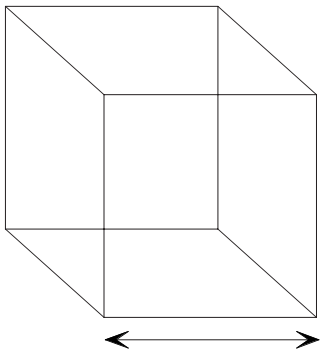
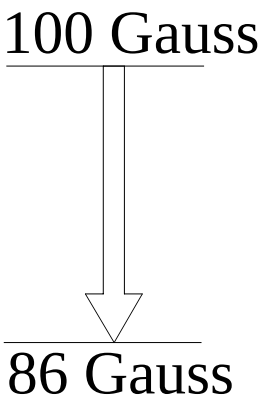
Sheared Magnetic Fields & Solar Eruptions

Energetics:

Observed: $W_{flare} \approx 10^{32}$ ergs



$L = 10^5$ km



$\Delta B = 14$ Gauss

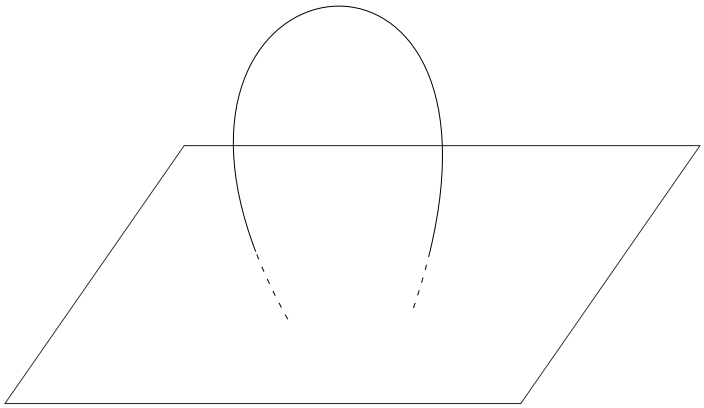
$L = 2 \times 10^5$ km

$\Delta B = 2$ Gauss

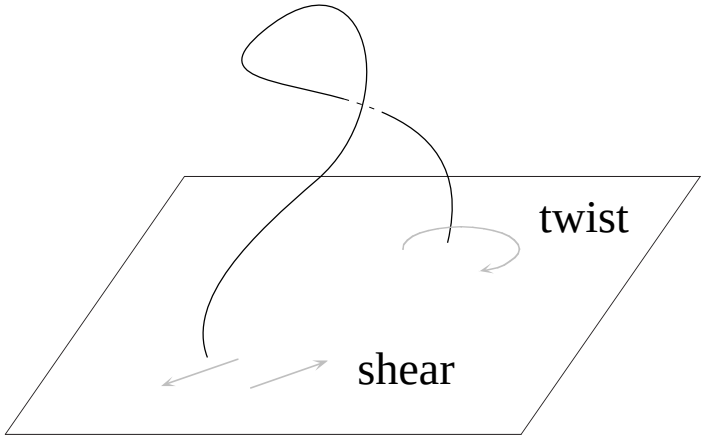
Creation of Coronal Currents

Scenario 1

Start with current-free field:



Photospheric motions stress field:

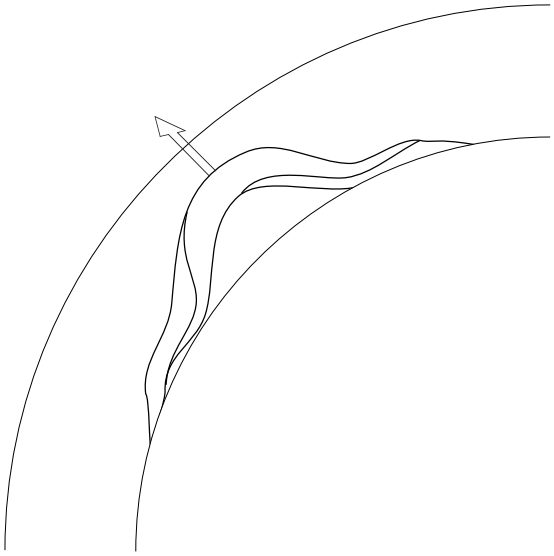


field remains close to force-free until eruption

Creation of Coronal Currents

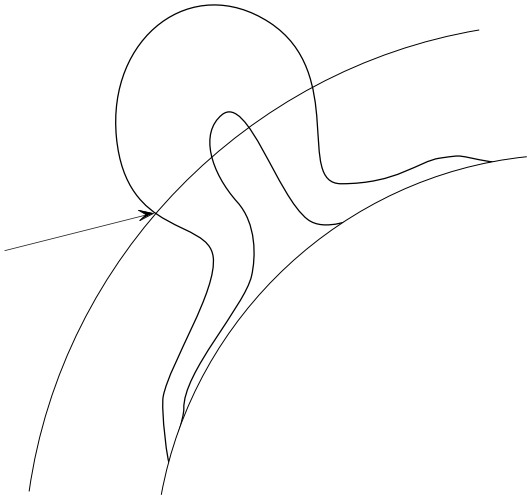
Scenario 2

Stress field in convection zone

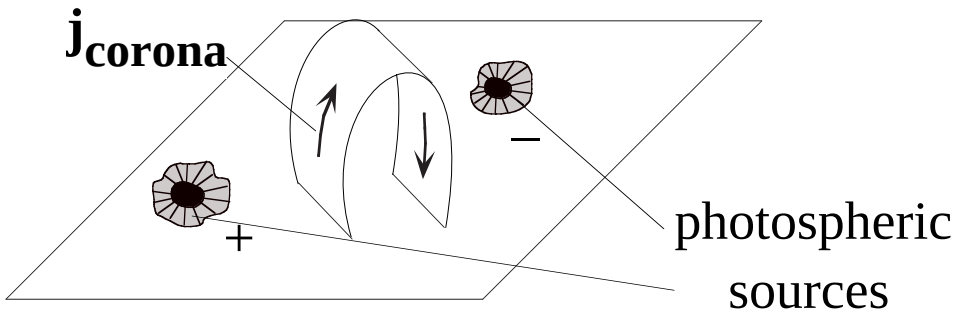


Emerge field into corona

Field evolves to force-free state during emergence



How Much Energy is Available?

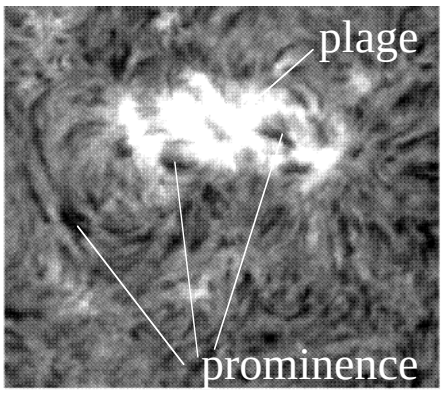


$$\mathbf{B} = \mathbf{B}_{\mathbf{photospheric\ currents}} + \mathbf{B}_{\mathbf{coronal\ currents}}$$

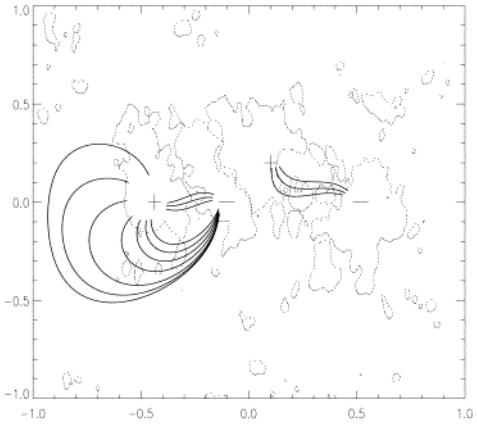
invariant during flare

source of flare energy

Hα image



model with magnetogram

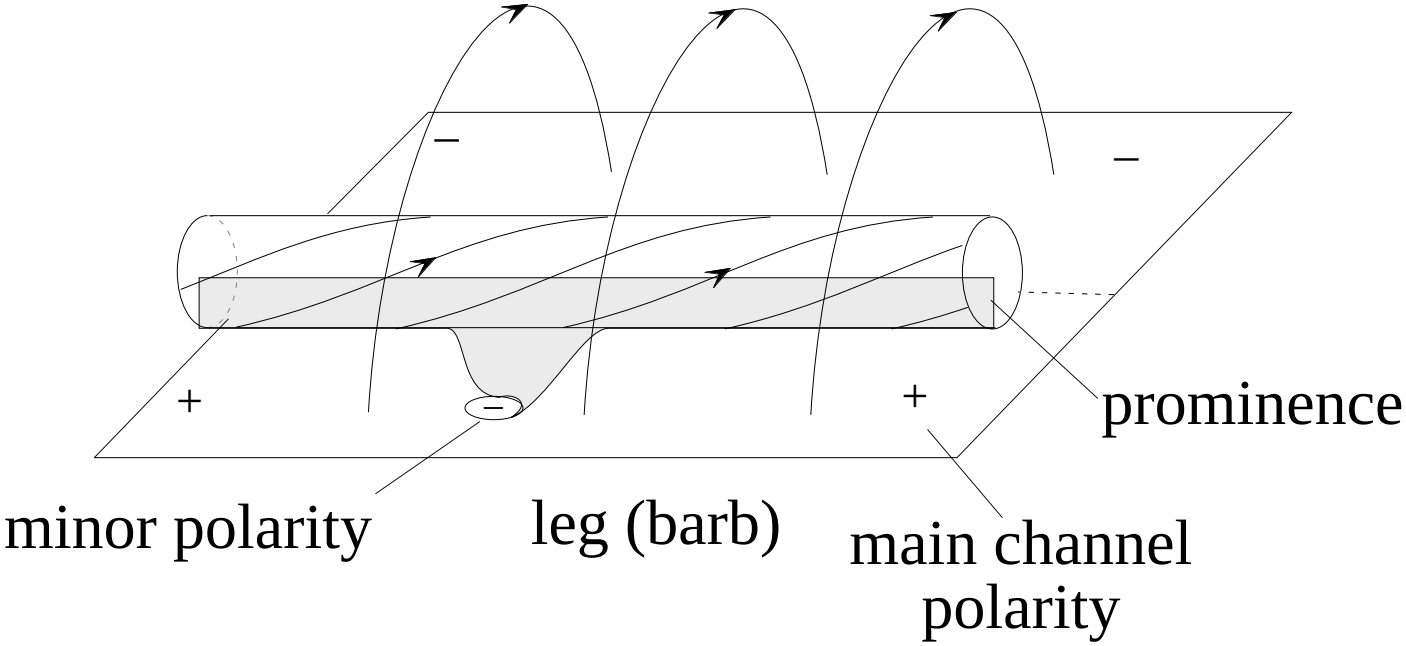


from Gaizauskas & Mackay (1997)

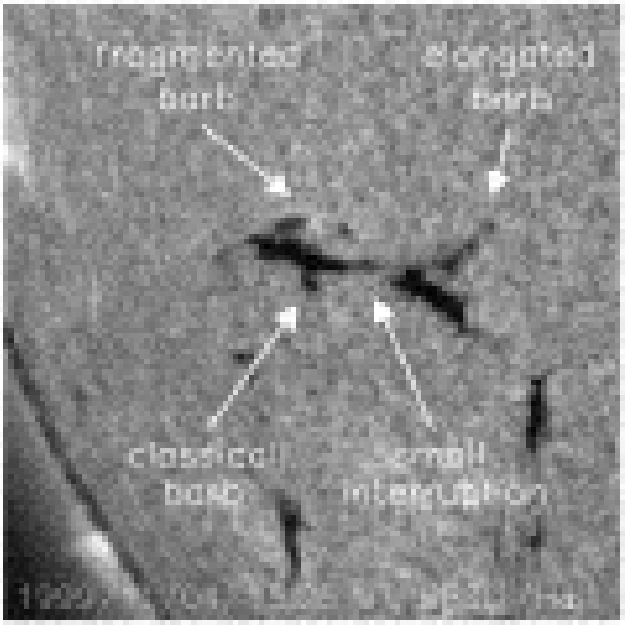
$$B_{corona} \approx B_{photosphere}$$

free magnetic energy ≈ 30% of total magnetic energy

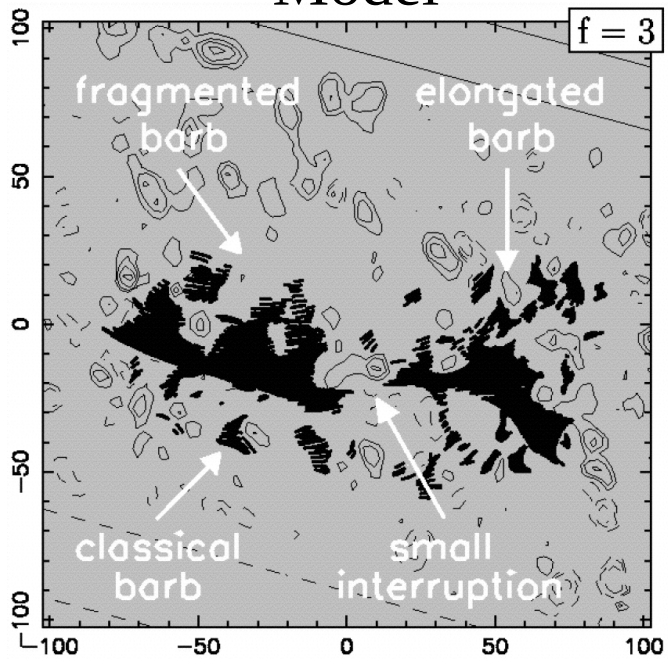
Flux-Rope Model of Prominences



Observed



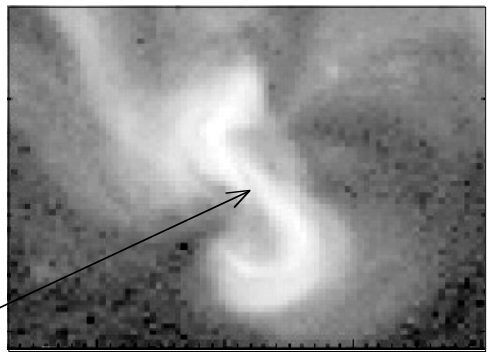
Model



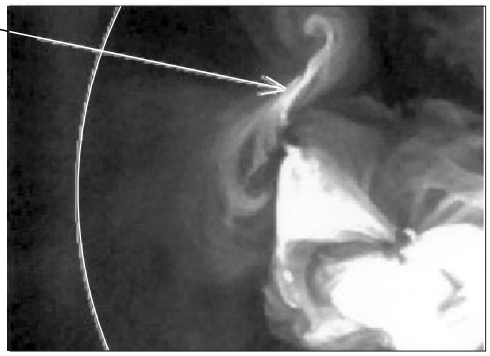
from Martin et al. (2000)

X-Ray Sigmoids Observed by *Yohkoh*

sigmoids

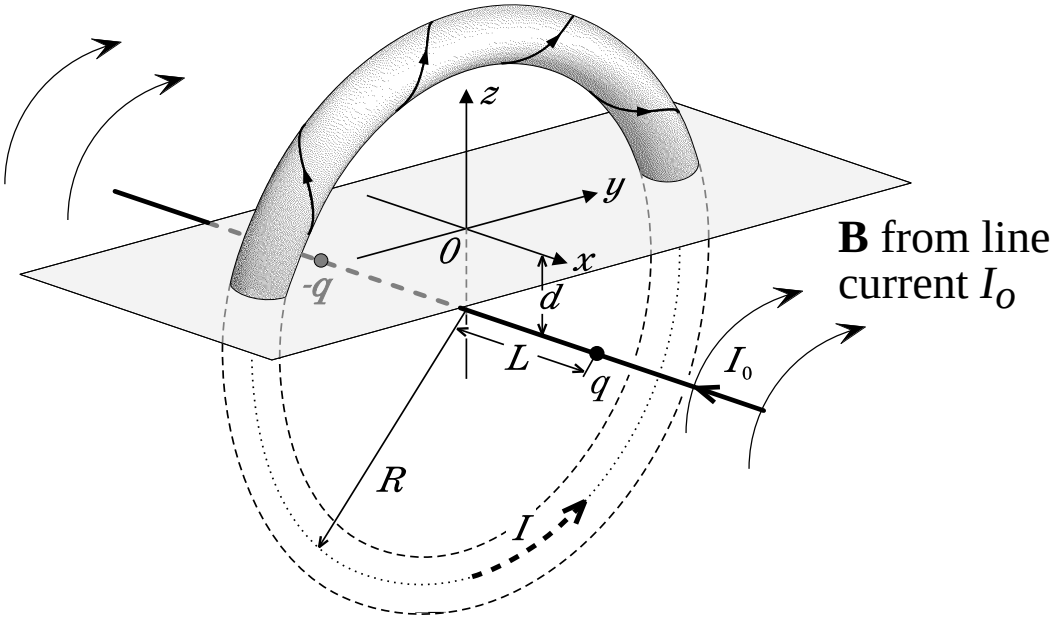


from Sterling et al. 2000

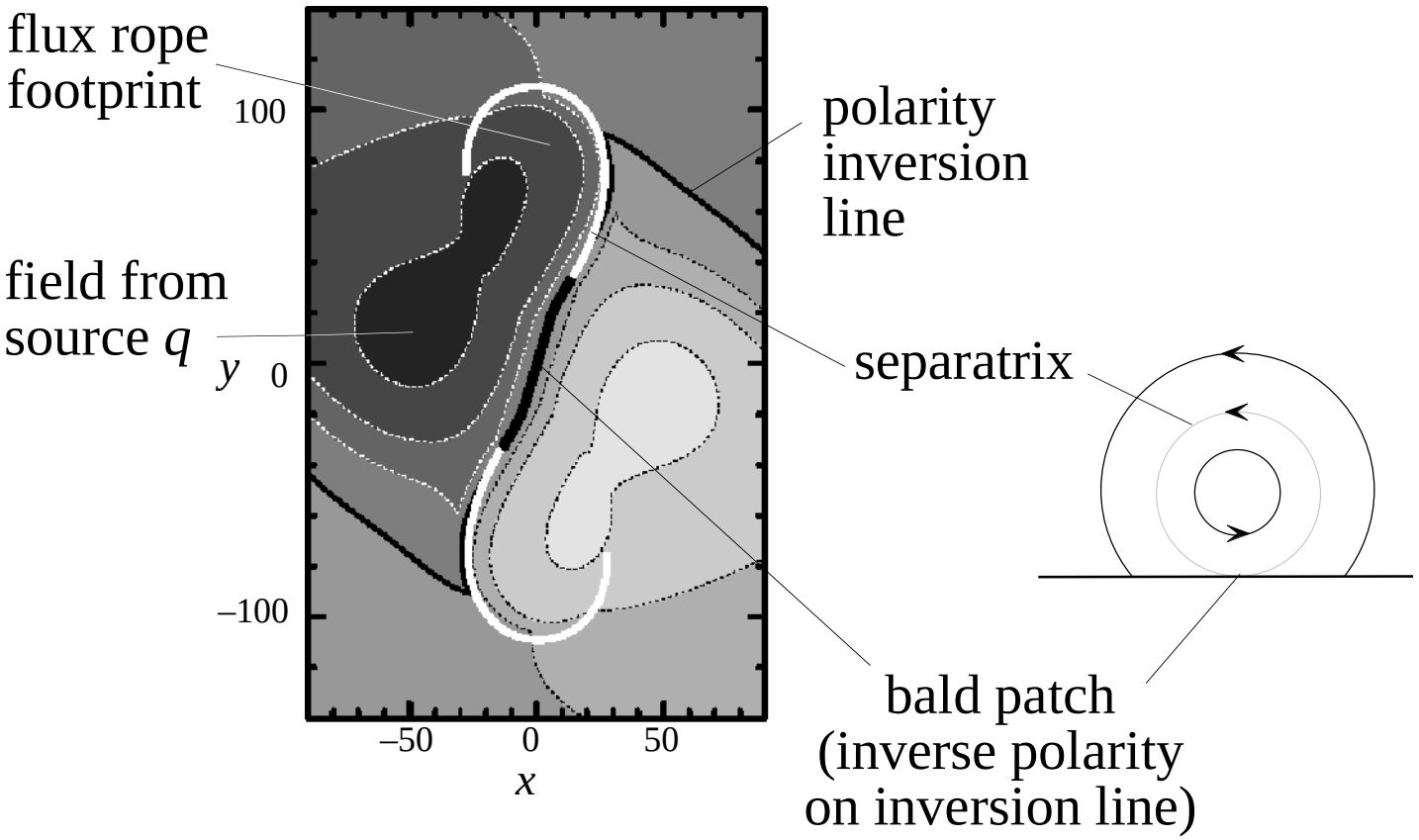


from Rust & Kumar 1996

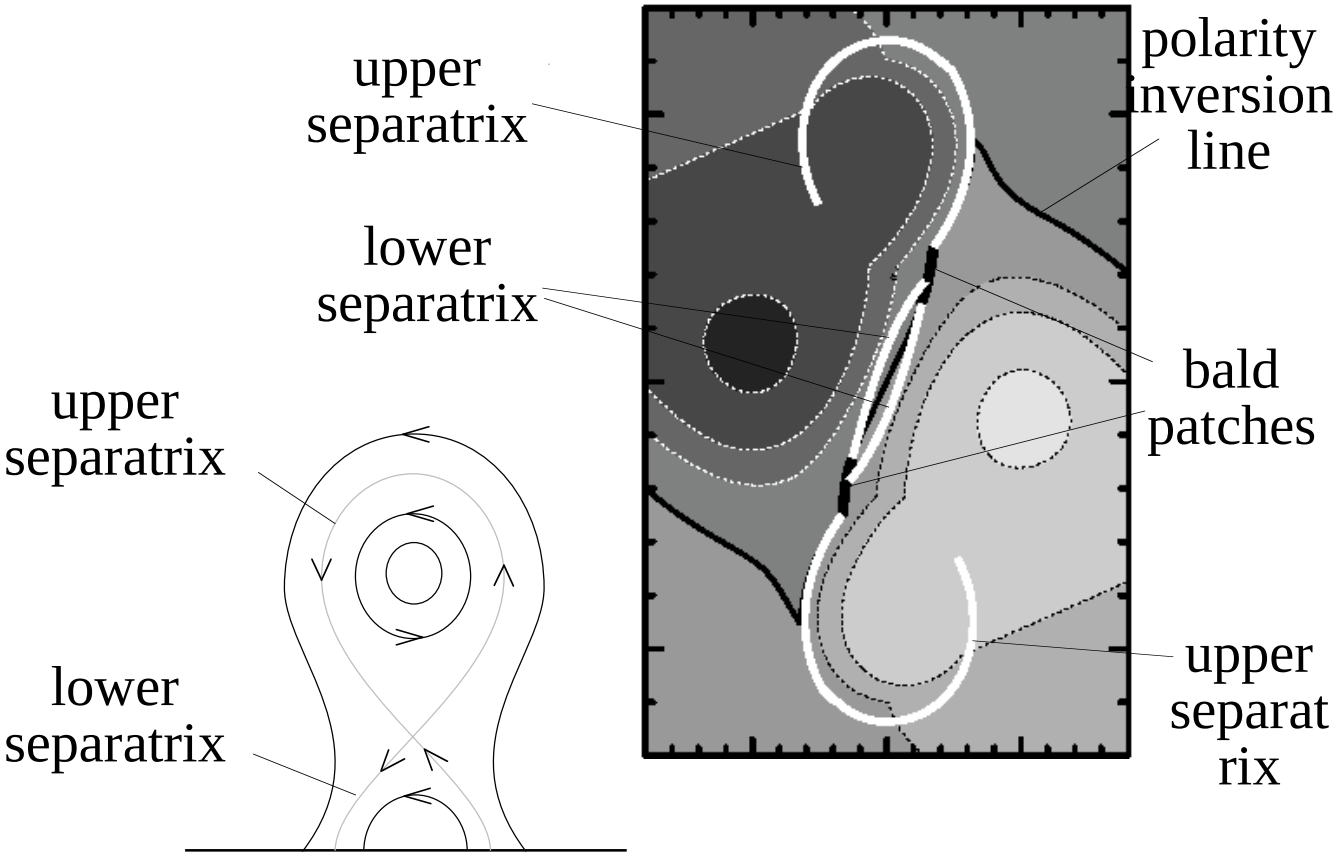
3D Flux Rope Model (Titov & Démoulin 1999)



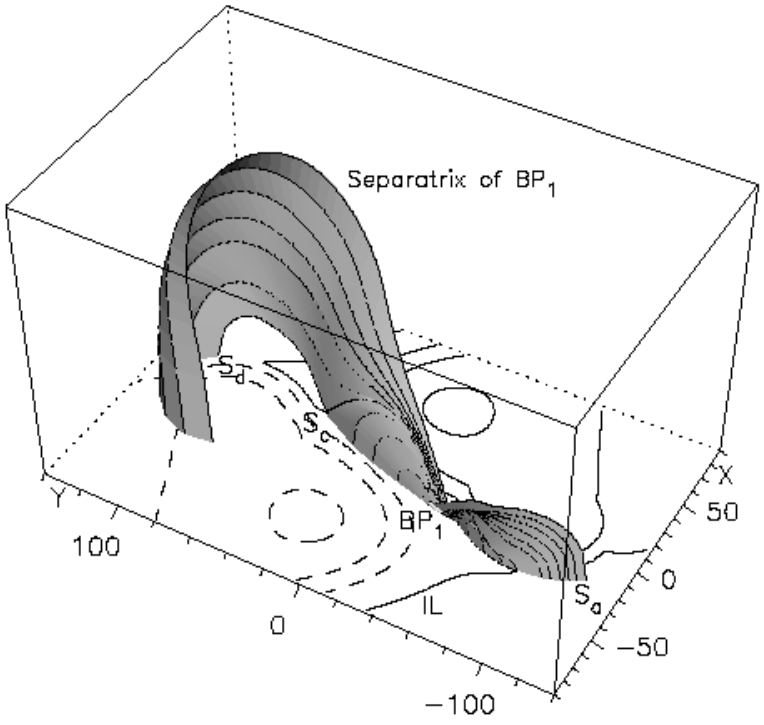
Photospheric Field Topology



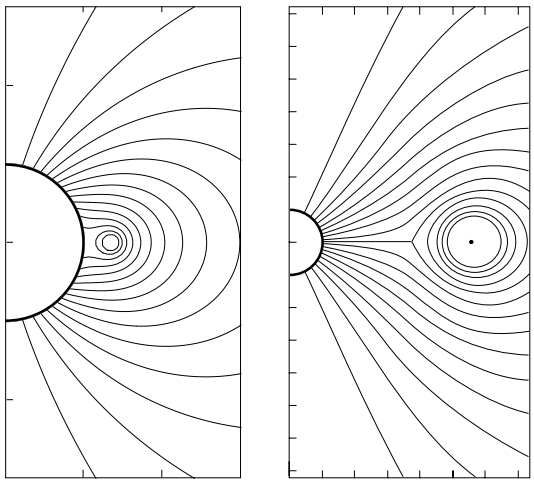
Flux Rope Model at Higher Altitudes



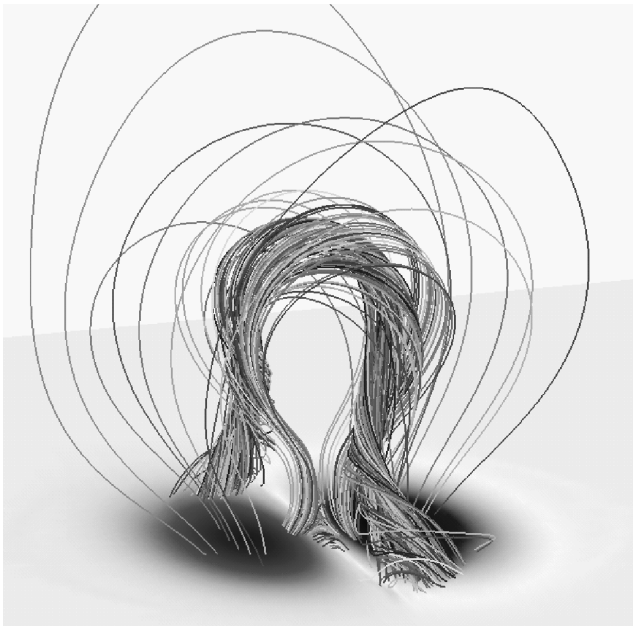
3D Structure of Separatrices



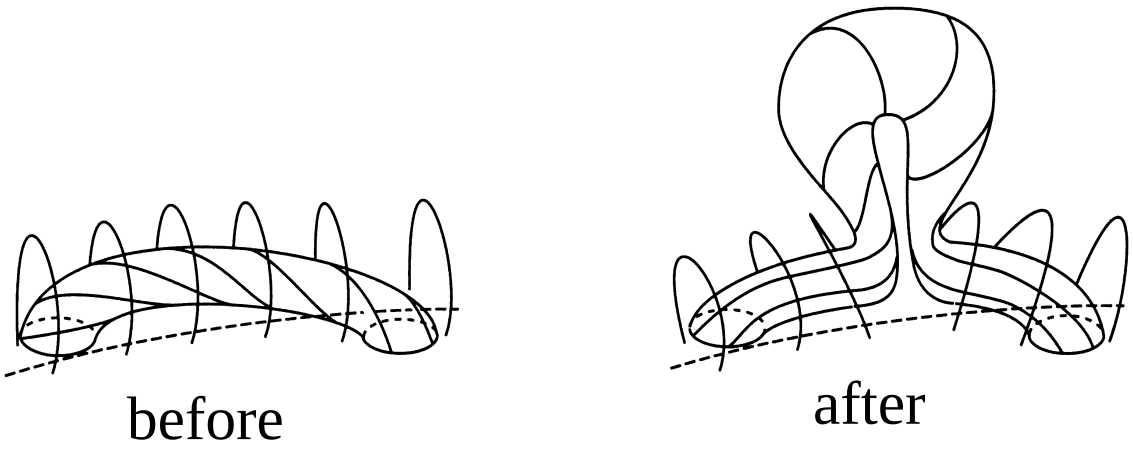
What are Conditions for Eruption?



Lin et al. (1998)



Amari et al. (2000)



Sturrock et al. (2001)

Some Unanswered Questions

1. Are structures emerging from the convection zone into the corona flux ropes?

2. What happens to the current upon emergence?

3. What is the pre-onset field configuration?

4. What are the mechanism(s) and conditions for eruption?