Plasmoid instabilities in CME current sheet system

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Outline

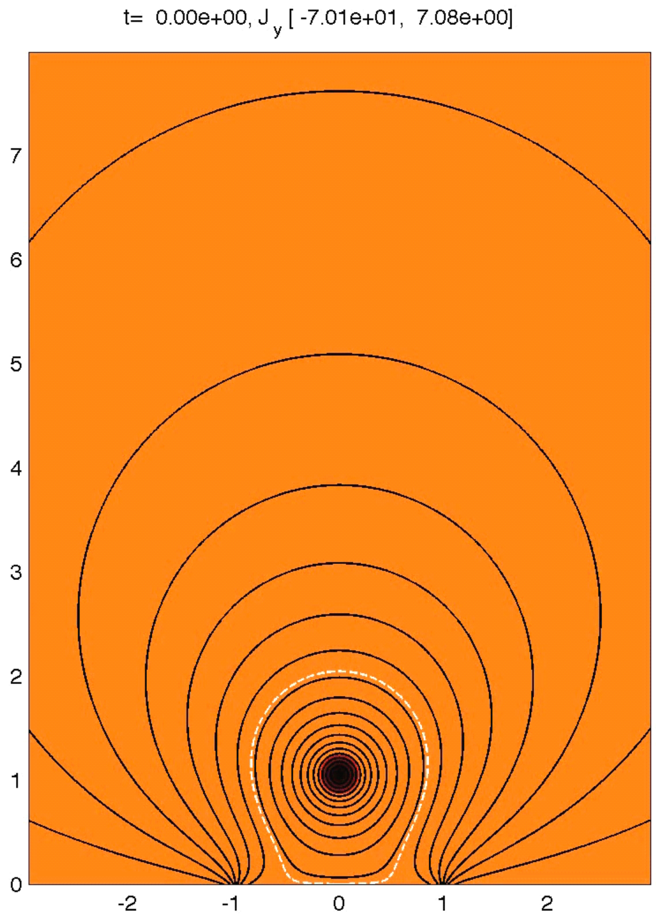
- Application of plasmoid instability model to CME eruption and statistical results regarding plasmoid flux and scale distribution from numerical simulations.

- Plasmoid observations in corona and statistical results regarding scale distributions.

  (1) Bright blobs in white light coronagraph

  (2) supra-arcade downflow in X-ray and EUV

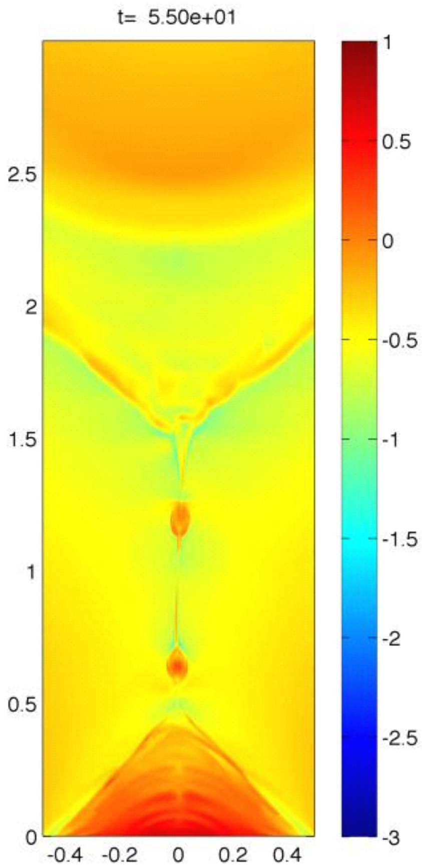
2D resistive MHD plasmoid instability model

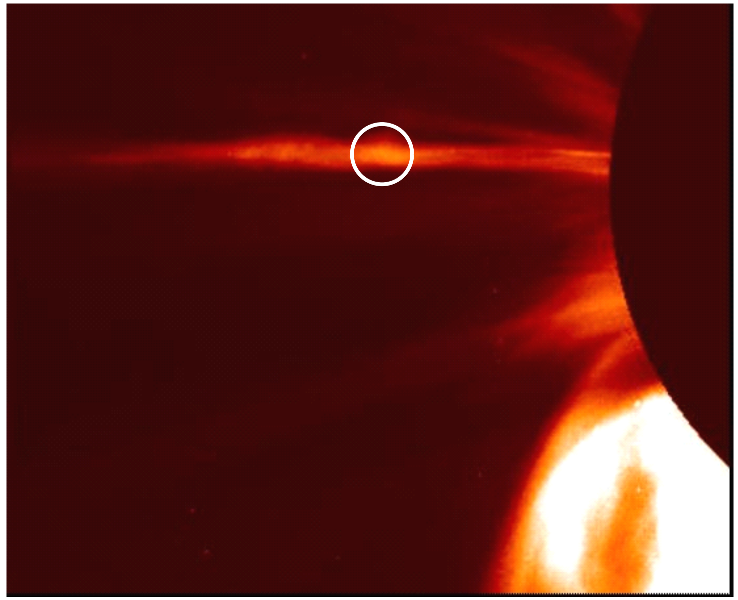


2D flux magnetic flux map

- We set the bottom of our box to be the photosphere, one height unit in our model equals one solar radius.
- In our model, Alfven speed is set to be 1, and therefore one Alfven time is about 200 second. We have one frame for one Alfven time, and a total of 74 frames.
- The Lundquist number for this run is 10^5

2D resistive MHD plasmoid instability model density map

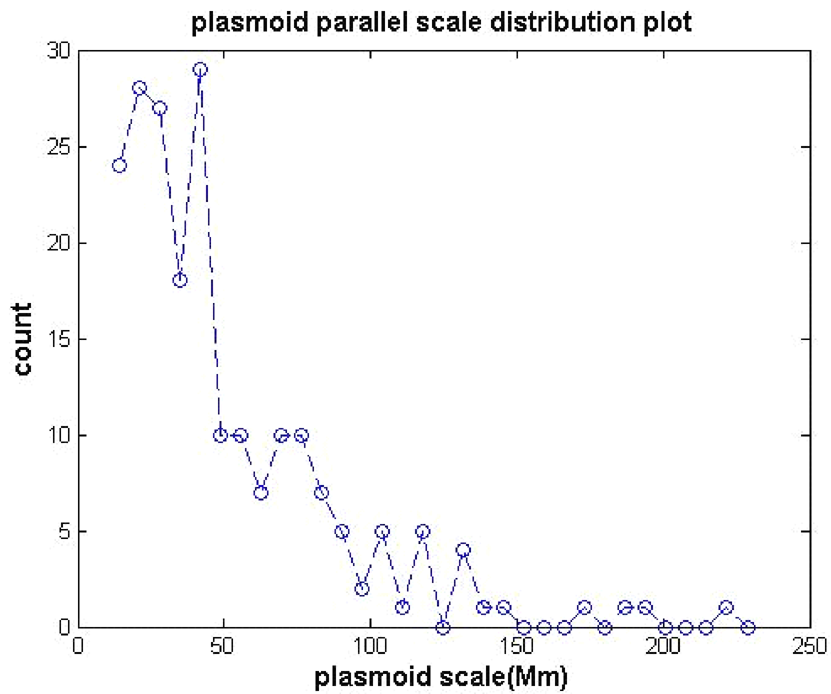


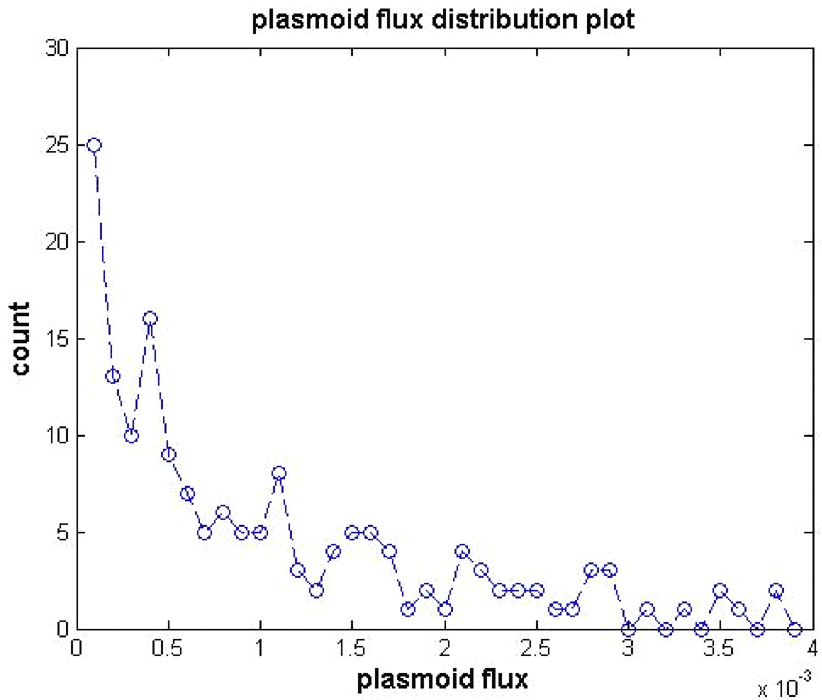


$$m = \frac{B_{obs}}{B_e(\theta)} \times 1.97 \times 10^{-24} g.$$

m ----- intrgral mass along line of sight for each pixel.
B obs ----- observed brightness for each pixel.
B e ----- brightness for single electron.
The density map generated by our model can be related to real white light observation through this simple equation.

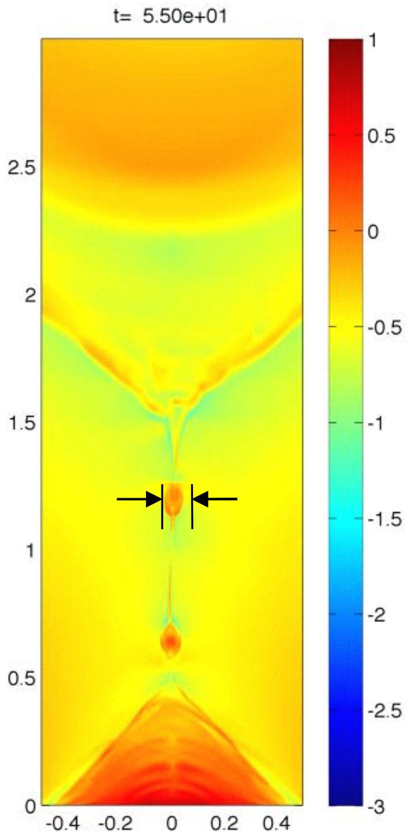
Plasmoid scale and flux distribution detected in flux map

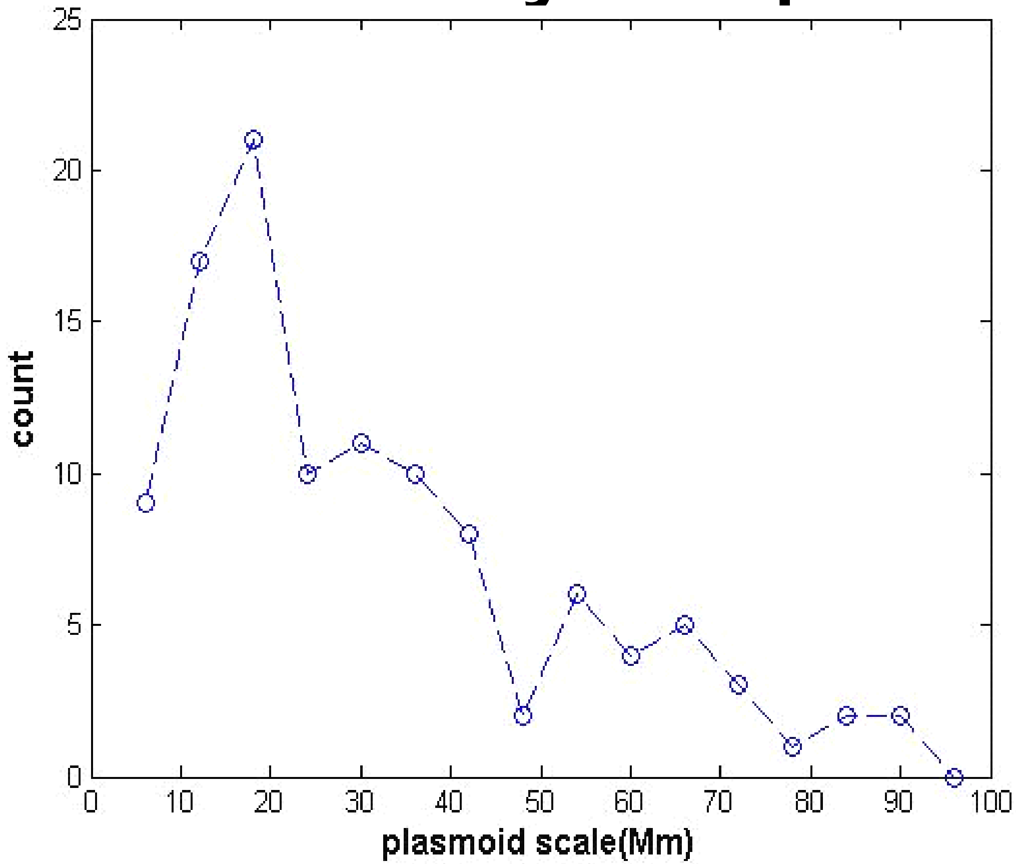




We take a slice along the middle of current sheet in each flux map frame, and get a 1D magnetic flux plot for each frame. Then using computer code to detect bump in this plot, the width of the bump is the scale of plasmoid, and magnetic flux within the bump is the flux of plasmoid.By this mean, we detect a total of 317 plasmoids within 43 frames.

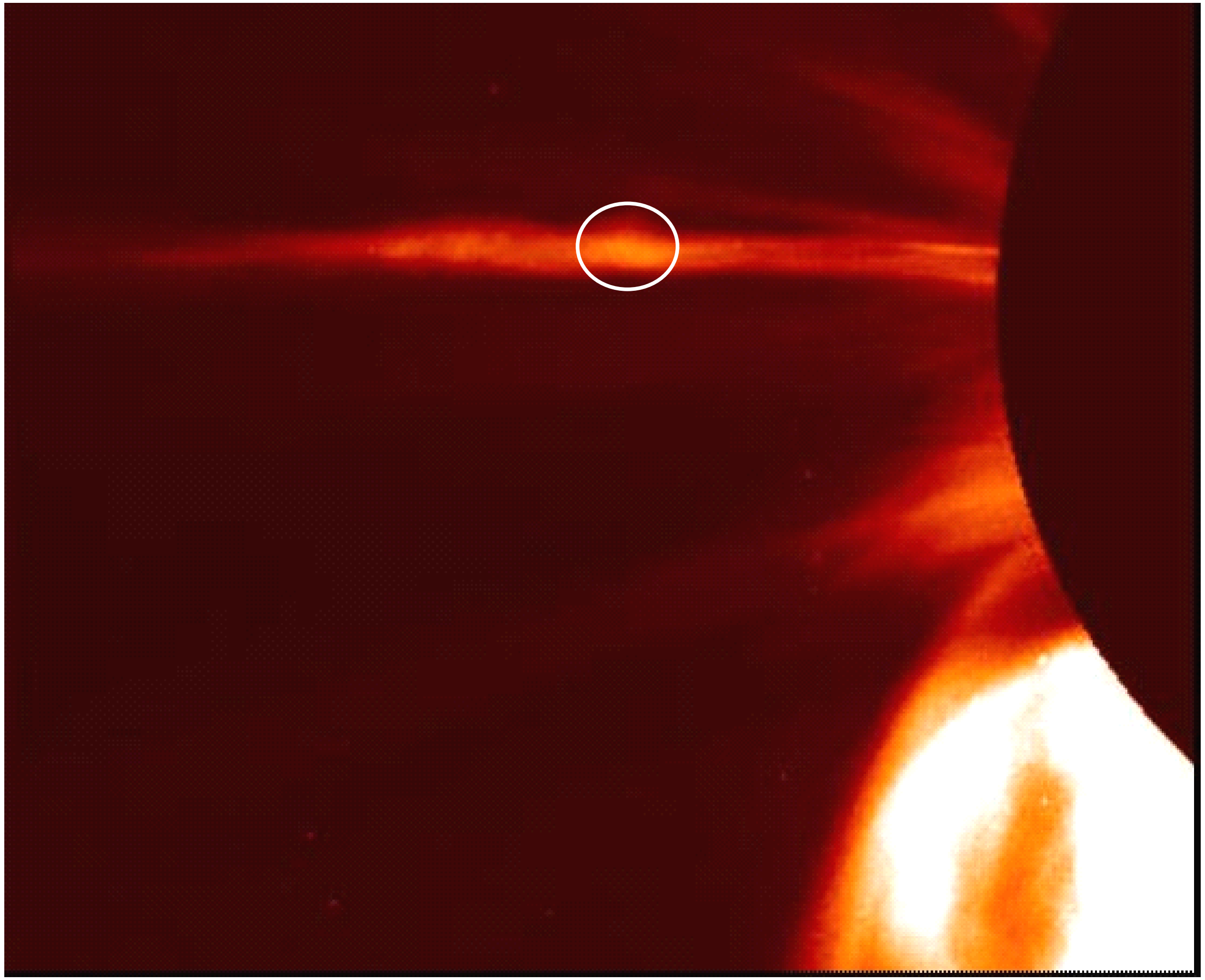
Plasmoid scale distribution plot resolved in density map



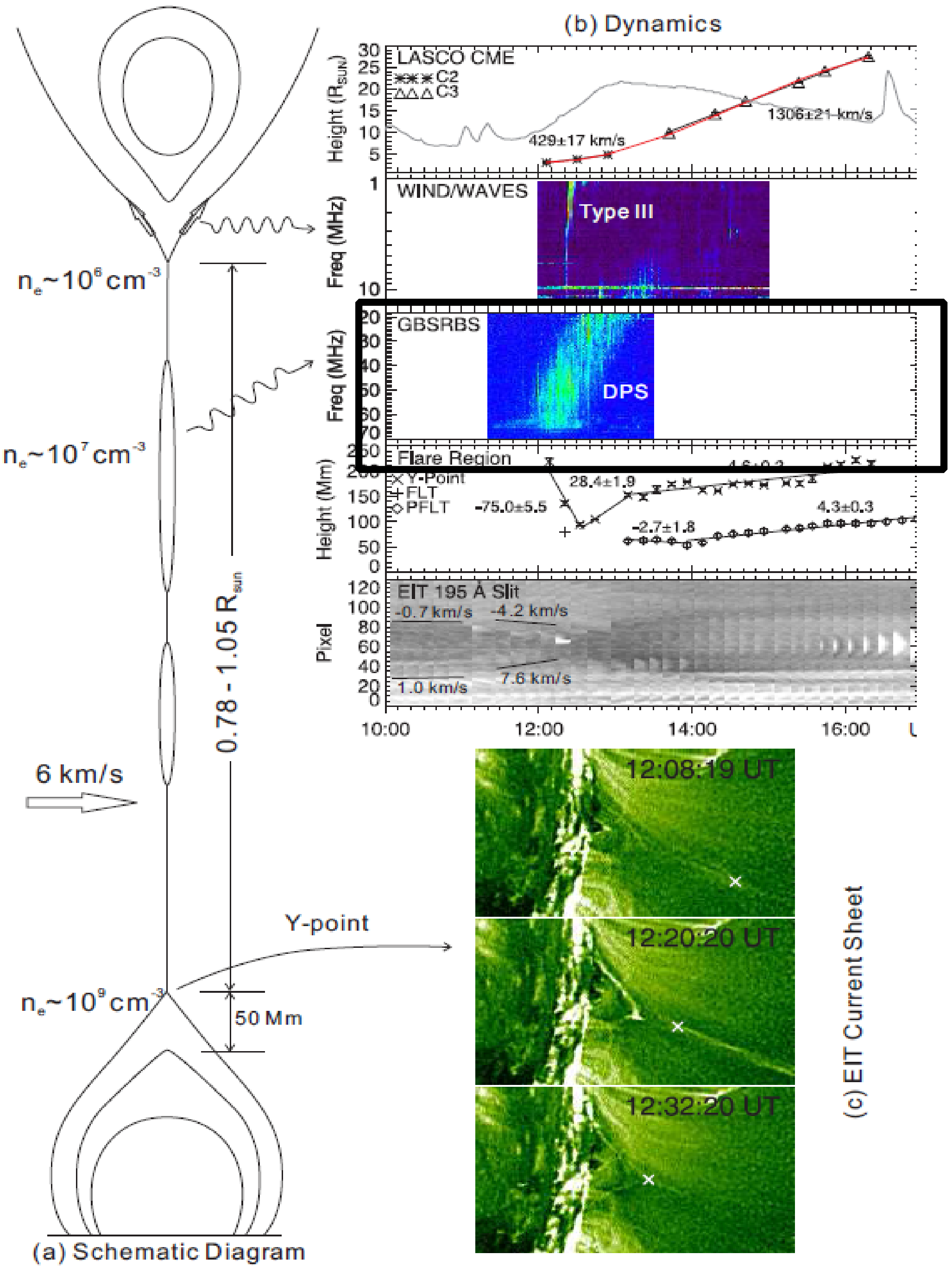


By looking at the density map frame by frame, we resolve plasmoids by visual inspection and record the plasmoid scale along the direction perpendicular to current sheet. There are total 119 plasmoids are resolved within 43 frames. We found out that the turning point in this plot is close to the average width of current sheet.

Plasmoid observation ---- (1) Bright blobs in white light coronagraph

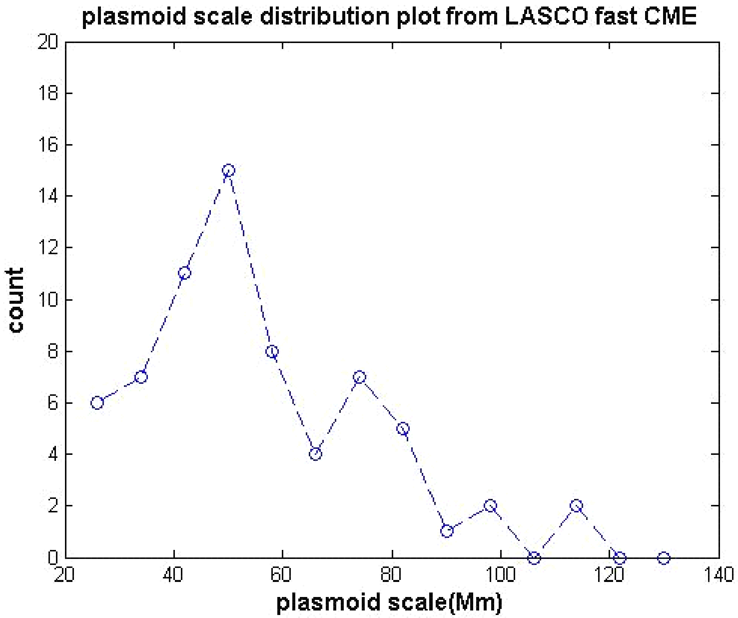


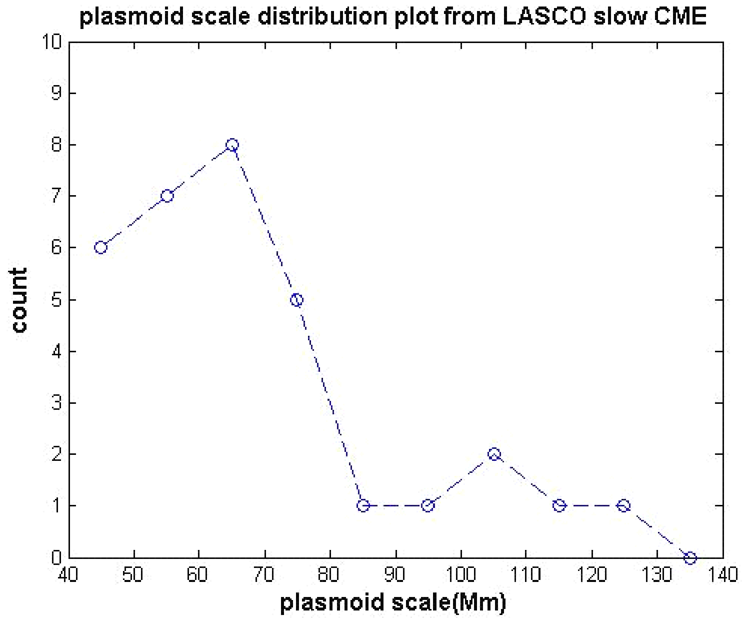
LASCO C2 white light ray structure and plasmoid



Rui Liu et al. found that from 11:30 till 13:30 UT, GBSRBS recorded drifting pulsating structures (DPSs) at metric frequencies. It suggests repeated formation of plasmoids and their coalescence, which generate the individual pulses of the DPSs; and motions of the plasmoids in the corona result in the global drift of the DPSs.

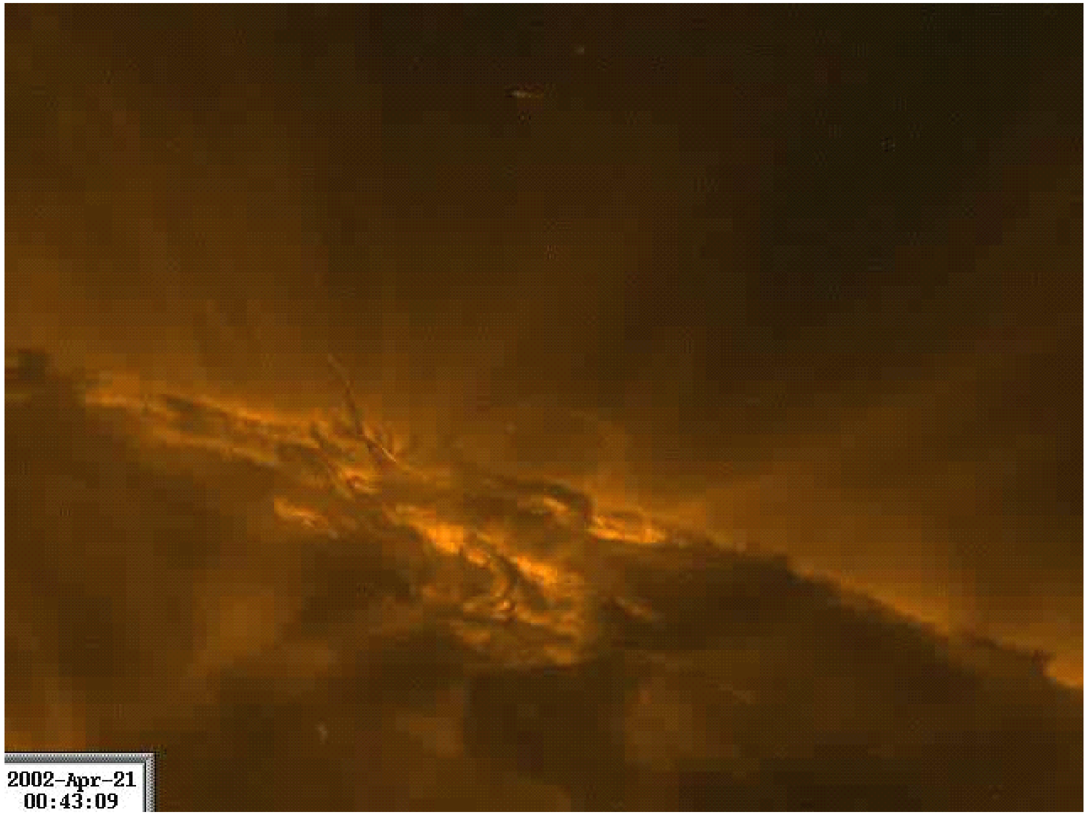
Plasmoid scale distribution plots



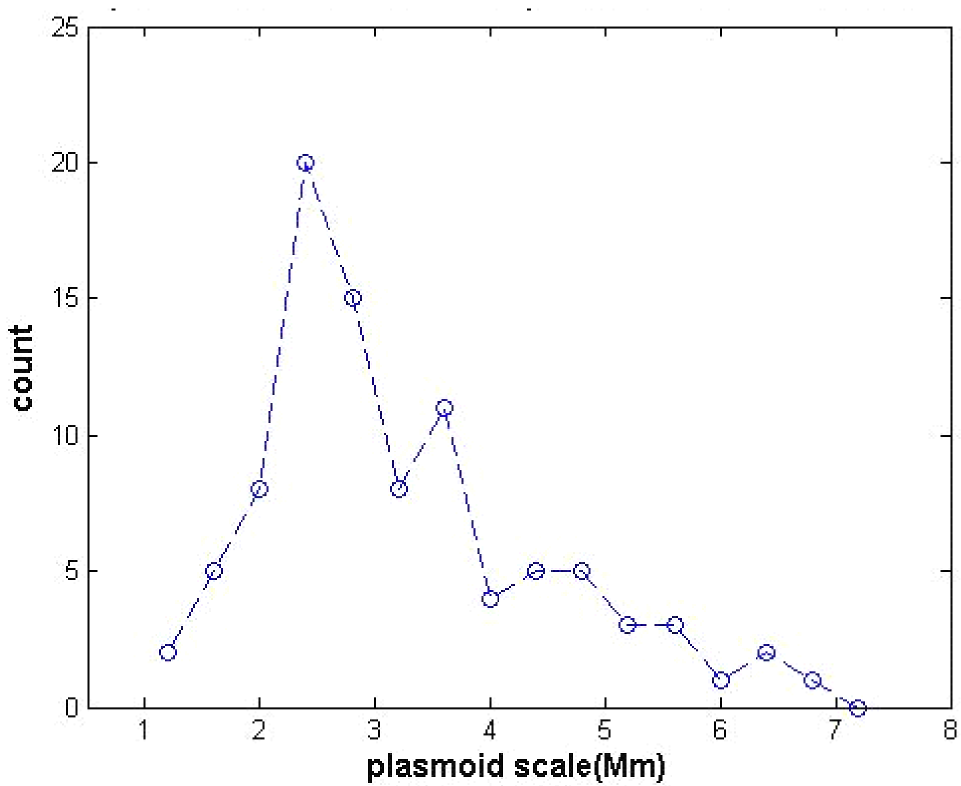


We observe near 72 plasmoids in LASCO in 2002/01/08 halo fast CME events, by recording the cross section of plasmoids, We make a distribution plot shows in the left panel. In 2005/06/25 slow CME event, we have near 30 plasmoids, their distribution plot is shown in the right panel. Despite some minor difference caused by poor sample number, two plots are in agreement with scale distribution plot from plasmoid instability simulation.

Plasmoid observation ----
(2) supra-arcade downflow

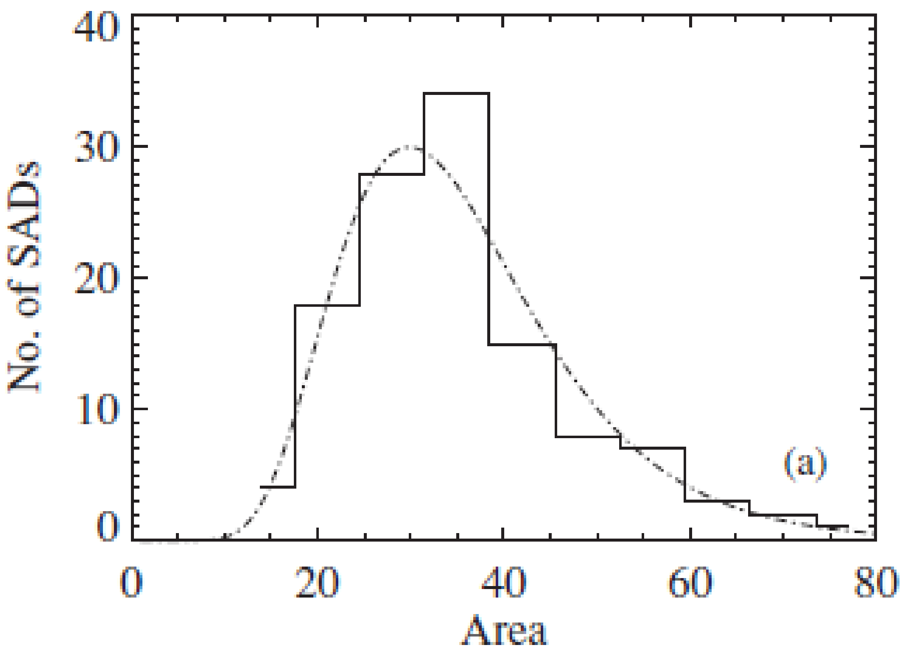


SADs scale distribution

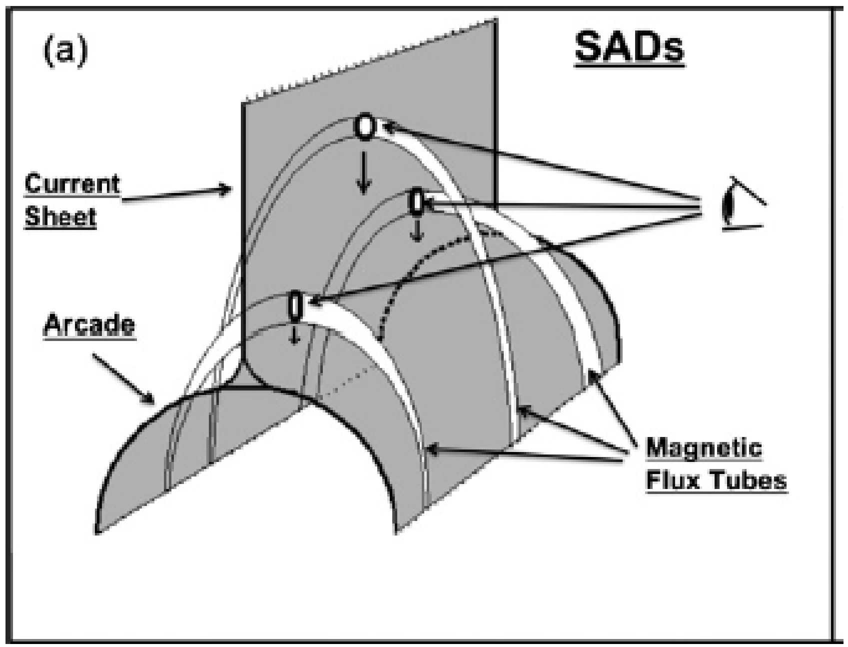


This figure shows the SADs scale distribution plot observed by TRACE, which has similar trends with those observed in LASCO and simulation.

Our result agree with observations of Mckenzie and Savage



Mckenzie & Savage, 2011, Apj



Savage & Mckenzie, 2011, Apj

Conclusion

- We cannot resolve all the small scale plasmoids. This fact cause the distribution plot to have a drop in the small scale regime, while other part of the plot seems to follow exponential distribution law.

- Plasmoid scale distribution plots observed by LASCO for both fast and slow CME, and distribution plot from supra-arcade downflow appear to be in qualitative agreement with the plot we obtain from simulation density map.

- We suggest that plasmoid instability is a possible mechanism for CME current sheet reconnection.

Future problems

- For now, our work only deals with the relatively large scale plasmoid. We are still not sure about the small-scale regime as we increase the Lundquist number of the simulation.

- Hall effects should also be considered in our future work.

Reference

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Thanks for your attention!

Comparison between downflows and x-ray plasmoid ejection

TABLE 1

COMPARISON BETWEEN THE FEATURES OF THE PLASMOID EJECTION AND THOSE OF THE DOWNFLOW

Parameter	Plasmoid Ejection	Downflow
Velocity (km s^{-1})	30–500	45–500
Size (km)	$(1–10) \times 10^4$	$(2–10) \times 10^3$
Density (cm^{-3})	$(1–10) \times 10^9$	$\sim 10^{9}$[a]
Impulsive phase	Yes	Yes
Decay phase	No	Yes
HXR/microwave	Yes	Yes[b]

[a] The temperature of downflows is still uncertain.
[b] New finding in this Letter.

- Asai et al. found downflows above the postflare loops on 2002 July 23 appear to correspond to the times when nonthermal bursts in microwaves and HXRs occurred.
- Past therotical and observational results shows that there are close relation between plasmoid ejection and HXR emission.
- Therefore, the correlations between plasmoid ejections, or downflow, and HXR bursts represent a plasmoid-induced, nonsteady reconnection (Shibata 1999; Shibata & Tanuma 2001).