

AIA Observations of Fast Counter-streaming Flows along a Solar Filament channel

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20/11/2013

Counter-Streaming Flows

- ▶ Filaments are composed of a multitude of threads, which can carry plasma
- ▶ Some flows in these threads are observed to travel in opposite directions along the filament
- ▶ What can this tell us about magnetic fields in filaments, and perhaps other contributory processes?

Previous Observations

- ▶ Most previous observations have been in H-alpha
- ▶ This allows a high resolution, and the use of Doppler shifts to determine flow speeds, but focusses on cooler denser material
- ▶ Flow speeds are consequently low, $5\text{-}20\text{Kms}^{-1}$ is typical
- ▶ The Hi-C team recorded speeds in the order of 100Kms^{-1} in the 193\AA line, using high resolution data
- ▶ No previous observations from AIA data - until now!

Previous explanations

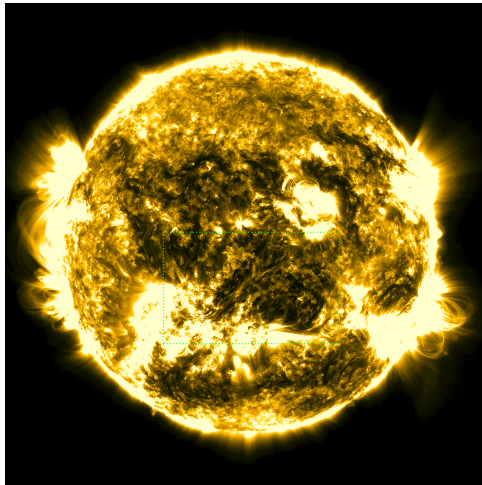
- ▶ Schmieder et al 2008 - perhaps a prelude to a filament eruption
- ▶ Gaizauskas 1998 - Related to dexterity - flows between main body and barbs
- ▶ Panasenco & Martin 2008 - Involves mass movements
- ▶ Alexander et al 2013 - Mass flows rather than a heating event
- ▶ Deng et al 2002 - Magnetic reconnection cause the movement of blobs

The Filament Under Study

- ▶ Slightly below the solar centre
- ▶ In the order of 500×10^3 Km long
- ▶ Sinistral and U-shaped
- ▶ Observed between midday on 2012-08-06 and midday on 2012-08-08
- ▶ Partial eruption observed on 2012-08-06
- ▶ Very fast flows observed between 08:20 and 08:40 on 2012-08-07
- ▶ Lots of visible counterstreaming
- ▶ Several areas of magnetic flux appear to interact with the filament



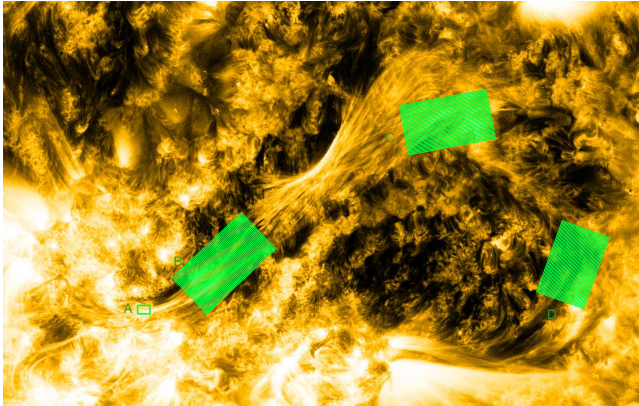
Location of the Filament



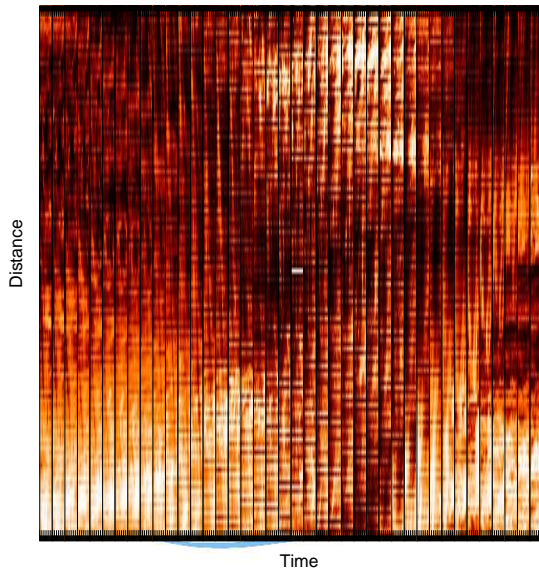
Estimating Flow Speeds

- ▶ Analyse flow speeds through stack plots: create distance-time plots along a number of lines
- ▶ Bright flows show as bright diagonal lines
- ▶ The gradient of these lines gives a minimum estimate of the speed and direction of the flows
- ▶ At 3 locations, 40 lines are established to roughly align with the filament threads

Location of the Distance-Time slices



A typical stack plot for 40 slices



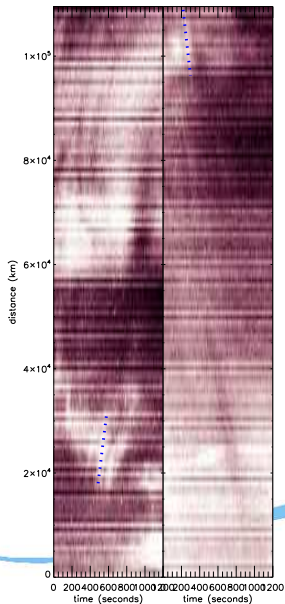
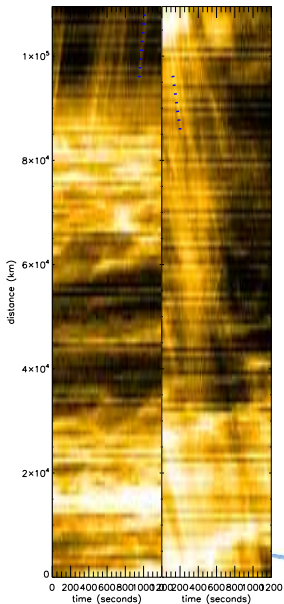
2012-08-06
15:00-15:20
location B
304Åline



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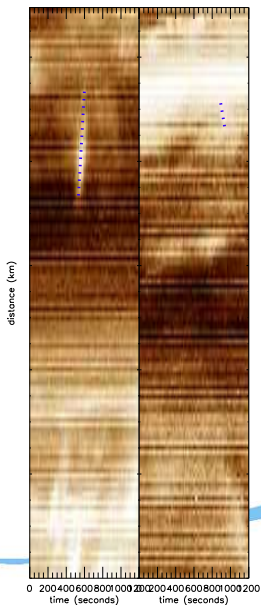
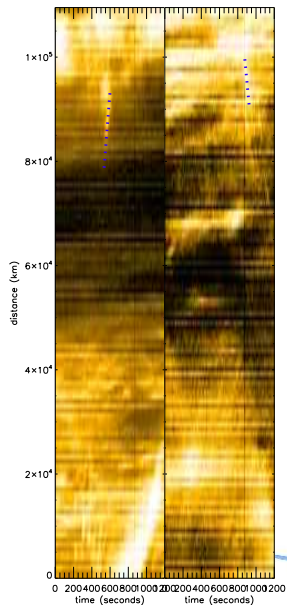
Stack Plots: Location B, 2012-08-06, 15:00-15:20



Left: 171Å line
40th thread:
275kms⁻¹ clockwise
12th thread:
180kms⁻¹ anticlockwise

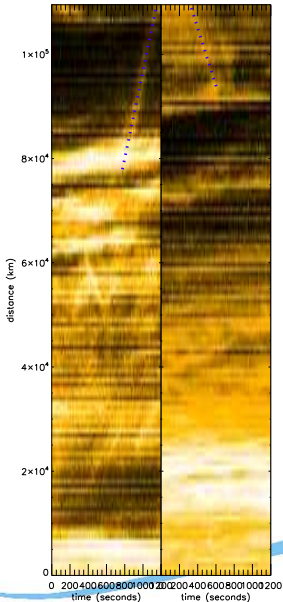
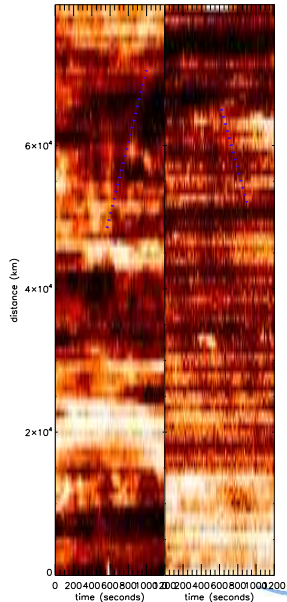
Right: 211Å line
30th thread:
225kms⁻¹ clockwise
9th thread:
250kms⁻¹ anticlockwise

Stack Plots: Location B, 2012-08-07, 08:20-08:40



Left: 171Å line
11th thread:
420kms⁻¹ clockwise
25th thread:
225kms⁻¹ anticlockwise

Right: 193Å line
8th thread:
430kms⁻¹ clockwise
23rd thread:
115kms⁻¹ anticlockwise



Left: Location D, 2012-08-07,
08:20-08:40, 304Åline

15th thread:

65kms⁻¹ clockwise

2nd thread:

60kms⁻¹ anticlockwise

Right: Location B, 2012-08-08

08:20-08:40, 171Åline

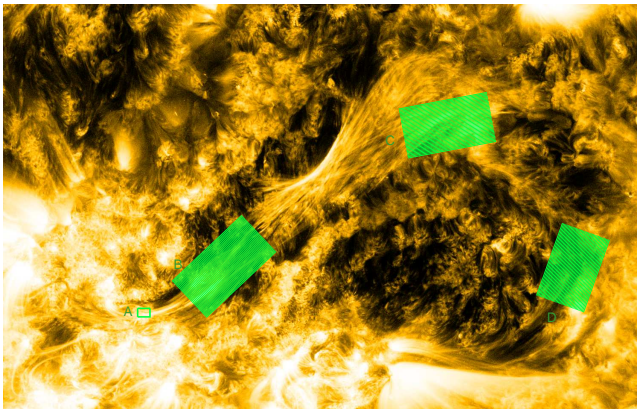
27th thread:

130kms⁻¹ clockwise

4th thread:

85kms⁻¹ anticlockwise

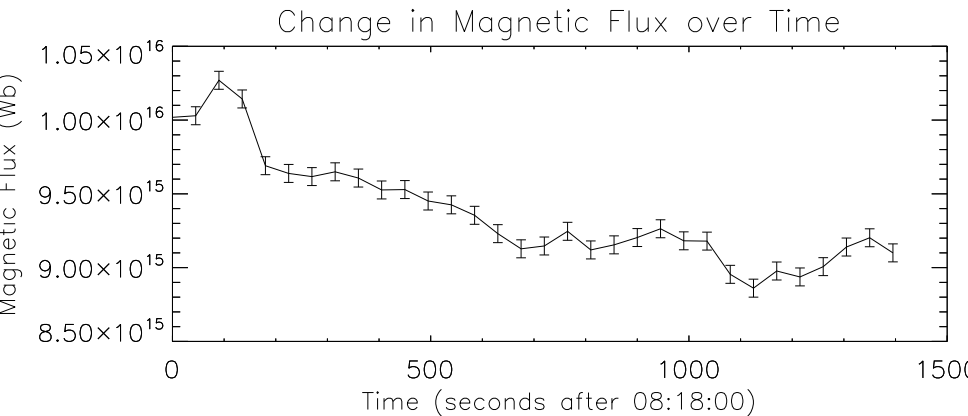
Location of the Distance-Time slices (a recap)



Connection with Magnetic Activity

- ▶ The filament is rooted in a positive polarity at the Eastern end
- ▶ Flows are observed to emit from here in both directions along the filament spine
- ▶ The flows later observed to be in the order of $420 - 430 \text{ km s}^{-1}$ originate here at around 08:20 on 2012-08-07
- ▶ The graph on the next slide shows a drop of 6.5×10^{14} Weber between 08:19:30 and 08:22:30

Change in Magnetic Flux Over Time at Location A



Some Conclusions

- ▶ First AIA observations of fast counter-streaming flows
- ▶ Very fast flows observed - up to 430Kms^{-1}
- ▶ Observations of counter-streaming were ubiquitous in our observations
- ▶ Flows emitted from a region of strong magnetic flux in both directions
- ▶ These emissions coincided with a fall in magnetic flux

Can we Explain Counter-streaming?

- ▶ Counter-streaming is probably ubiquitous. It doesn't appear to be limited to the time leading up to a filament eruption
- ▶ Our observations suggest that interaction with regions of strong magnetic flux can produce flows in both directions along the length of the filament
- ▶ Suggest that magnetic reconnection plays a major role in solar filaments - counter-streaming is a diagnostic of this