

Driven and Spontaneous Reconnection in MST

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Motivation

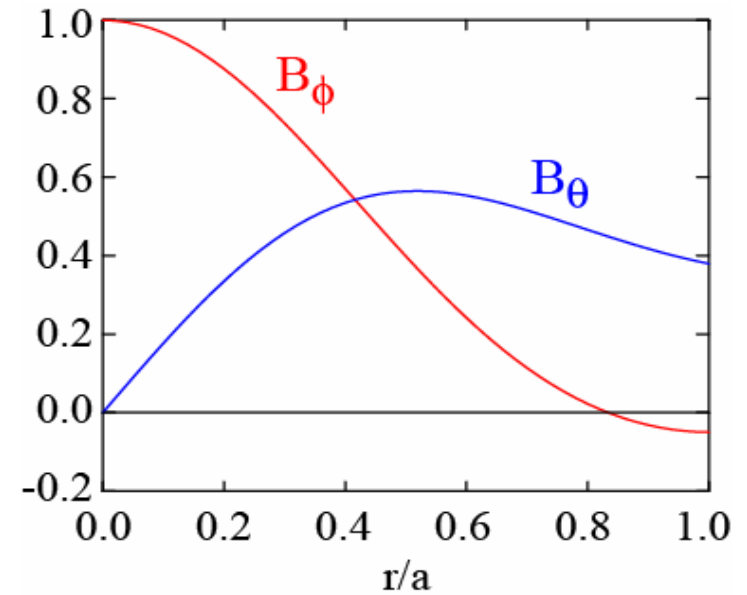
- In astrophysics, driven reconnection thought to dominate
- In lab, both spontaneous and driven reconnection can occur
- To what extent does it matter? What differences are there between the two types of reconnection?

Outline

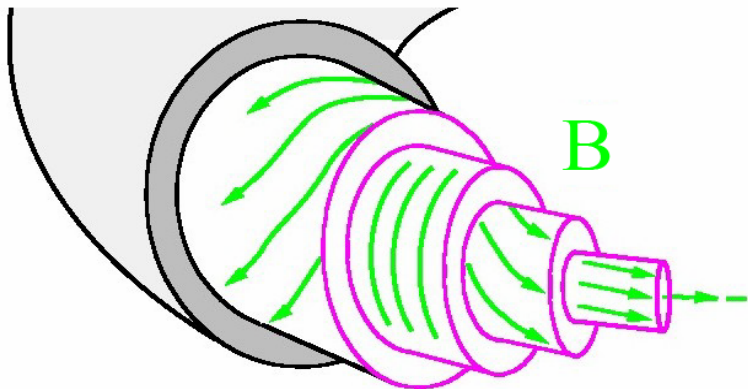
- Where and when does reconnection occur in MST?
- Recent measurement of driven reconnection
- Comparisons of spontaneous and driven reconnection

MST Parameters and Magnetic Structure

$R = 1.5 \text{ m}$ $n \sim 10^{19} \text{ m}^{-3}$
 $a = 0.52 \text{ m}$ $T_{e,i} \sim 300 \text{ eV}$
 $B \sim 0.2 \text{ T}$ $\beta \sim 10 \%$



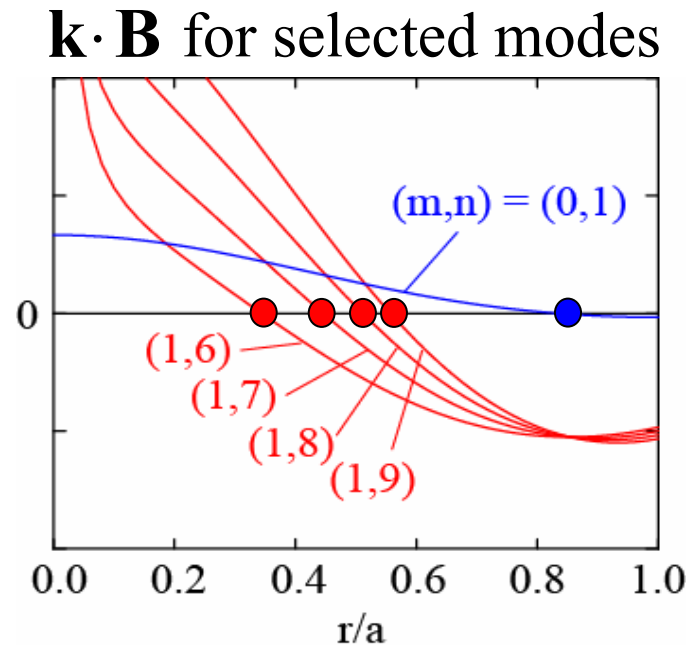
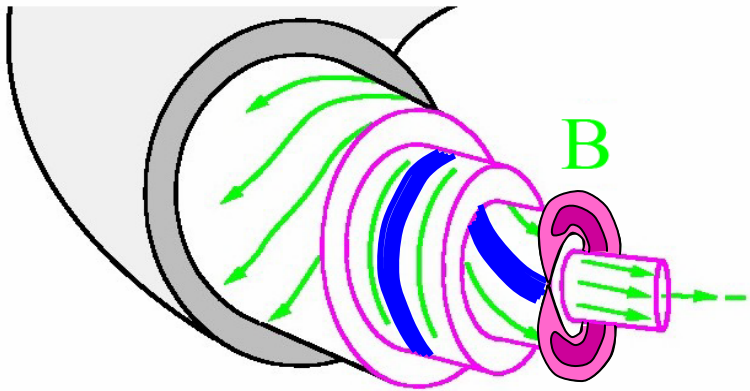
Reversed Field Pinch
Magnetic Topology



Where does reconnection happen in MST?

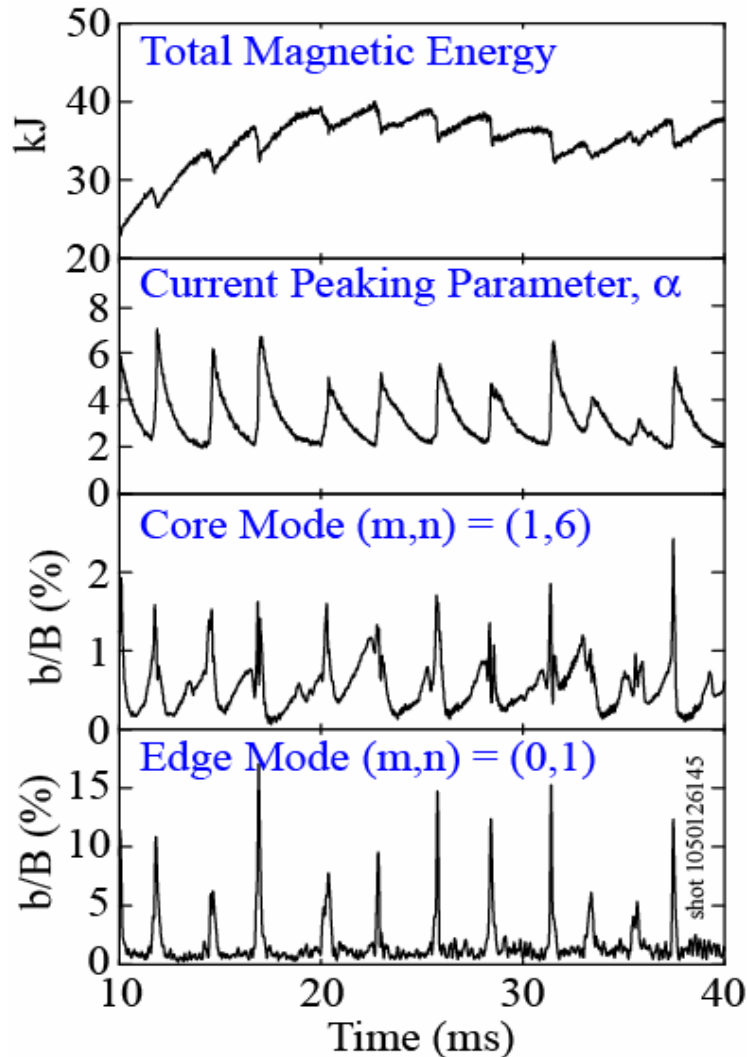
Reconnection occurs at many positions simultaneously, on helical strips aligned with B

- x-points of tearing modes with mode numbers (m,n)
- most significant for small m and n (long wavelength)
- concentrated at radii where $\mathbf{k} \cdot \mathbf{B} = 0$



When does reconnection happen in MST?

Reconnection happens primarily in bursty events associated with a “sawtooth cycle”



- Magnetic energy builds slowly and is released quickly
- Current profile peaks slowly and is flattened quickly

$$\frac{J_{\parallel}}{B} \sim 1 - \left(\frac{r}{a}\right)^{\alpha}$$

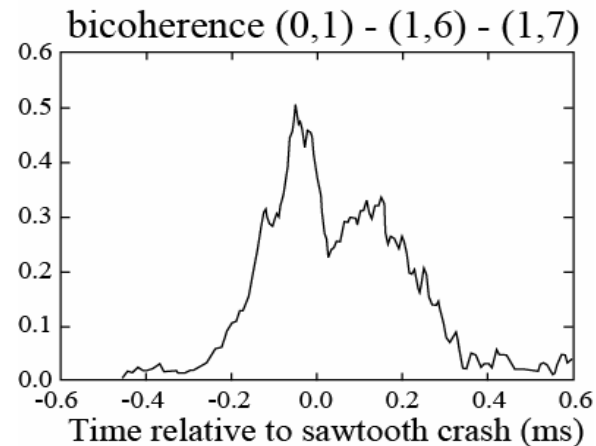
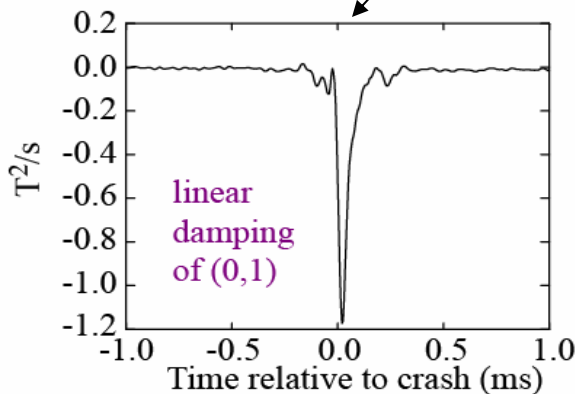
- Core modes excited by evolution of current profile
→ spontaneous reconnection
- Edge modes *not* excited by evolution of current profile
→ driven reconnection

Growth of m=0 modes appears to be the result of driven reconnection

MHD equation for evolution of mode k:

$$\frac{\partial |\mathbf{b}_k|^2}{\partial t} = \nabla \times (\mathbf{v}_k \times \mathbf{B}_0) \cdot \mathbf{b}_k^* + C.C. + \text{nonlinear} + \text{dissipation}$$

linear driving (if +) or damping (if -)



Most likely conclusion is that the (0,1) mode is nonlinearly driven.
 (This is consistent with MHD computation.)
 Implies the m=0 reconnection is forced by coupling of m=1 modes

How do spatial scales of spontaneous and driven reconnection compare?

They are similar and comparable to c/ω_i or island width

$$\rho_e \sim 0.01 \text{ cm}$$

$$r_{S-P} \sim c/\omega_{pe} \sim 0.2 \text{ cm}$$

$$\rho_i \sim 0.5 \text{ cm}$$

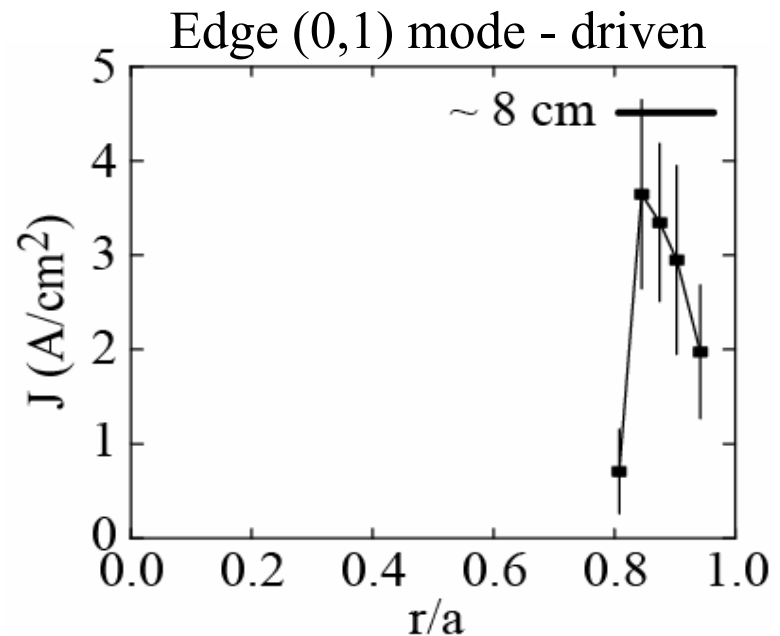
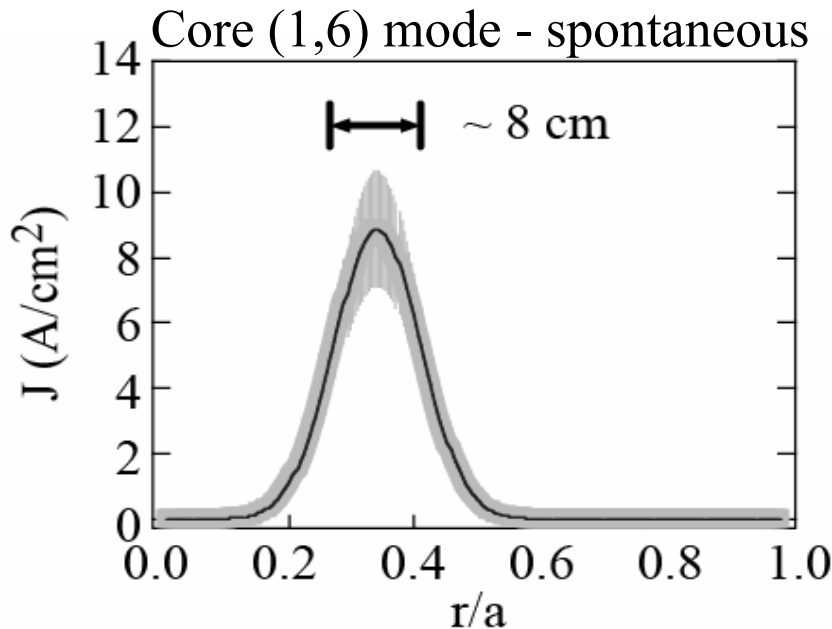
$$c/\omega_{pi} \sim W_{\text{island}} \sim 10 \text{ cm}$$

$$\rho_e \sim 0.02 \text{ cm}$$

$$r_{S-P} \sim c/\omega_{pe} \sim 0.5 \text{ cm}$$

$$\rho_i \sim 1.5 \text{ cm}$$

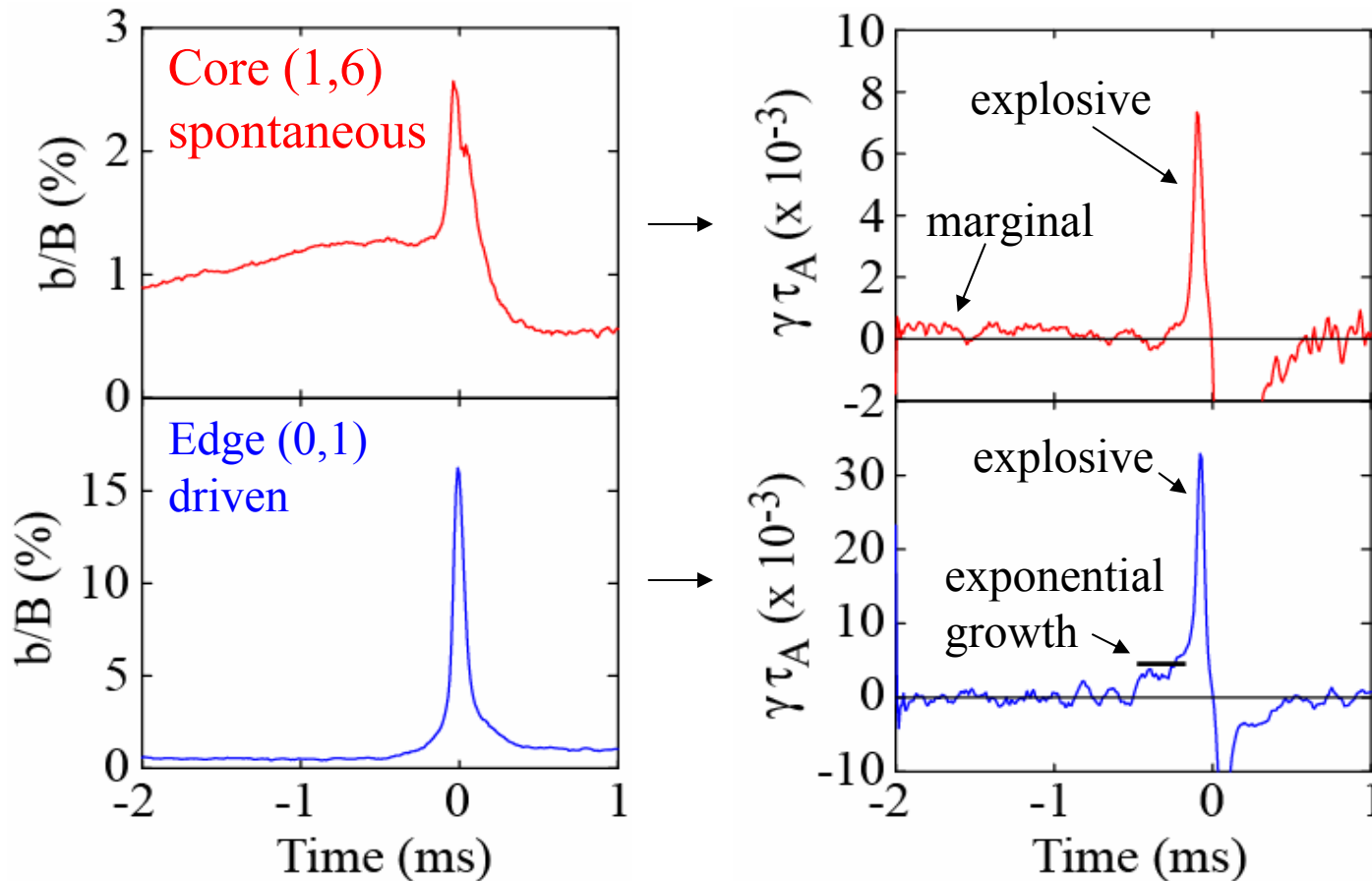
$$c/\omega_{pi} \sim W_{\text{island}} \sim 10-15 \text{ cm}$$



How do rates of spontaneous and driven reconnection compare?

How to define reconnection rate?

→ Use time rate of change of mode amplitude $\gamma = \frac{1}{b} \frac{\partial b}{\partial t}$



Both show an explosive character

Driven reconnection appears faster

Summary

- Reconnection in MST occurs at many spatial locations and has a bursty time behavior
- Both spontaneous and driven reconnection are present
- The spatial scales of spontaneous and driven reconnection are similar in MST
- The rate of reconnection for both types shows an explosive character – driven has a somewhat higher rate
- Still many questions:
 - What is the general way to measure the reconnection rate?
 - Should spontaneous and driven reconnection be different?
 - How is rate of change of magnetic energy related to the local reconnection rate?