, the jet spire starts at the same time of the onset external brightening. In jet J4, the jet spire starts before the onset of the external reconnection whereas in jet J9 , the jet spire starts both before the onset of the external reconnection and the minifilament rise, in this jet the brightenings from the internal reconnection appears at the end.

References

- Moore, R. L., Sterling, A. C., & Panesar, N. K. 2018, ApJ, 859, 3.
- Panesar, N. K., Sterling, A. C., Moore, R. L., et al. 2016, ApJL, 832, L7.

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