Distinguishing Between Supra-Arcade Downflows and Plasmoids

Sabrina Savage
NASA / MSFC

Abstract: Supra-arcade downflows (SADs) observed above flaring active regions during long-duration events are theorized to be signatures of magnetic reconnection. Observations of SADs strongly indicate an association with shrinking reconnected flux tubes characterized by a specific magnetic topology. Plasmoids comprise another proposed group of observational reconnection signatures. While some plasmoids occur under nearly the same conditions as SADs, the magnetic configuration of the two phenomena are quite incongruous, yet they are often categorized together. We present distinguishing characteristics between SADs and plasmoids and indicate how their respective observations may yield insight into the conditions within the current sheet above eruptive active regions.

Sabrina.Savage@nasa.gov

Supra-Arcade Downflows (SADs) Observations

Fig 1

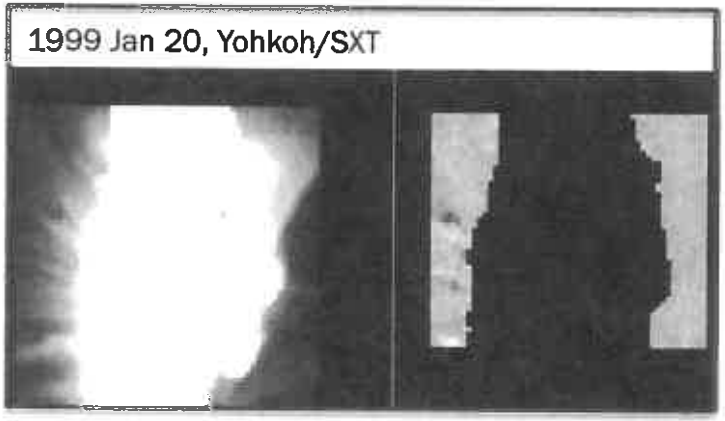


Fig 2

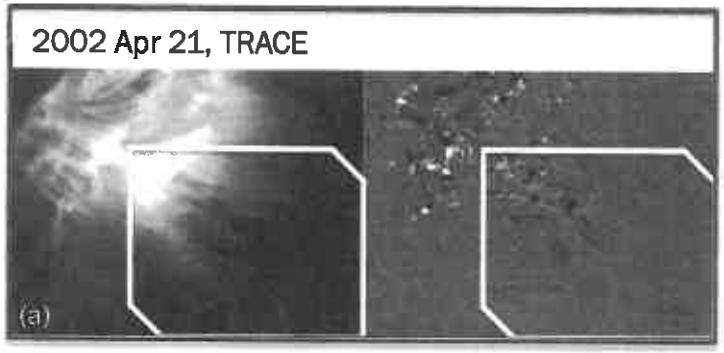


Fig 3

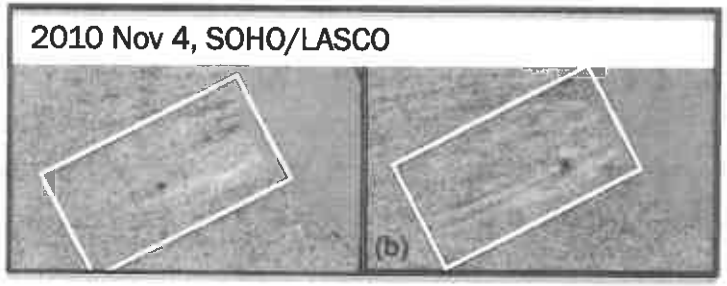


Fig 4

- Teardrop-shaped voids observed to travel sunward through the bright, hot fan extending outward along the spine of developing post-flare arcades.
- Observed with high-temperature instrumentation (EUV, X-ray) & white-light coronagraph (density)

Fig 5

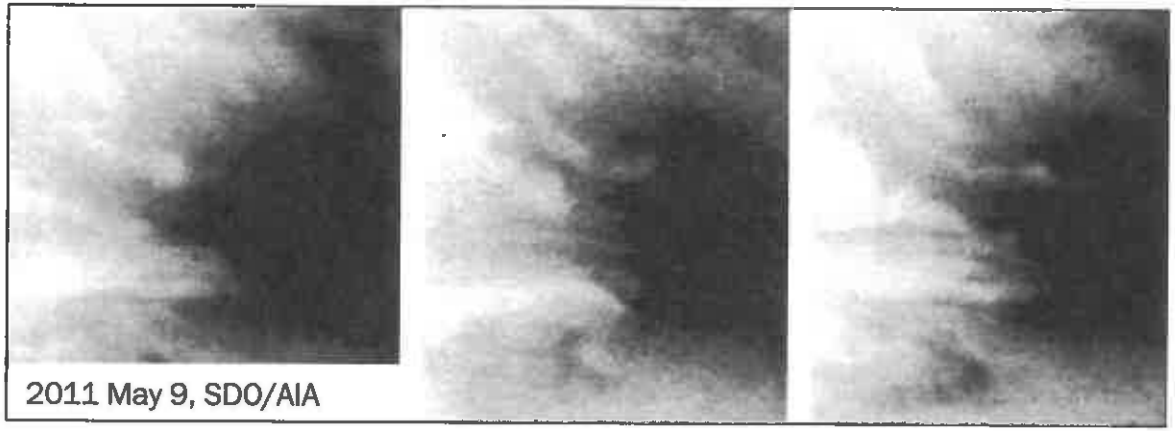


Fig 1: McKenzie & Savage 2009 Fig 2: Savage et al. 2011 Fig 3: Savage et al. 201

Plasmoid Observations

- Coherent 'bubble' of emitting plasma held together by magnetic fields.

- Observed with broadband-temperature instrumentation (EUV, X-ray, Hard X-ray) & white-light coronagraph (density)

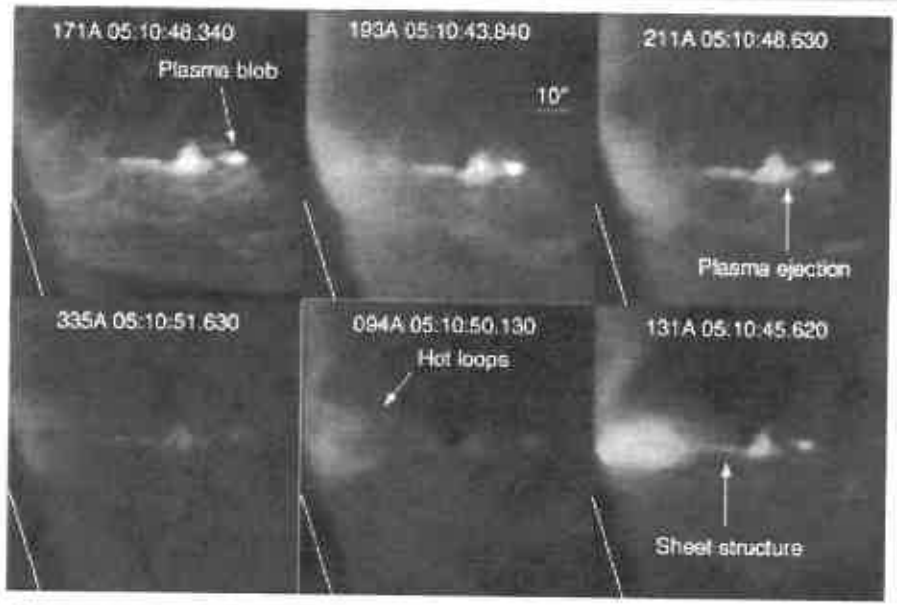


Fig 3

Fig 1

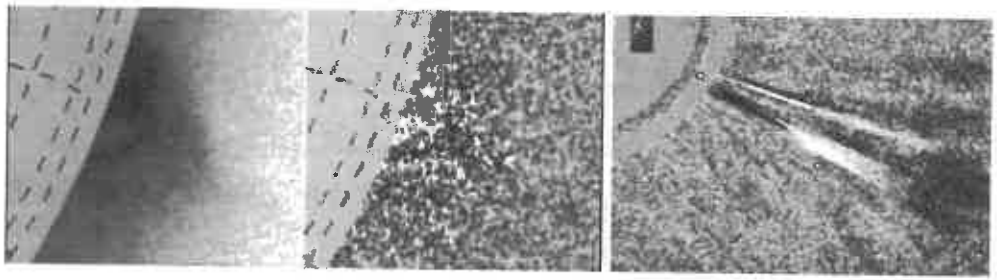
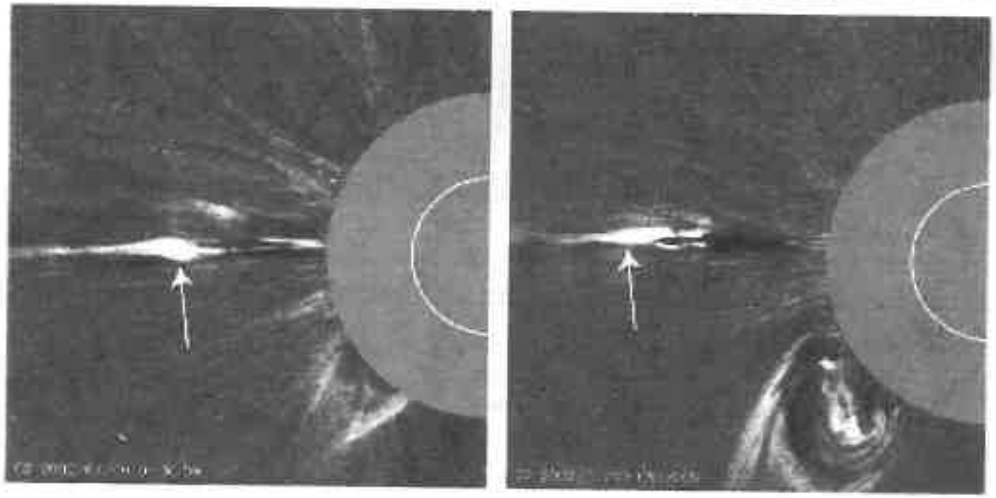


Fig 2



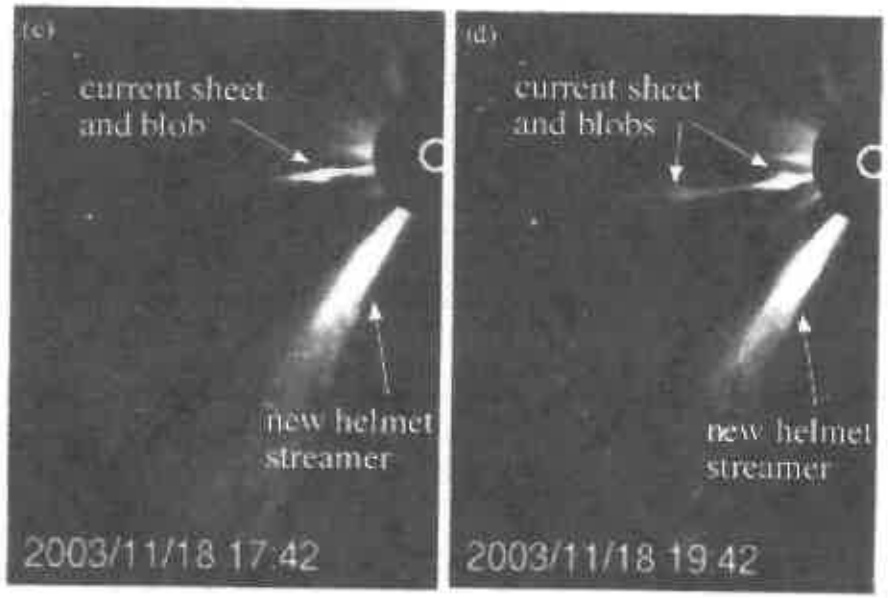


Fig 4

Fig 1: Savage et al. 2010 Fig 2: Ko et al. 2003 Fig 3: Takasao et al. 2012 Fig 4: Lin et al. 2004

Supra-Arcade Downflowing Loops (SADLs) Observations

Fig 1

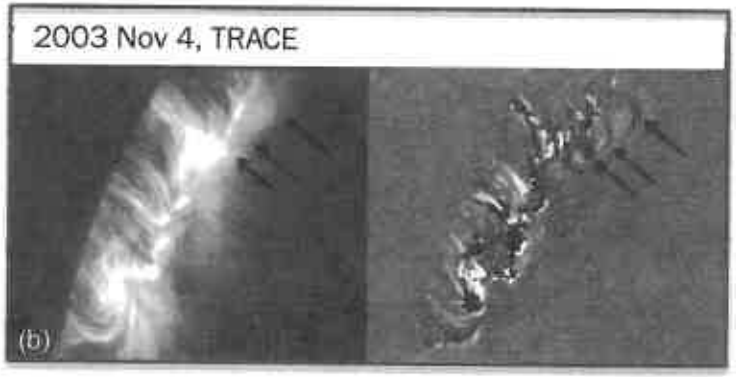


Fig 2

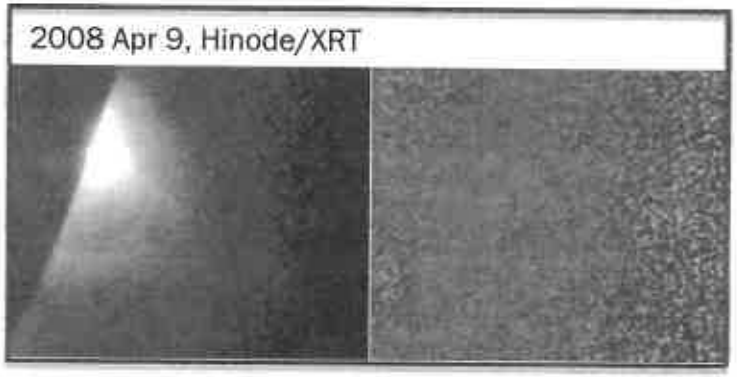


Fig 3

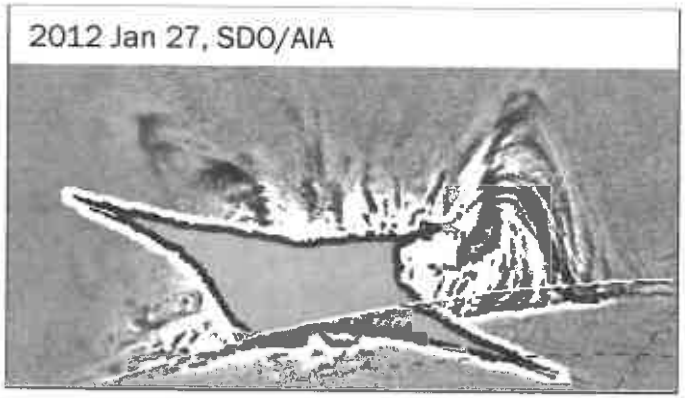


Fig 5

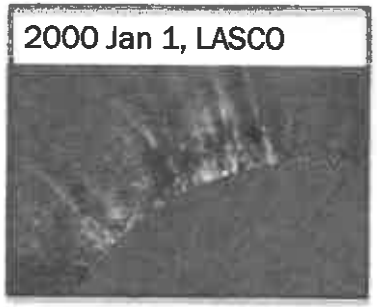


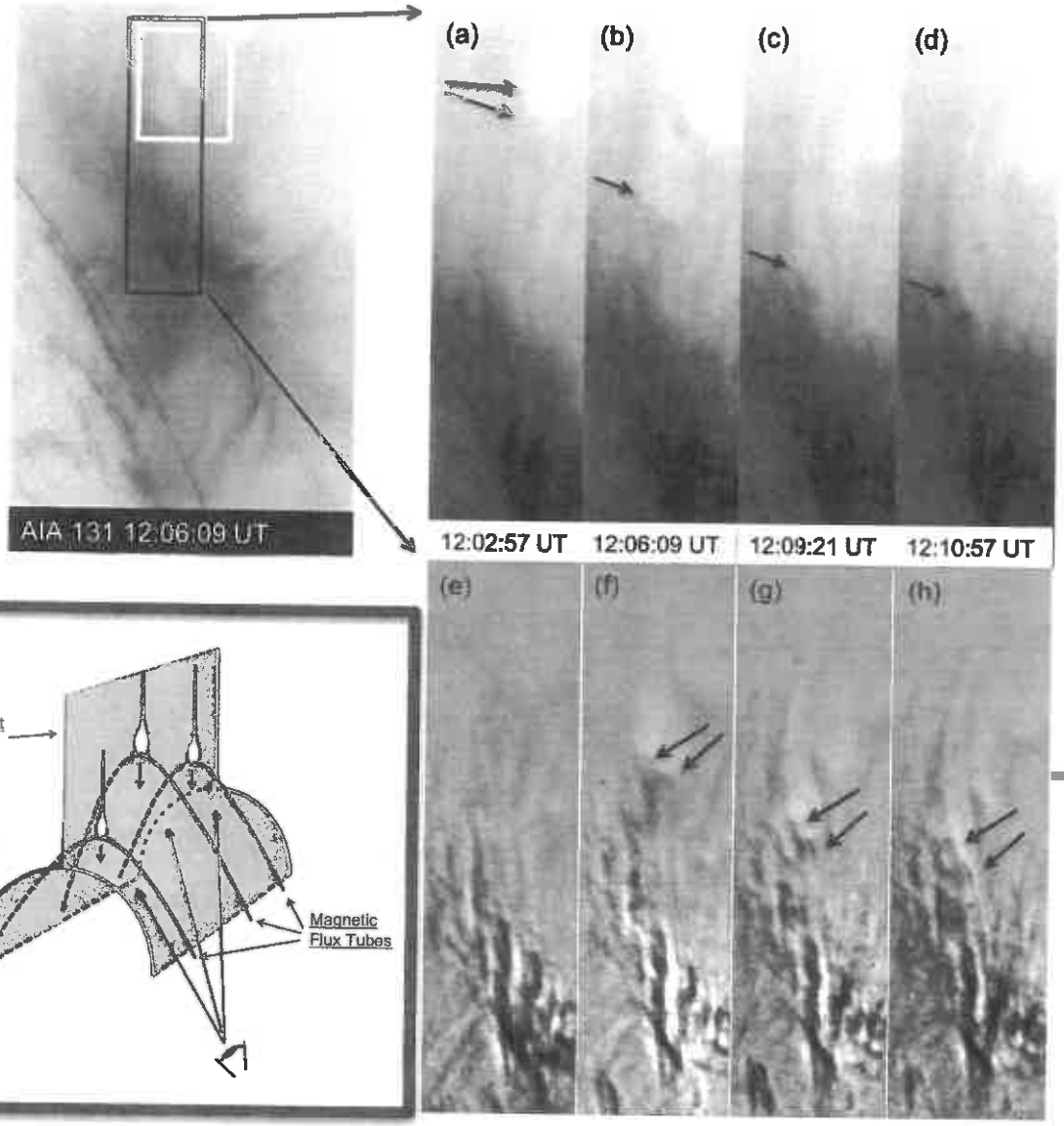
Fig 4

- Shrinking loops observed to travel sunward across the bright, hot fan extending outward along the spine of developing post-flare arcades.
- Observed with high-temperature instrumentation (EUV, X-ray) & white-light coronagraph (density)

Fig 1: Savage & McKenzie 2011 Fig 2: Savage et al. 2010 Fig 4: Savage et al. 201

SADs + SADLs

Fig 1



- SADs appear to be voids created by loops (SADLs) shrinking through the fan plasma.

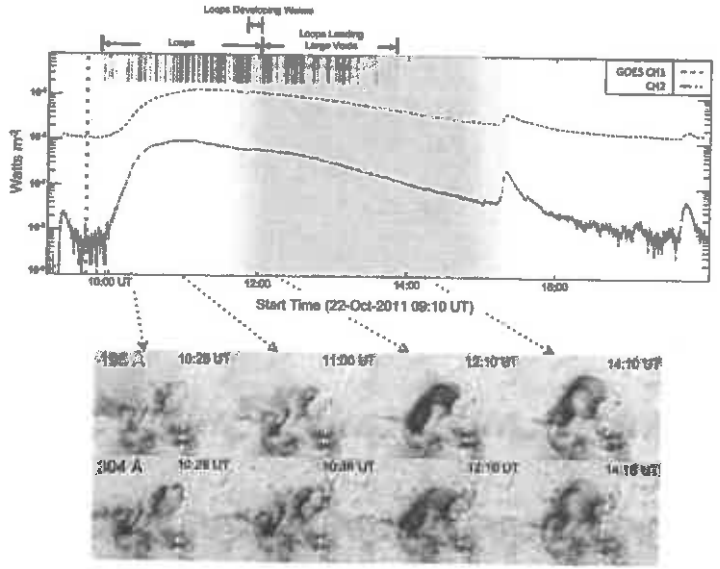


Fig 2

Fig 4

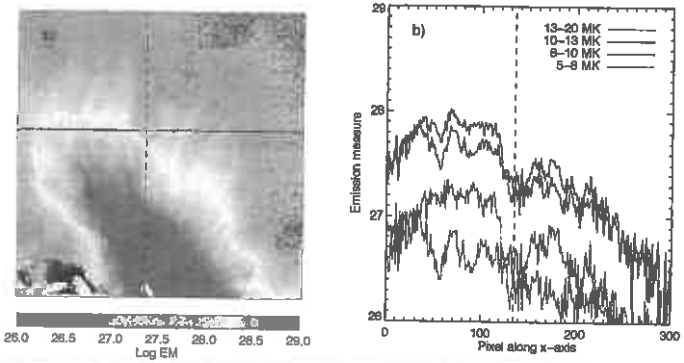


Fig 3

Fig 1, 2, 3, 4: Savage et al. 2012

Example Models & Simulations

Fig 1

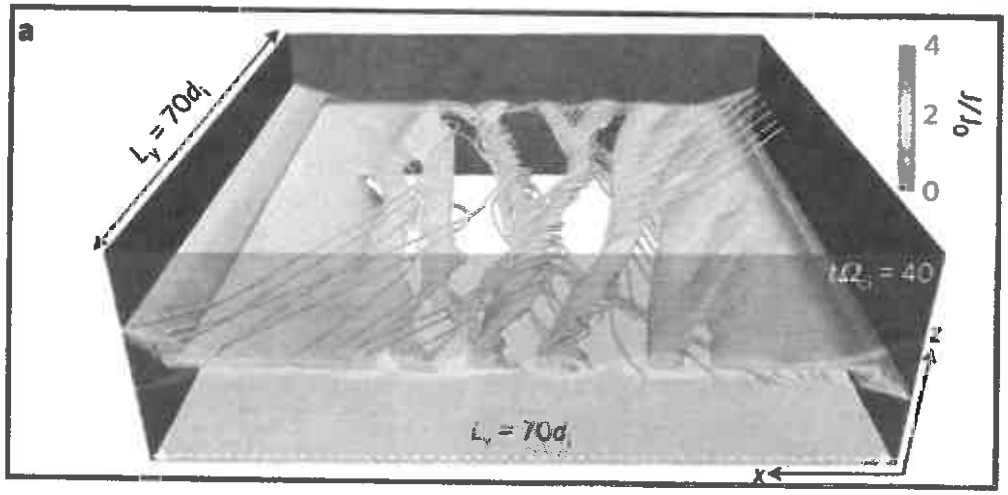
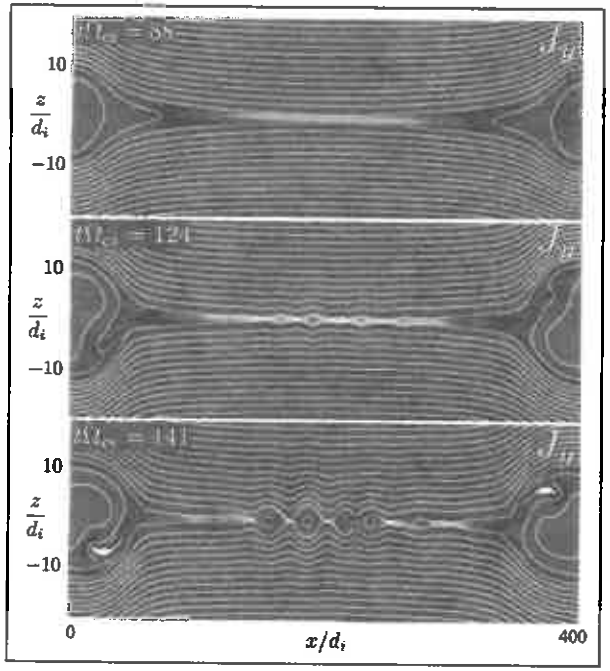


Fig 2



- Thin flux tubes created during the reconnection process across the current sheet.
- Plasmoids a 3-D product of reconnection concurrent to single loop creation.

Fig 3

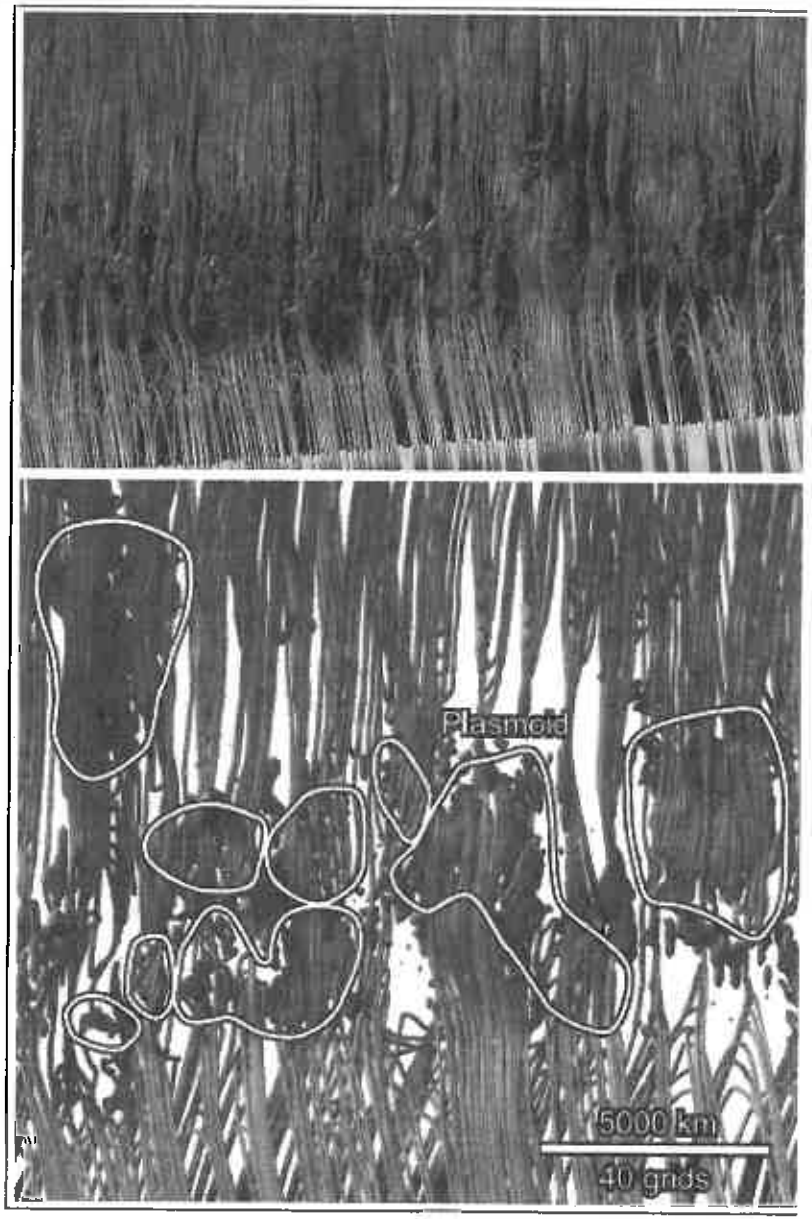


Fig 1, 2: Daughton et al. 2012

Fig 3: Nishizuka et al. 201

Diagram Models

Fig 1

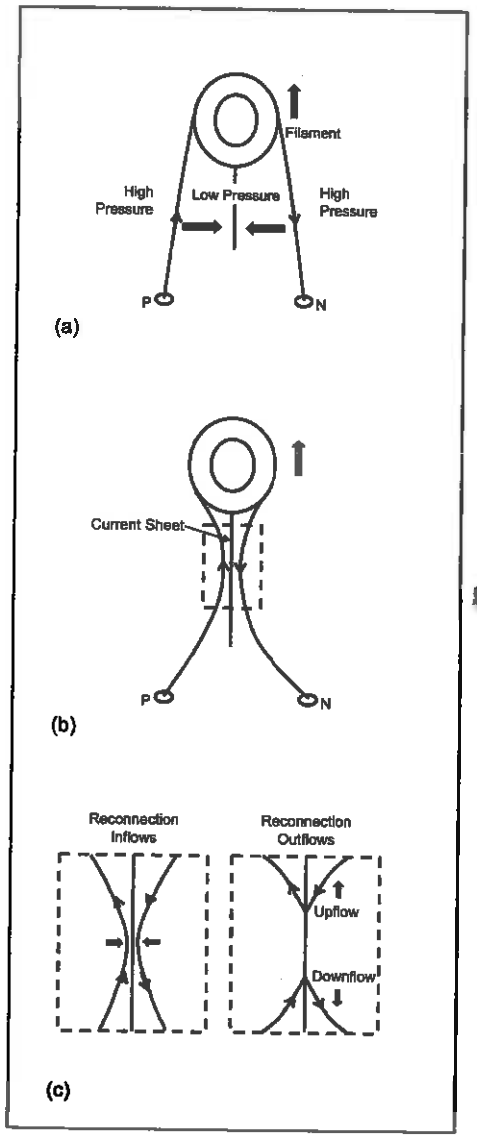
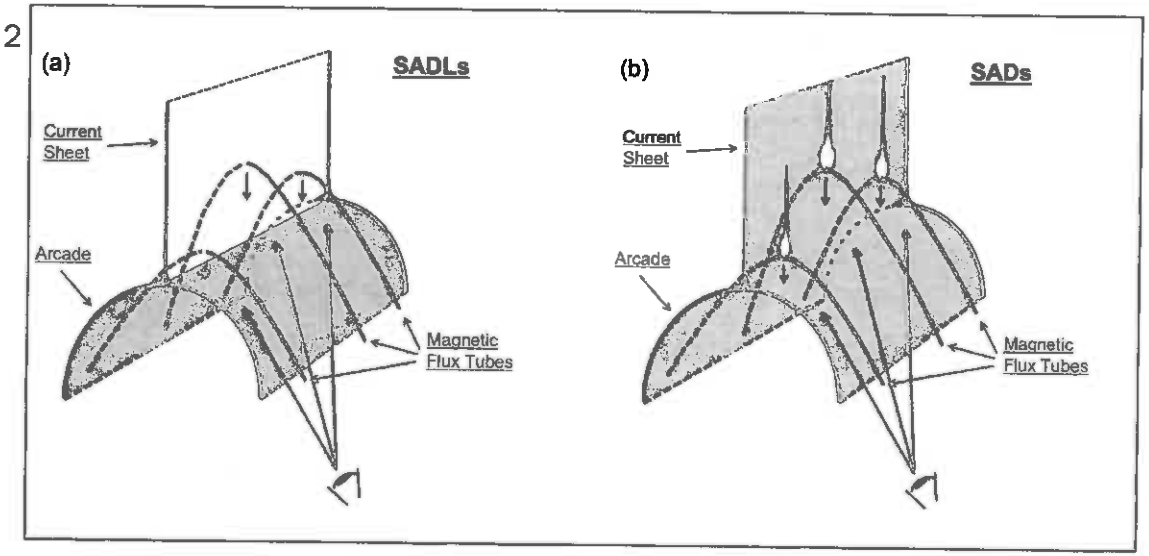


Fig 2



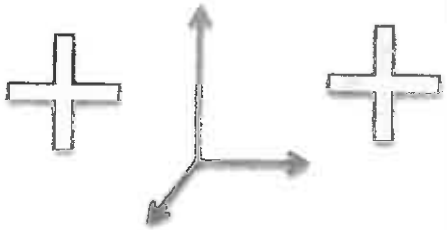


Fig 3

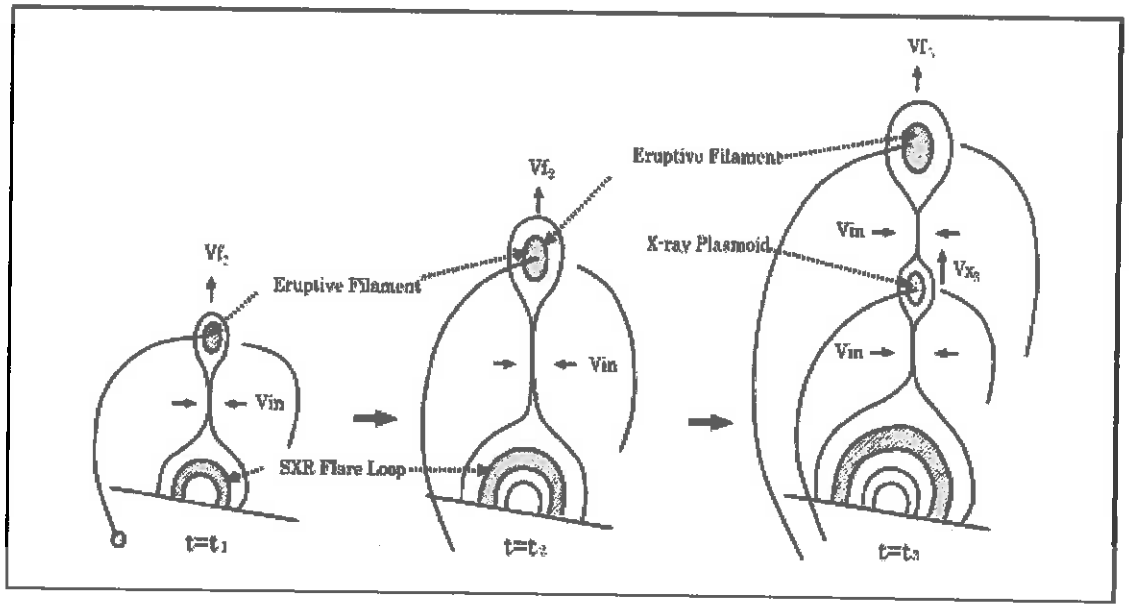
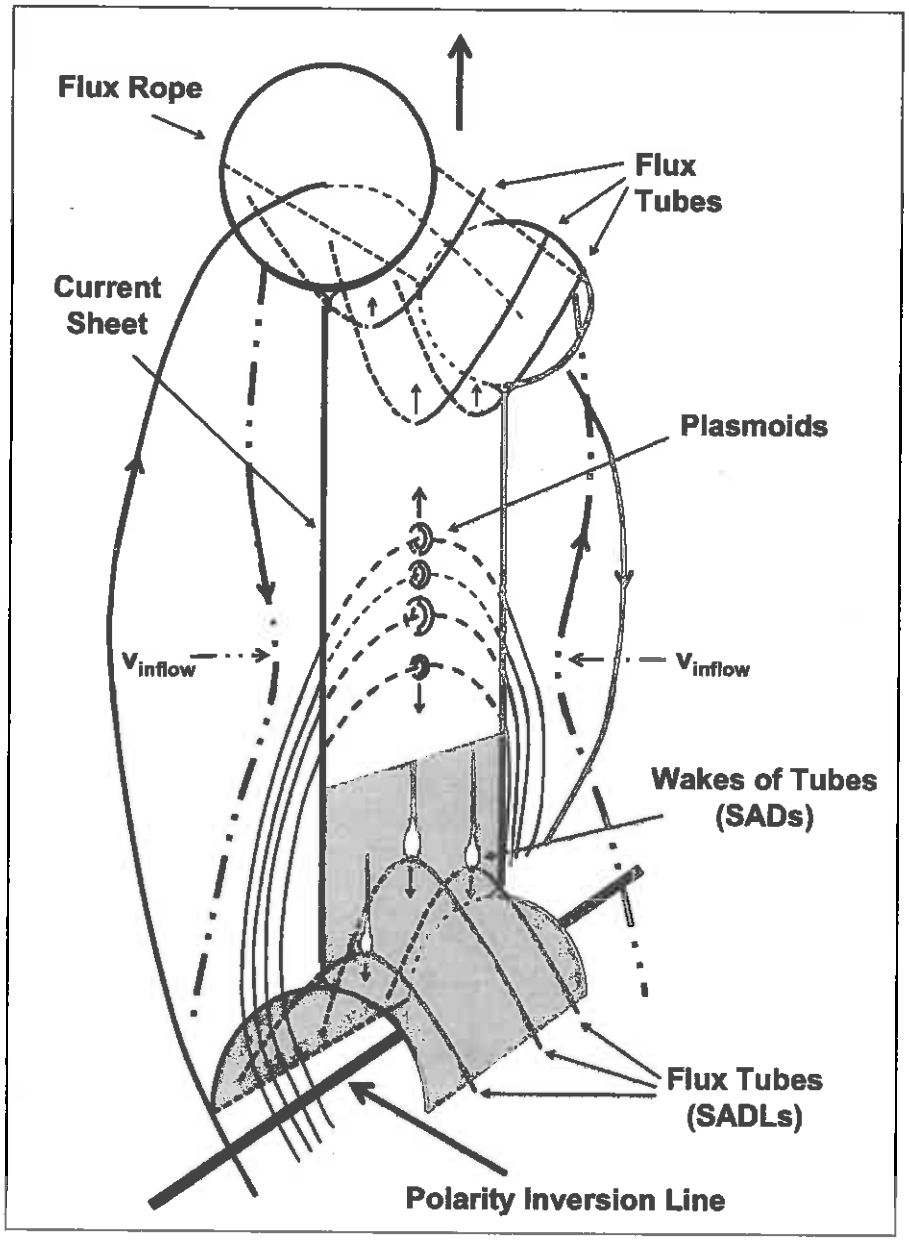


Fig 1, 2: Savage et al. 2012

Fig 3: Ohyama & Shibata 2000

Fig 1



- Basic reconnection scenario, post initial flux rope formation and release.
- General organization of the magnetic field of the various components (SADs, SADLs, plasmoids).
- Field lines reconnect across the current sheet to form outflowing flux tubes while plasmoids form in the current sheet.
- SADs are formed as the flux tubes (SADLs) retract through hot plasma in the fan (*otherwise, only SADLs are observed*).

Fig 1: Savage et al. 2012

Sum up

- Plasmoids and SADs consequences of the same general process.
  - i.e., reconnection in the current sheet fan above arcade-forming eruptions
- *However*, plasmoids and SADs have very disparate morphologies.
  - ergo, inappropriate to lump size, speed, field strength, etc. distributions into one category
- What can be learned through comparison?
  - timing of formation (do plasmoids typically form later in the event, as in the case for XRT flare 2008 Apr 9?)
  - 3-D structure of the current sheet (length scales)
  - Strength of the guide field
  - Do plasmoids create an effective drag on the shrinking loops?
  - Indications of a source for patchy reconnection (turbulence, instabilities)