

The April 25, 2007 *Hinode* quiescent prominence & the general role of prominences in solar activity

B. C. Low

High Altitude Observatory

National Center for Atmospheric Research



NCAR

The National Center for Atmospheric Research is operated by the University Corporation for Atmospheric Research under sponsorship of the National Science Foundation. An Equal Opportunity/Affirmative Action Employer.

3 aspects of the prominence problem

- The April 25, 2007 *Hinode* quiescent prominence – filamentary structures & macroscopic stability.
- What is the larger-scale coronal magnetic structure containing a quiescent prominence? - The 3-part coronal helmet – dense dome, low-density cavity plus a quiescent prominence.
- What do the prominences do? - CMEs and the atmospheric processing of magnetic flux in each solar cycle.

Quiescent prominence

• **Density** : $n_e \approx 10^{10-11} \text{ cm}^{-2}$

$$n_H \approx 10^{10-12} \text{ cm}^{-2}$$

(*Hirayama, Bommier, Landman*)

• **Total Mass** : $M_{prom} \approx 10^{13-15} \text{ g}$

$$M_{CME} \approx 10^{15-16} \text{ g}$$

(*Rusin & Rybansky, Gilbert, Heinzel*)

• **Temperature** $\approx 10^4 \text{ K}$

• **Magnetic Field** : 3 - 30G

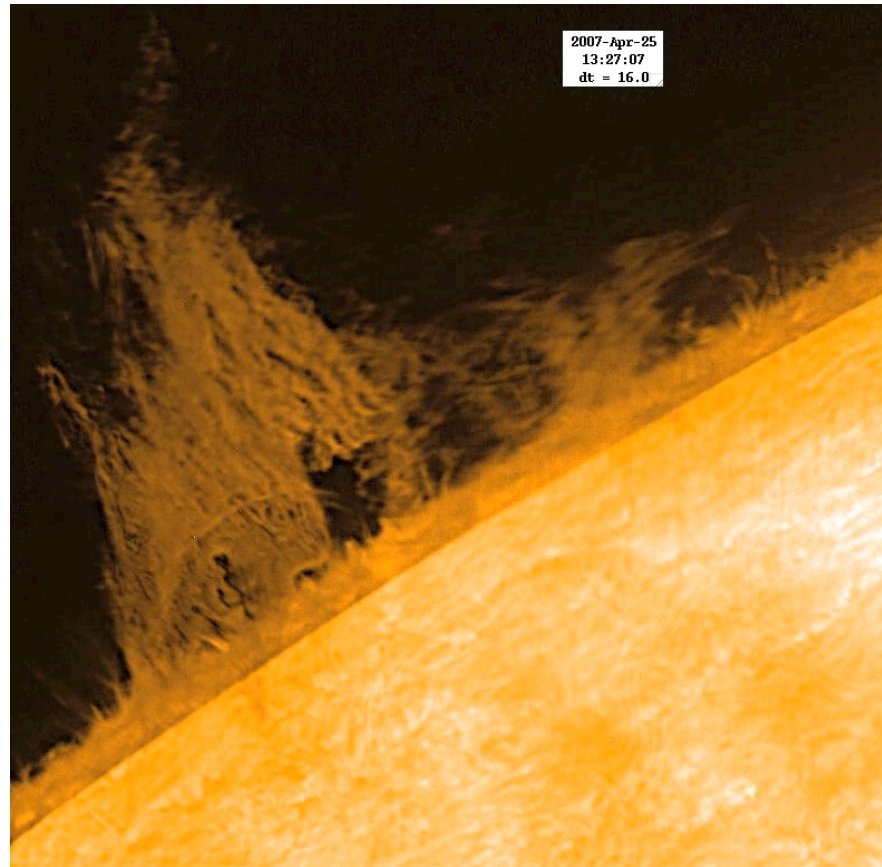
(i) horizontal

(ii) near alignment with filament

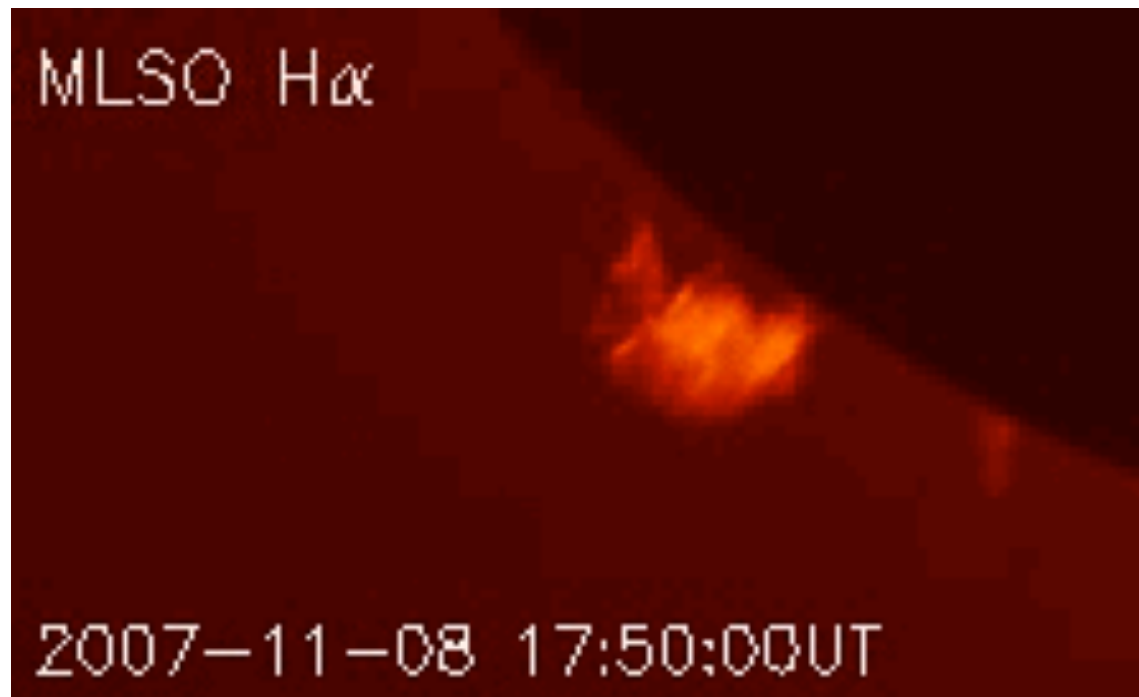
(*Athay, Leroy, ... Casini, Kuhn, Lin, Lopez - Ariste, Trujillo - Bueno, Martinez - Pillet, ...*)



Hinode movie of the April 25, 2008
H_alpha prominence



**The Nov 8, 2007 prominence of
DeToma et al. (2008 ApJ 687, L123)**



The April 25, 2007 *Hinode* movie

(Berger et al. 2008, ApJ 676, L89)

- Typically - falling filaments

width $\approx 100 - 700$ *km*

$v \leq 20$ *km/s* vs $v_g \approx 100$ *km/s*

- Typically - rising dark inclusions between filaments
- Macroscopic cavities forming quasi - statically and rising thru the prominence structure, pushing the dense filaments aside - repeatable 2 hour episodes.
- The remarkable macroscopic hydromagnetic stability

The physical origin of dense filaments & voids

(Low & Petrie 2005, *ApJ* 626, 551; Chae et al 2008, *ApJ* 689, L73)

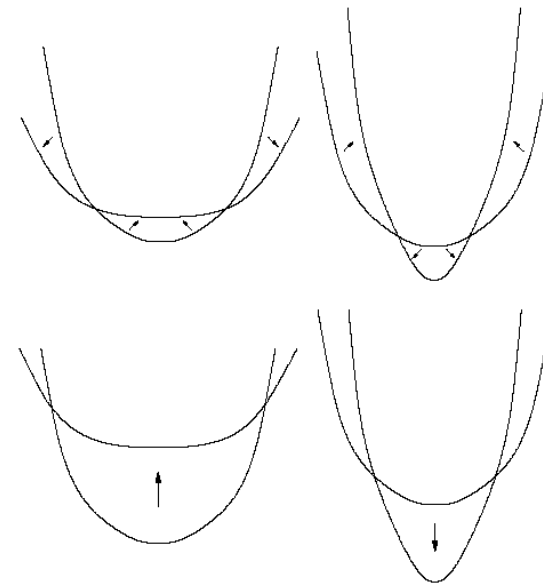
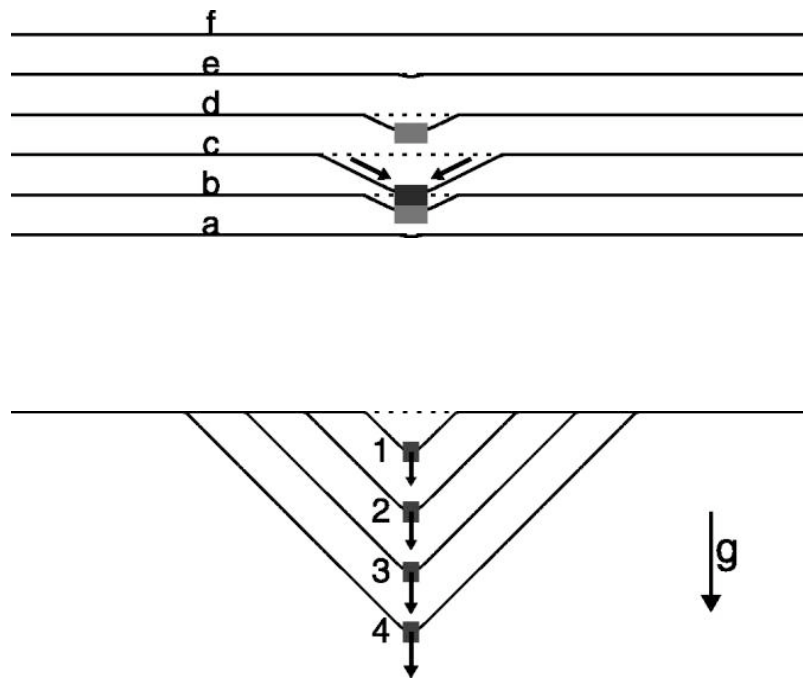
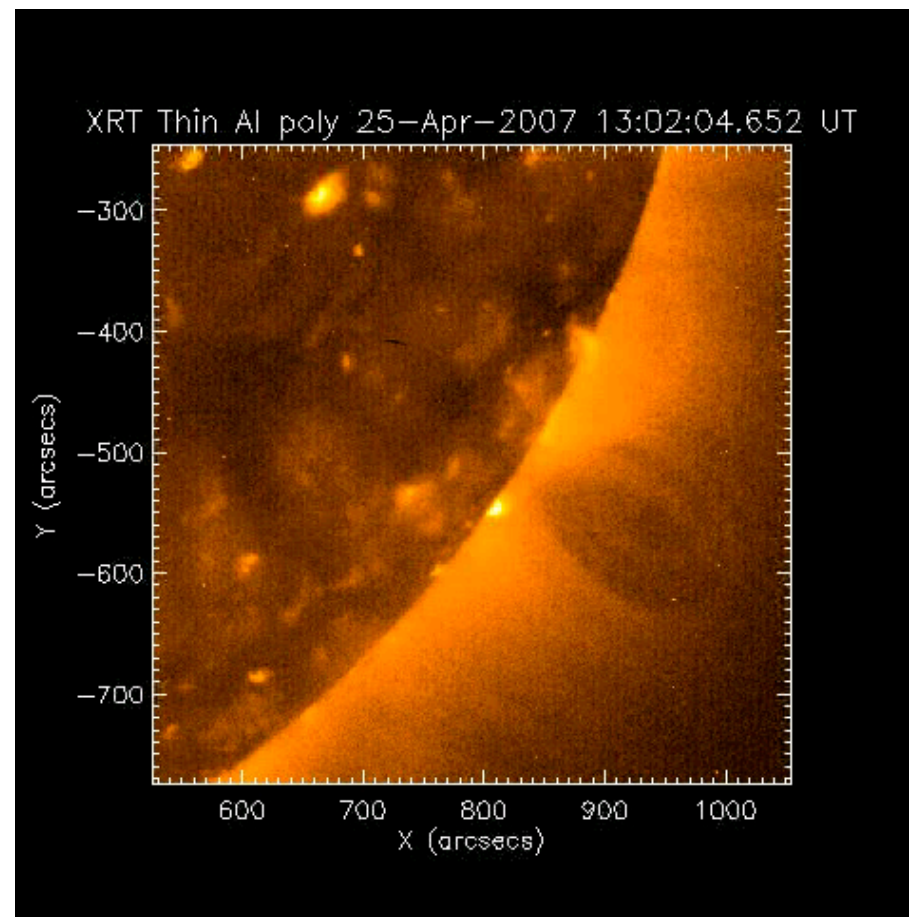


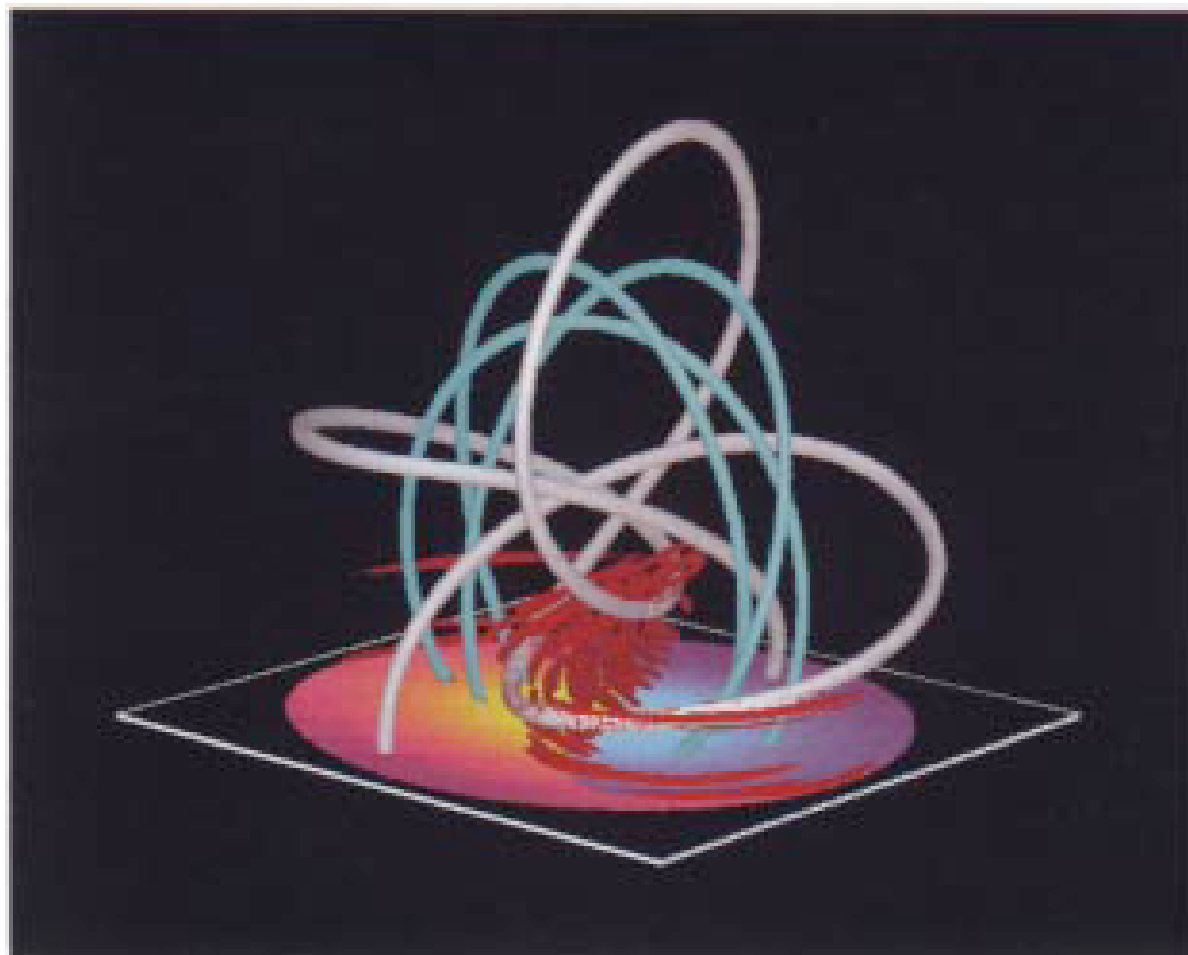
FIG. 6.—Movement of the field line in $x < 0$ (left) and $x > 0$ (right) implied by the unbalanced forces in Fig. 5.

The cavity of the April 25, 2007 *Hinode* prominence

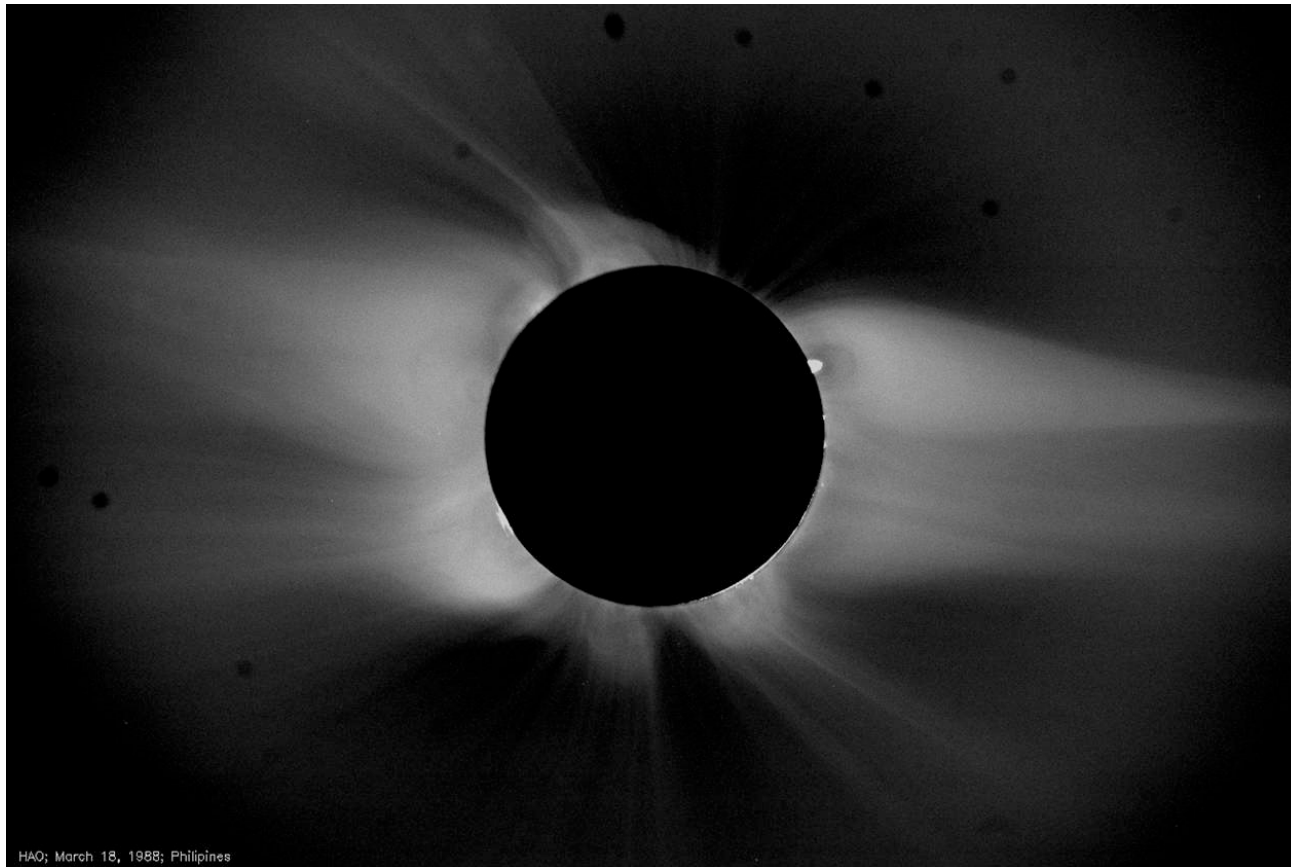


A possible flux-rope field topology – Connection with flux emergence

Lites & Low (1997, Sol. Phys. 174, 91), Lites et al. (1995, ApJ 446, 877),
Okamoto et al. (2008, ApJ 673, 215)

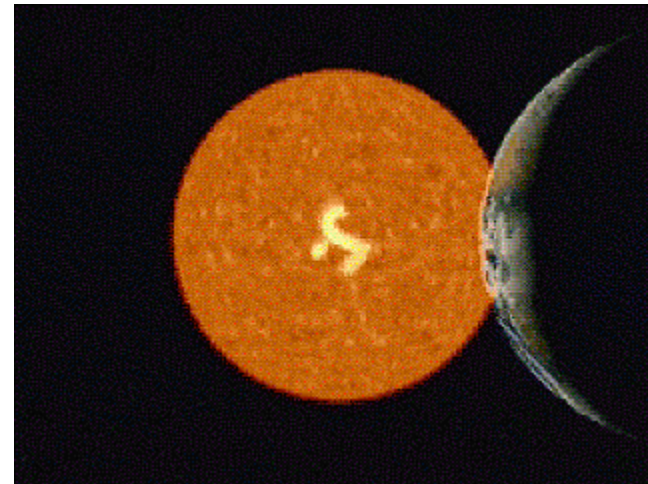
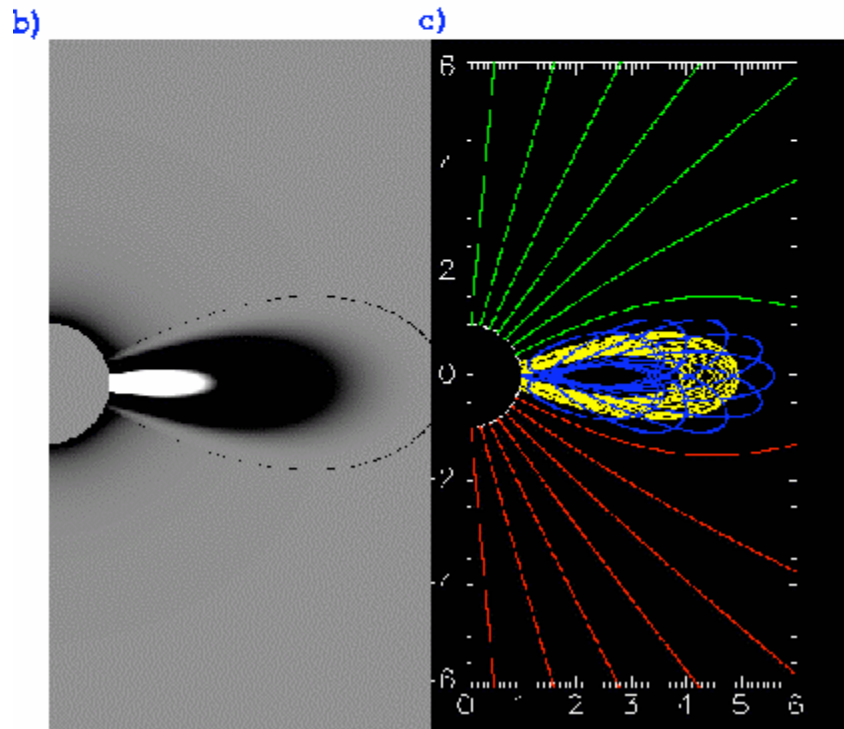
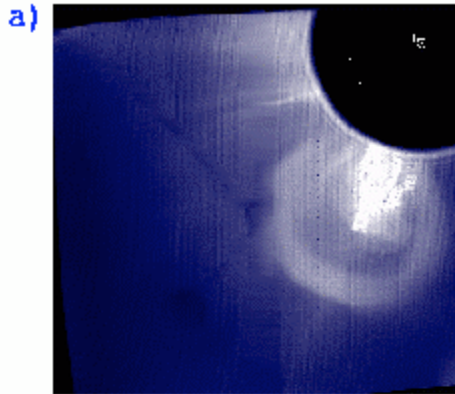


The 3-part coronal helmet streamer



A Theoretical 3-Part CME

1

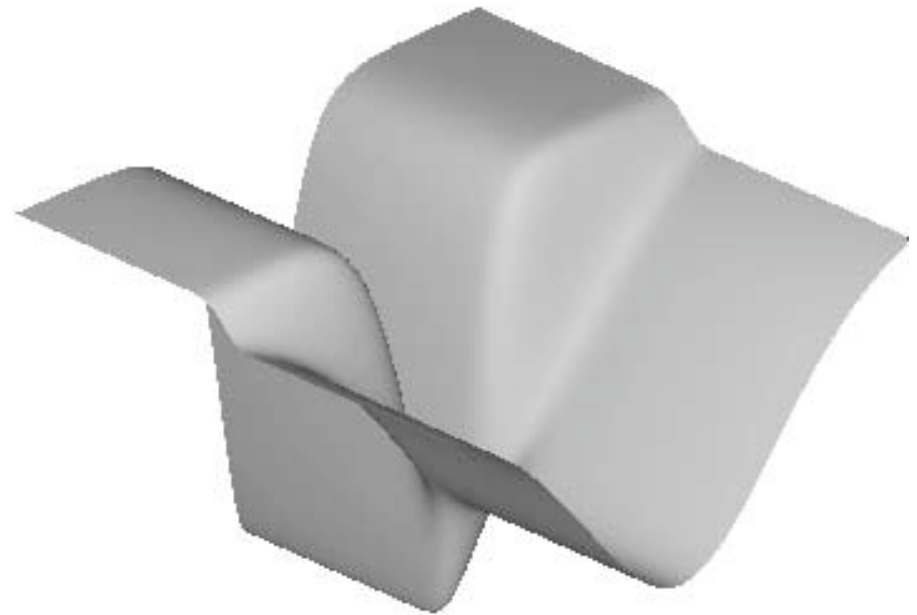


Gibson & Low (1998, ApJ 496, 460)

Atmospheric cycling of magnetized cool plasma & buoyant emptied magnetic flux

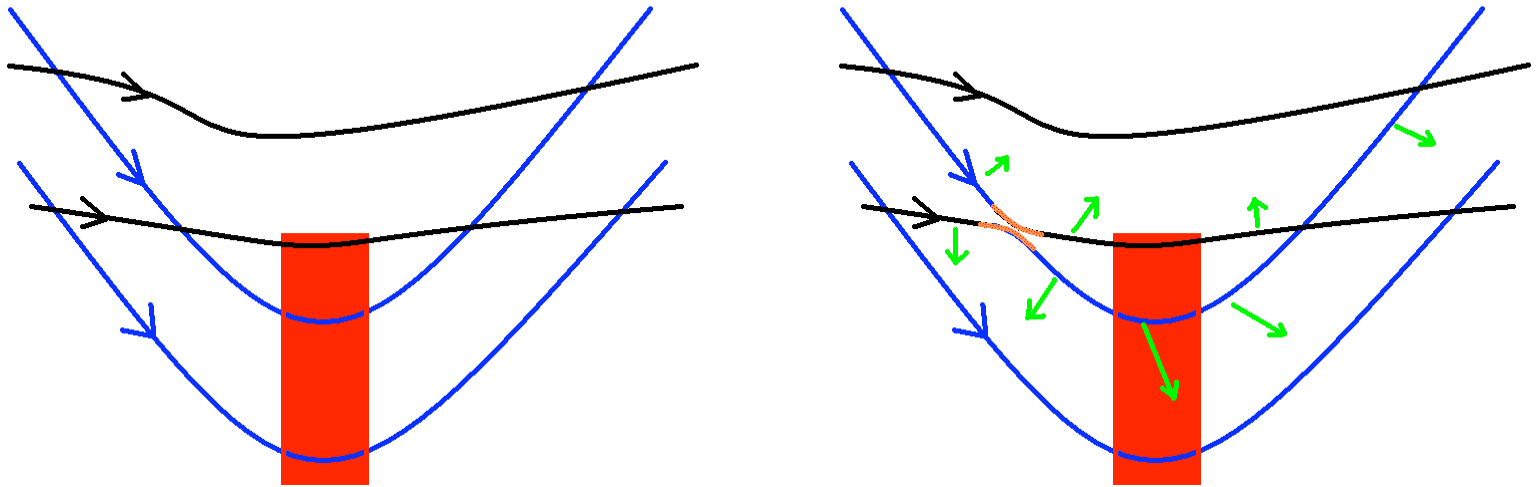
{Petrie & Low 2005, ApJS 159, 288}

- Frozen-in state, magnetic tangential discontinuities, resistive reconnection
- Gravity & reconfiguration – falling plasma and buoyant field
- Systematic gain of flux to form cavity

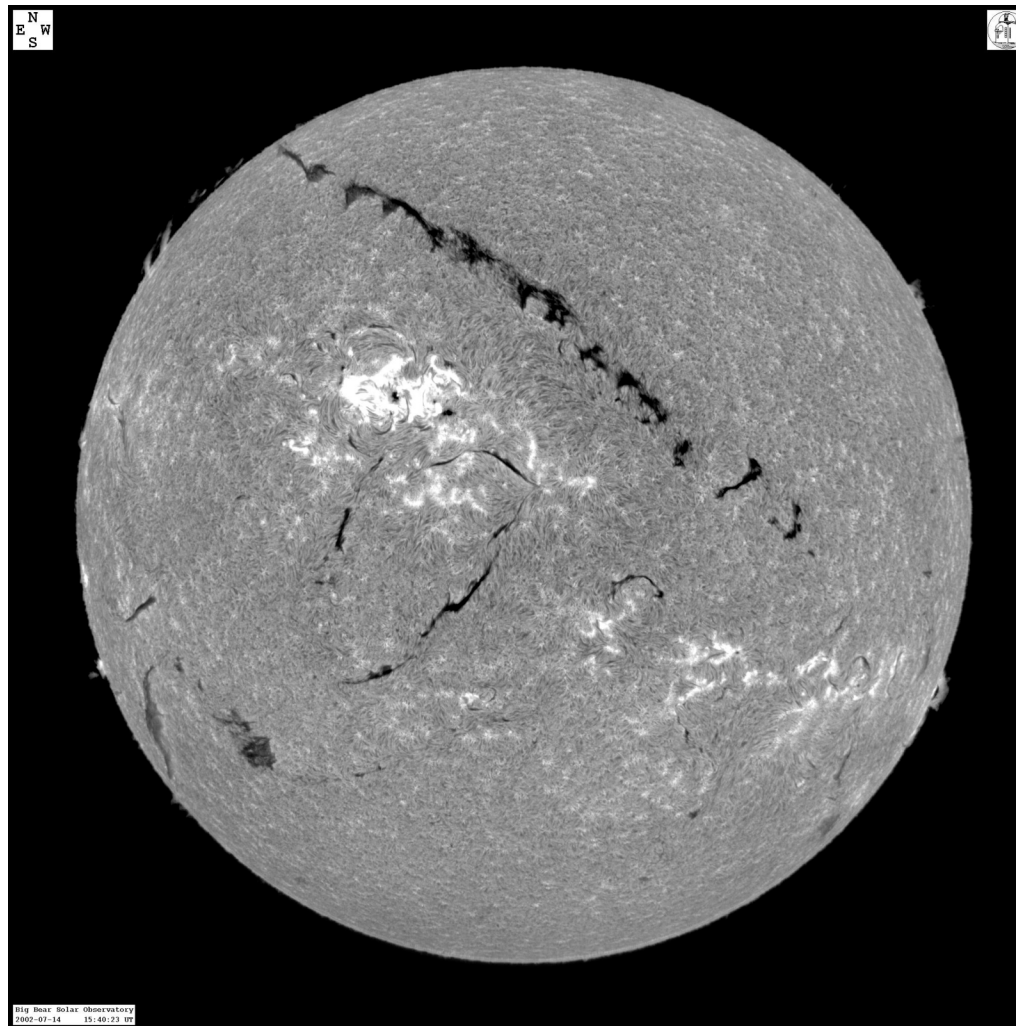


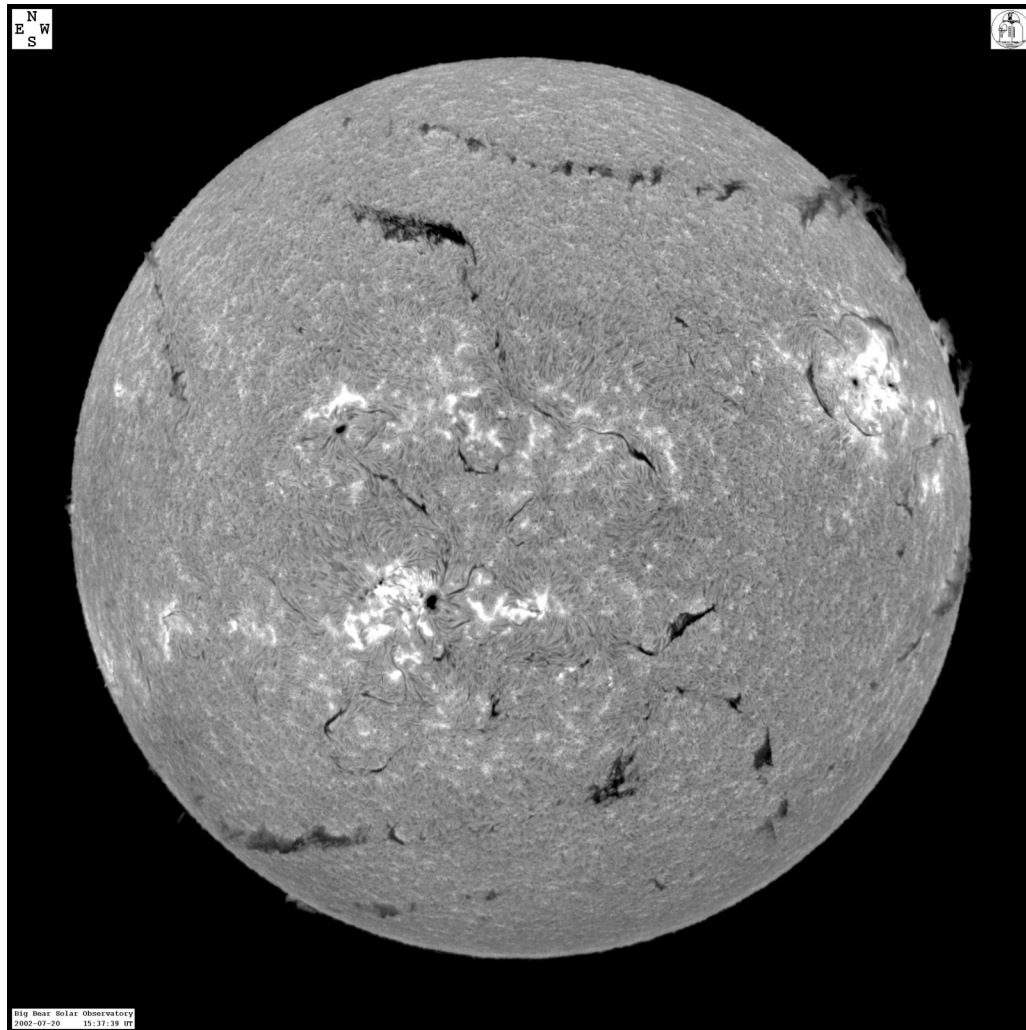
A Reconnection Sequence

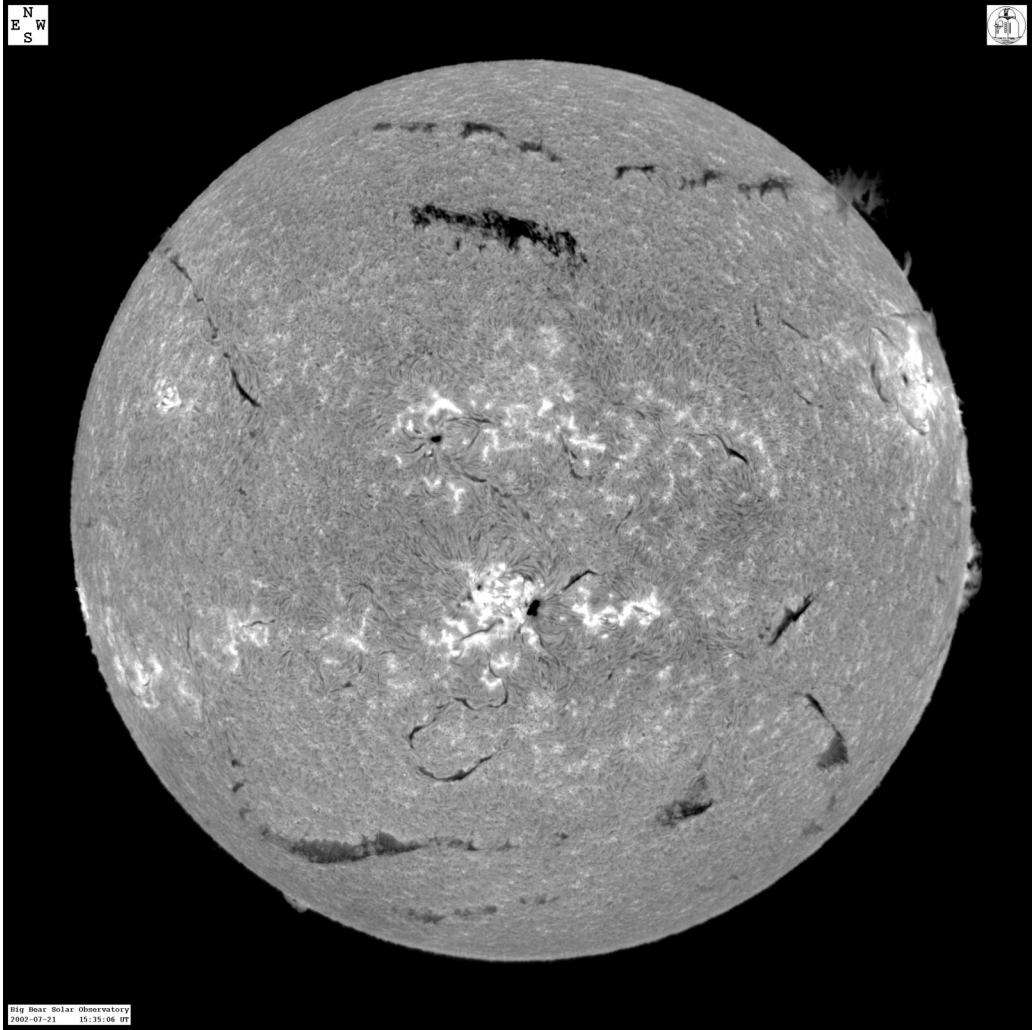
(Low, McIntosh & Berger 2008, in progress)



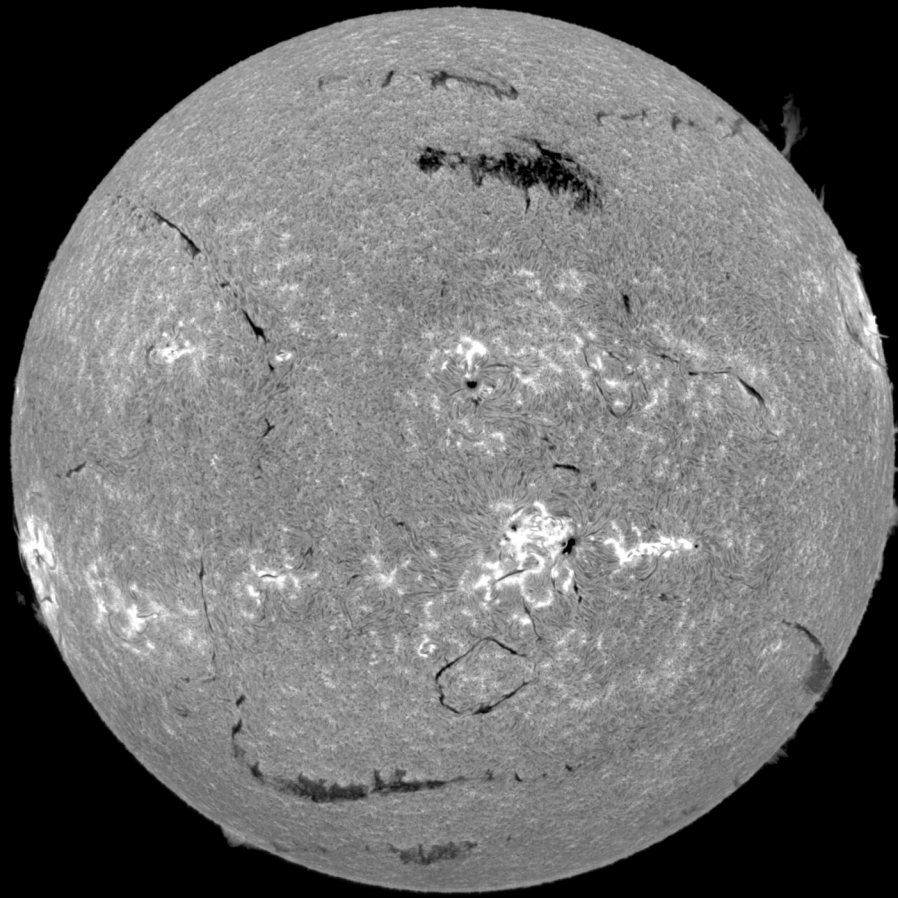
Quiescent Prominences & Atmospheric Processing of Magnetic Flux





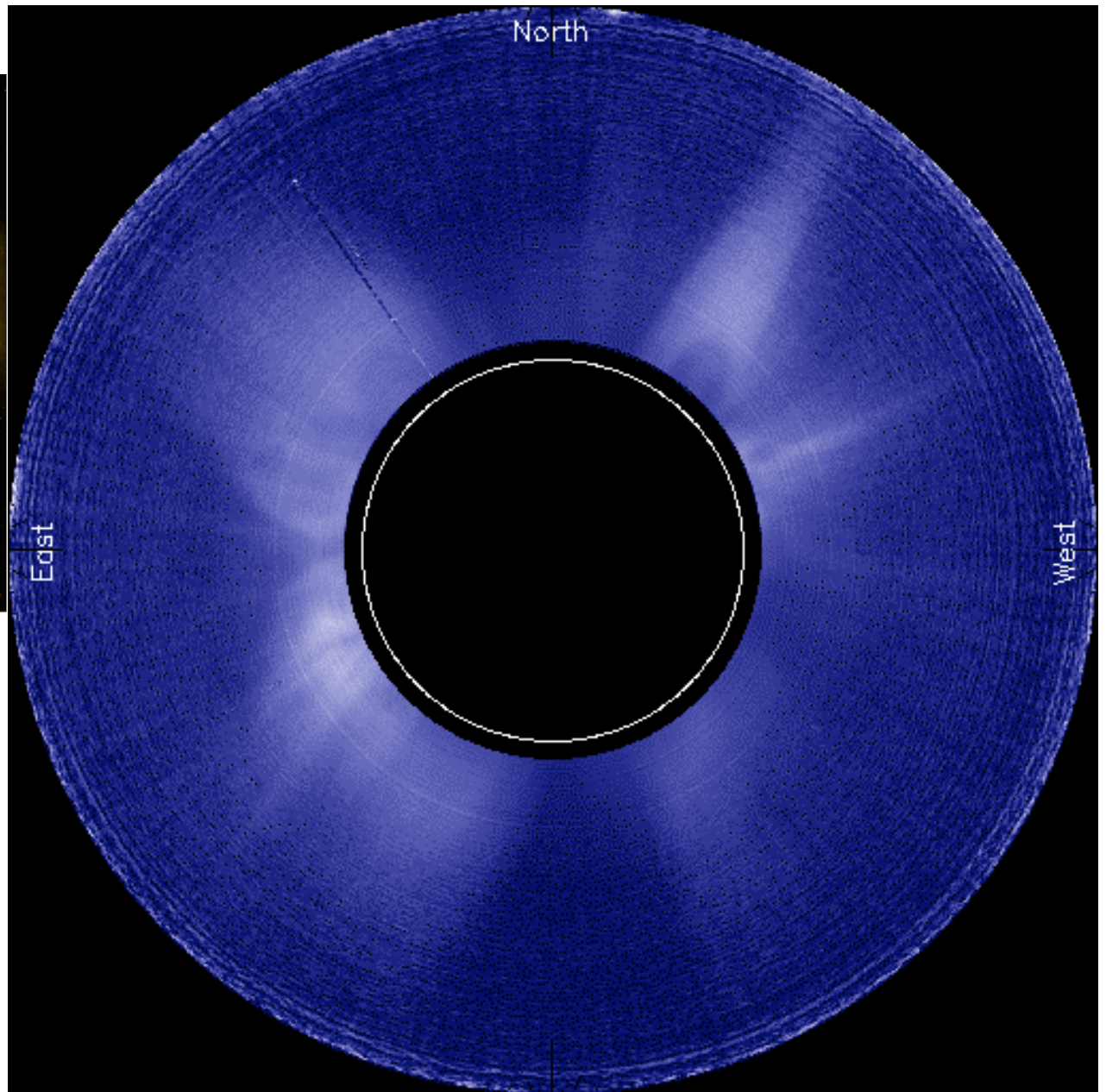
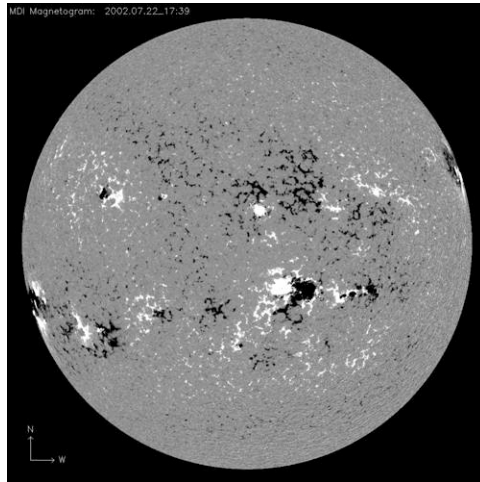
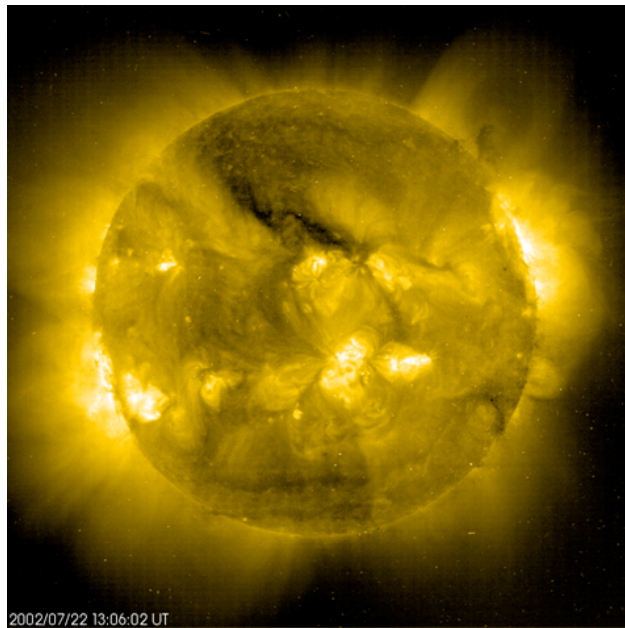


N
E W
S

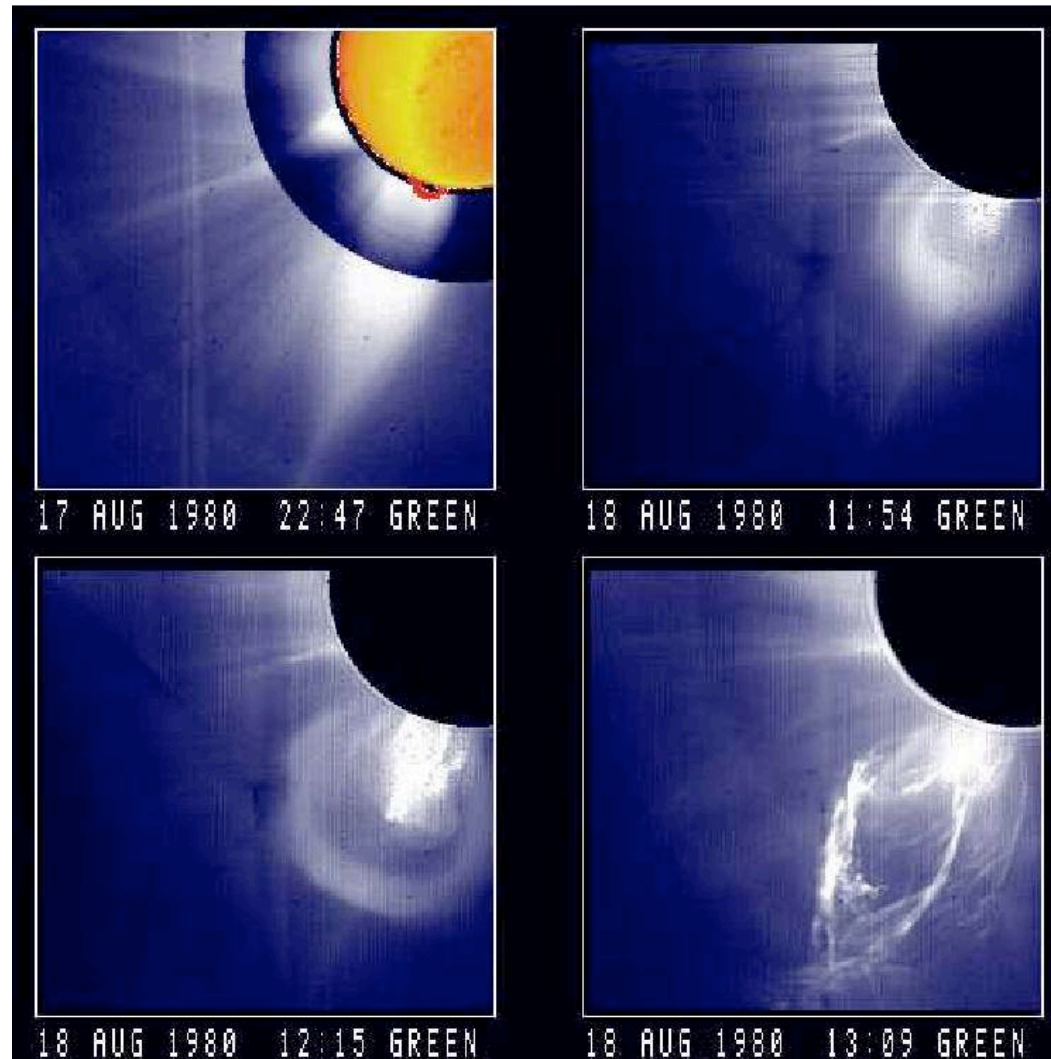


Big Bear Solar Observatory
2002-07-22 16:22:36 UT

The July 22, 2002 coronal helmet

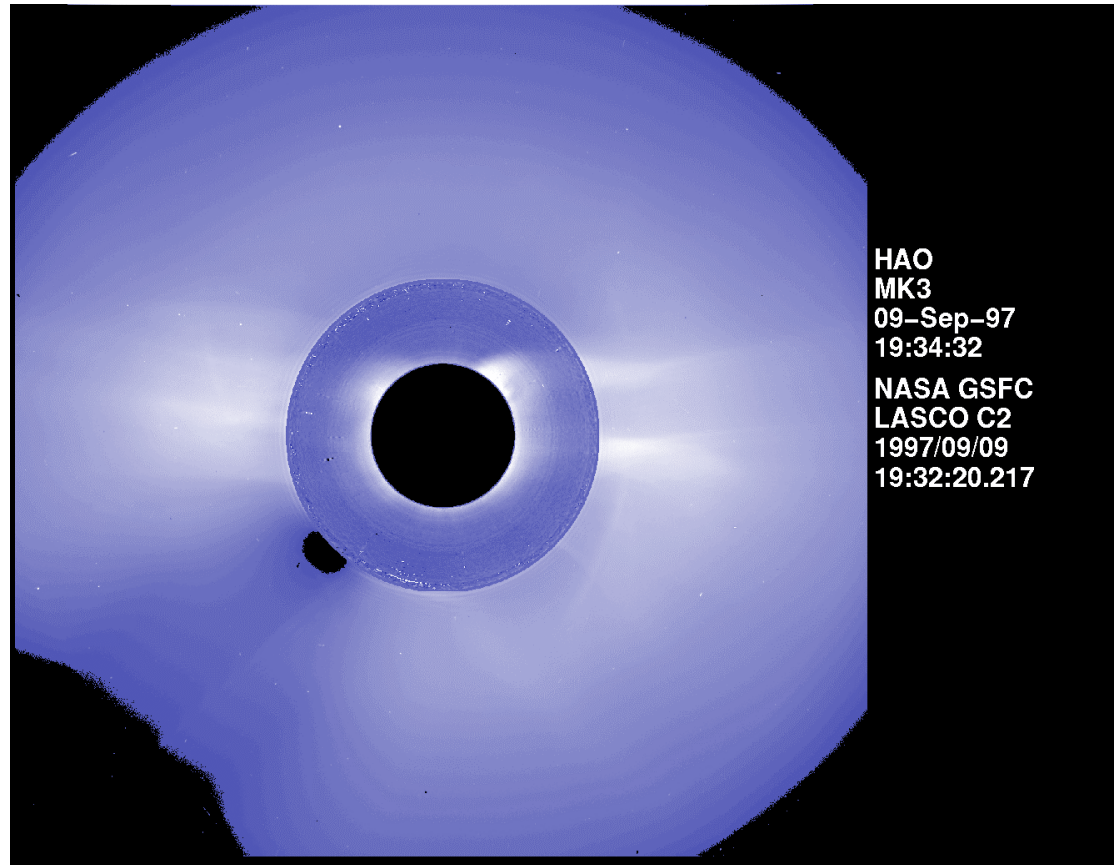


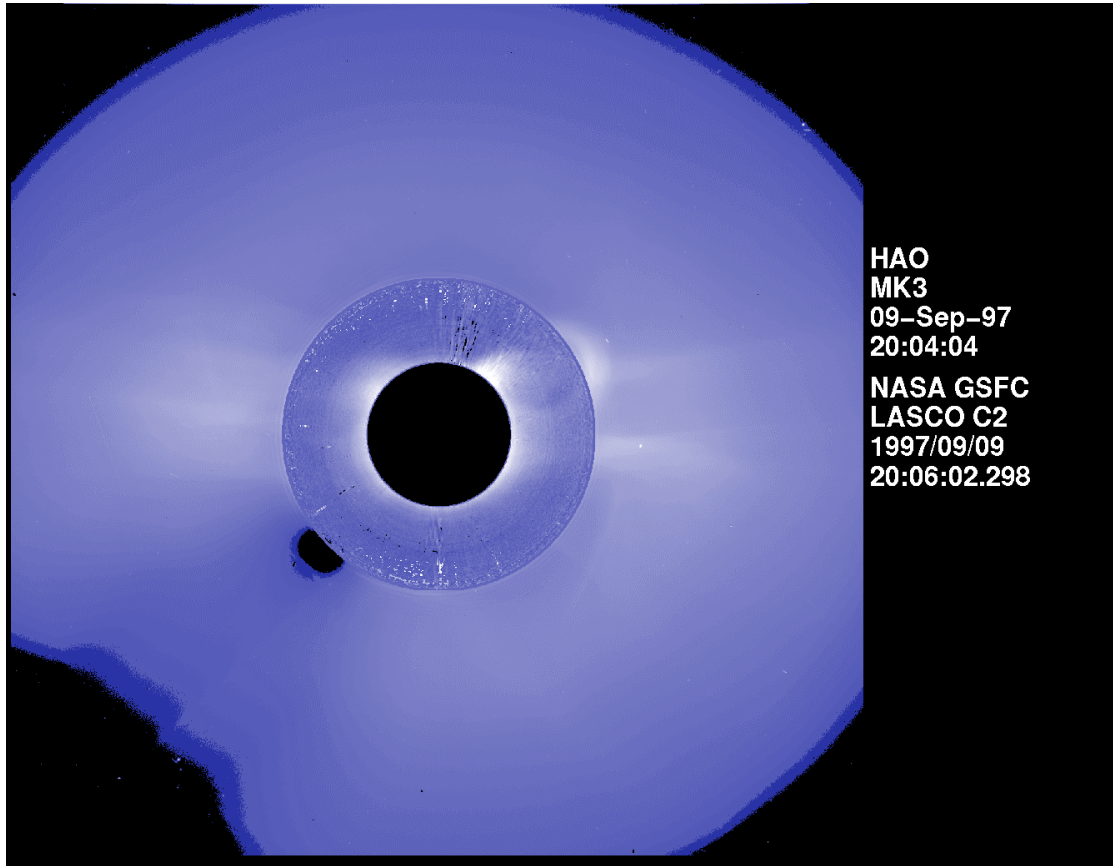
August 17, 1980 CME



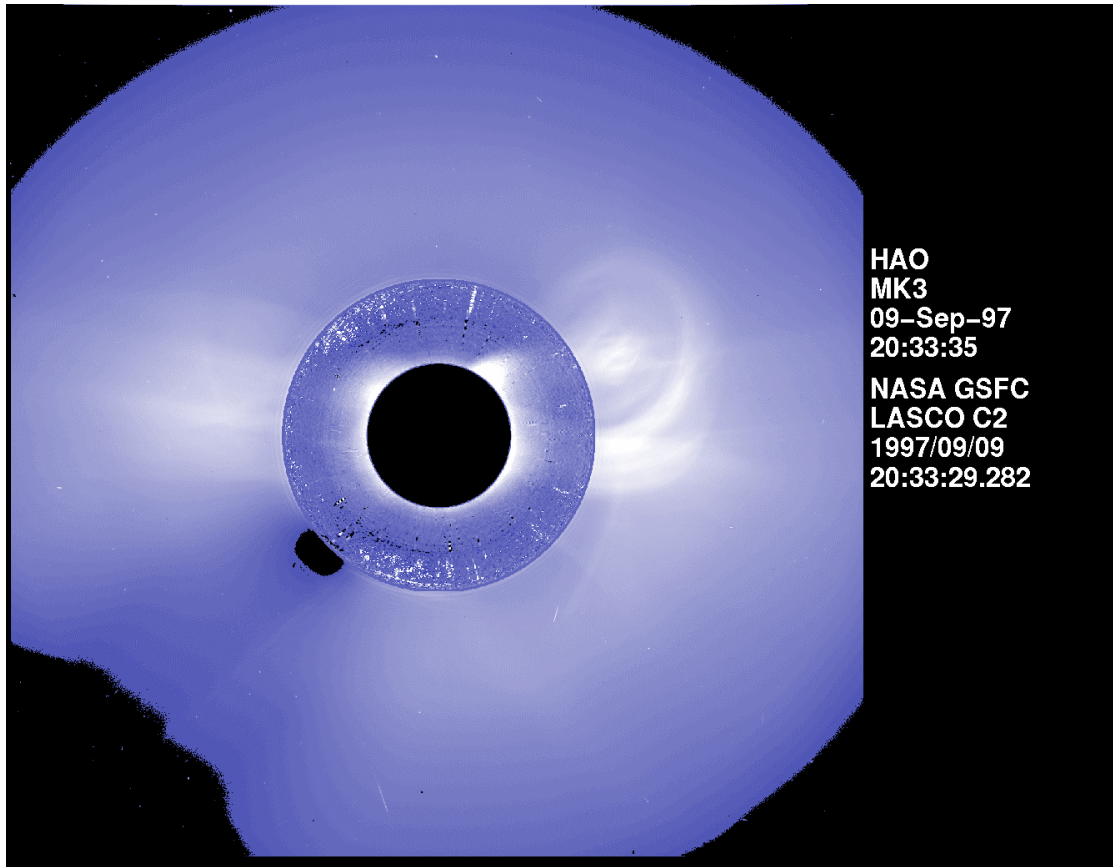
September 9, 1997 CME – in full view

(J. Burkepile, HAO)

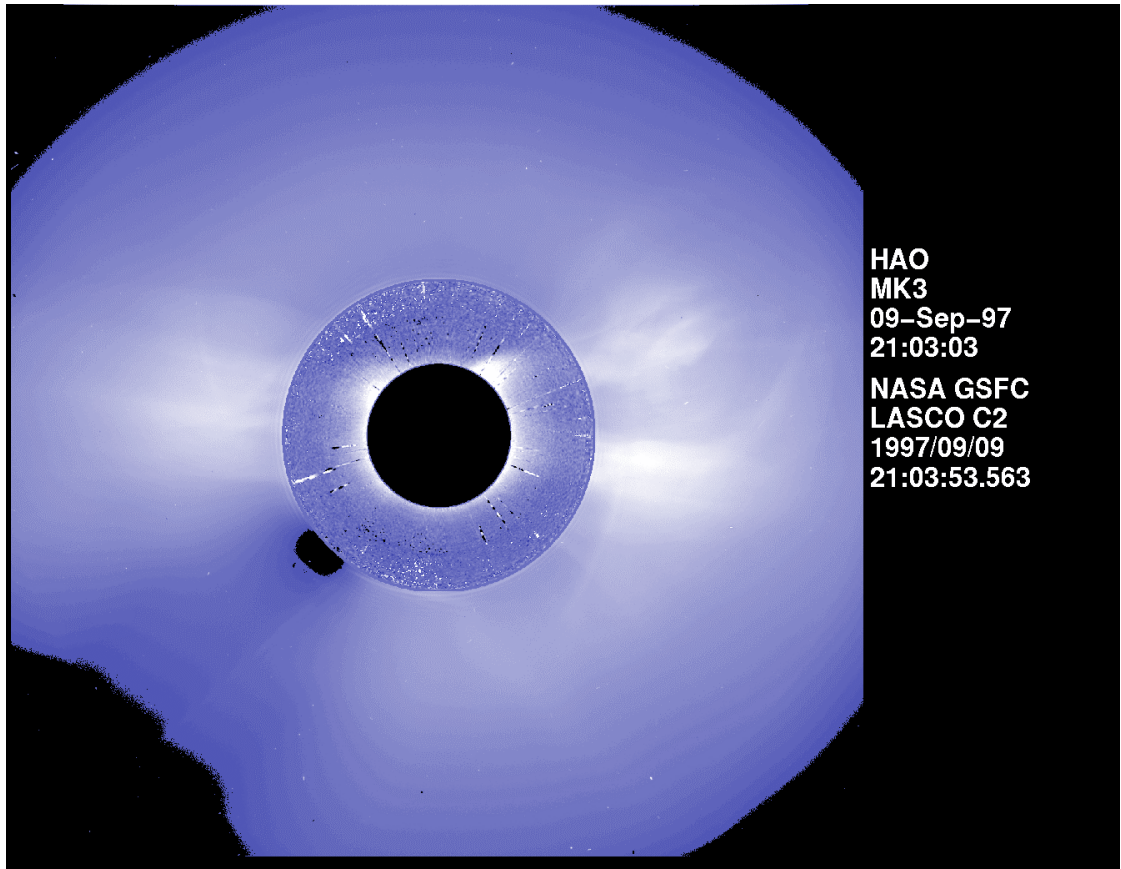




HAO
MK3
09-Sep-97
20:04:04
NASA GSFC
LASCO C2
1997/09/09
20:06:02.298



HAO
MK3
09-Sep-97
20:33:35
NASA GSFC
LASCO C2
1997/09/09
20:33:29.282



HAO
MK3
09-Sep-97
21:03:03
NASA GSFC
LASCO C2
1997/09/09
21:03:53.563

Important observational questions

(Low 2001 JGR 106, 2514; Zhang & Low 2005 ARAA 43, 103)

- What is the total mass of a prominence? What is the global field topology of the 3-part helmet?
- What is the physical nature of the bubbling and at times vortical dark inclusions, both the narrow ones between the bright filaments and the macroscopic ones pushing up thru the prominence? Are these pockets of hot-plasmas, or, plasma-evacuated magnetic flux tubes, or both?
- What is the connection between flux emergence and prominences? Post-Hinode thoughts on accumulation of horizontal fields and magnetic helicity?

