The Onset of Magnetic Reconnection

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Background

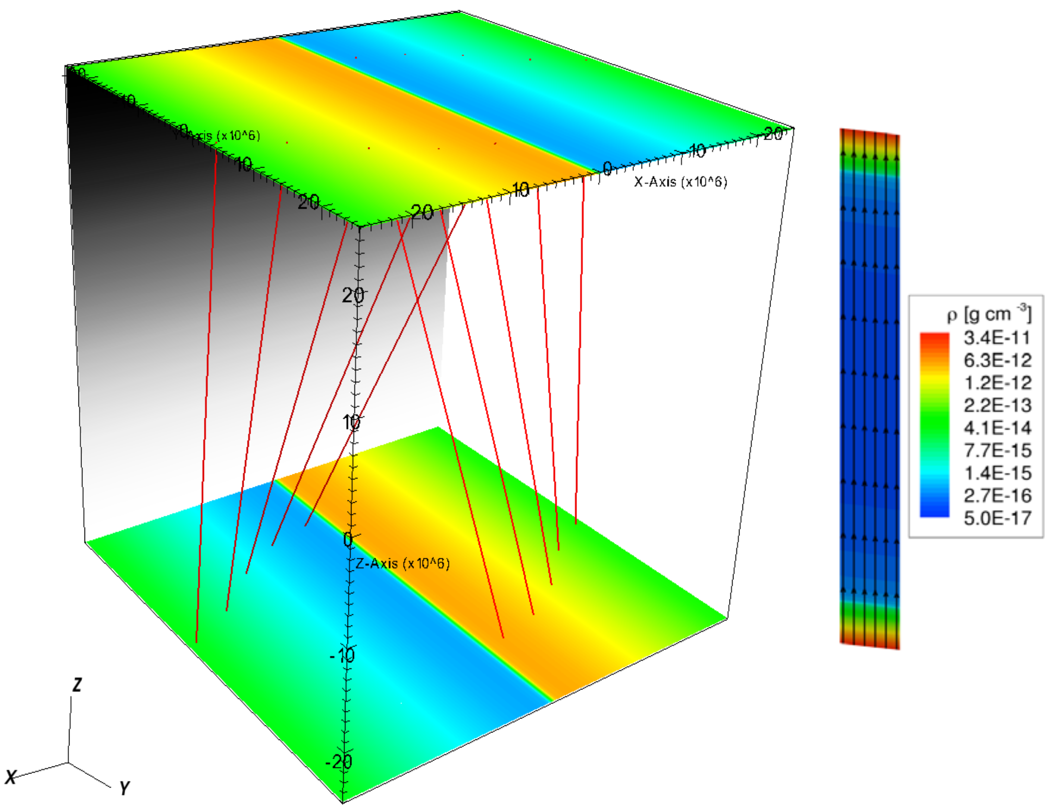
Traditional loop models (field-aligned hydro)
- Passive magnetic field
- Heating prescribed

3D MHD models
- Heating generated self consistently from equations
- Ohmic heating a proxy for the real heating mechanism
- Real mechanism involves spatial scales below the resolution

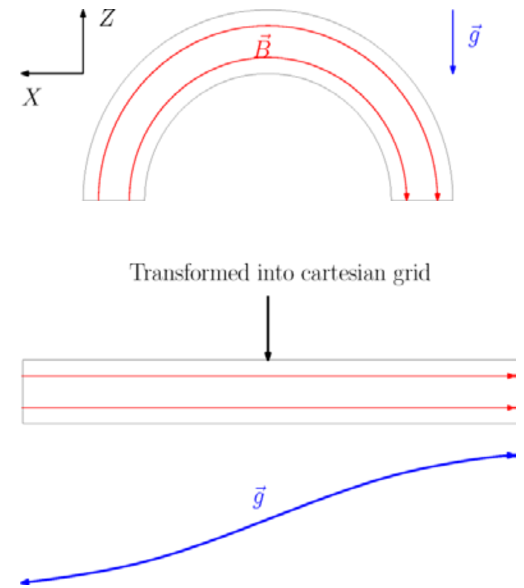
DC heating mechanisms must have a “switch on” property to allow stresses to build (coronal heating, flares, CMEs, jets, spicules)

What are the onset conditions for magnetic reconnection?

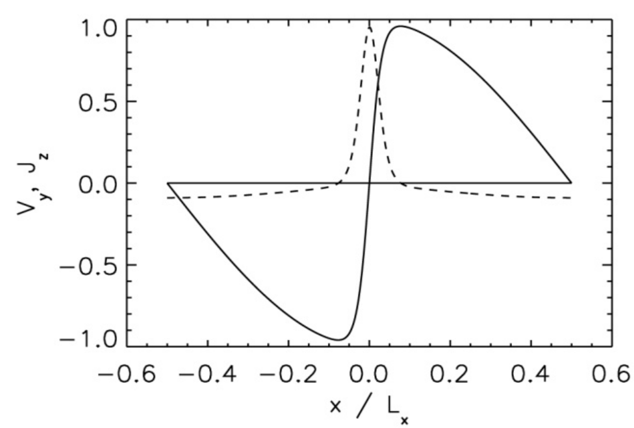
BATS-R-US Simulation



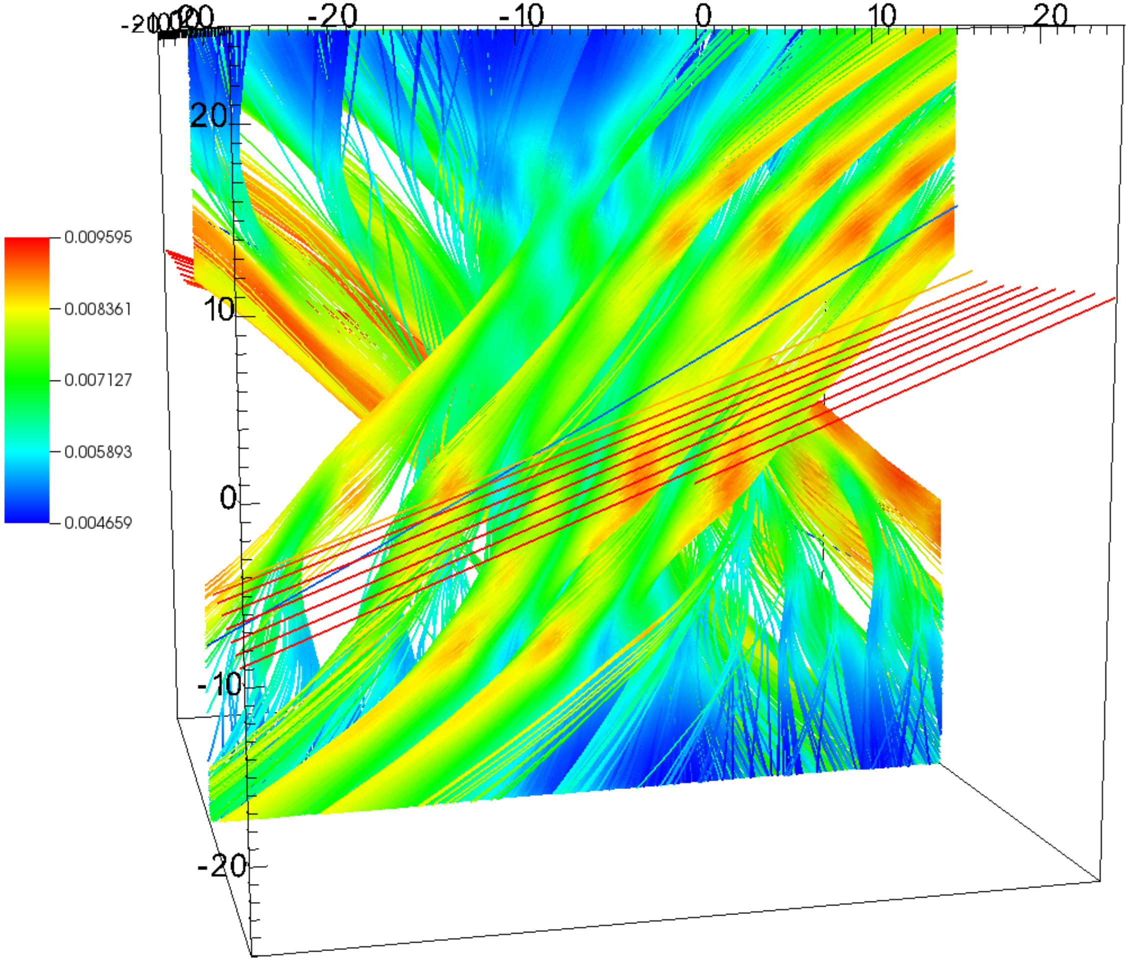
Gravity of a semi-circular loop



Shear profile



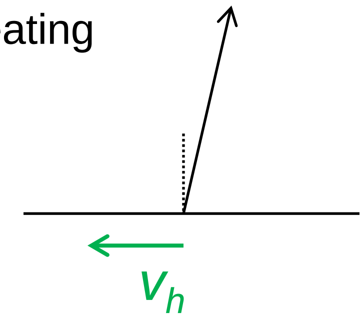
Field lines showing tearing flux tubes



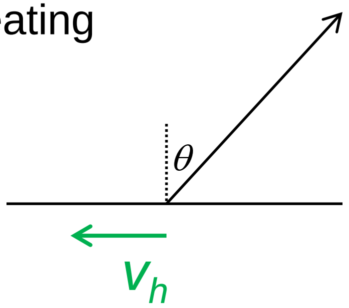
Poynting Flux and Heating Rate

Poynting flux: $$F = \frac{1}{4\pi} B_v^2 \; V_h \tan(\theta)$$

Small *F*
Weak heating

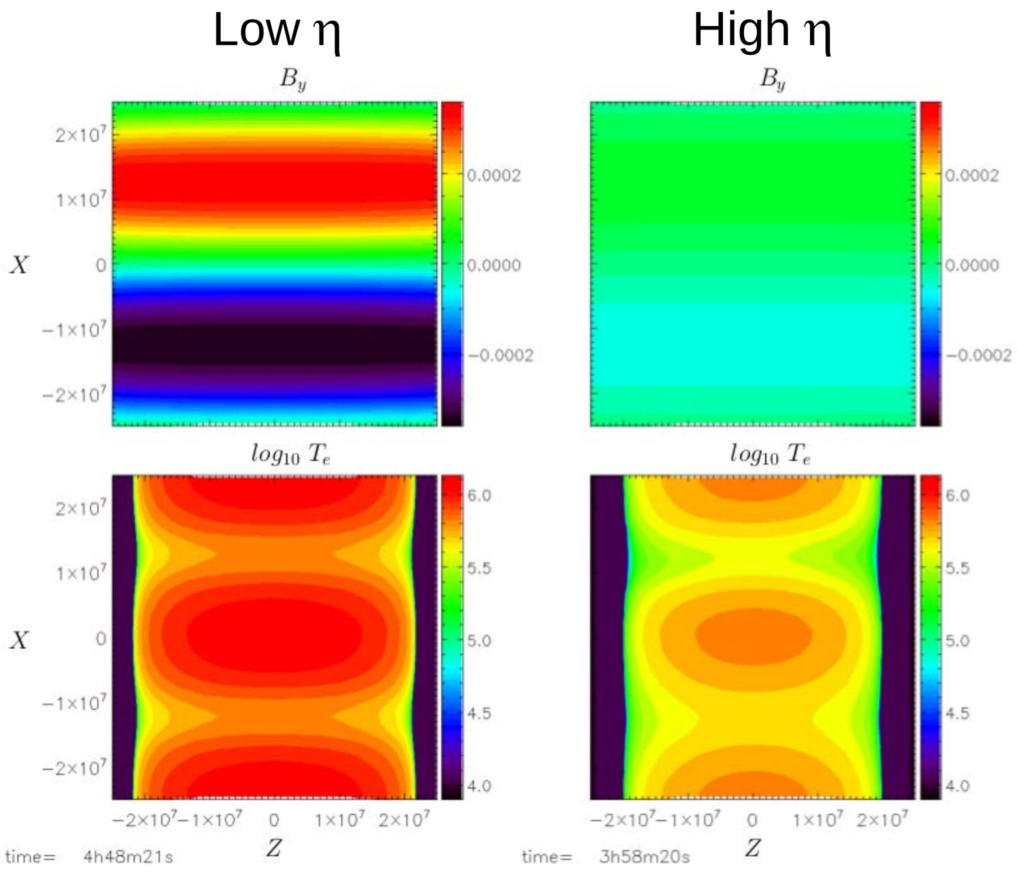


Large *F*
Strong heating



The heating rate depends on the tilt of the field (level of stress), which is determined by the heating mechanism.

Steady-State Ohmic Heating



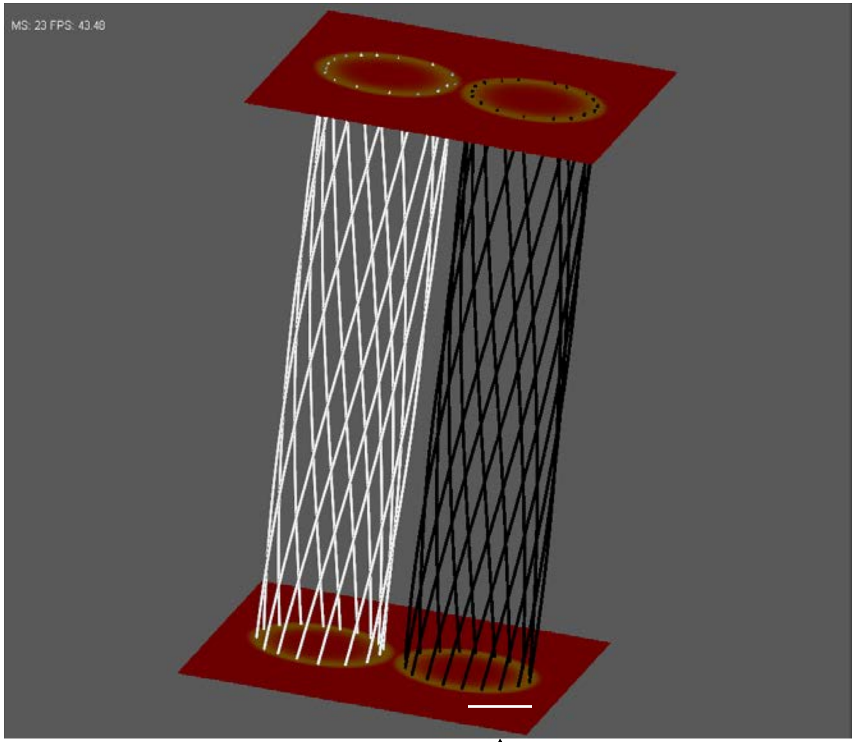
50 x 50 Mm^2
10 G
3 km/s

At 10 times higher resistivity:

Maximum tilt decreases from 20° to 3°

Mean apex temperature decreases from **1.1 to 0.6 MK**

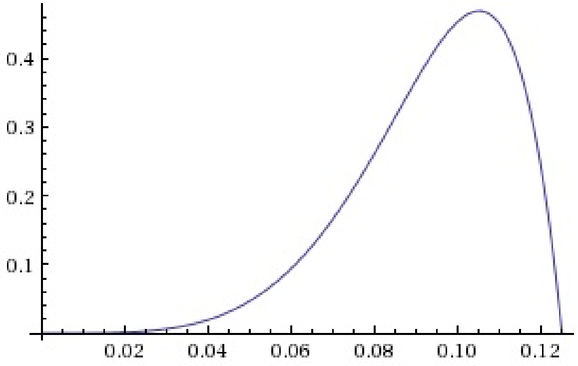
Two Twisted Flux Tubes



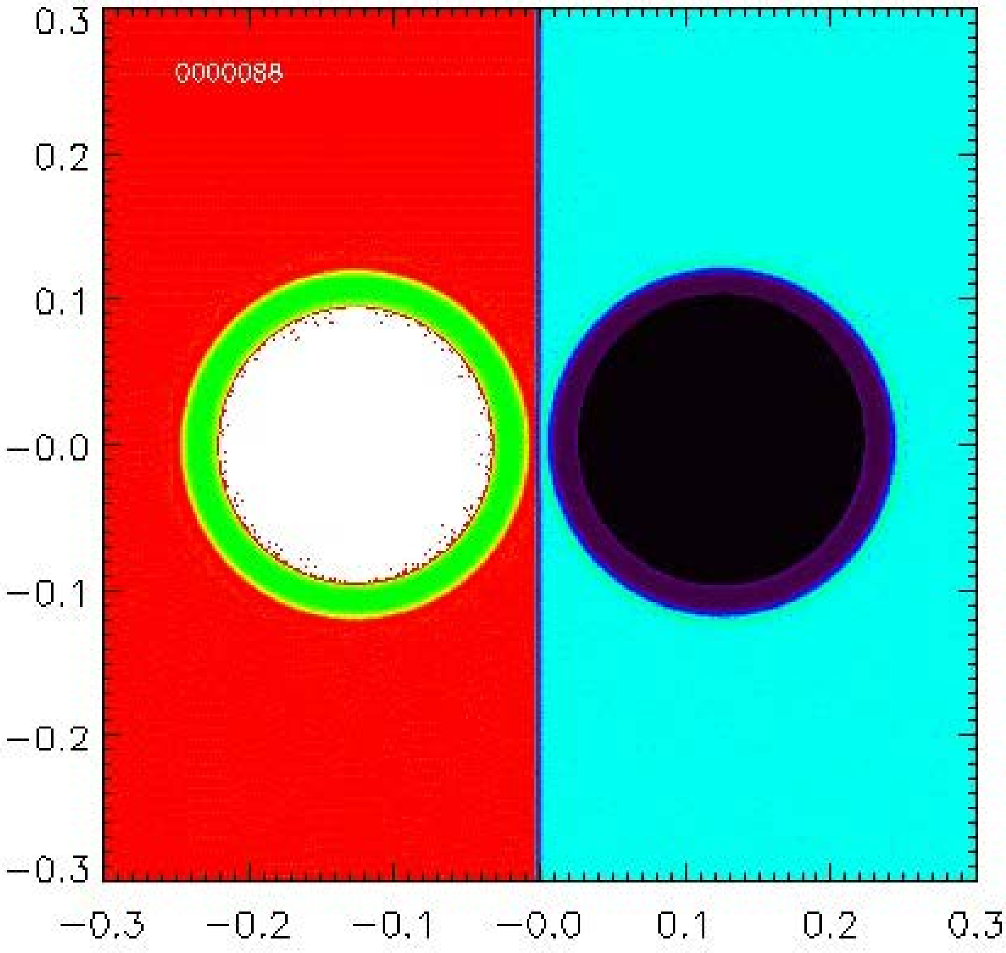
Knizhnik poster

ARMS Code
Twist annulus
Initially uniform low-β plasma

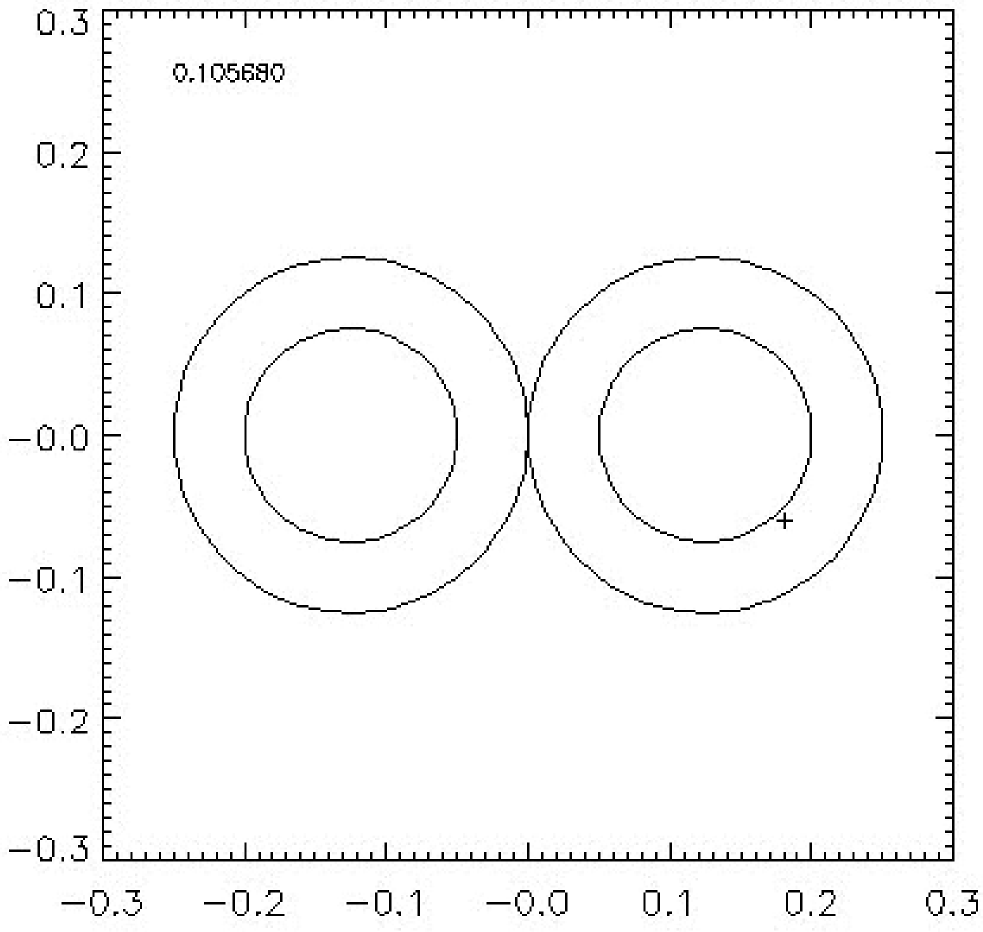
V_ϕ Twist Profile



Connectivity Map



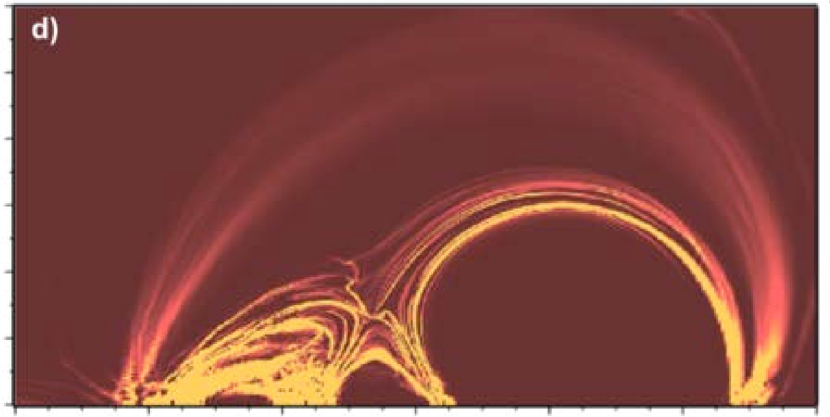
Connectivity Map
(single field line)



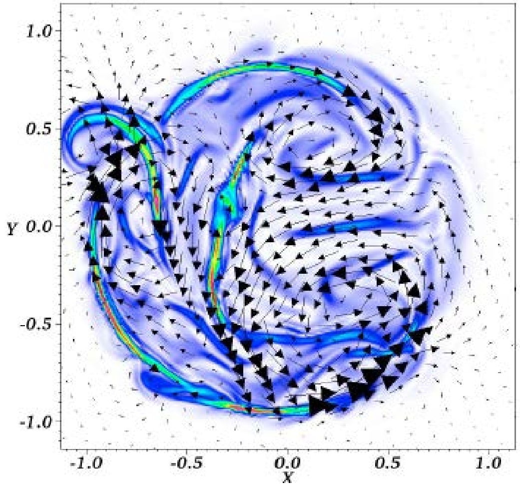
Black: bottom footpoint
Red: top footpoint

Proliferation of Current Sheets

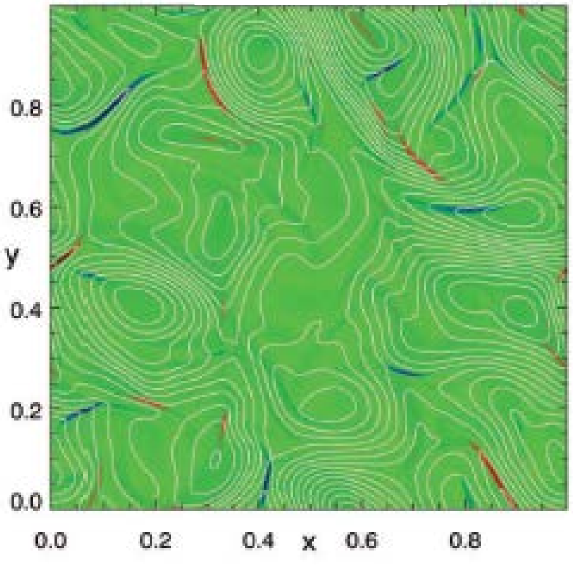
Karpen et al. (1996)



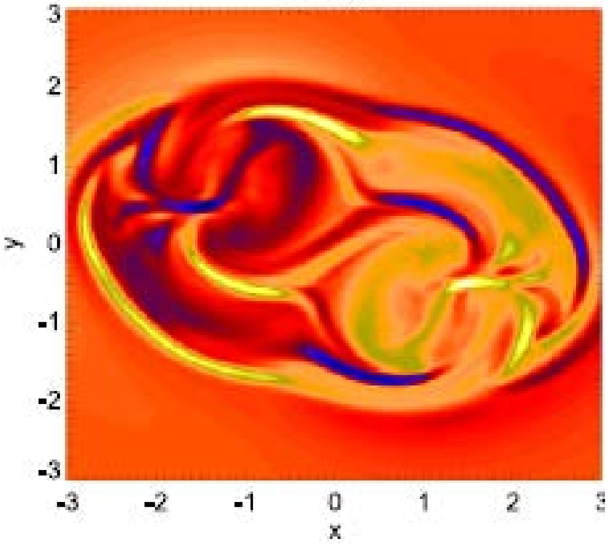
Hood et al. (2009)



Rappazzo et al. (2008)



Wilmot-Smith et al. (2011)



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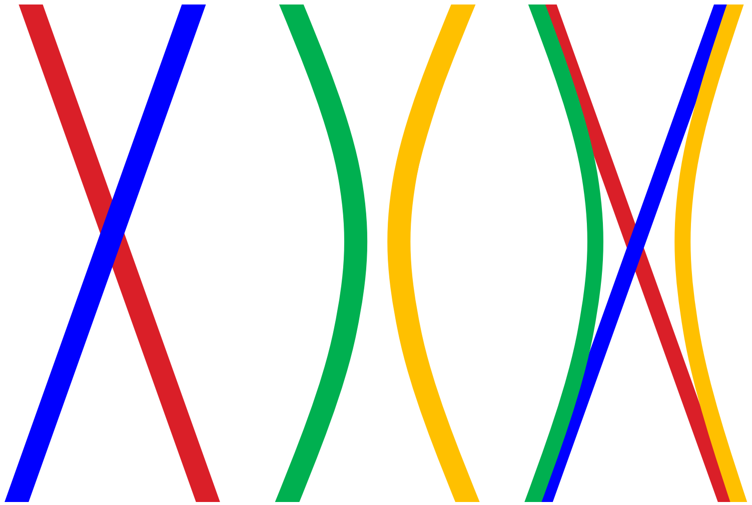

- Flux systems with different footpoint connectivity have current sheets at the separatrix boundaries between them.

- Partial reconnection leads to a doubling of the number of distinct flux systems.

- This produces a proliferation of current sheets when flows are present (due to footpoint driving or large-scale instability).

Summary

- The magnitude of coronal heating, as well as its temporal and spatial properties, depend on the mechanism of heating.

- There seems to be a fundamental tendency for current sheets to proliferate in number.

- Stay tuned for future results on the onset conditions for magnetic reconnection.