What determines CME velocities ?

Apparently many important (partly related) parameters, e.g.:

- size, complexity, and strength of source region
- available free magnetic energy
- magnitude of accompanying flare
- length and number of PILs
- others ?

One important parameter: overlying (ambient) coronal field

Role of overlying field for CME velocities: 1.) morphology

TABLE 1

STATISTICAL PROPERTIES OF THE 99 HALO CMEs FROM 2000 TO 2004

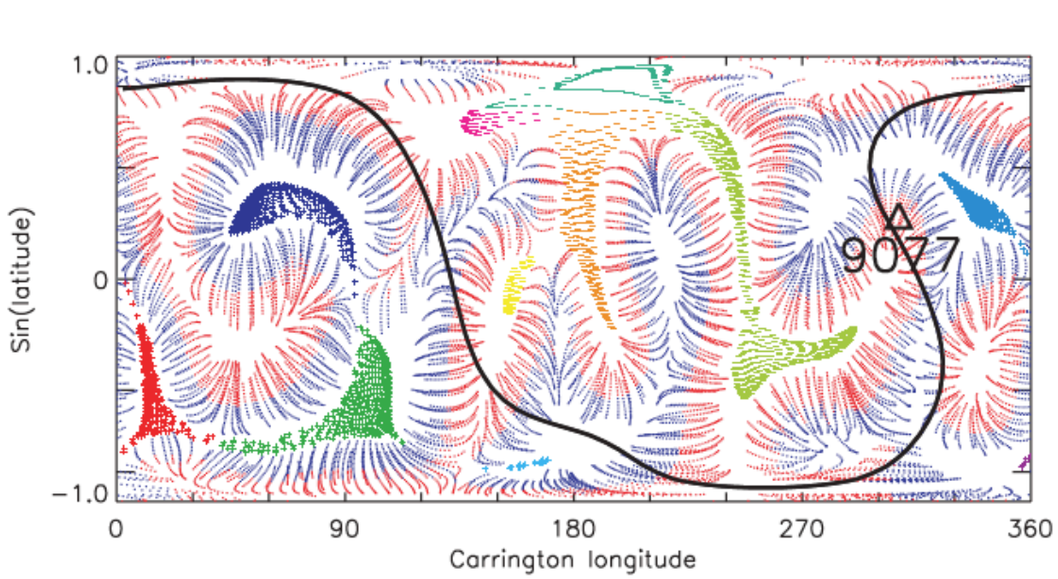
Parameter	Type 1	Type 2	Type 3
Number	39	46	14
Percentage	39%	47%	14%
Median speed (km s^{-1})	728	1208	1443
Mean speed (km s^{-1})	883 ± 403	1345 ± 596	1530 ± 736

Liu Y. (2007)

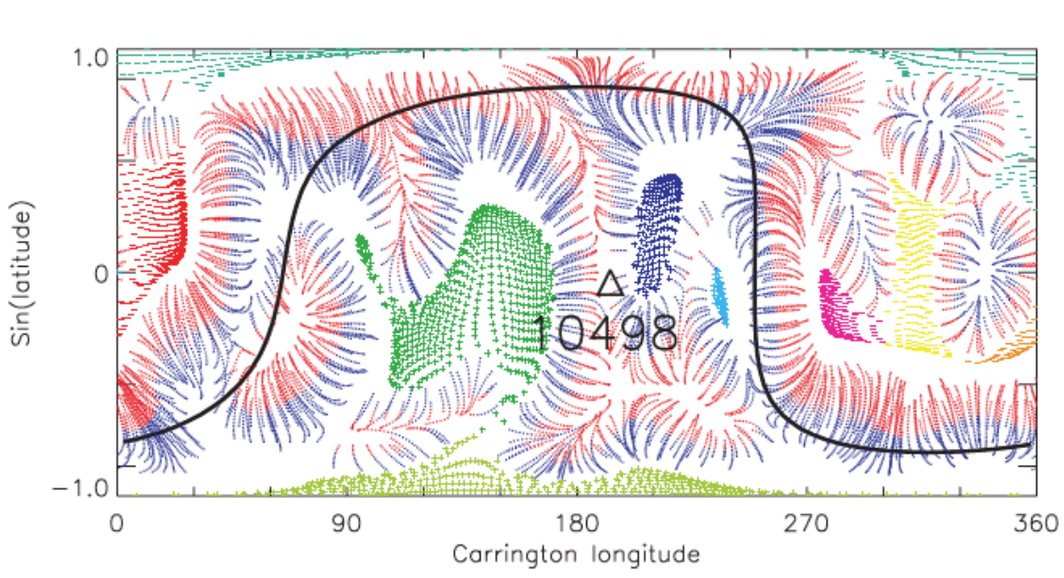
Type 1: below HCS

Type 2: close to open field region

Type 3: below Pseudo-streamer



2000 July 14 (Type 1)

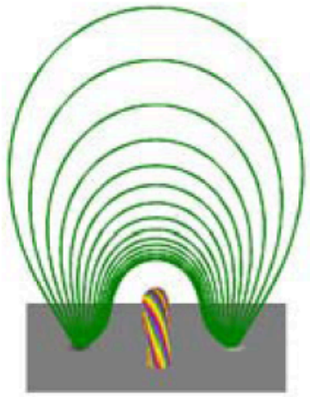


2003 Nov 11 (Type 3)

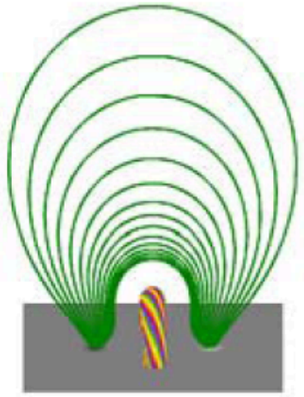
Eruption within or close to Pseudo-streamer or "open" field → fast CME

Role of overlying field for CME velocities: 2.) decay index

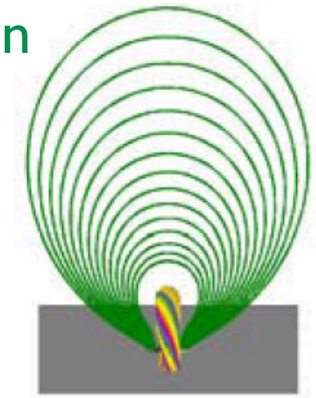
red



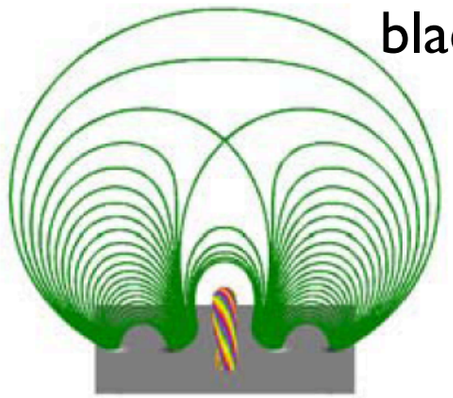
blue



green

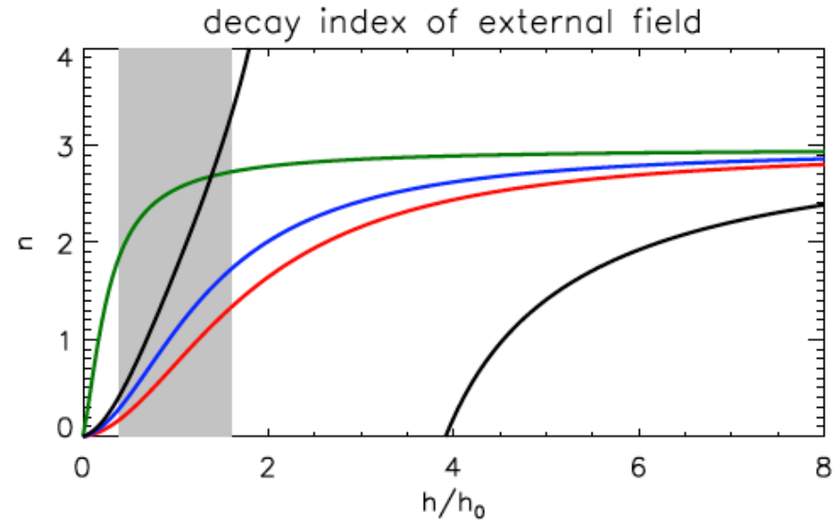


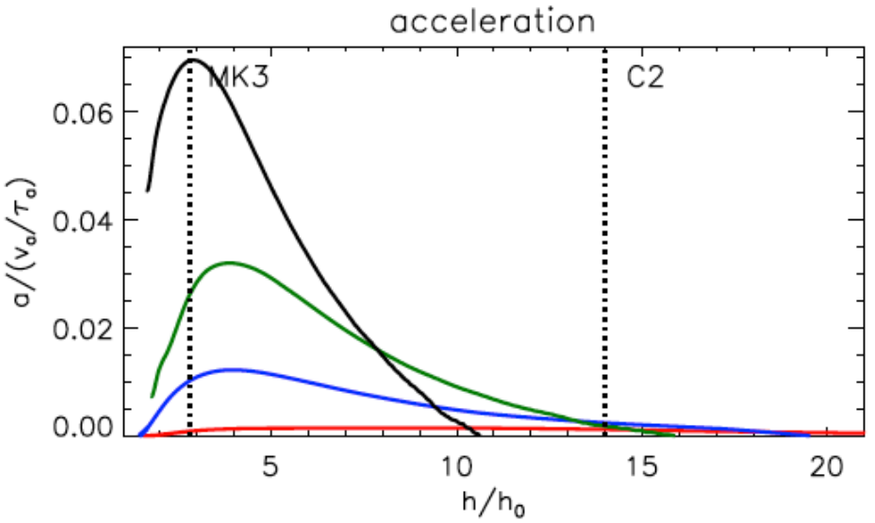
black

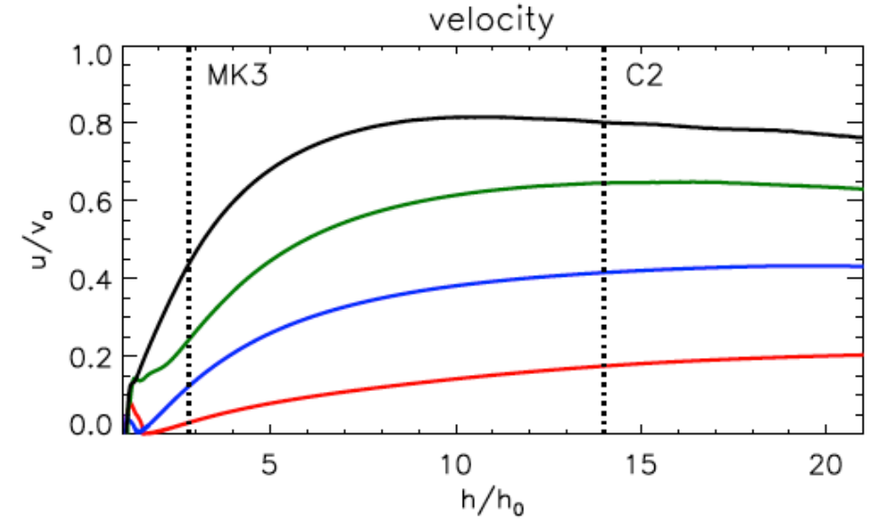


Török & Kliem (2007)

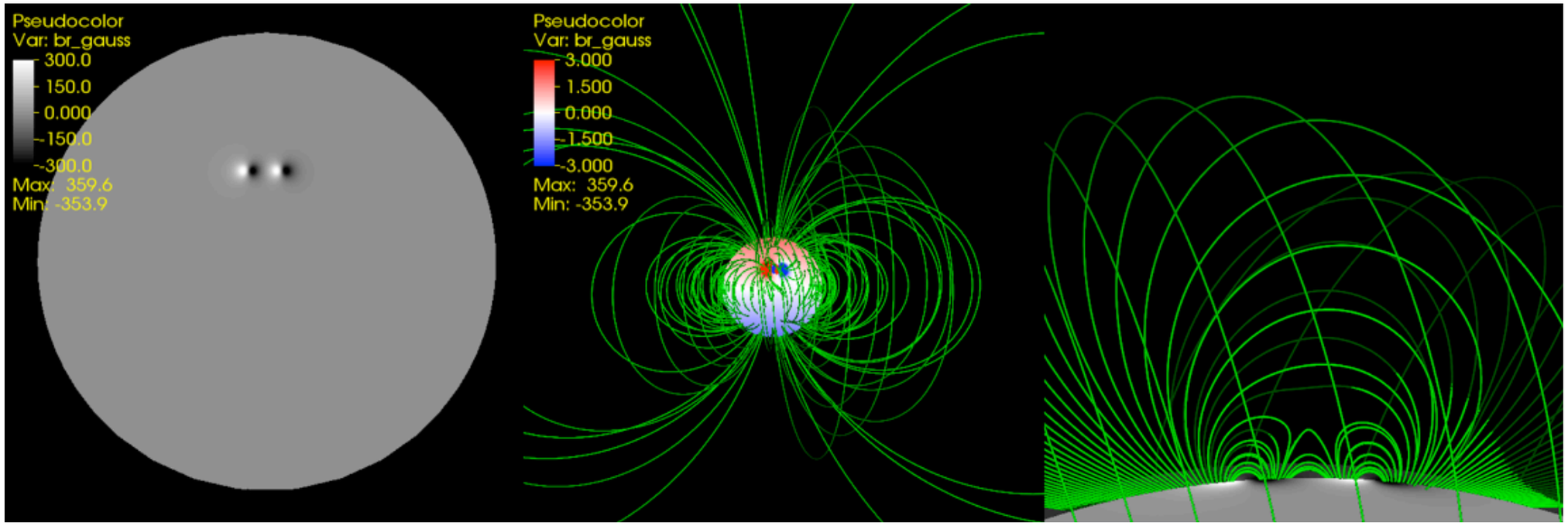
Strong decay of external field → fast CME



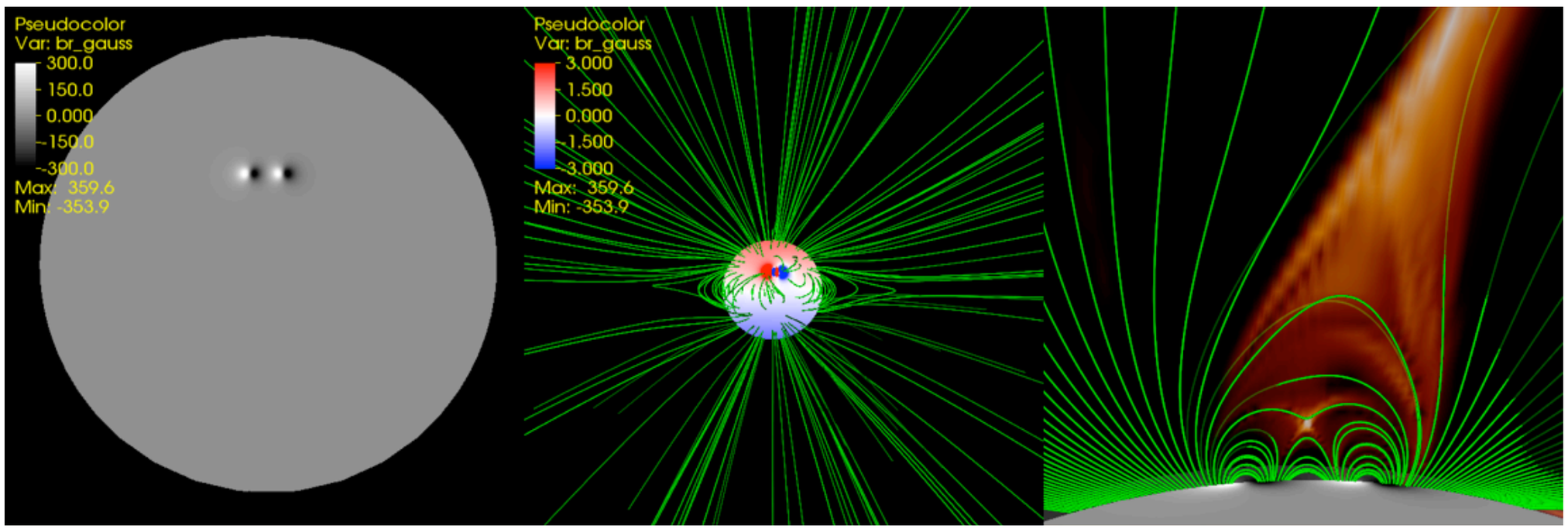




Modeling a fast CME: initial field & full MHD solar wind relaxation

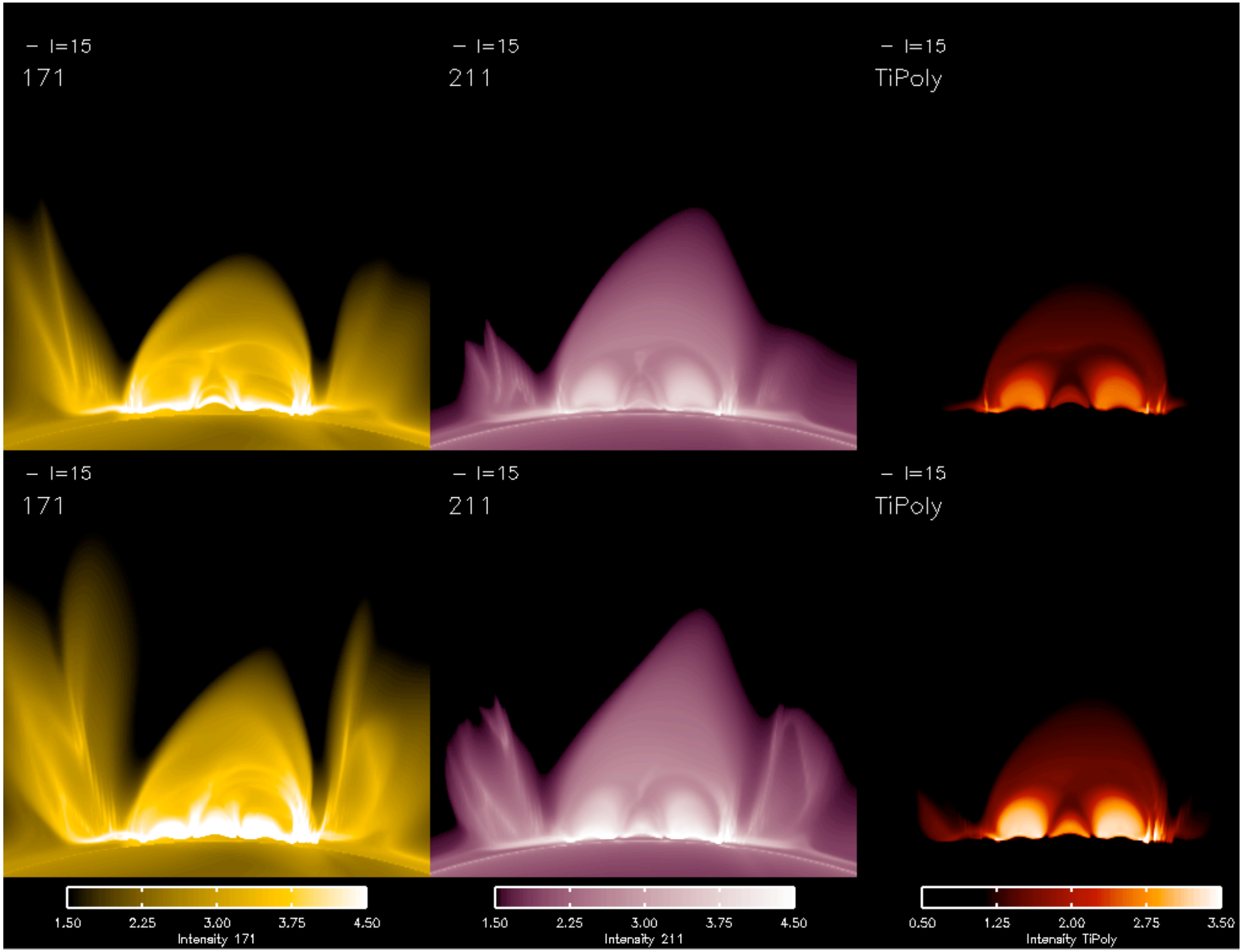


global dipole + quadrupolar active region (large decay index)

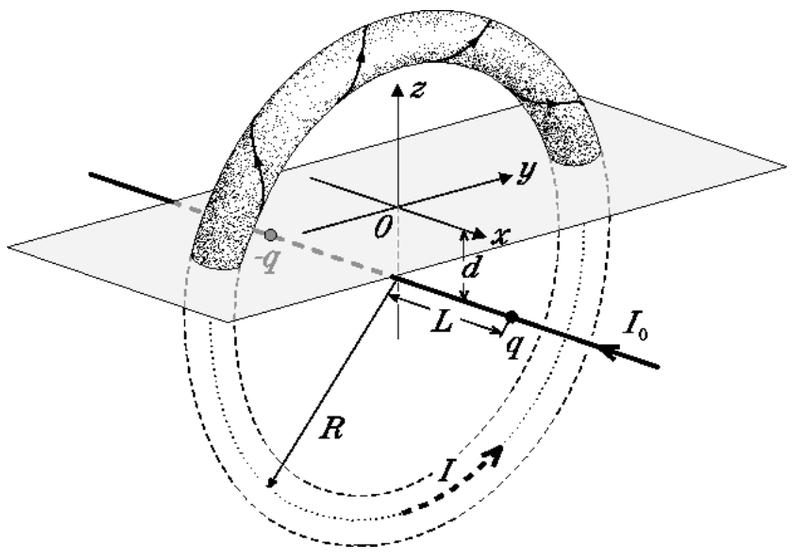


relaxation: coronal field opens up + streamer forms above active region

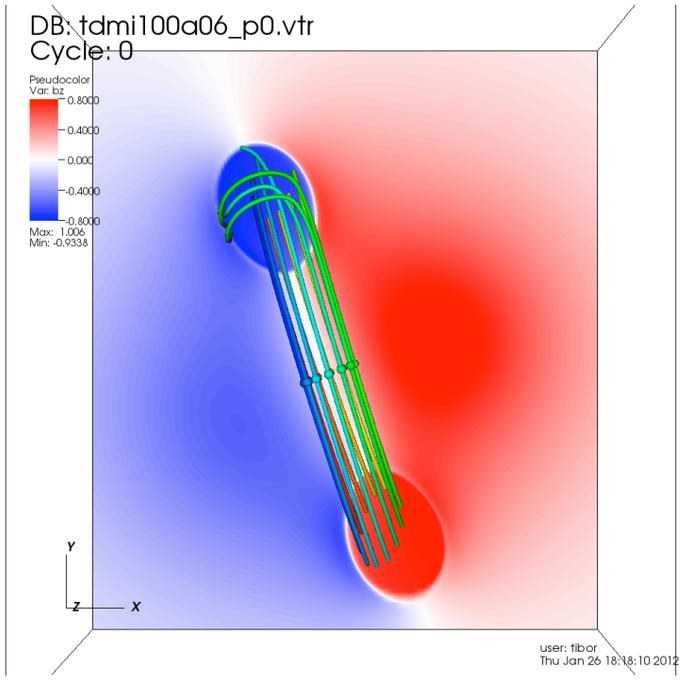
Modeling a fast CME: adjust coronal heating parameters

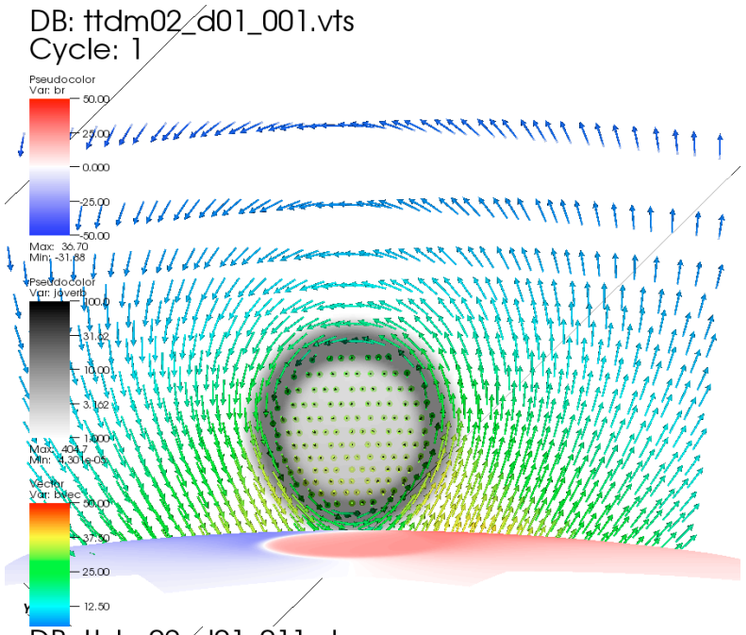


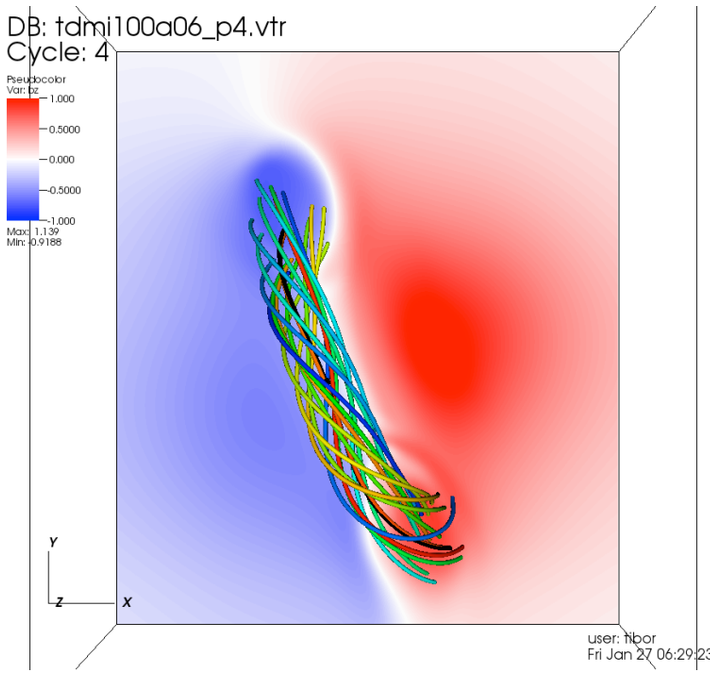
Modeling a fast CME: flux rope insertion

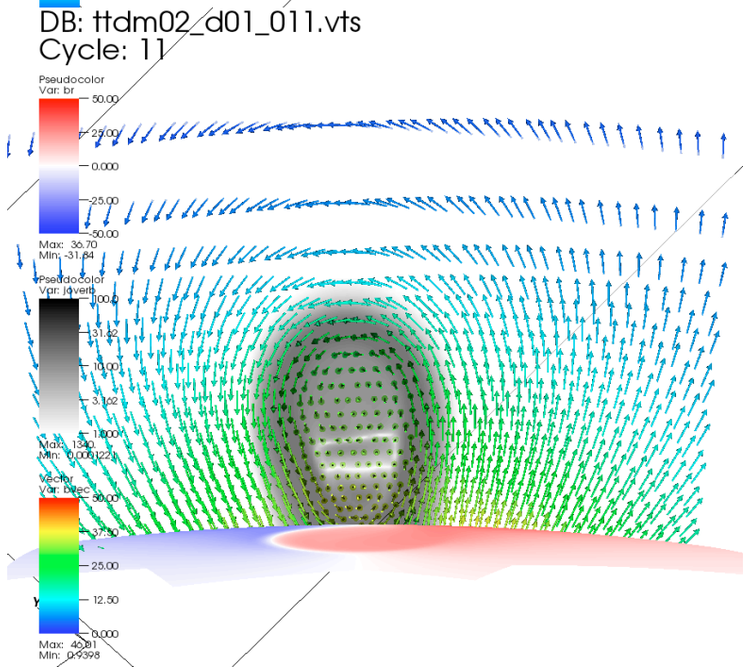


Titov & Démoulin (1999)



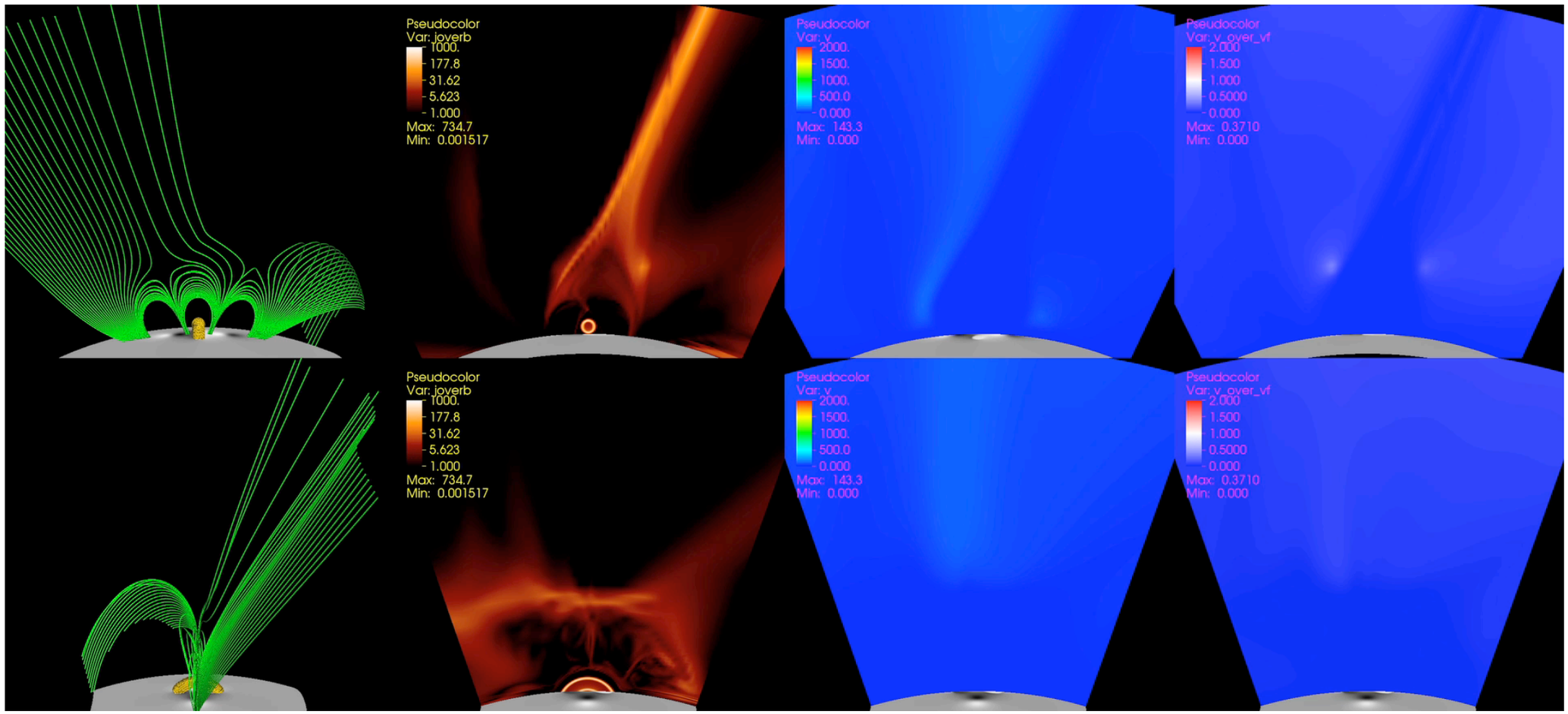




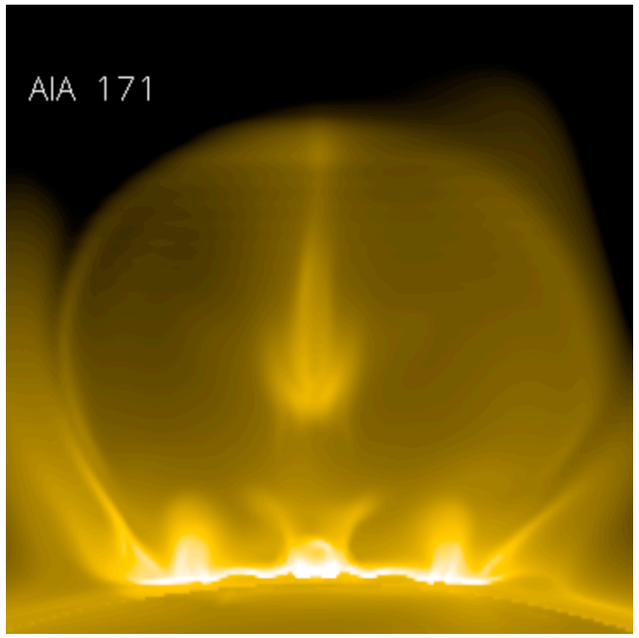


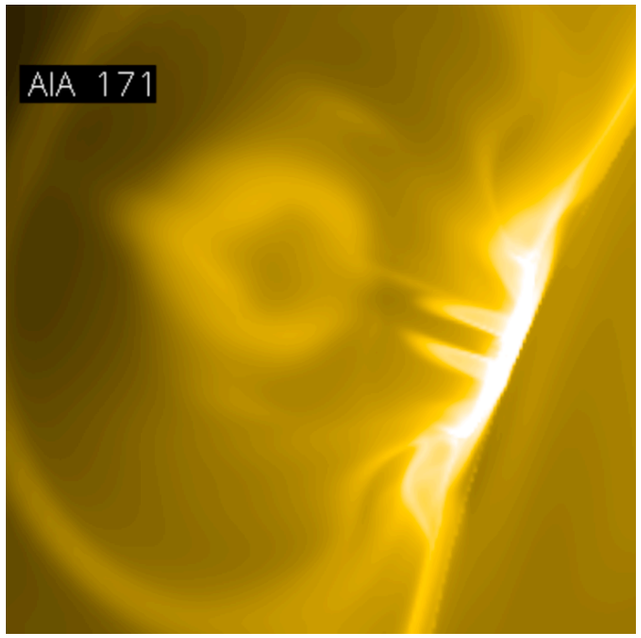
insert (modified) TD model (in equilibrium) into stabilizing ambient coronal field

Modeling a fast CME: eruption



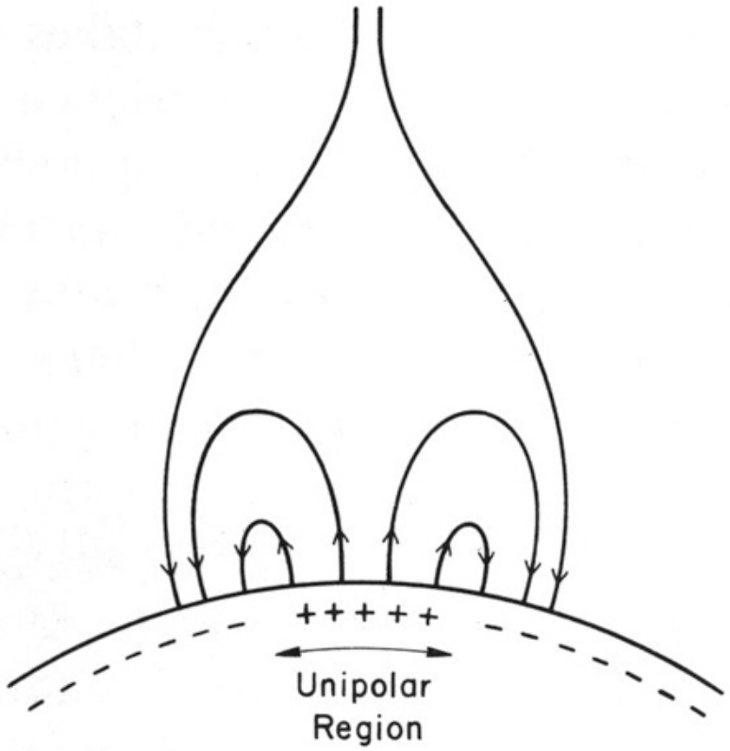
- B_max ≈ 600 G
- AR flux ≈ 2 * 10^22 Mx
- max. CME speed ≈ 2000 km/s
- W release ≈ 1.5 * 10^32 ergs

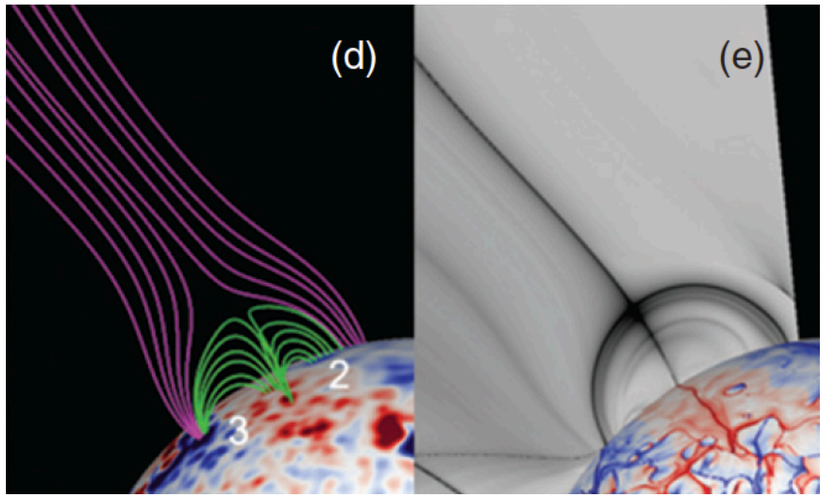


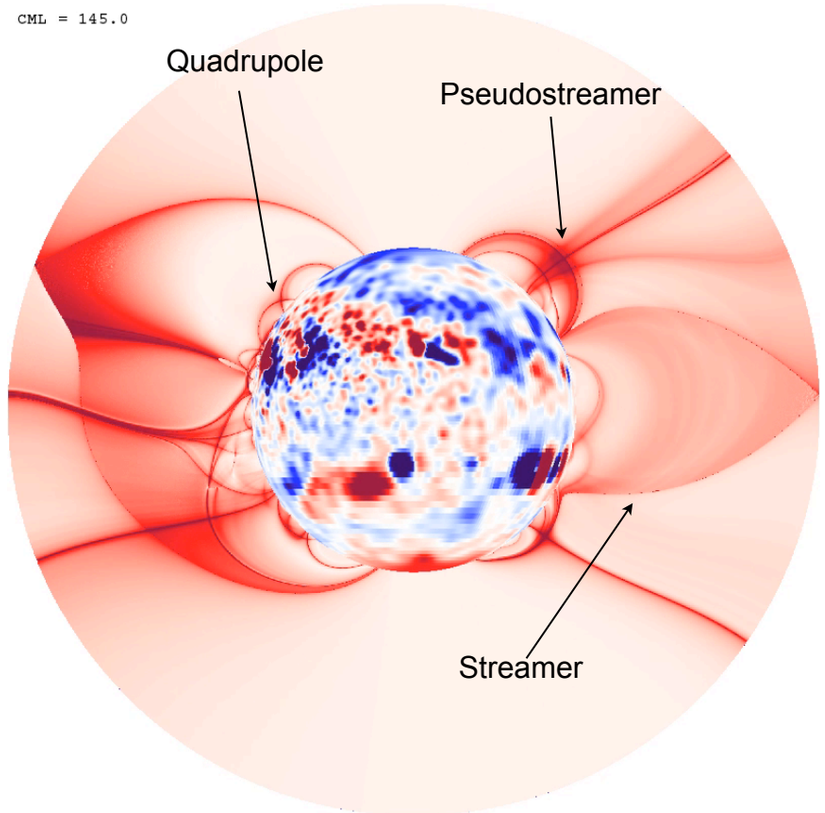


Backup slides

Pseudo-streamer





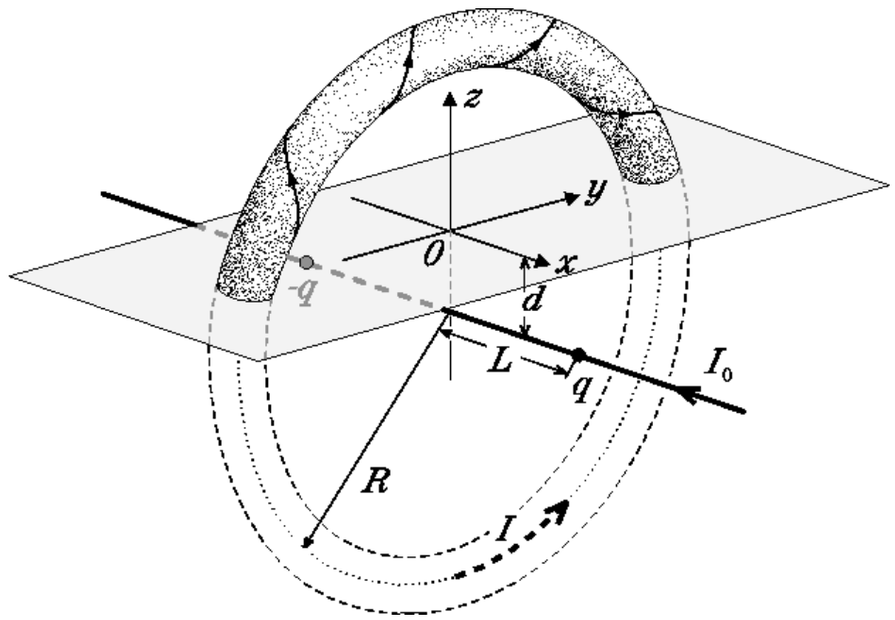


- PS: amount of stabilizing closed flux determined by size of parasitic polarity

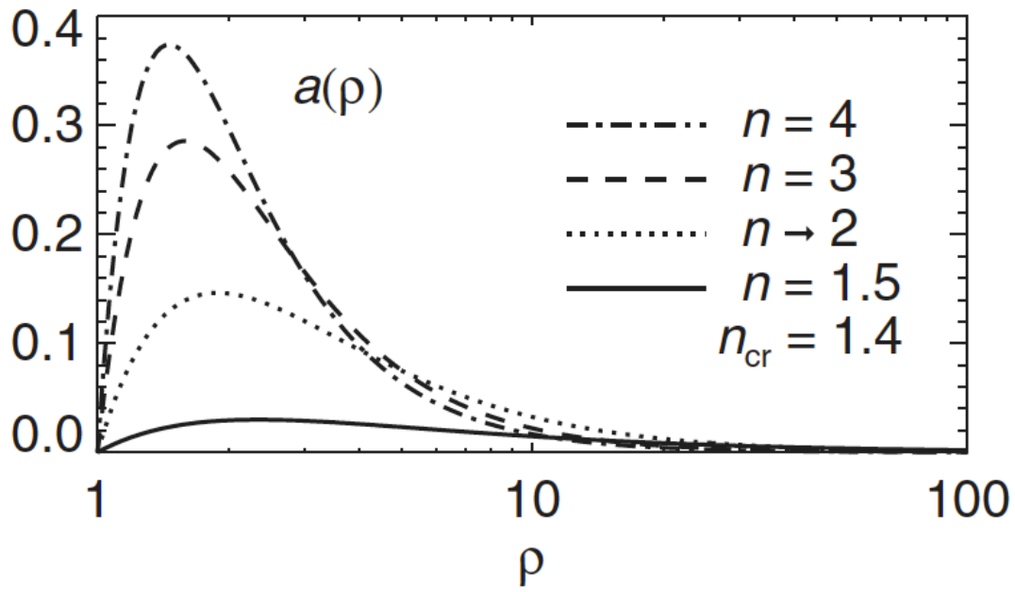
- HS: amount of closed flux essentially determined by height of SW acceleration region

→ eruptions from PS have less closed flux to overcome

Torus instability



Titov & Démoulin (1999)



Kliem & Török (2006)

- ideal MHD instability; occurs if overlying field drops sufficiently fast with height

- acceleration profile depends on decay index $n = -h\, d(\ln B)/dh$ of overlying field:

  $n \approx 1.5$ (quiet Sun): weak & long-lasting acceleration (gradual)

  $n > 2$ (active regions): strong & short acceleration (impulsive)