Magnetic Multipoles and Magnetic Reconnection

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KEY Questions

(ACE/RHESSI/WIND workshop, Taos, 2003, Wkgroup3)

How is the energy driven, stored, and where it is released?
What is the link between particle acceleration and reconnection?
What is the role of topology and complexity?
What are the drivers of energy buildup and release?
How are energetic particles released onto open field lines?
What are the properties of energetic particle sources?

How is the released energy channeled into bulk plasma and particle acceleration?
What are the respective roles of shock and stochastic acceleration?
How is the ubiquitous background of EP's produced?

Why are flares sporadic?
Questioning the role of topology in global coronal energetics.

Reconnection -- Cause or Effect?
Questioning the drivers of global and local topological evolution.

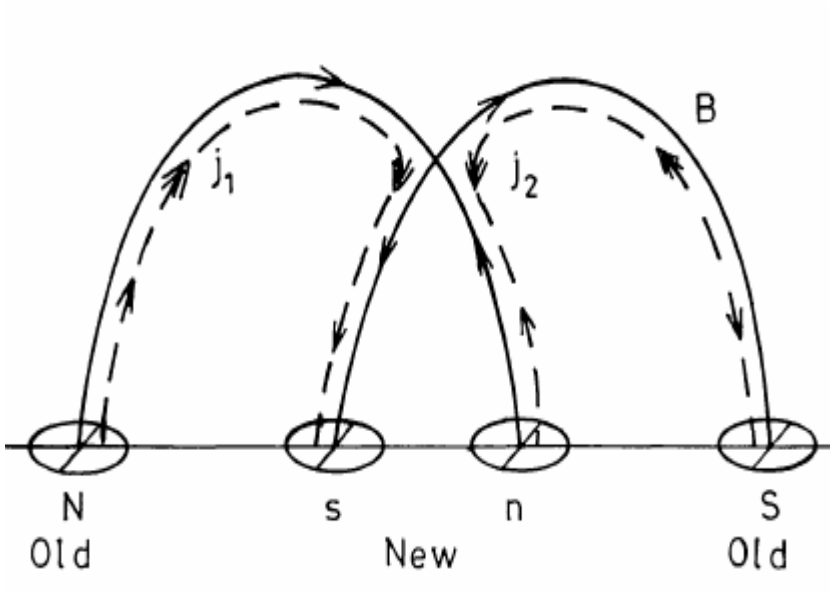
Does topology choose an acceleration scenario? *Is there any correlation between acceleration mechanism(s) and global magnetic topologies?*

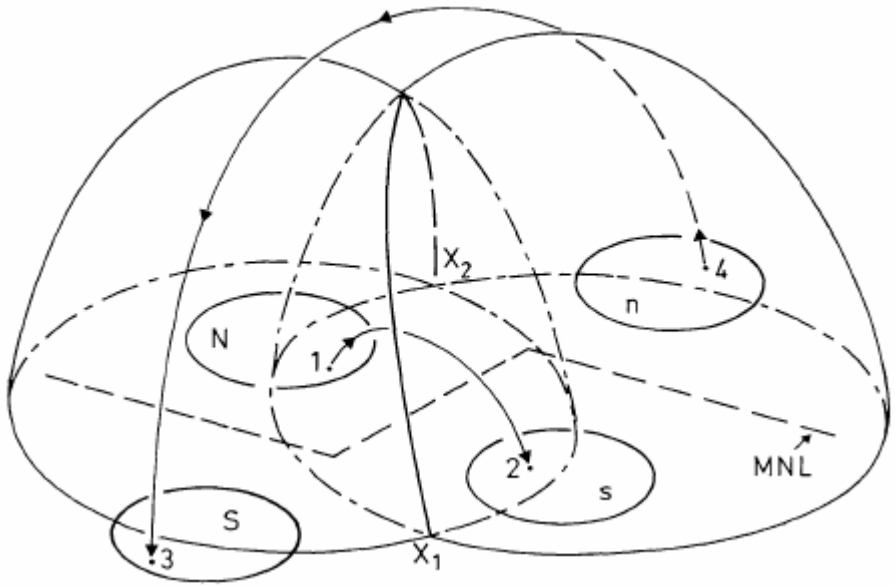
My Key Questions

- **What is <u>the role of topology</u> and complexity?**

- **What is the link between <u>particle acceleration and reconnection</u>?**

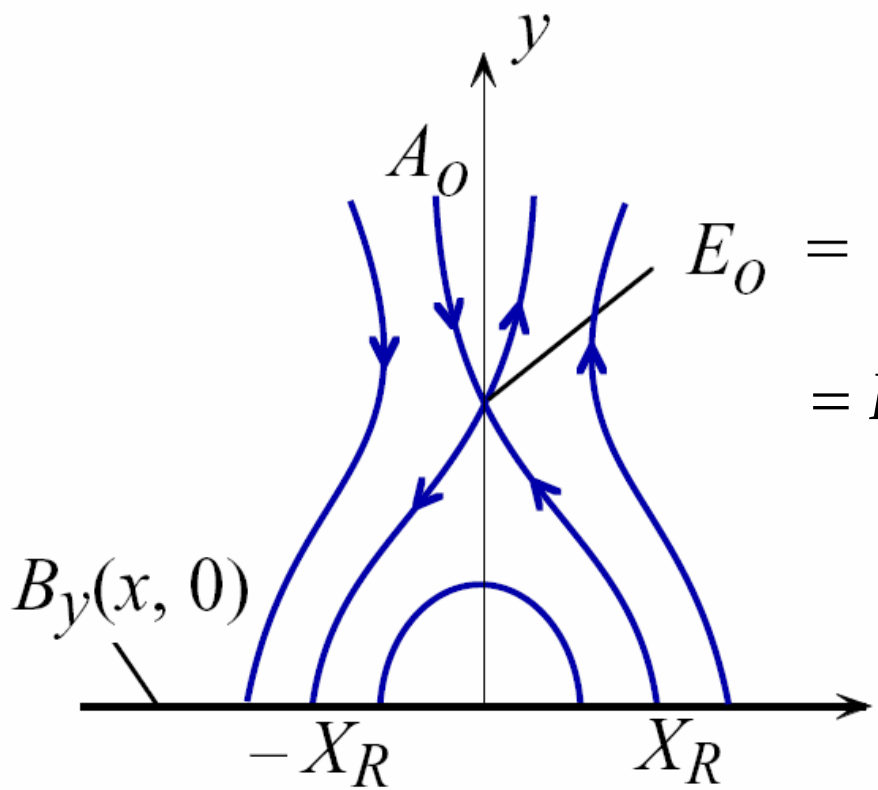
Reconnection in a quadrupolar AR





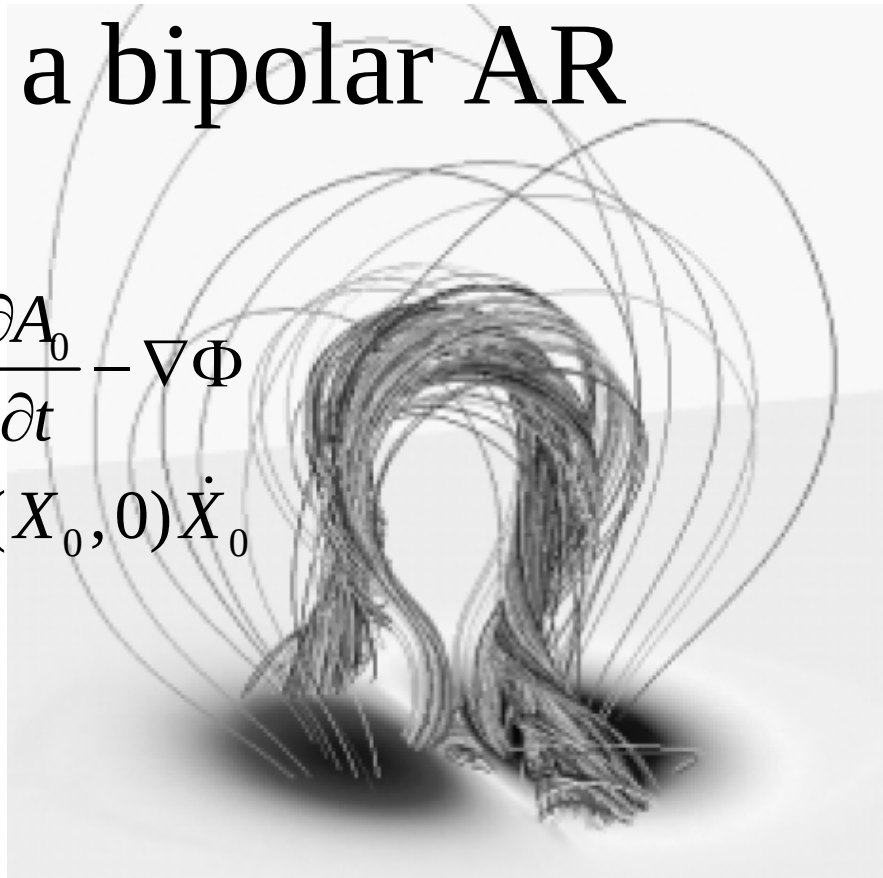
Henoux & Somov 1987 cf. Mandrini et al. 1995
Demoulin et al. 1996

Reconnection in a bipolar AR



$$E_O = -\frac{\partial A_0}{\partial t} - \nabla\Phi$$

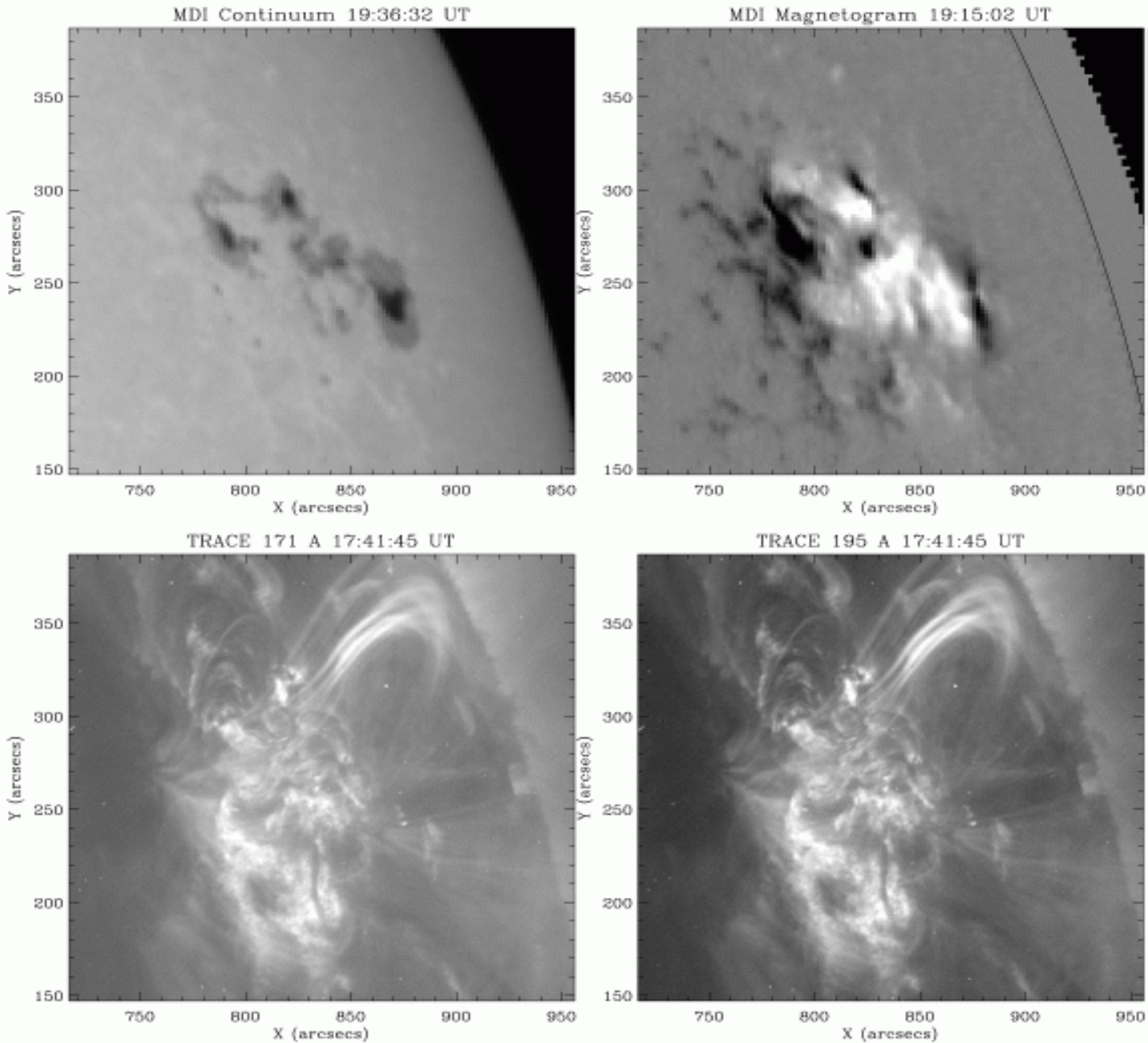
$$= B_y(X_0, 0)\dot{X}_0$$



Forbes & Priest 1984

Amari et al. (2000)
Linker et al. (2001)

Part A: Quadrupole Active Region



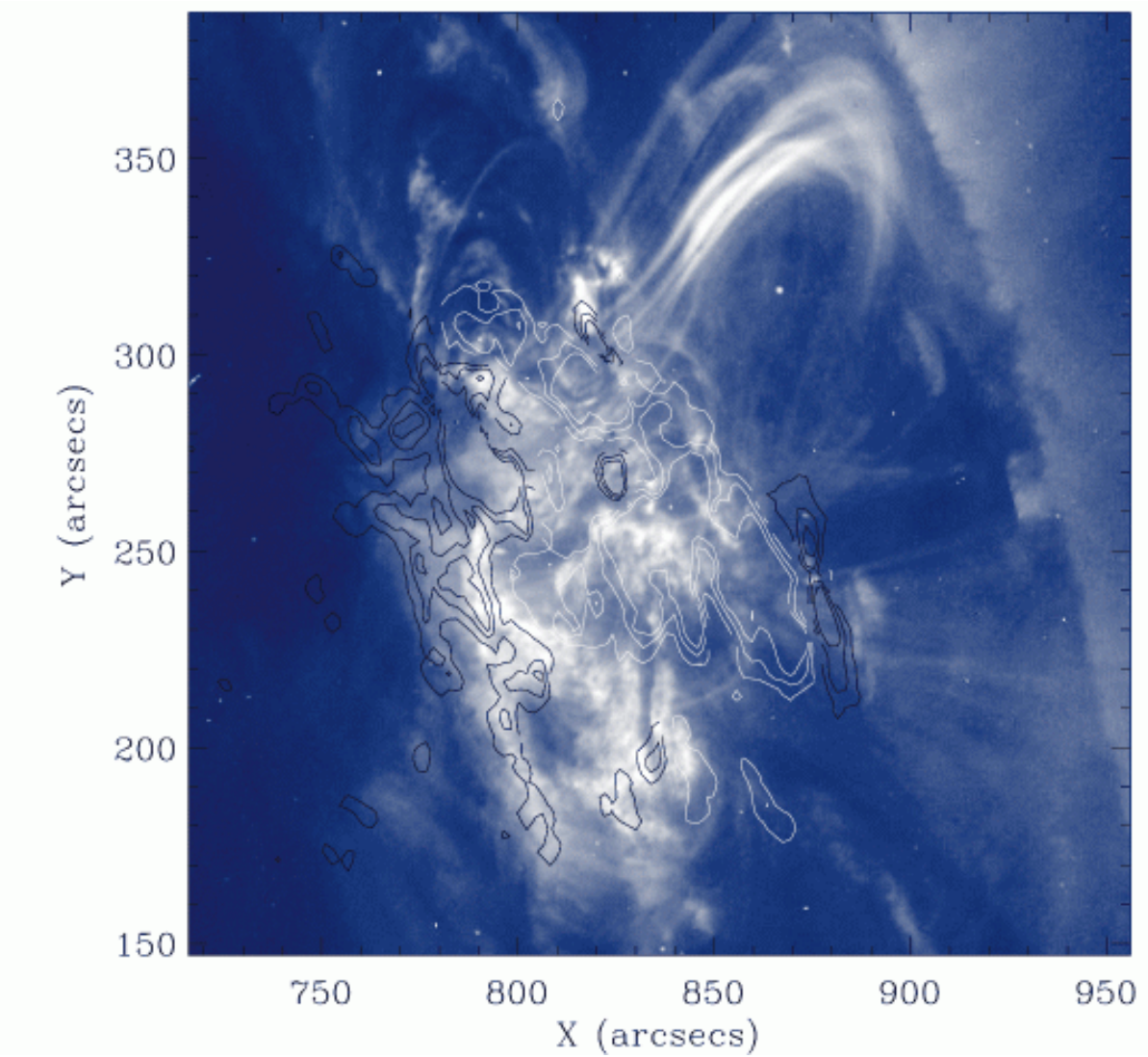
00 Mar 22
AR 8920,
X1.1 flare

CME:
500-600 km/s
-92 m/s2

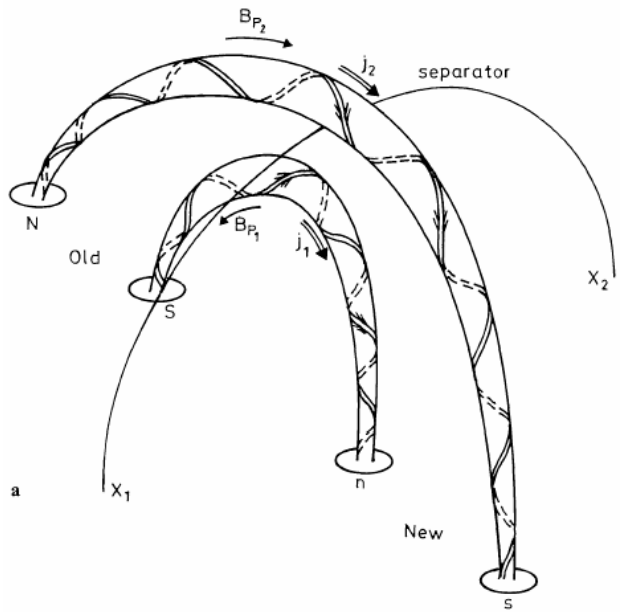
Data obtained:

- μ -OVSA
- Hα -BBSO
- EUV -TRACE
- B - MDI
- CME -LASCO

Magnetic Topology on EUV images



TRACE 171 A and MDI on 2000 March 22



Henoux & Somov 1987

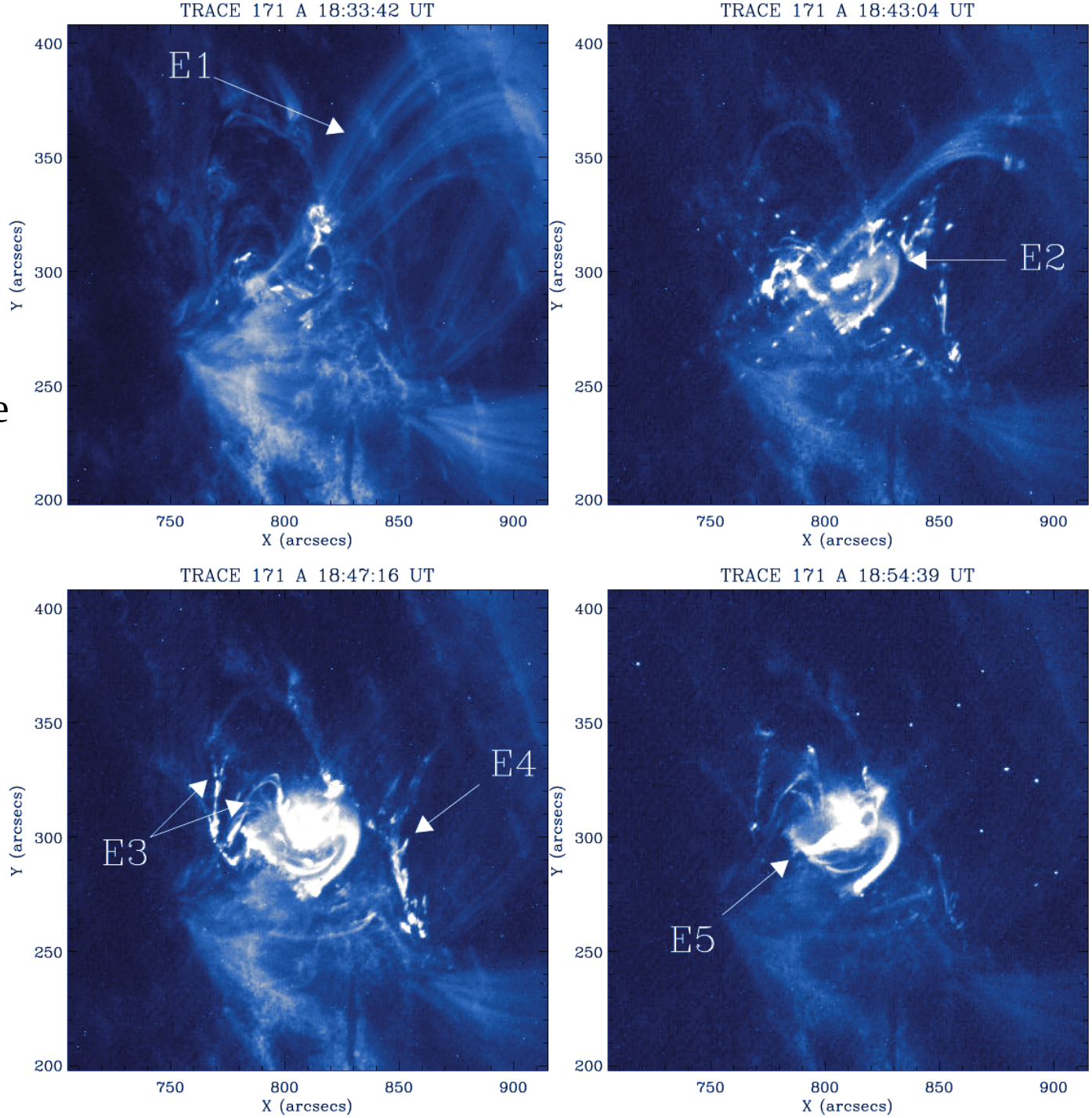
EUV 171 A

Evolution of the EUV loops:

1. E1 (P1-N1): a large loop before the flare

2. E2 (P2-N2): just before the impulsive phase

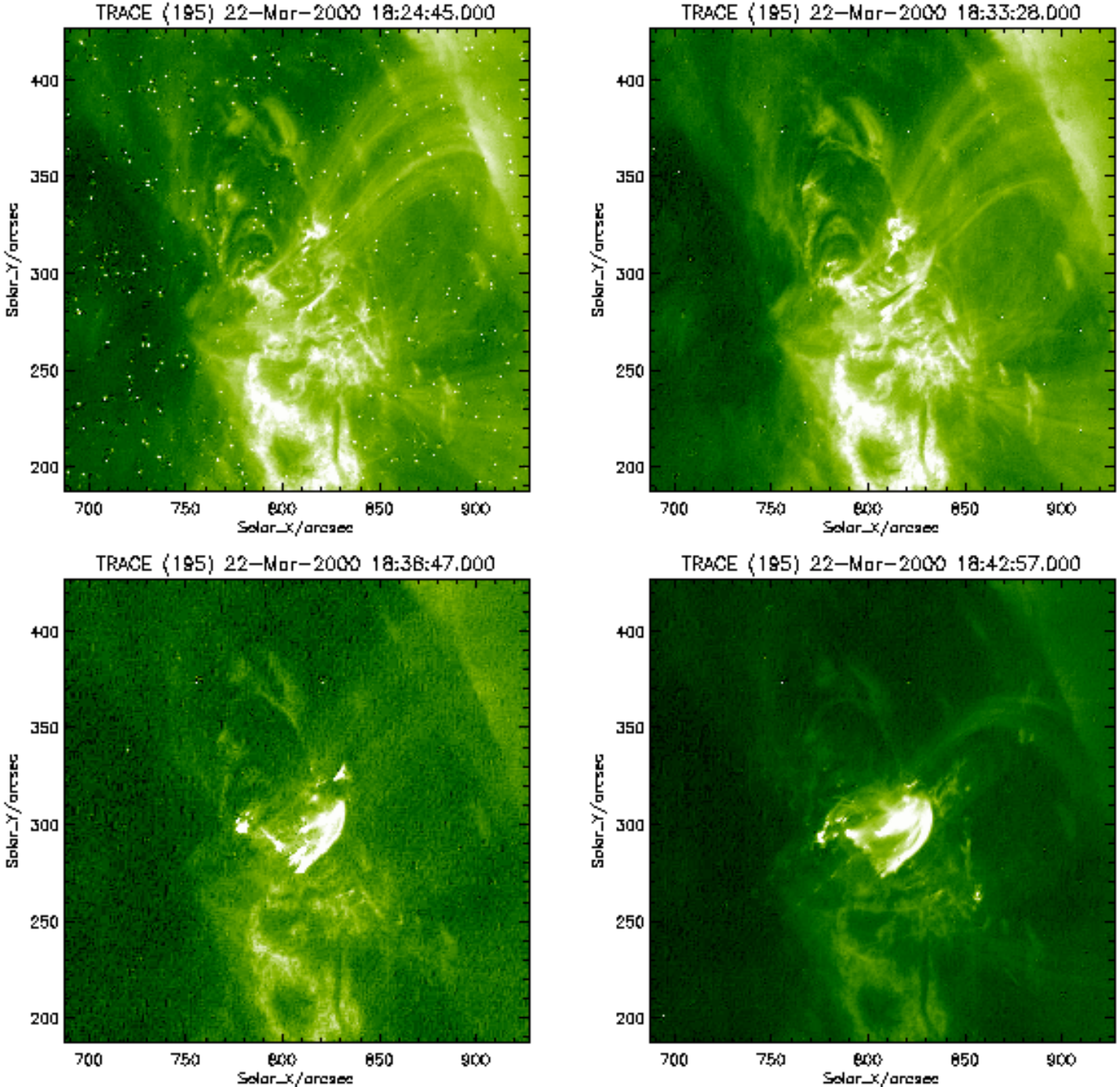
3. E3--E5: post-flare loops along the NLs which are probably new connectivity.



EUV 195Å

The EUV images at 195Å at four time intervals before the impulsive phase show a large loop present until the onset time of the flare UT. After the flare the large loop is no longer seen and a core brightening follows.

Images at 195Å appear similar to 171Å, while 1600Å images are similar to those of Hα.

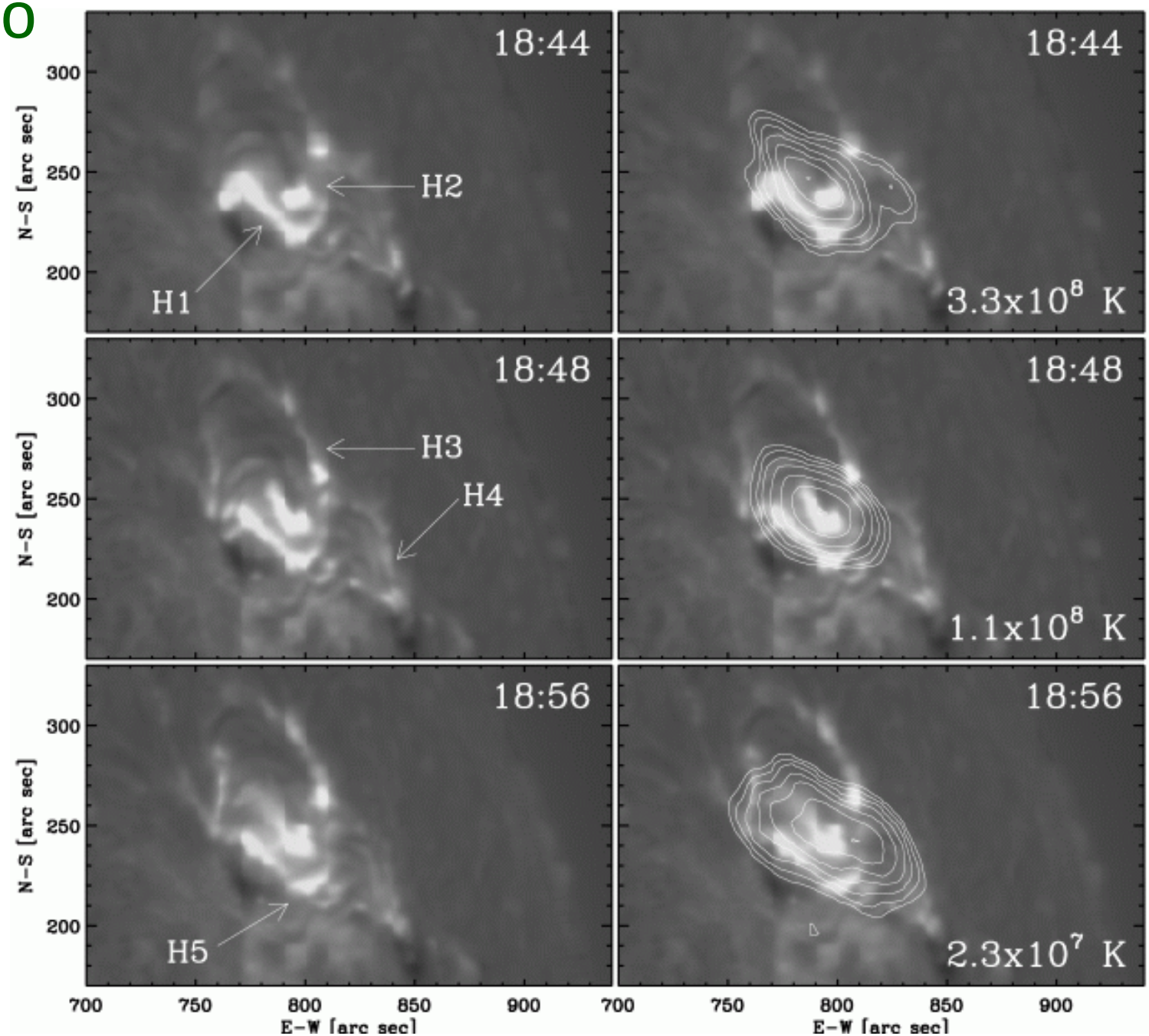


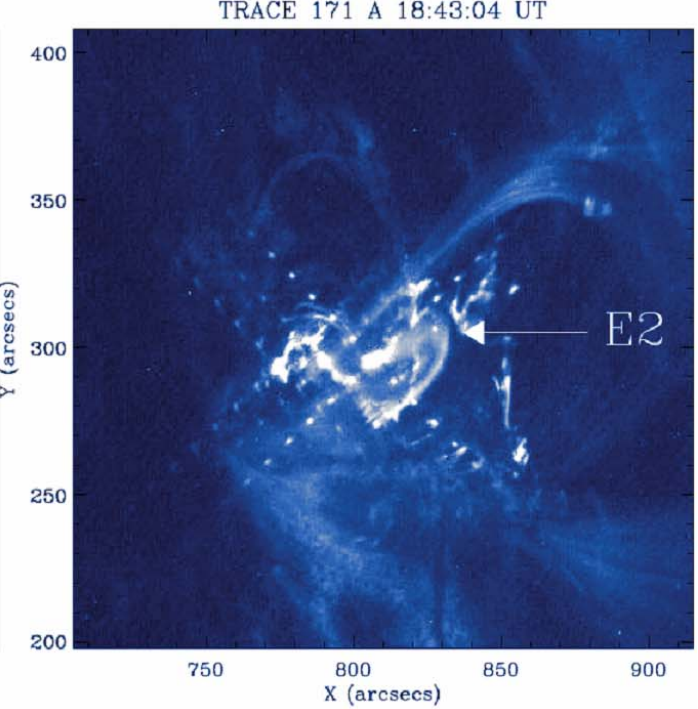
Hα/Radio

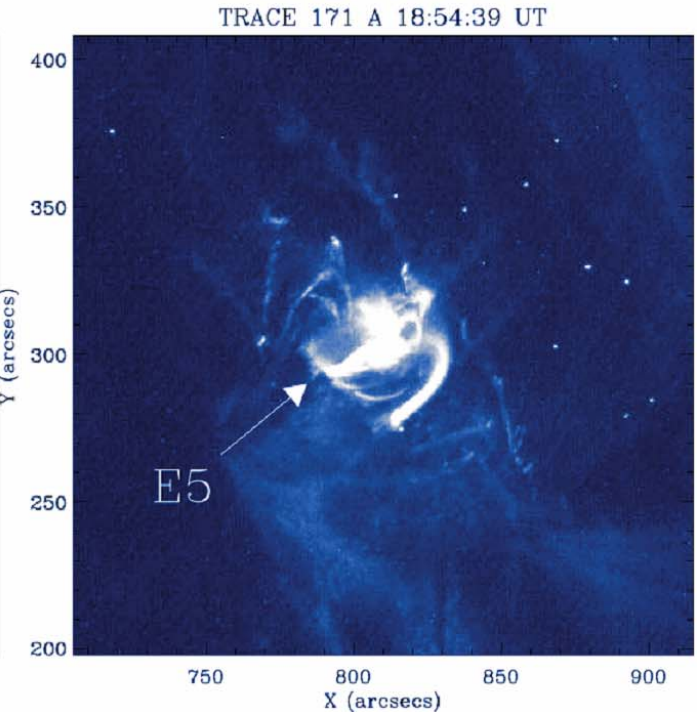
H1-H2 appear at the time of maximum radio flux (4.9 GHz).

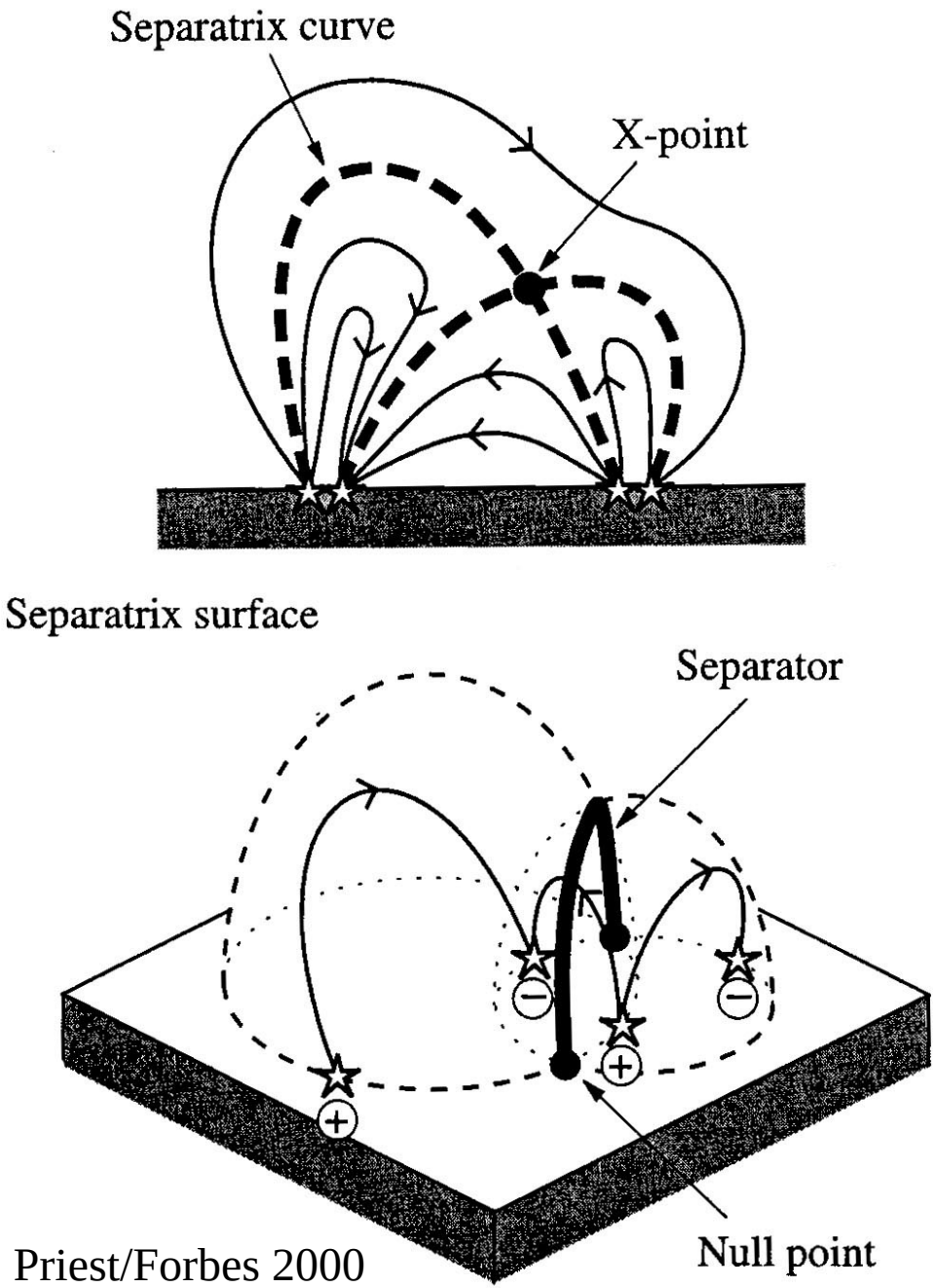
H3-H4 appear at the time of maximum GOES flux.

H5 appears in the decay phase along the NL bet. N1--P2.



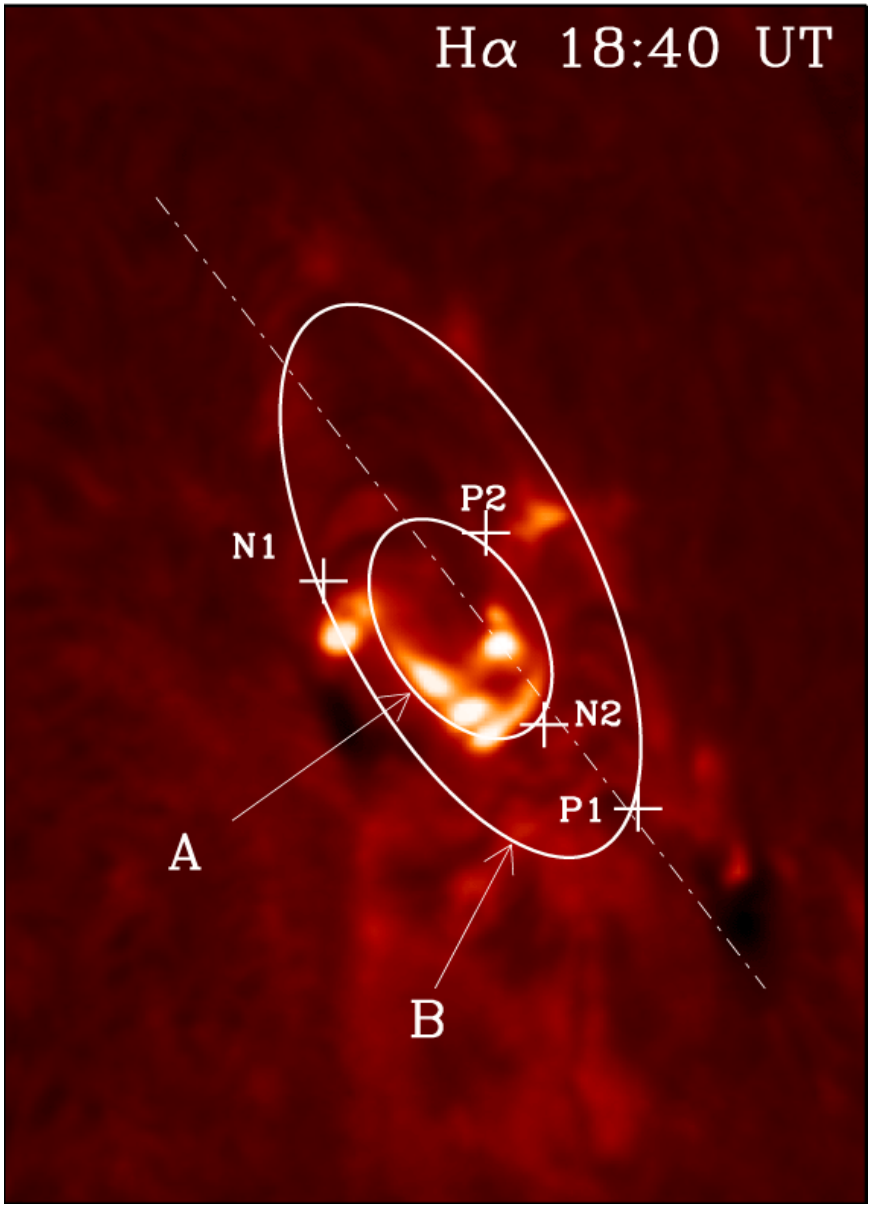




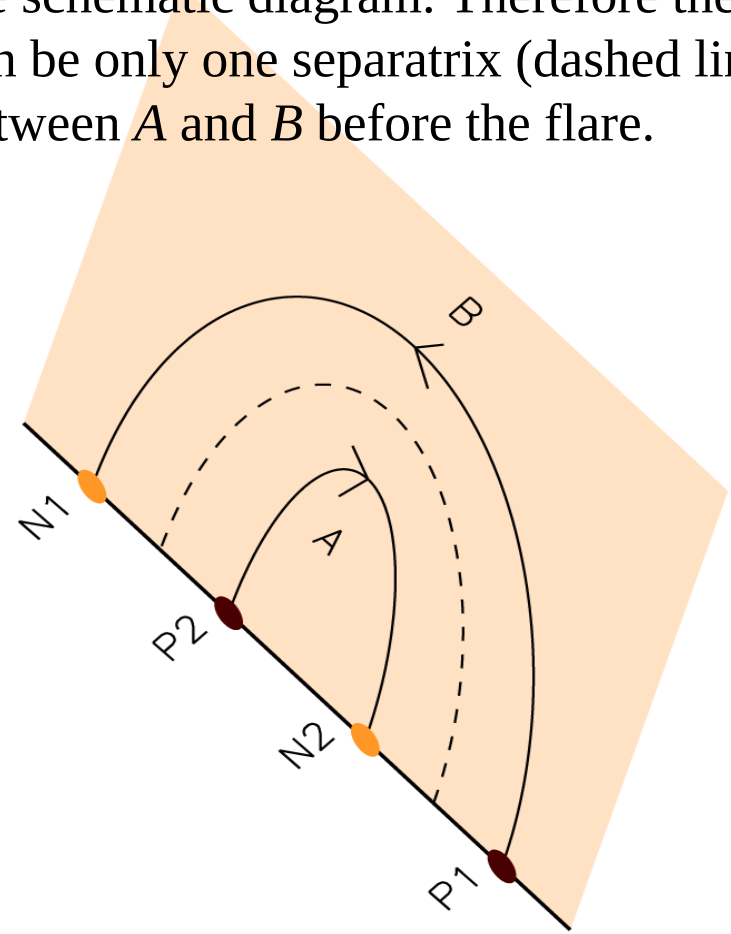


Priest/Forbes 2000

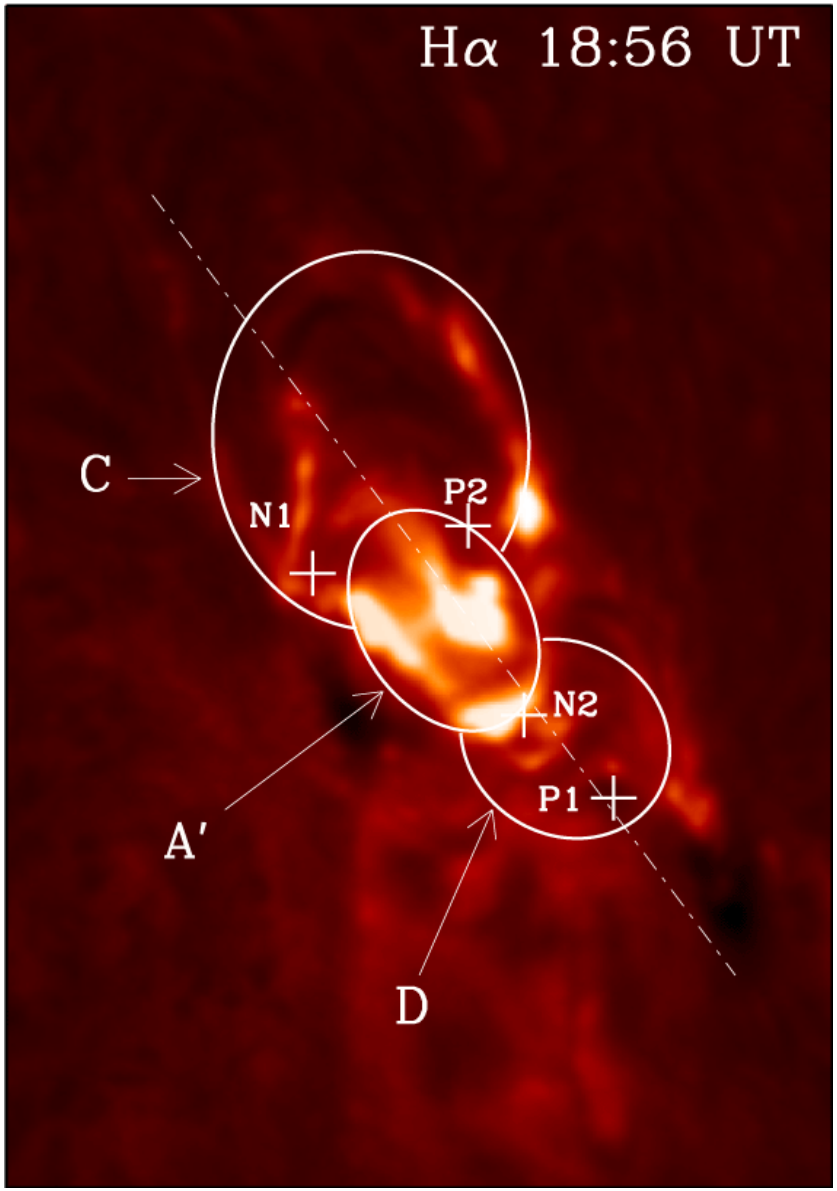
• BEFORE magnetic reconnection



Before the flare, there are only two connectivities: N1-P1 & N2-P2, which we denote as *B* and *A*, respectively, in the schematic diagram. Therefore there can be only one separatrix (dashed line) between *A* and *B* before the flare.

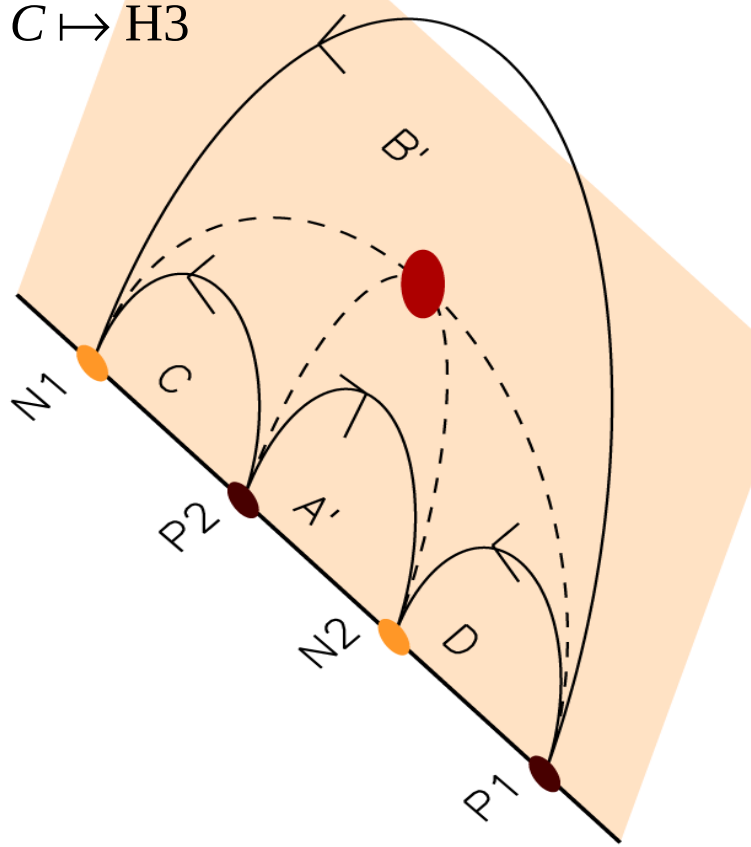


• AFTER magnetic reconnection

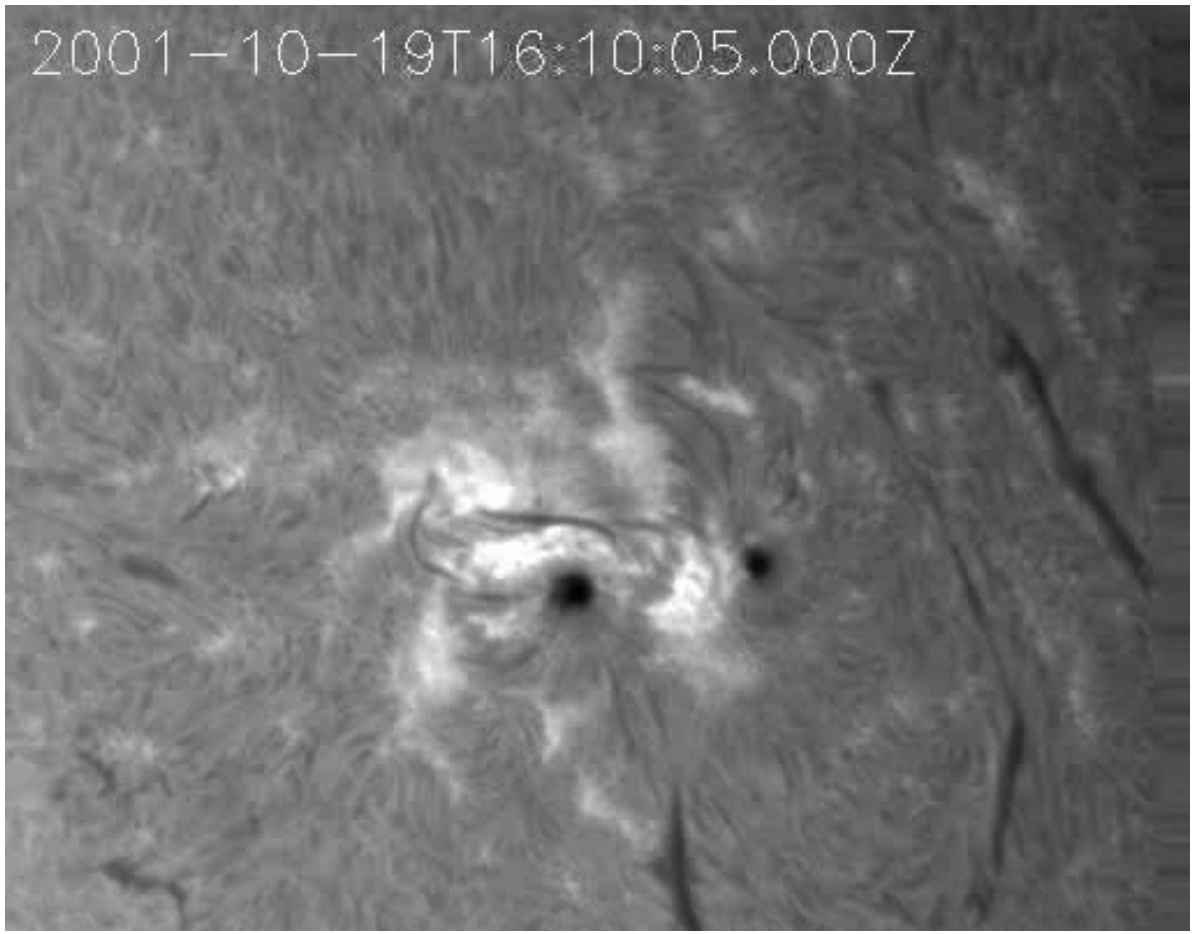


There are now four regions of connectivity: *A'*, *B'*, *C*, and *D*, and therefore three separatrices (dashed lines):

- *C*-*A'* & *A'*-*D* ↦H1, H2
- *B'*-*C* ↦the eastern tip of H1
- *D*-*B'* ↦ H4 or E4
- *C* ↦ H3



Part B: Bipolar Active Region

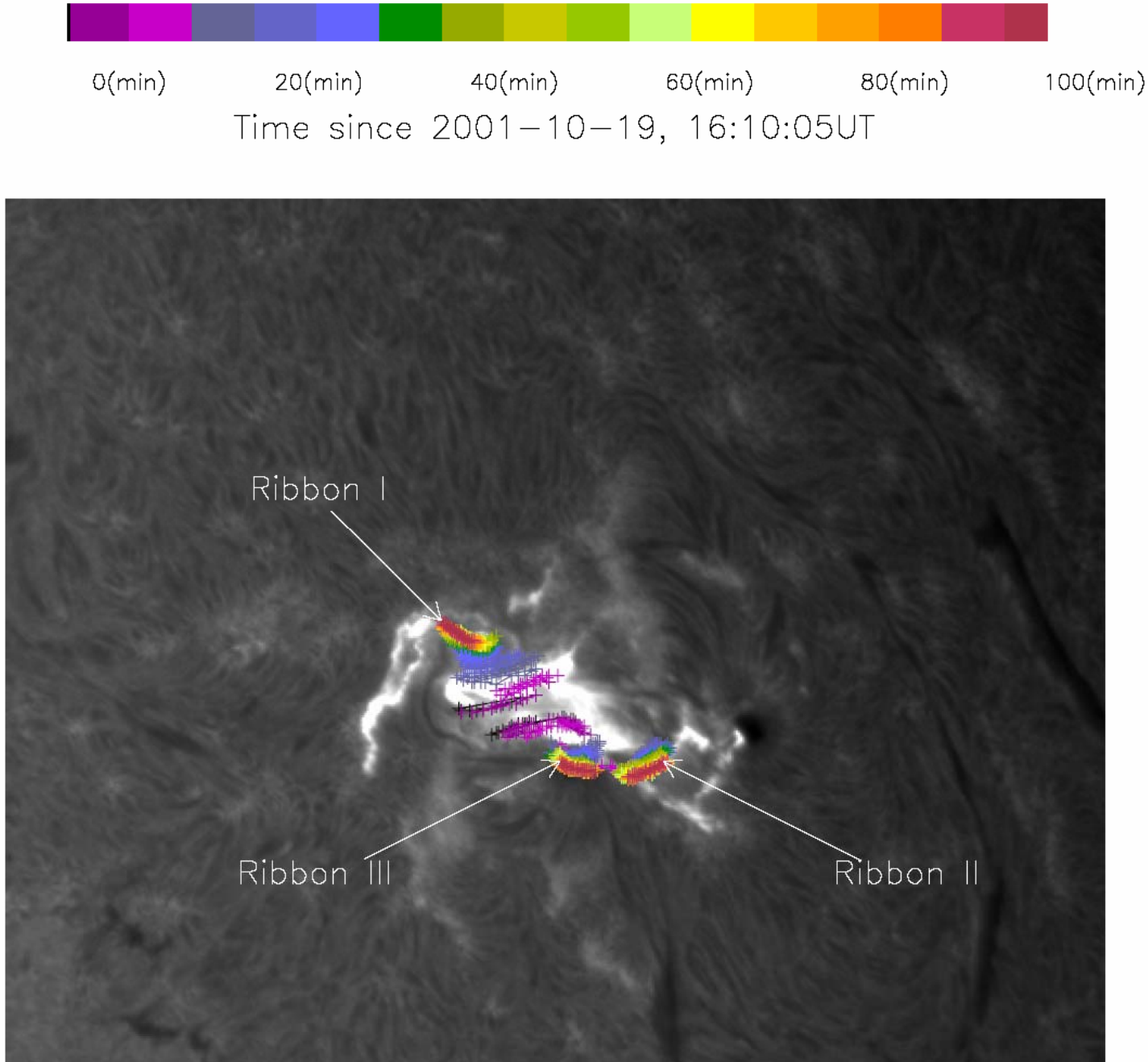


X1.6 Flare (16:25)
N15W29 2B,
AR9661

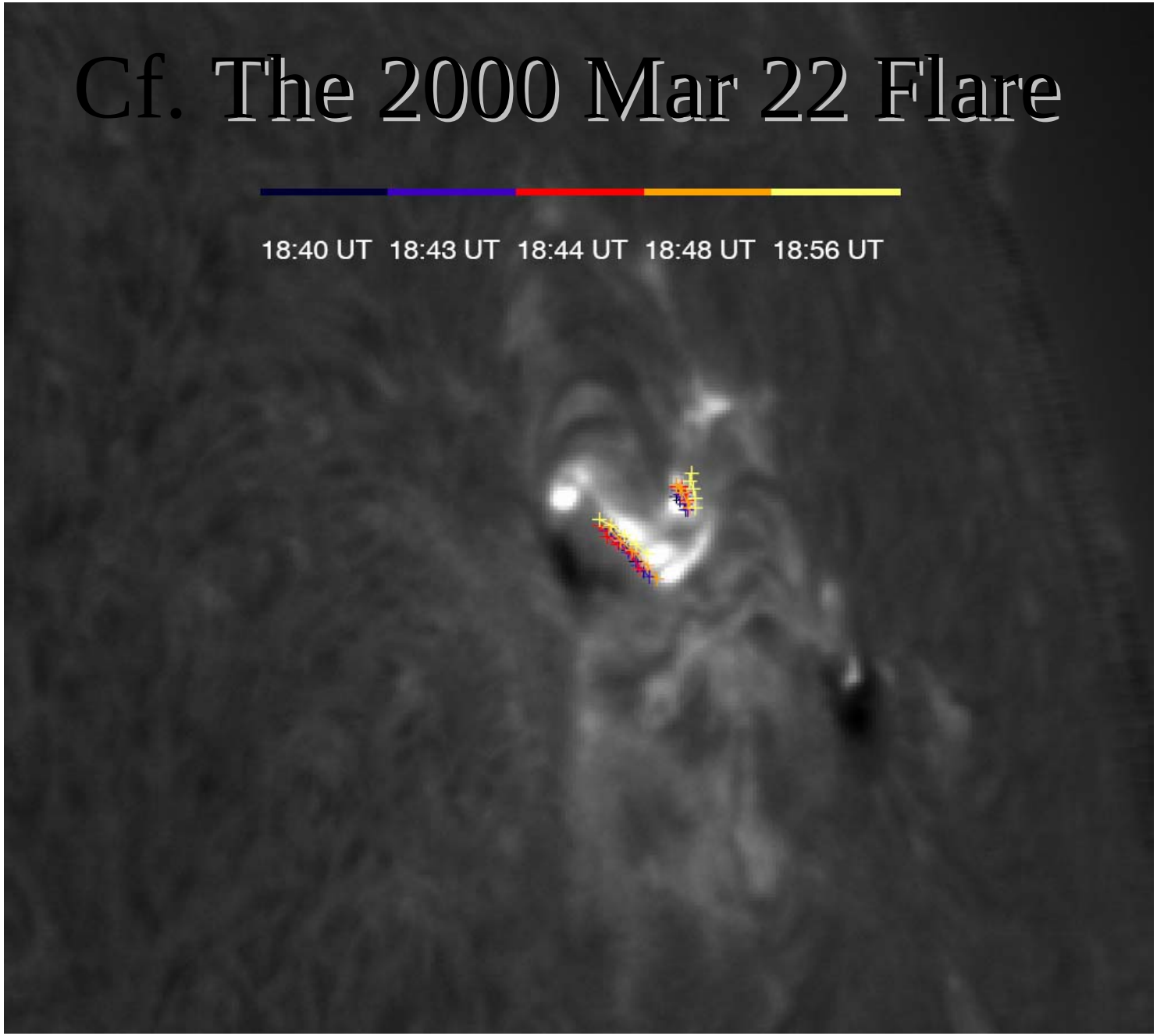
CME (16:50)
Halo
Wide bright
ragged front first
appears over W
limb,
full halo CME by
17:26
Faster than
earlier halo event.

900 km/s
-0.72 m/s^2

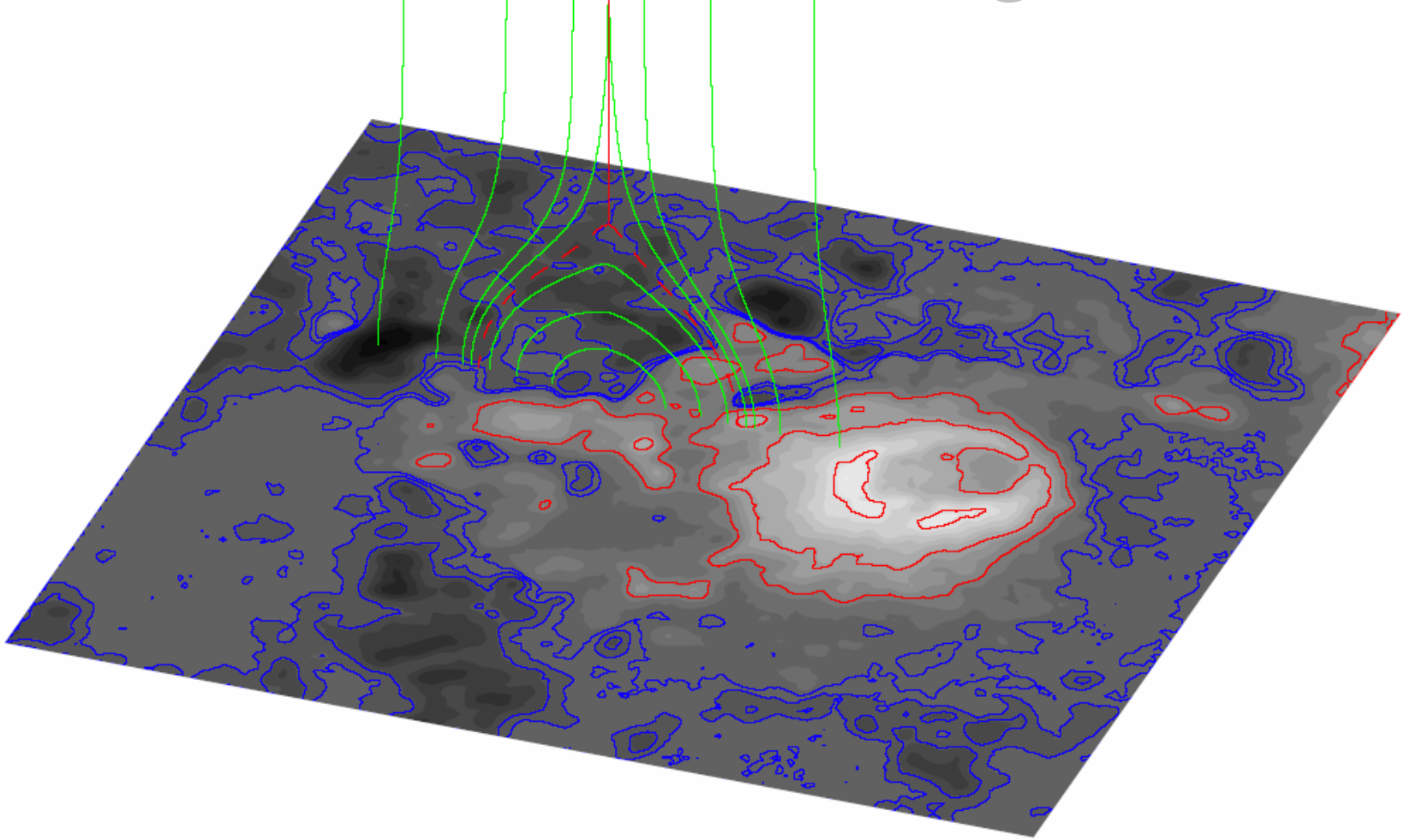
H-α ribbon motion



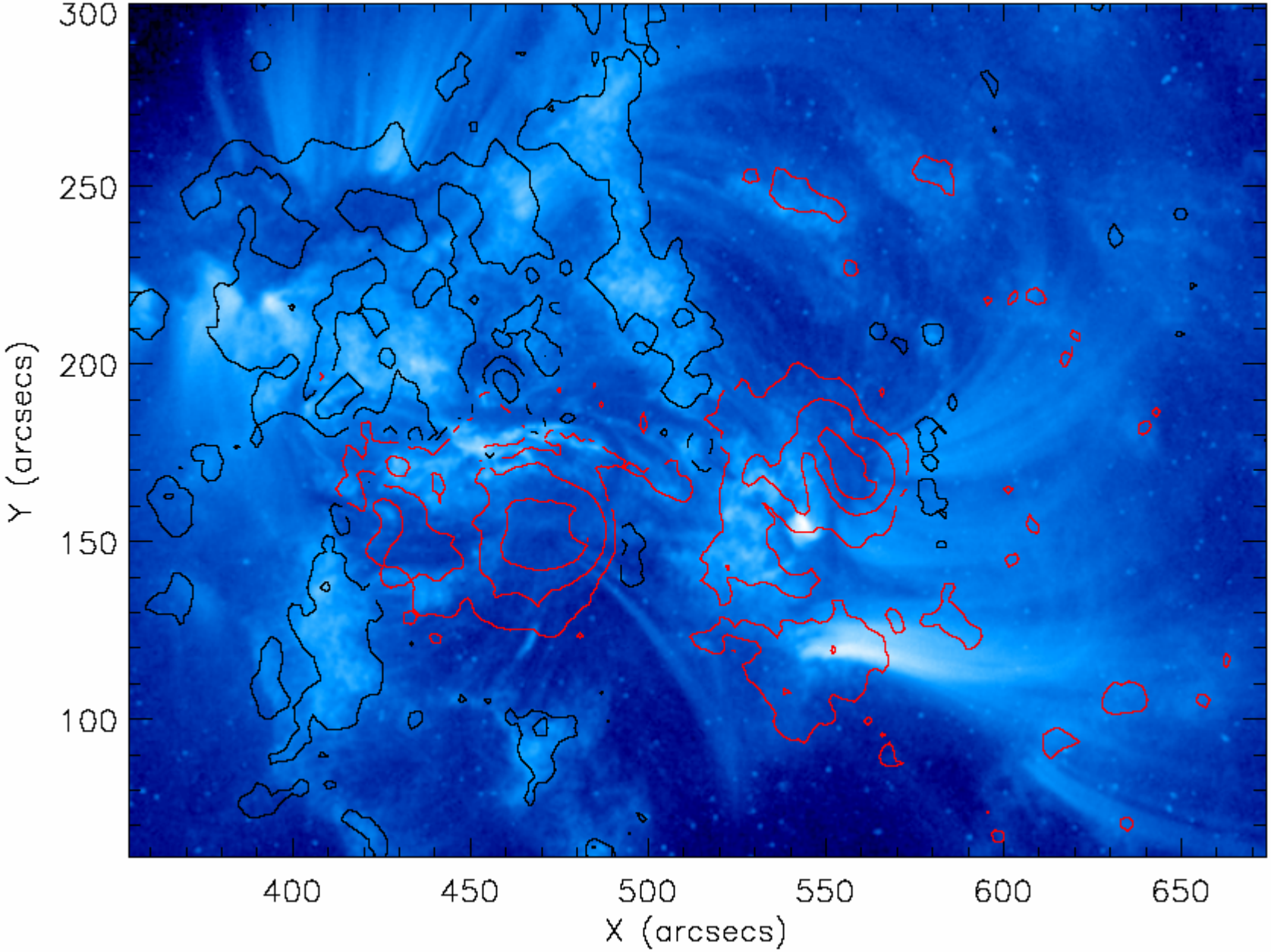
Cf. The 2000 Mar 22 Flare



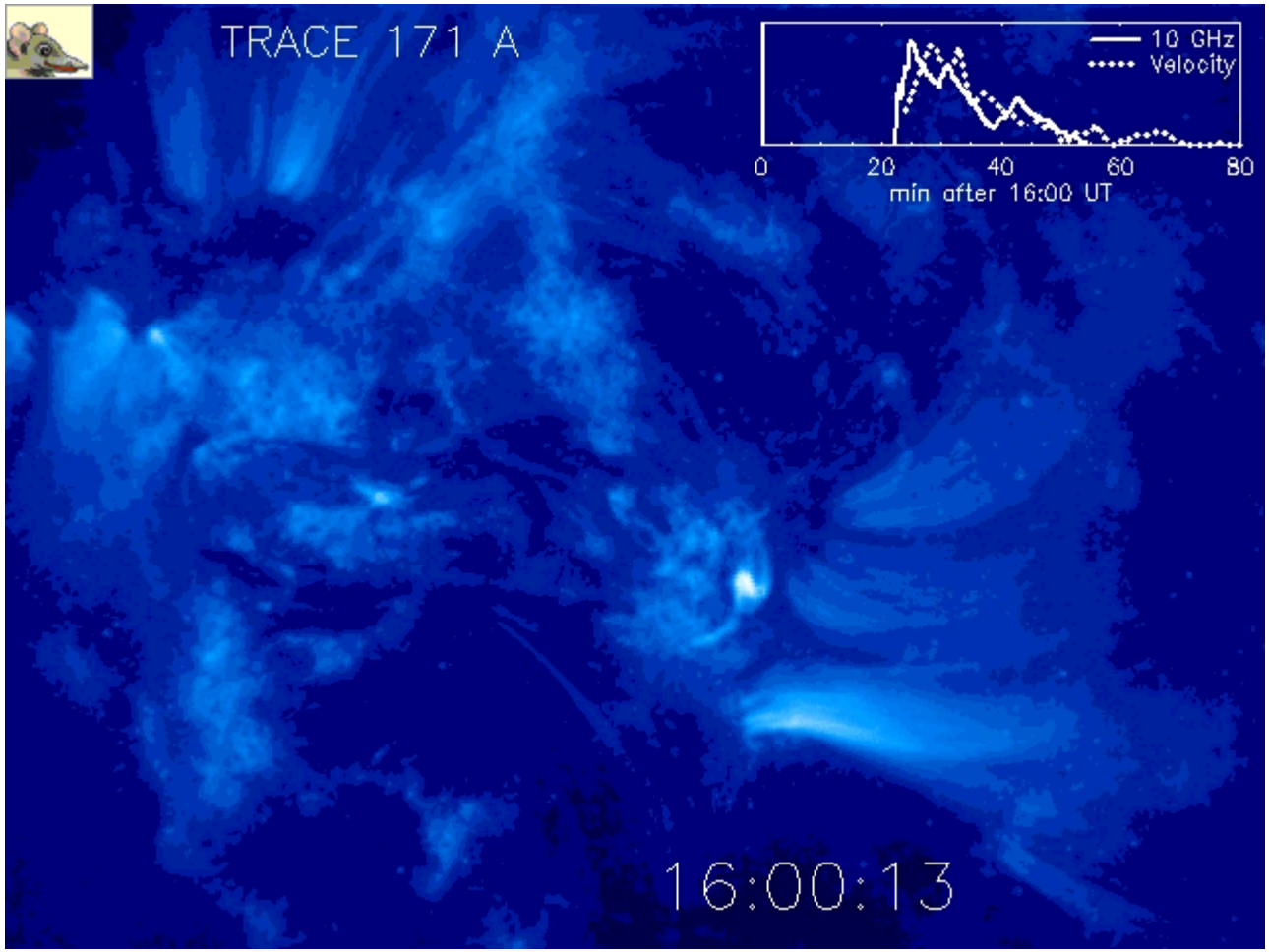
Will the reconnecting field lines (red) be seen at other wavelengths?



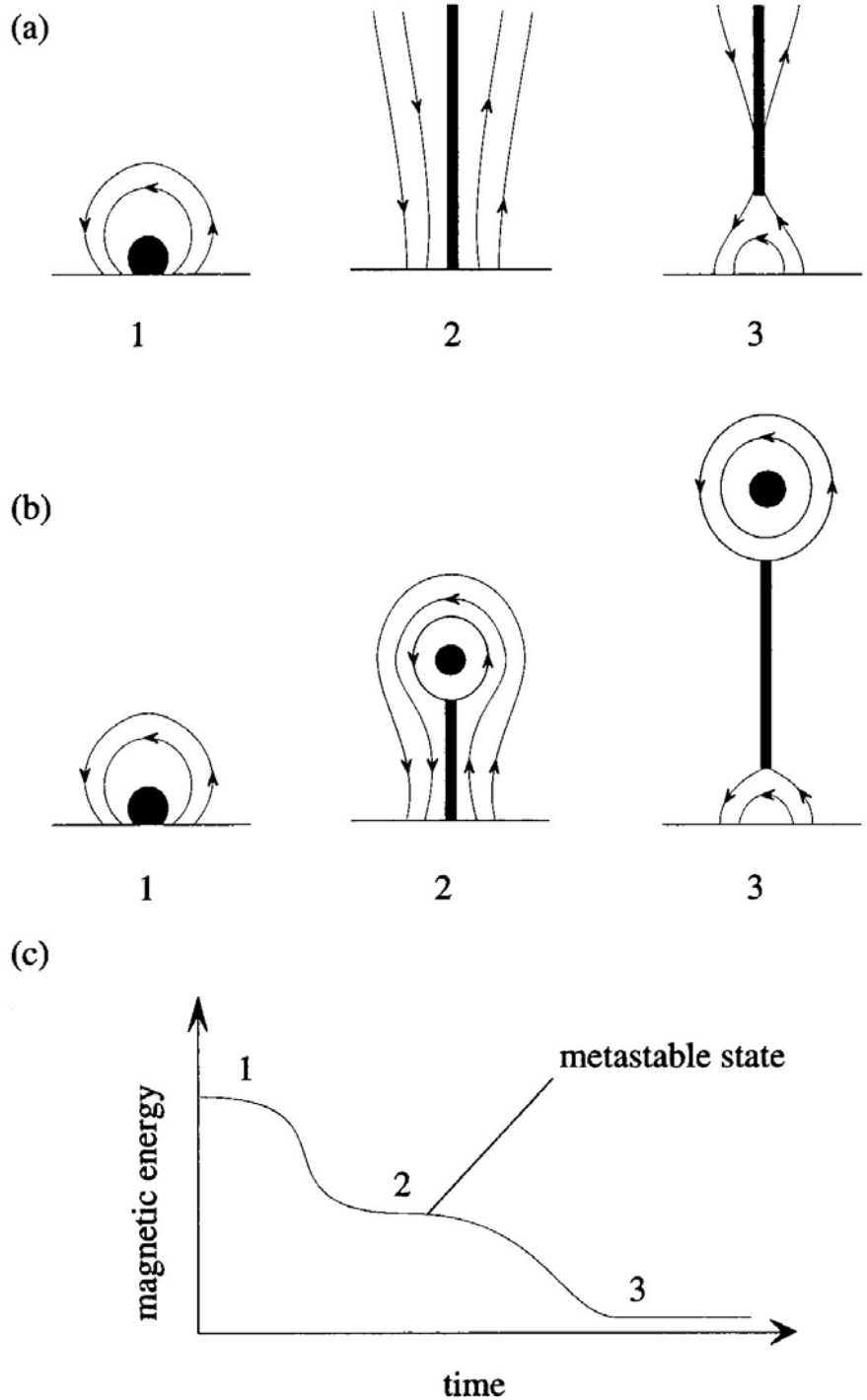
16:09:47 UT



TRACE movie

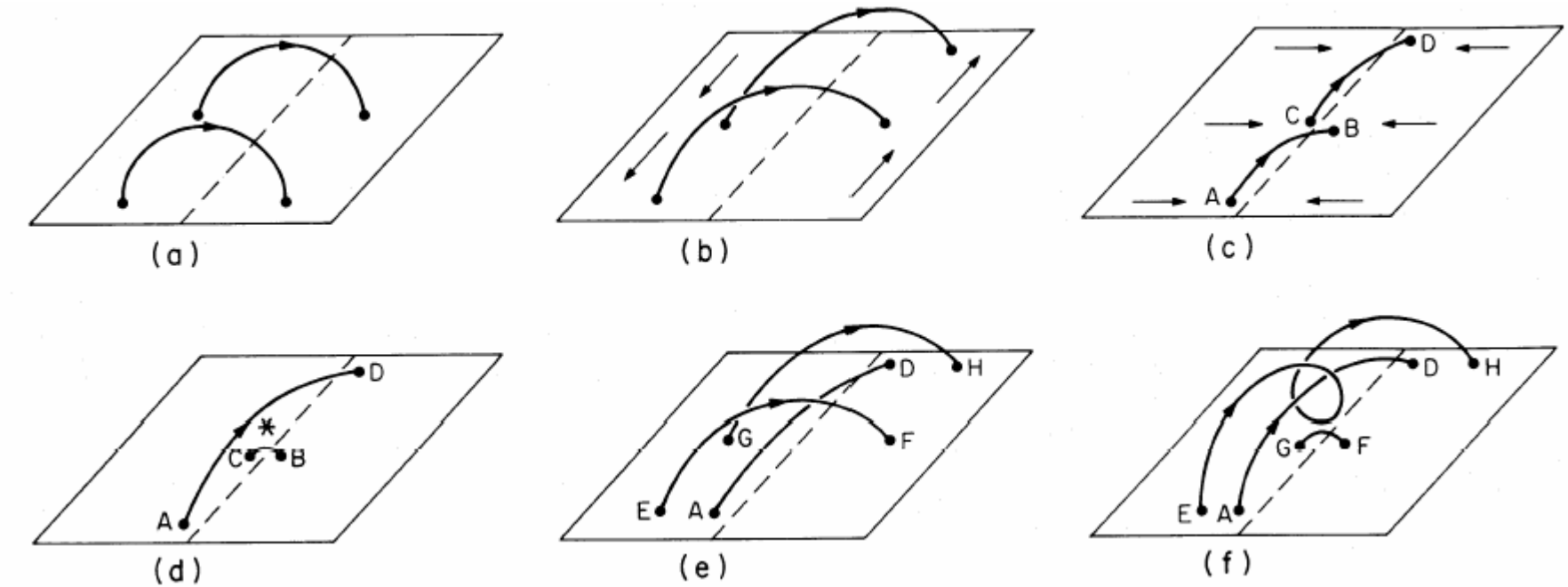

TRACE 171 A
10 GHz
Velocity
0
20
40
60
80
min after 16:00 UT
16:00:13

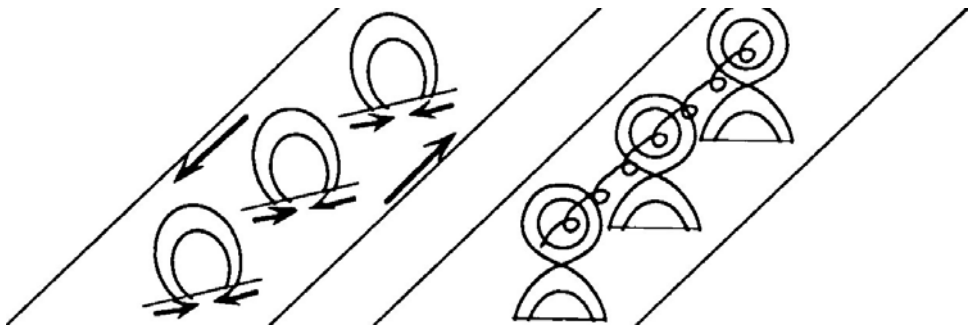
2-D mechanism for an eruptive flare model



3-D mechanism for an eruptive flare(?) model

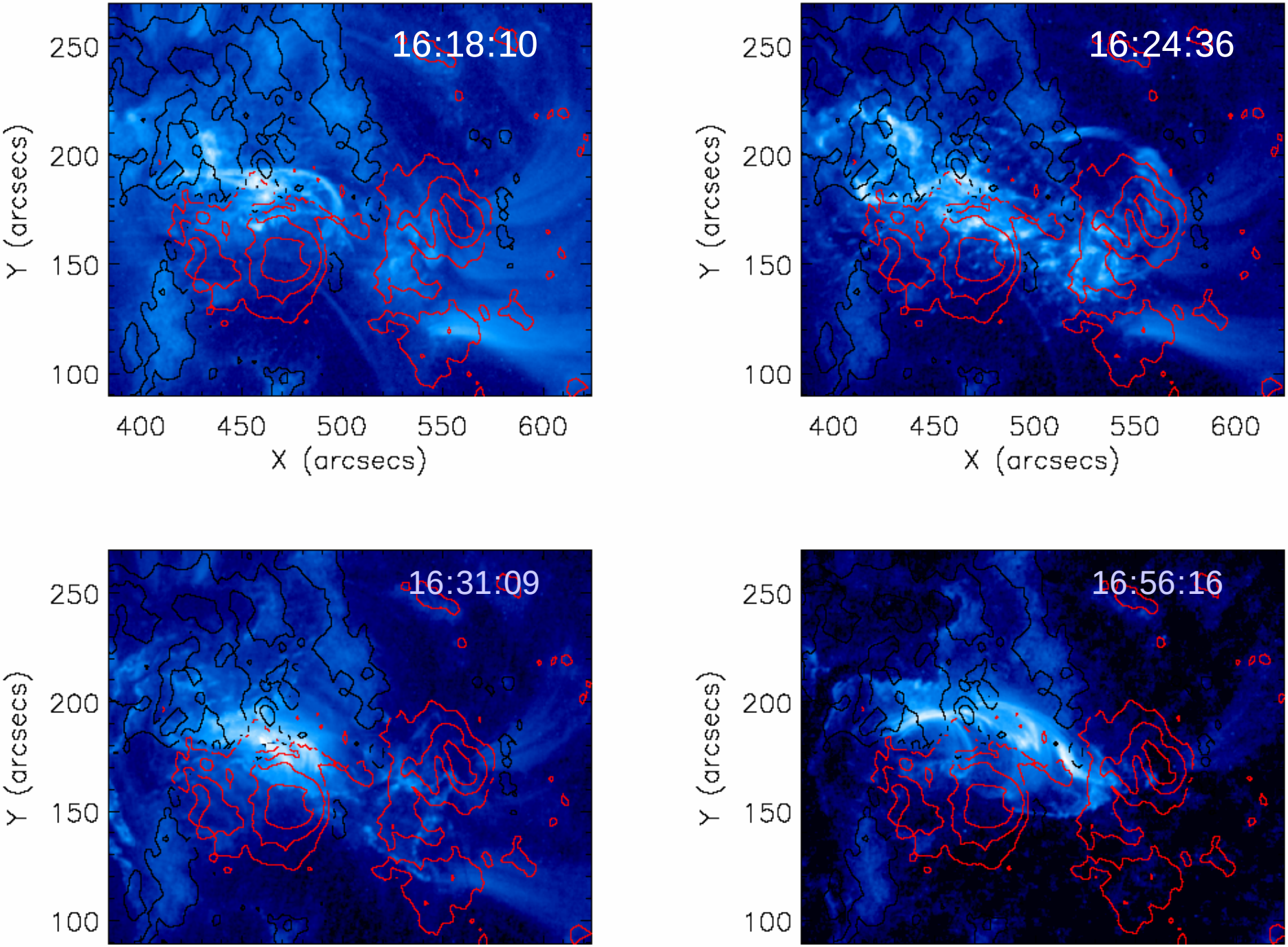
-Originally “Formation and Eruption of Prominences” Ballegooijen & Martens 1989





Up: Ballegooijen & Martens 1989

Left: Redrawing by Forbes 1991


16:18:10
16:24:36
16:31:09
16:56:16
250
200
150
100
400
450
500
550
600
X (arcsecs)
Y (arcsecs)

Summary

	Eruptive reconnect.	Confined reconnect.
Magnetic poles	Bipolar	Quadrupolar
Nature	2D	3D
H-alpha ribbons	Dynamic	Static
Electric currents	New	Stored
CME motion	Motion~CME accel.	CME but decel.
High energy ems.	~Mass ejection	~Mass ejection?
Size	Large/small	Small, but intense
Possibly,	confined	eruptive