Origin of Pre-Coronal-Jet Minifilaments: Flux Cancellation

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Coronal jets are frequent magnetically channeled narrow eruptions.

All coronal jets observed in EUV and X-ray images show a bright spire with a base brightening, also known as jet bright point (JBP).

Recent studies of jets show that coronal jets are driven by small-scale filament eruptions (e.g. Hong et al. 2011, Shen et al. 2012, Adams et al. 2014, Sterling et al. 2015).

We recently investigated the triggering mechanism of ten ondisk quiet-region coronal jet eruptions and found that magnetic flux cancellation at the neutral line of minifilaments is the main cause of quiet-region jet eruptions (Panesar et al. 2016).

What leads to the formation of these pre-jet minifilaments?
We investigate the magnetic field evolution that leads to pre-jet minifilament formation.

Measured parameters for the observed quiet-region pre-jet minifilaments:

<table>
<thead>
<tr>
<th>Event No.</th>
<th>Minifil. formation(a) time (UT)</th>
<th>Minifil. eruption(b) time (UT)</th>
<th>Location(^c) helio. cord.</th>
<th>Duration of(^c) minifil. (hrs)</th>
<th>Width of(^d) minifil. (km)</th>
<th>No. of(^e) Jets</th>
<th>(\Phi) values(^f)</th>
<th>% of (\Phi)(^g) reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>J1</td>
<td>2012 Mar 21 22:46</td>
<td>2012 Mar 22 04:46</td>
<td>S09, E29</td>
<td>6</td>
<td>2000±500</td>
<td>1</td>
<td>1.6</td>
<td>20 ± 6.8</td>
</tr>
<tr>
<td>J2</td>
<td>2012 Jul 01 05:58</td>
<td>2012 Jul 01 08:29</td>
<td>N12, E02</td>
<td>2.5</td>
<td>1500±200</td>
<td>1</td>
<td>1.9(^h)</td>
<td>20 ± 7.3</td>
</tr>
<tr>
<td>J4</td>
<td>2012 Aug 04 05:14</td>
<td>2012 Aug 05 01:58(^j), 2012 Aug 05 02:20</td>
<td>N07, E30</td>
<td>21</td>
<td>2500±500</td>
<td>2</td>
<td>5.8</td>
<td>14 ± 4.6</td>
</tr>
<tr>
<td>J5</td>
<td>2012 Aug 10 19:43</td>
<td>2012 Aug 10 23:03</td>
<td>S31, E11</td>
<td>3.2</td>
<td>1500±200</td>
<td>1</td>
<td>0.9</td>
<td>27 ± 6.1</td>
</tr>
<tr>
<td>J6</td>
<td>2012 Sept 19 17:15</td>
<td>2012 Sept 20 22:52</td>
<td>S34, E11</td>
<td>34</td>
<td>2500±500</td>
<td>2</td>
<td>3.0</td>
<td>9 ± 5.3</td>
</tr>
<tr>
<td>J7</td>
<td>2012 Sept 21 00:51</td>
<td>2012 Sept 21 03:33</td>
<td>S34, E08</td>
<td>3.5</td>
<td>2500±500</td>
<td>1</td>
<td>1.7</td>
<td>38 ± 2.6</td>
</tr>
<tr>
<td>J8</td>
<td>2012 Sept 21 23:55</td>
<td>2012 Sept 22 01:25</td>
<td>N01, E20</td>
<td>1.5</td>
<td>1500±500</td>
<td>1</td>
<td>0.9</td>
<td>38 ± 5.5</td>
</tr>
<tr>
<td>J10</td>
<td>2012 Dec 13 08:06</td>
<td>2012 Dec 13 10:11, 2012 Dec 13 10:36</td>
<td>S01, W01</td>
<td>2.5</td>
<td>1600±200</td>
<td>2</td>
<td>1.2</td>
<td>7.0 ± 8.3</td>
</tr>
</tbody>
</table>

\(^a\) Time at which the minifilament formation is observed.  
\(^b\) Time at which the minifilament eruption is observed.  
\(^c\) helio. cord. = helioheliographic coordinates (°).  
\(^d\) Width of minifilament = width measured along the filament axis.  
\(^e\) No. of Jets = number of bright jet-like structures associated with the filament.  
\(^f\) \(\Phi\) values = magnetic flux density in T.  
\(^g\) % of \(\Phi\) reduction = percentage reduction in magnetic flux density.  
\(^h\) \(\Phi\) value for J2 is slightly higher than for other events.  
\(^i\) This event was not included in the statistics.  
\(^j\) Event J4 includes an additional eruption on 2012 Aug 05.  
\(^k\) J9 did not show any clear reduction in magnetic flux density.  

Minifilament Formation (J2)
Minifilament Formation (J2)

- Duration of minifilament ~ 2.5 hours.
- Brightenings appear at the location where the minifilament subsequently forms.
Minifilament Formation and Flux Cancelation

[Images of data plots and graphs showing distance vs. time and flux vs. distance]
Homologous Jet Eruptions (J6 and J7)

- We also observe more than a single jet from the same neutral line. A minifilament erupts and drives a jet, reforms/reappears at the same location, and then again erupts, driving the next jet.

- This process occurs as flux cancelation is ongoing and continues until all the minority-polarity flux vanishes. Eventually, the neutral line disappears, no more minifilaments and homologous jets are produced.
Homologous Jet Eruptions (J6 and J7)
Continuous flux cancelation between a minority-polarity flux clump and a majority-polarity flux clump builds a highly sheared minifilament field, leading to the formation of a minifilament.

These results are consistent with the models for the formation of the field of typical solar filaments (van Ballegooijen & Martens 1989; Martens & Zwaan 2001).
We examined in detail the formation mechanism of ten random on-disk quiet-region pre-jet minifilaments.

We found that flux cancelation is the key agent responsible for building a highly sheared minifilament field, leading to the formation of minifilaments. Sometimes continuous flux cancelation results in homologous eruptions.

Persistent flux cancelation at the neutral line finally destabilizes the field holding the minifilament, and that field then erupts to make a coronal jet.

Our observations support that quiet region flux cancelation results in both the formation of the pre-jet minifilament and its jet-driving eruption.