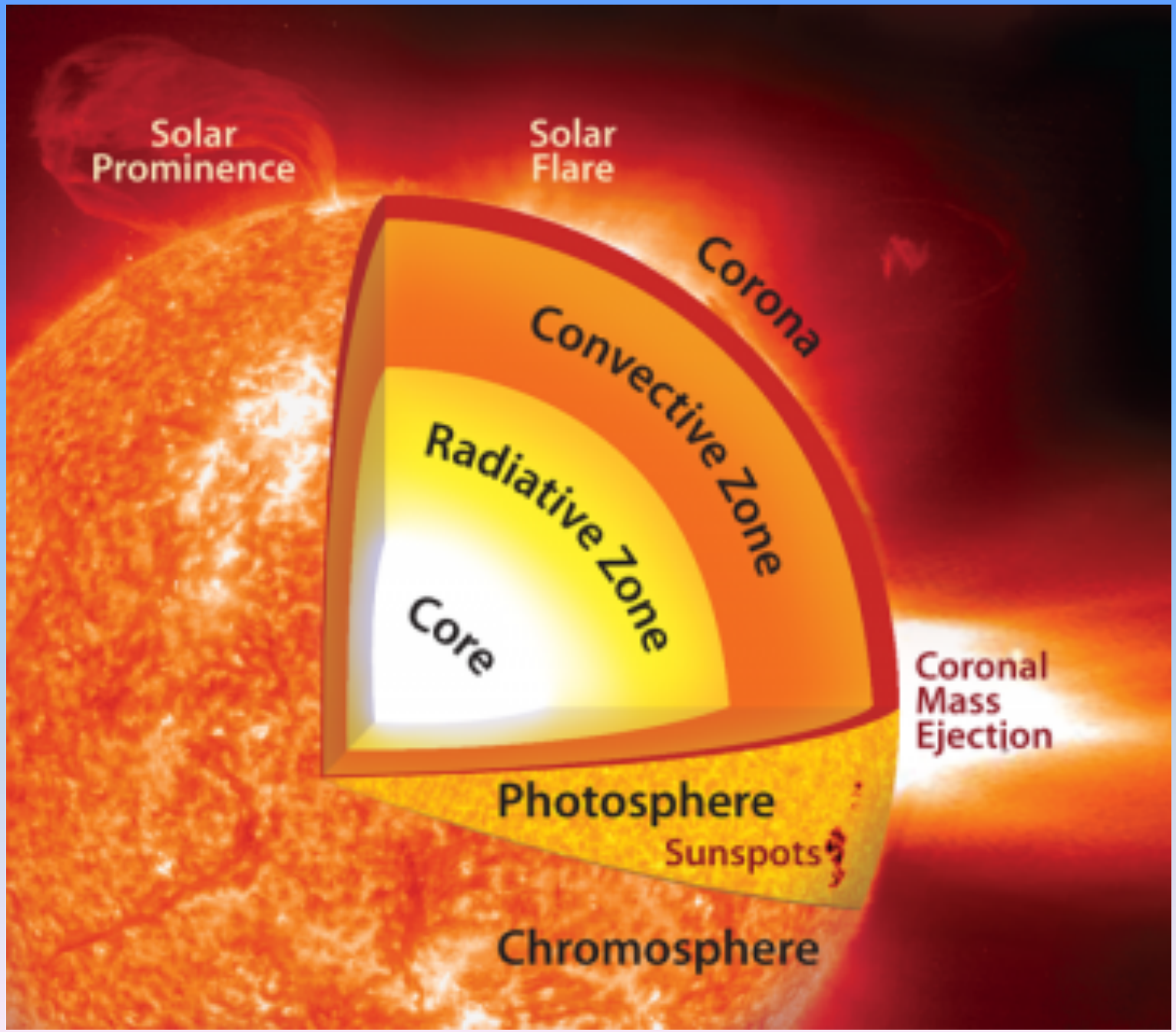
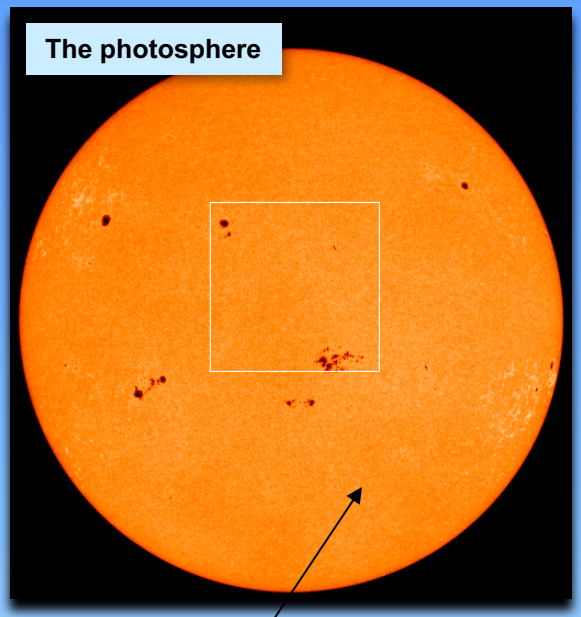
Solar Physics for the 21 August 2017 Eclipse

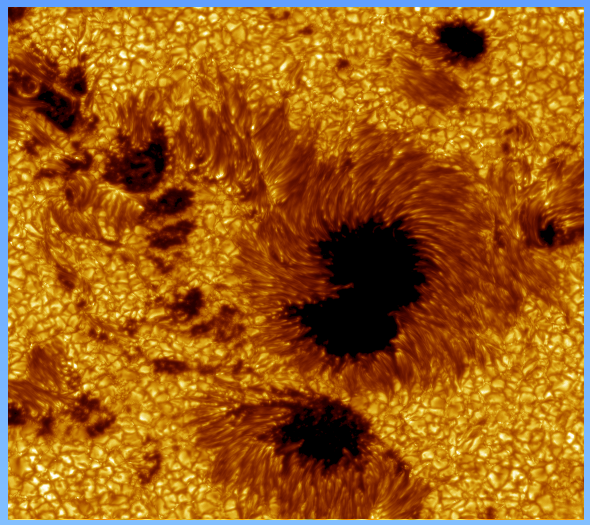
by
Dr. George A. Doschek
Northern Virginia Astronomy Club &
Naval Research Laboratory, Washington, DC

Presented at:
Almost Heaven Star Party
Spruce Knob, WV
24 July 2017


Solar Prominence
Solar Flare
Corona
Convective Zone
Radiative Zone
Core
Coronal Mass Ejection
Photosphere
Sunspots
Chromosphere

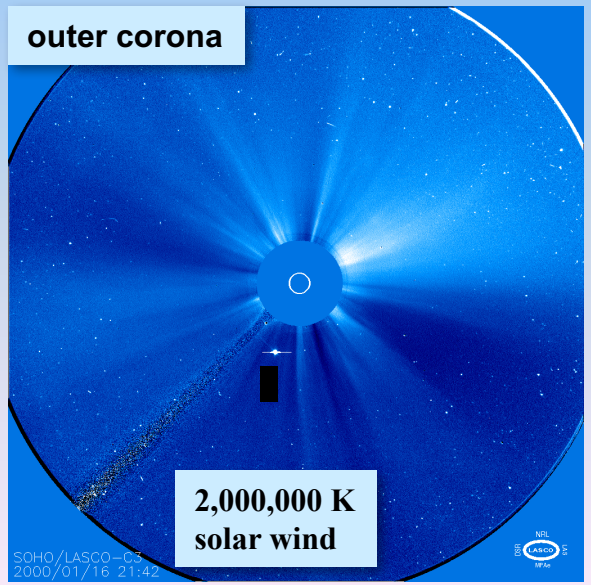
Instruments are flown on rockets and spacecraft that observe the solar transition region and inner & outer coronae. Together, these instruments provide observations of the atmosphere from the Sun to the Earth.

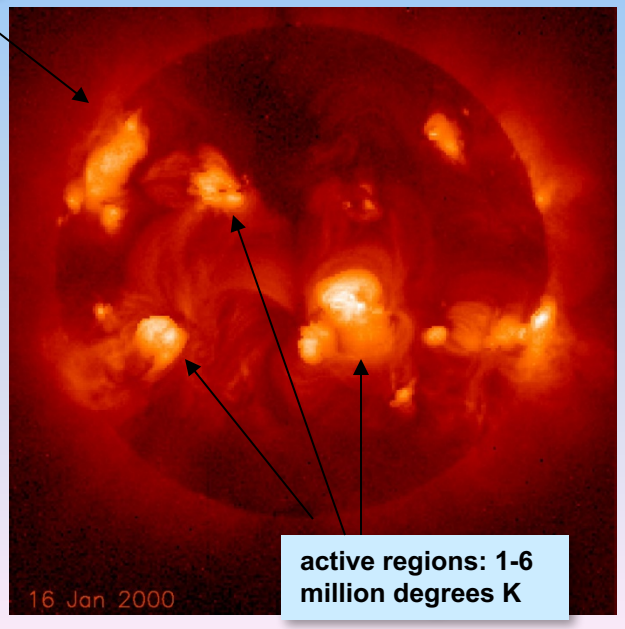


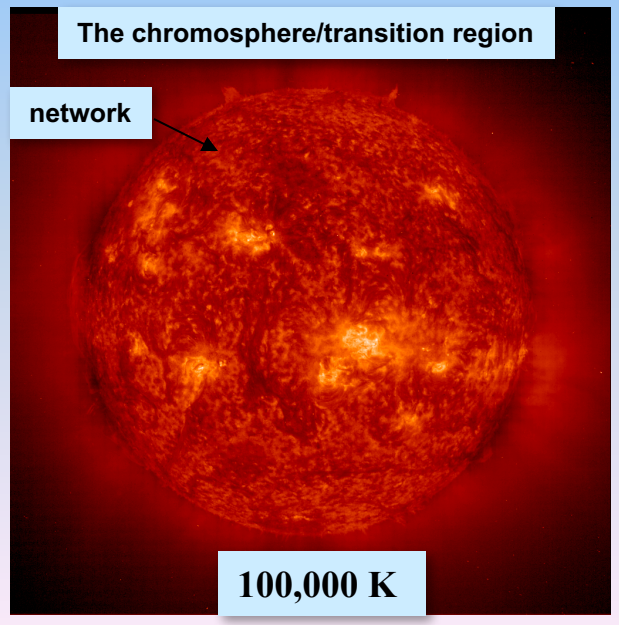


Solar "granules" or convection cells near sunspots in an active region. Granules are about 620 miles in size.

2,000,000 K inner corona

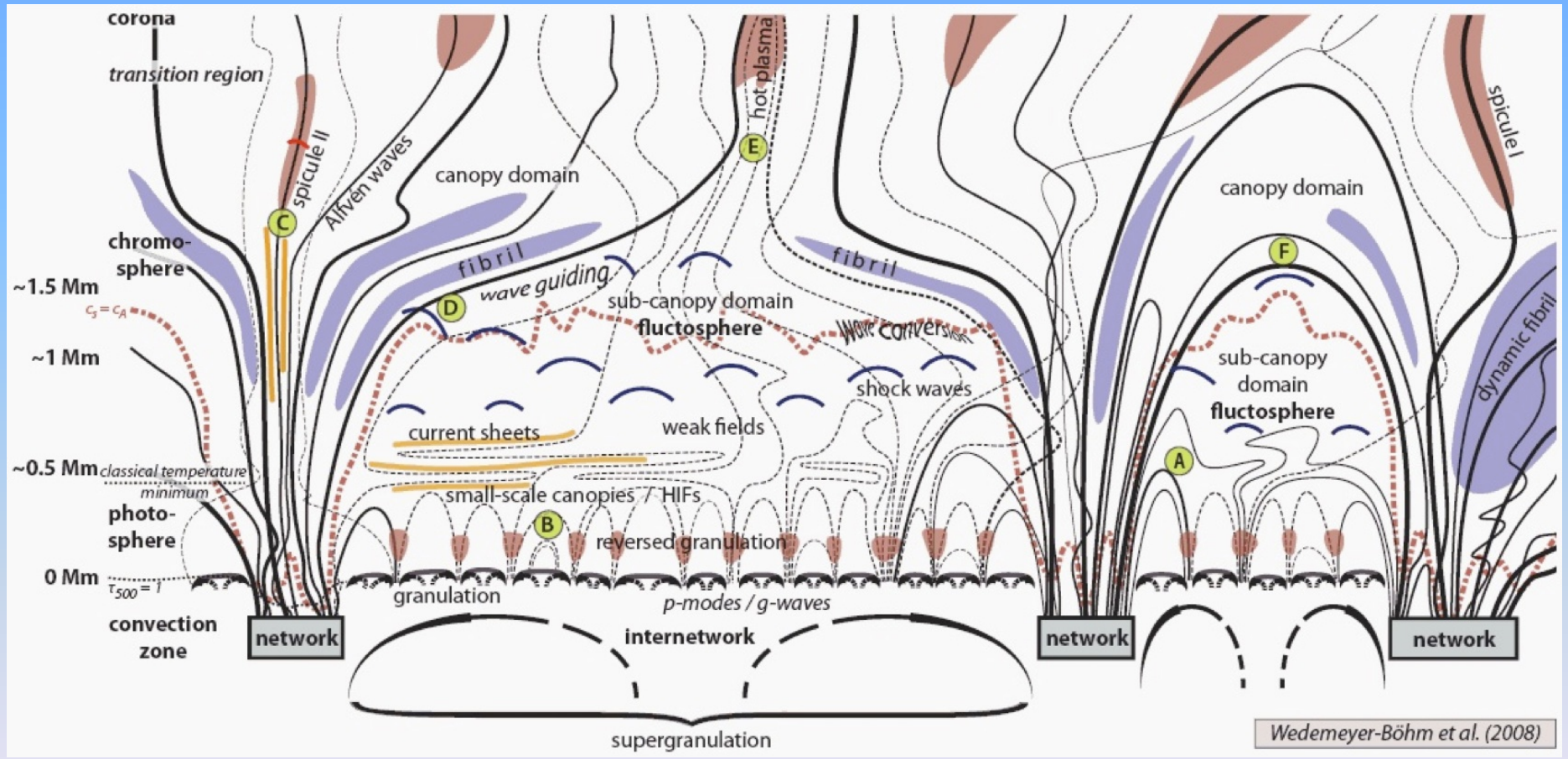


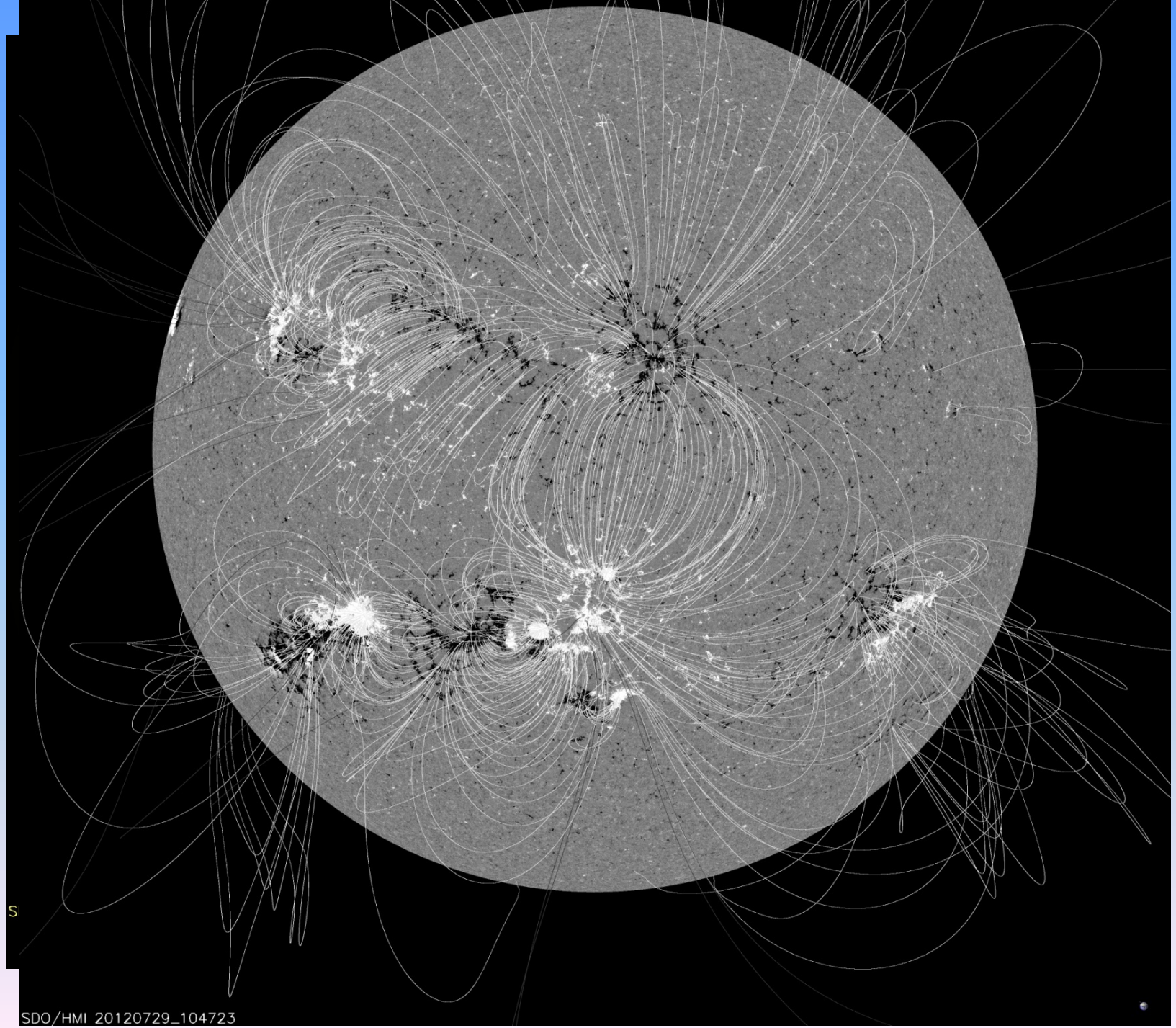




The Solar Atmosphere is Highly Structured

How do mass and energy flow through the atmosphere?

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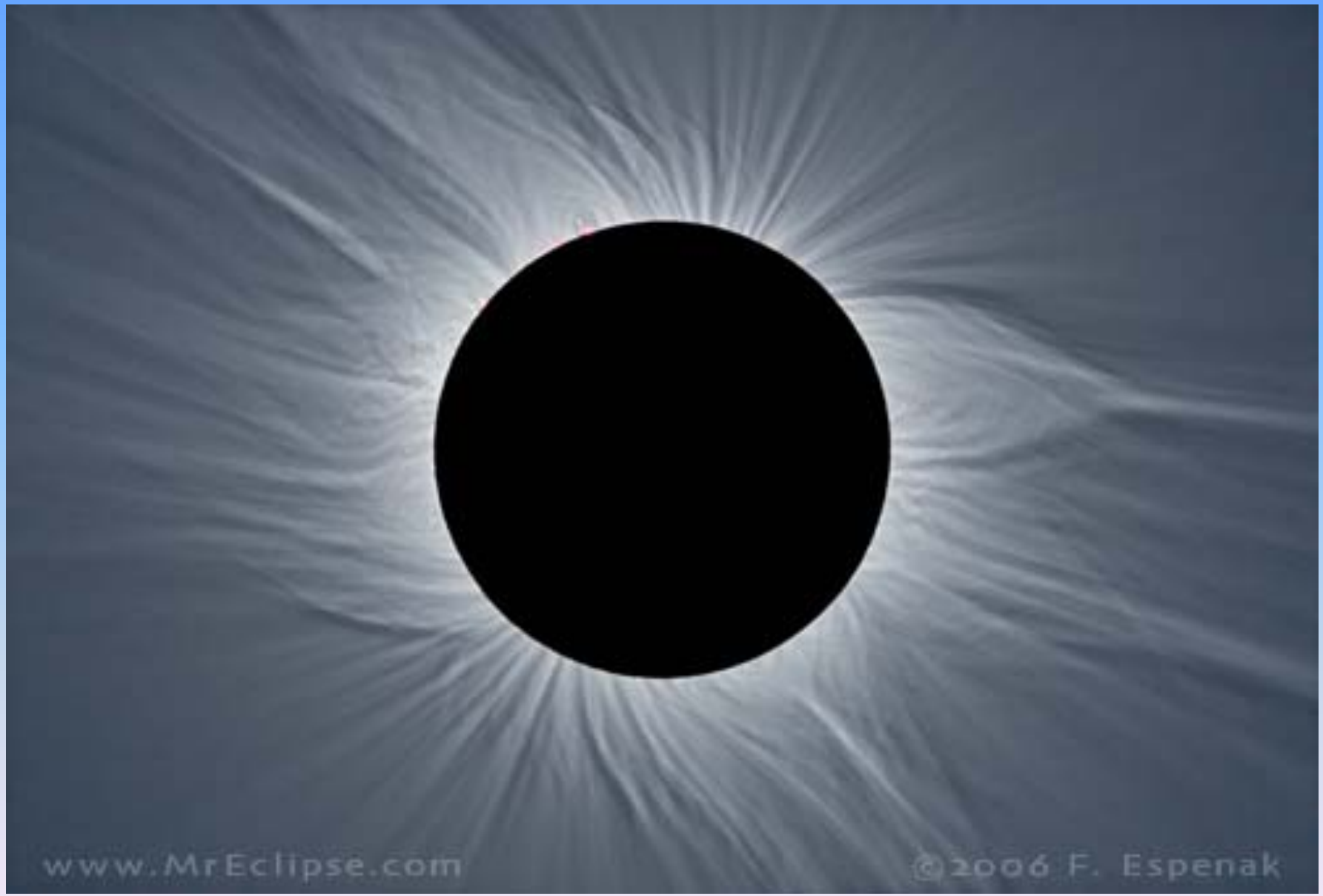
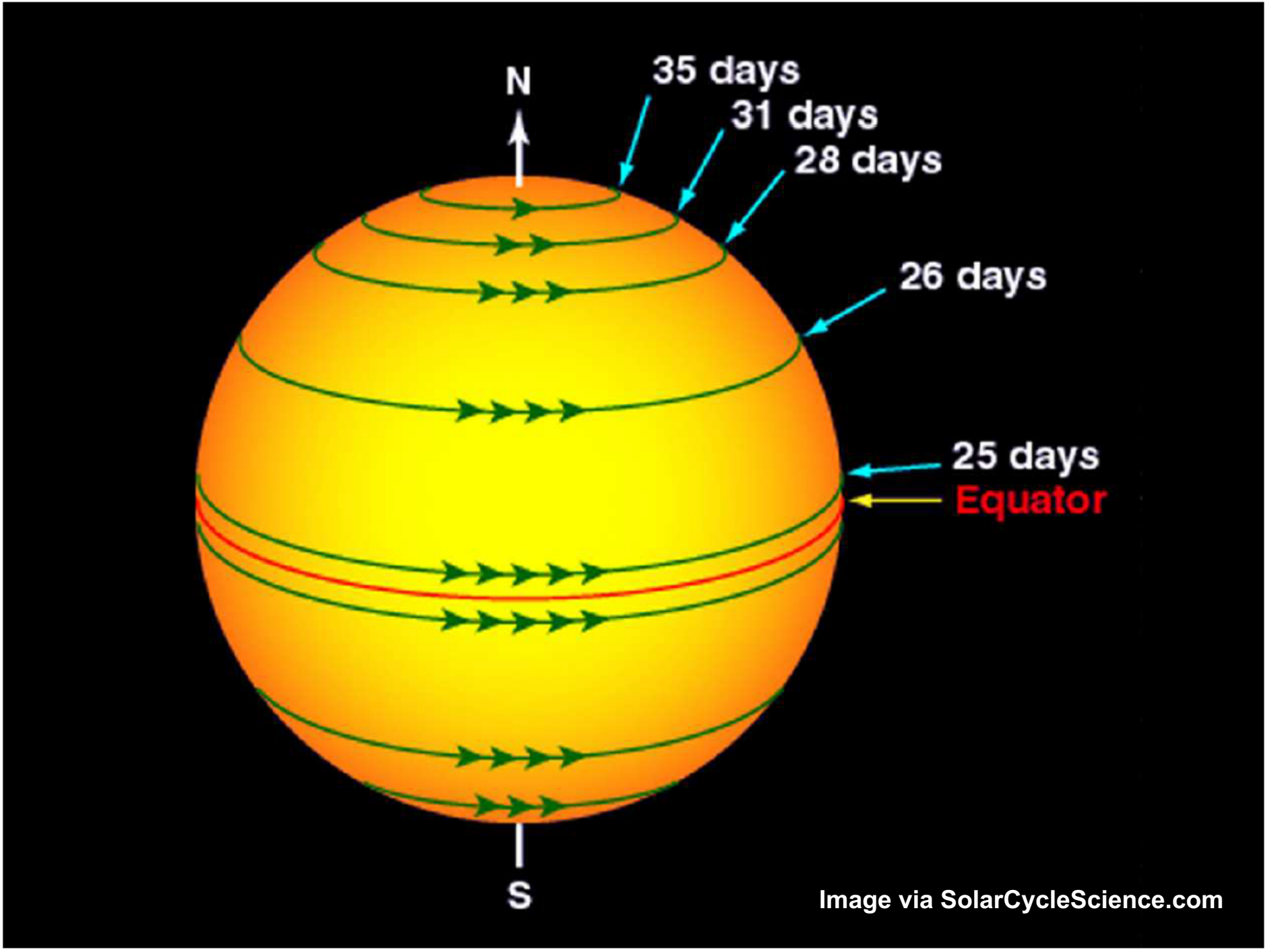
SDO/HMI 20120729_104723


www.MrEclipse.com
©2006 F. Espenak


N
35 days
31 days
28 days
26 days
25 days
Equator
S
Image via SolarCycleScience.com

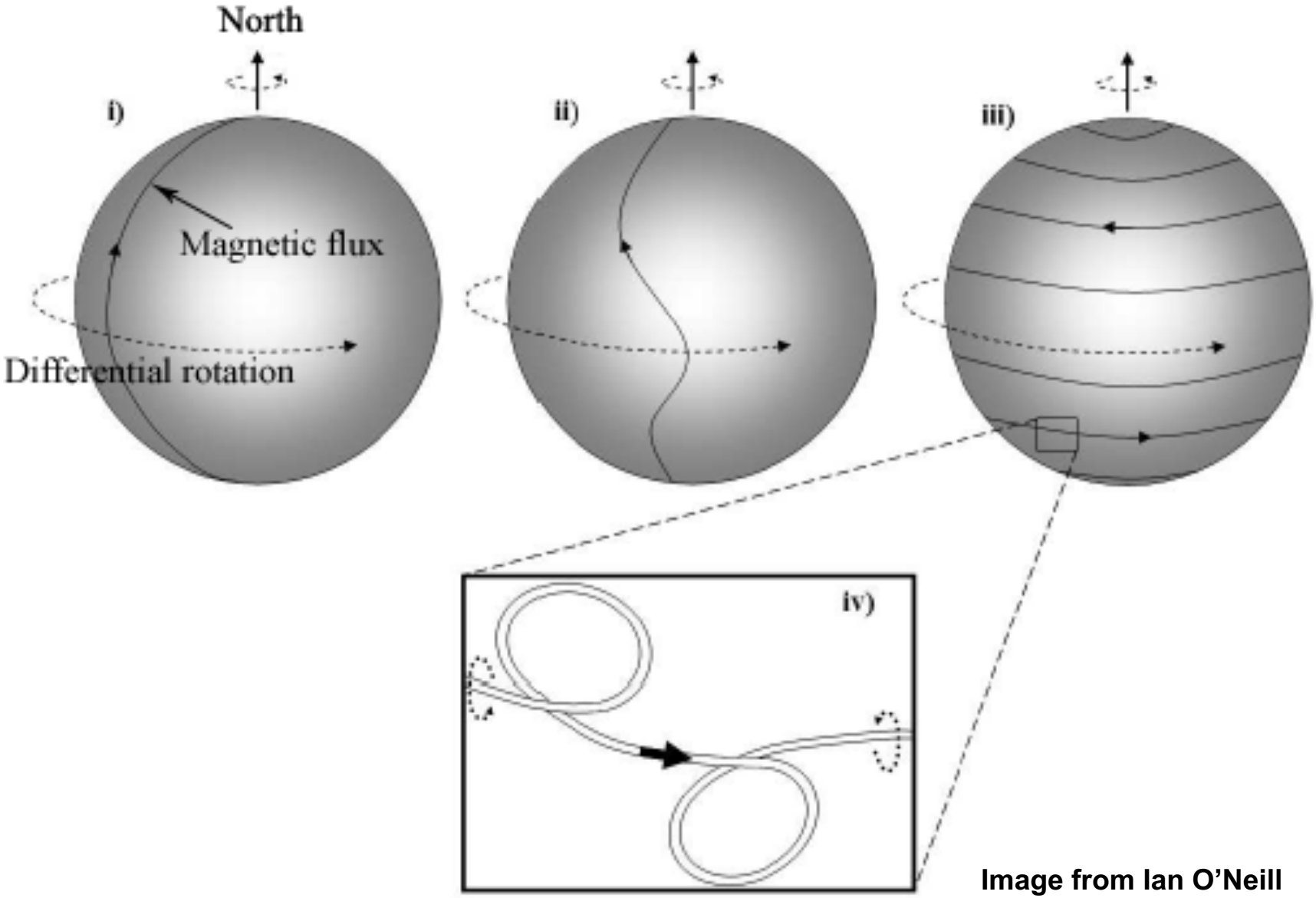
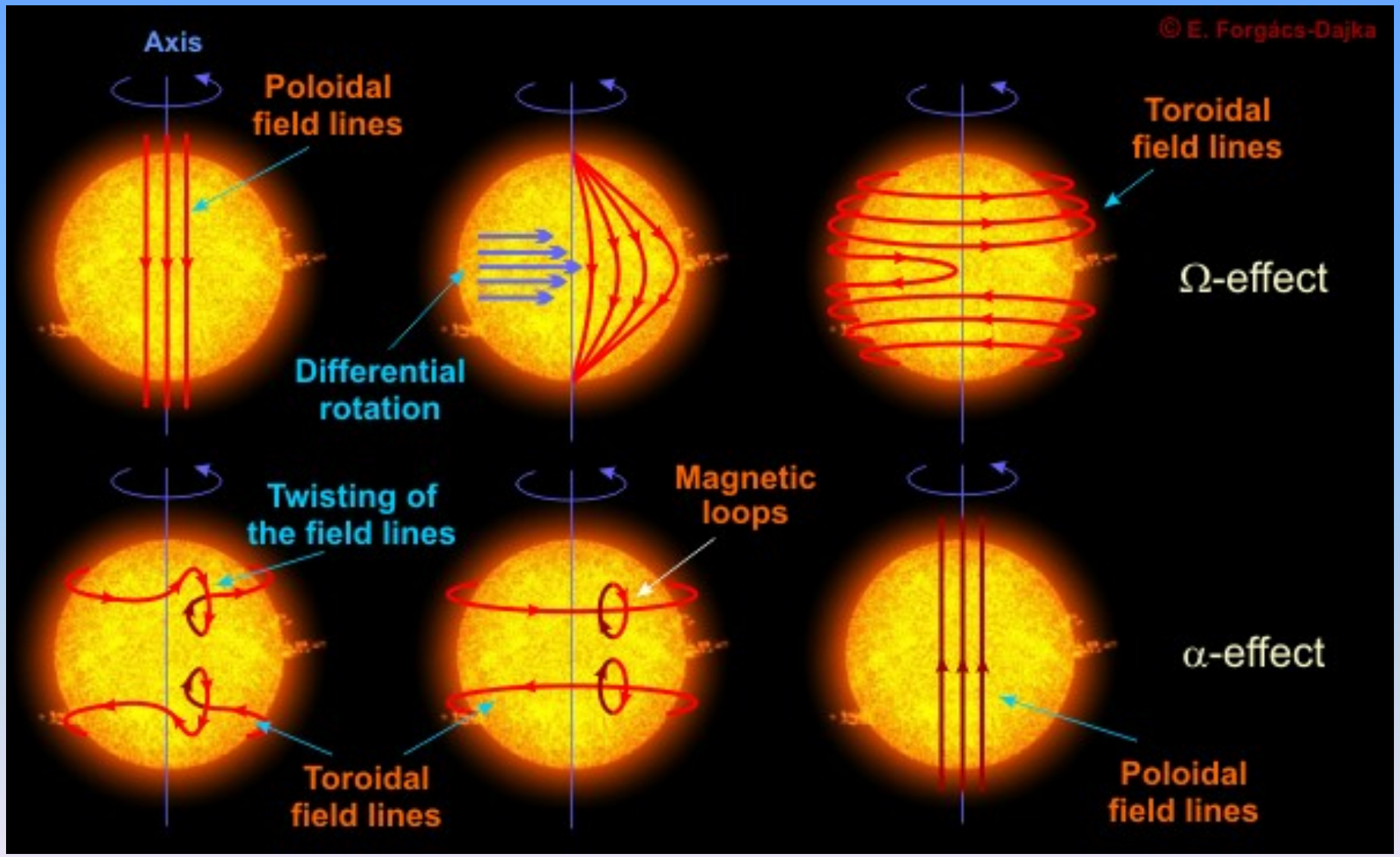
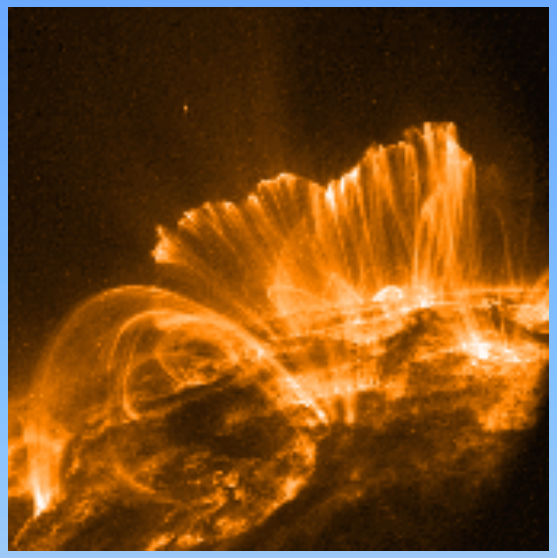
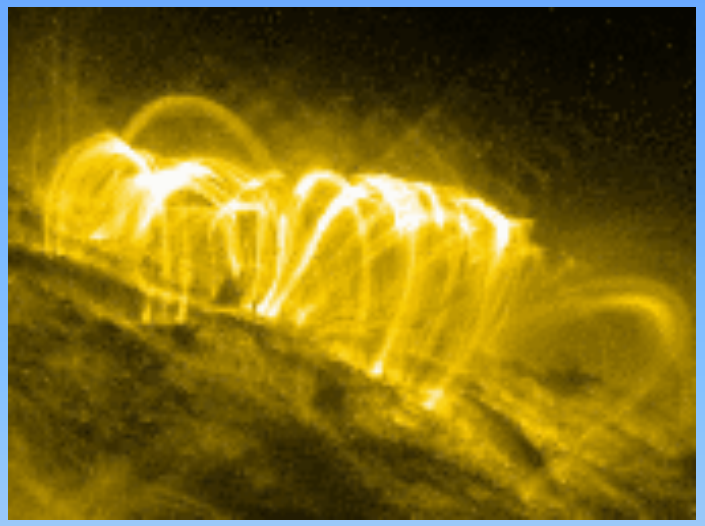


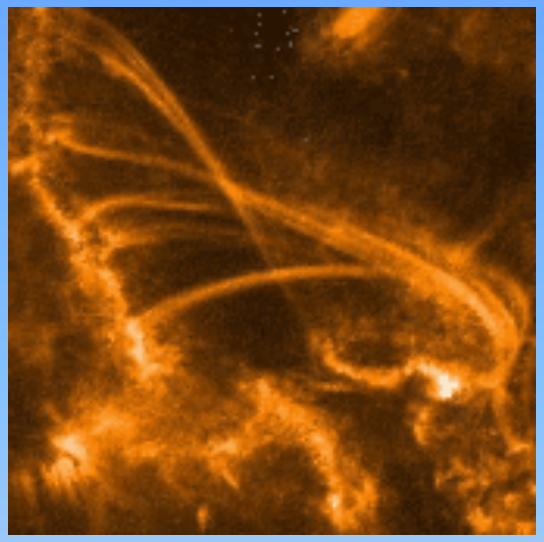
Image from Ian O'Neill


© E. Forgács-Dajka
Axis
Poloidal field lines
Differential rotation
Toroidal field lines
Ω-effect
Twisting of the field lines
Magnetic loops
Toroidal field lines
α-effect
Poloidal field lines

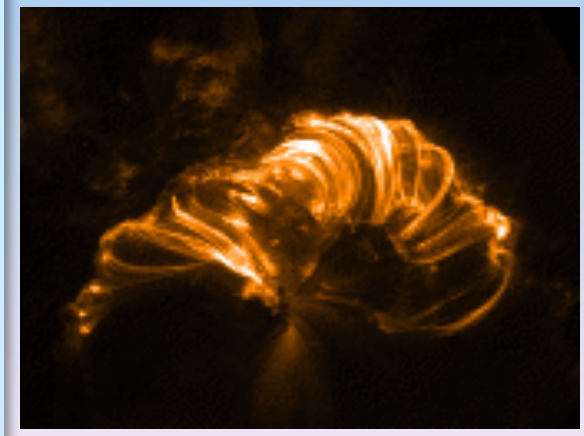
Flare Arcades and Loop Morphology – TRACE (171 Å)

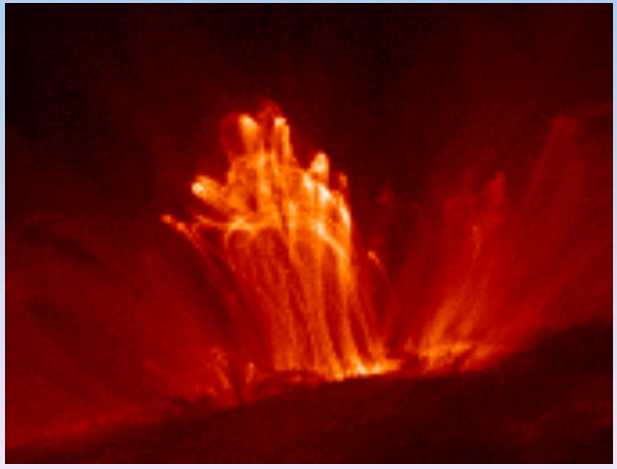


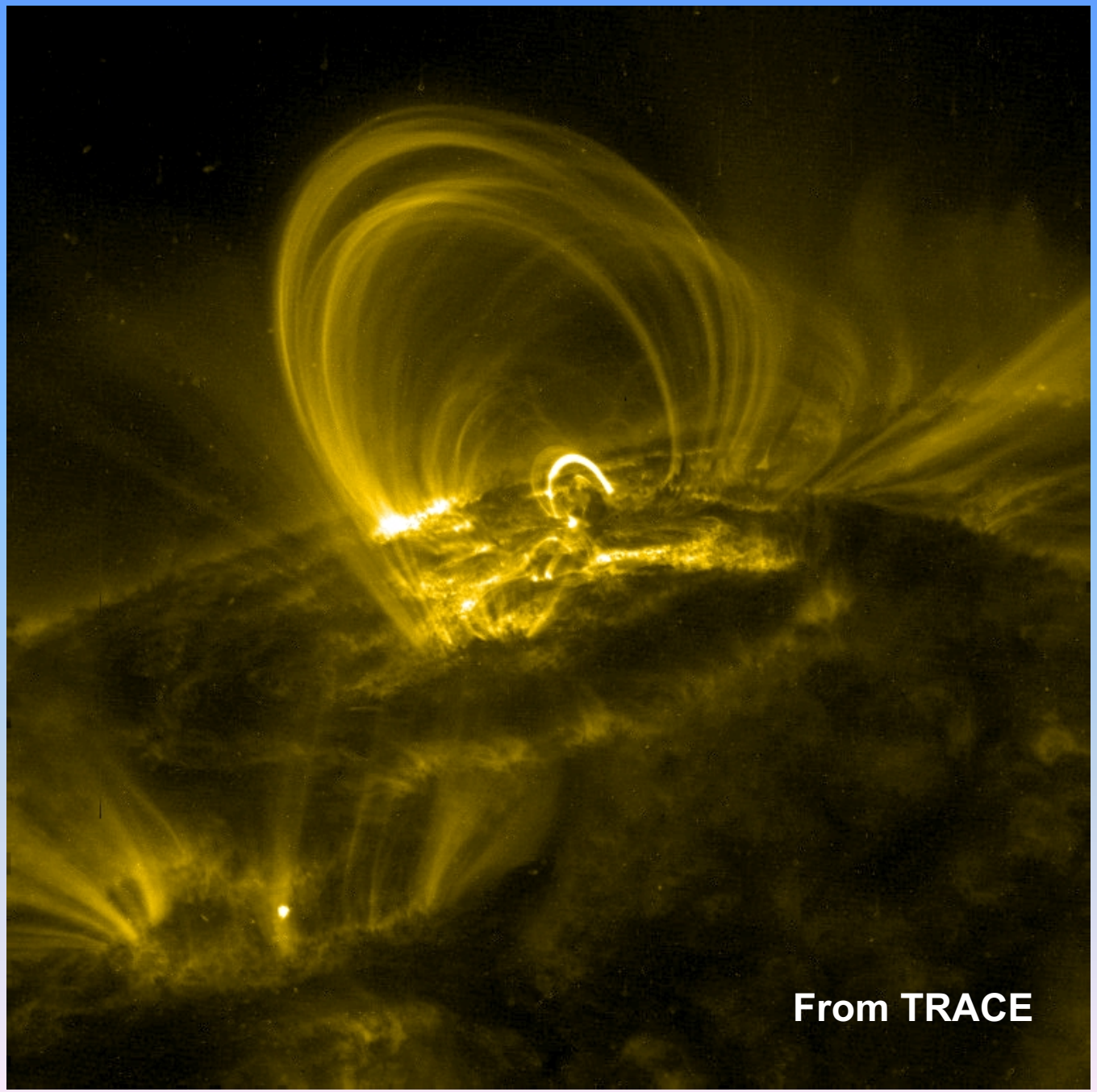




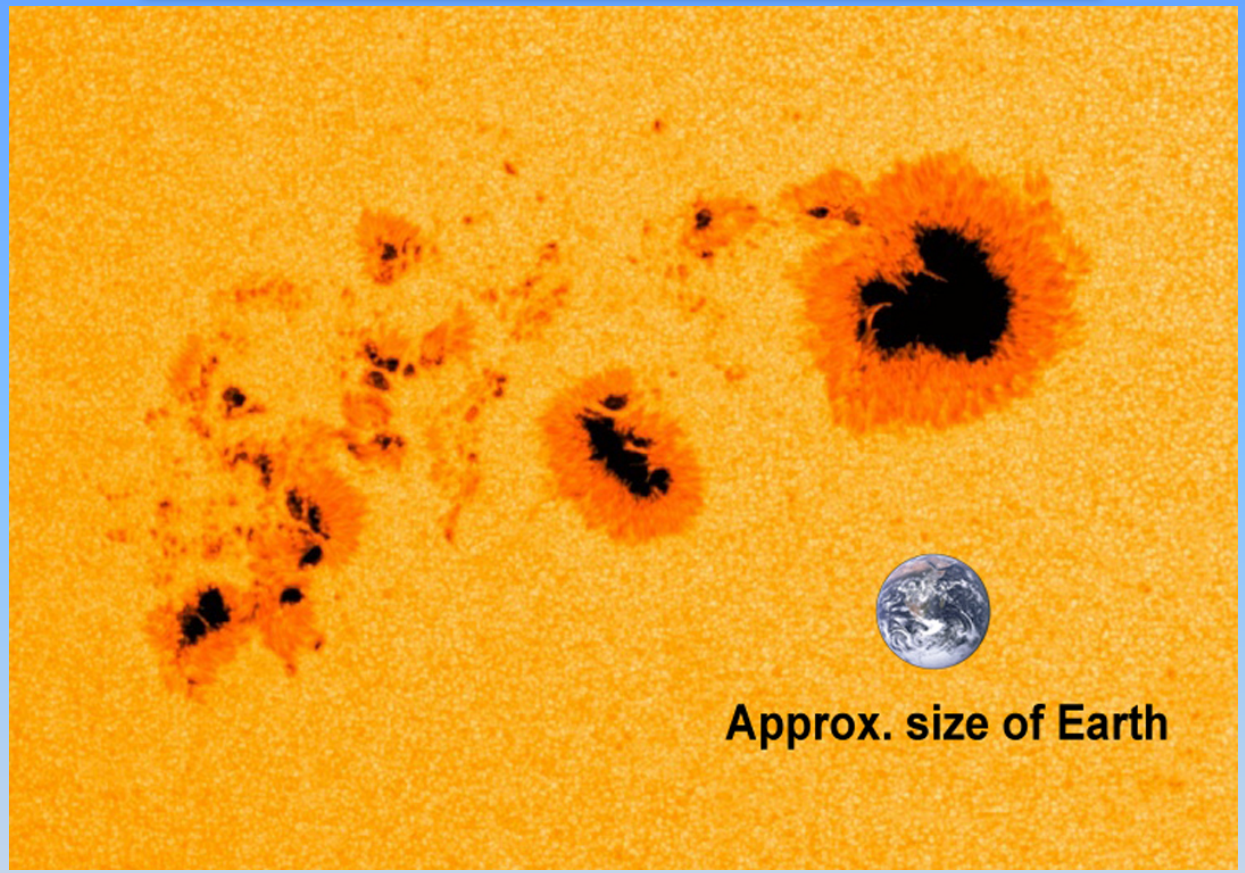
We now a huge database of flare and active region observations. The different view angles provide critical inform-ation for modeling. Note the non-dipole shapes of the individual loops in the upper right panel.





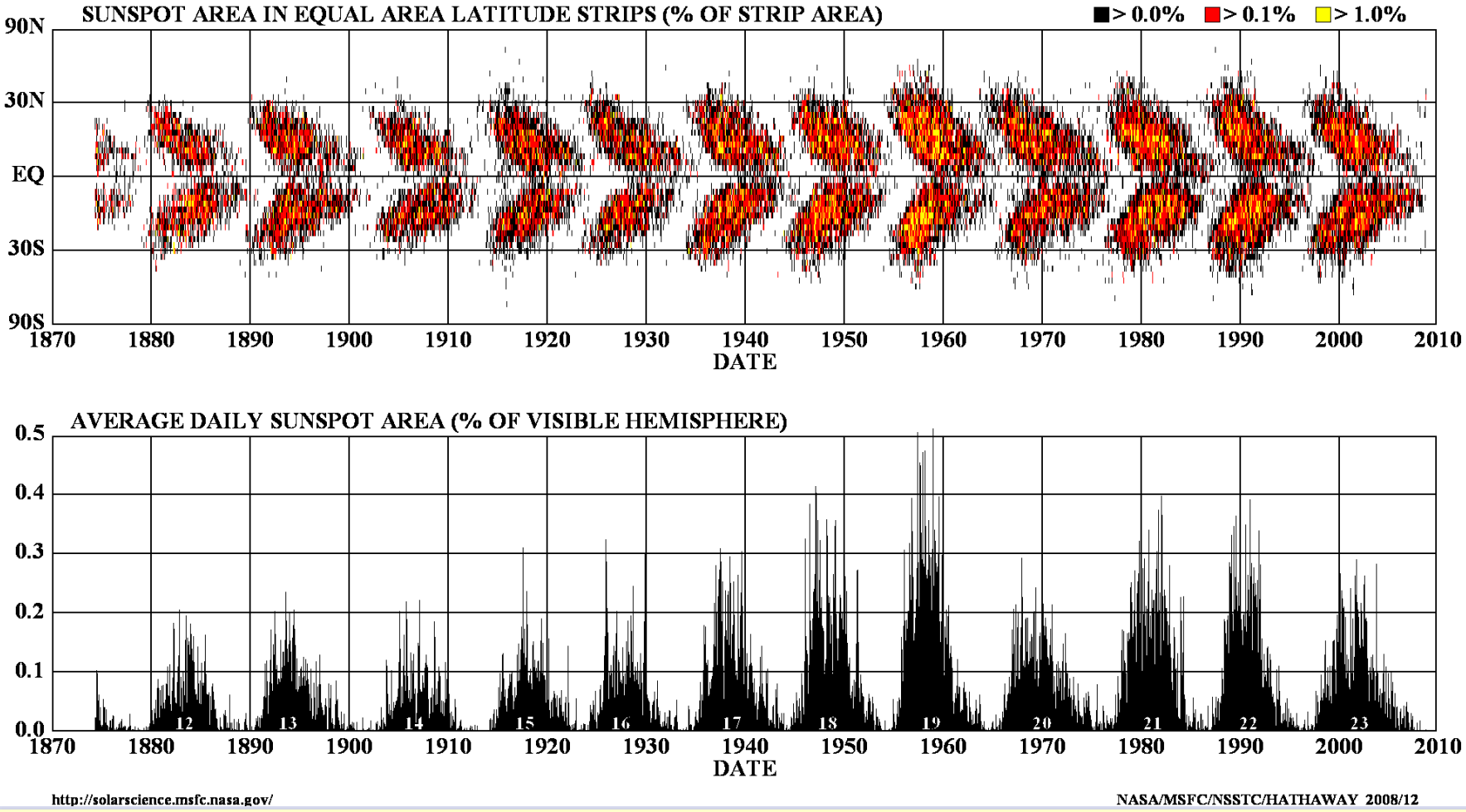

From TRACE

What are sunspots?



- *Sunspots*
  - Formed by strong magnetic fields (a few thousand Gauss) that inhibit heating within them
  - Cooler than the surface by about 2000 K
  - Formed below the Sun's surface
- *The emergence of many sunspots produces an active region*
  - Source of flares, coronal mass ejections

DAILY SUNSPOT AREA AVERAGED OVER INDIVIDUAL SOLAR ROTATIONS

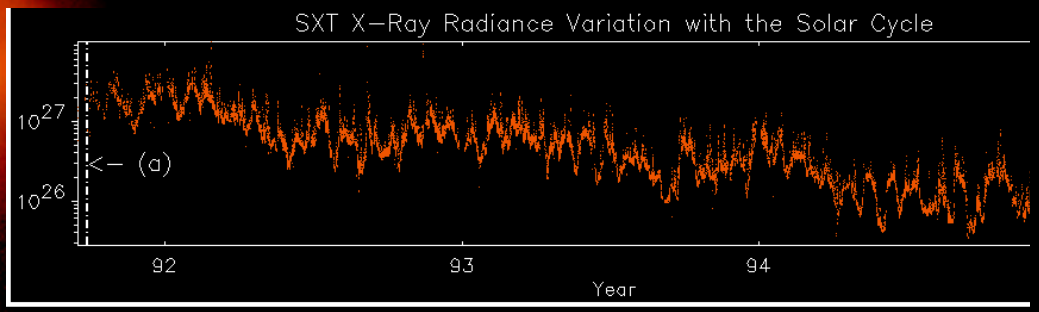


Sunspot: a region on the Sun's surface marked by intense magnetic activity, which inhibits convection, forming areas of reduced surface temperature

Image by David Hathaway via SolarCycleScience.com

The 11 Year Solar Cycle in X-rays: Maximum to Minimum

Yohkoh/SXT



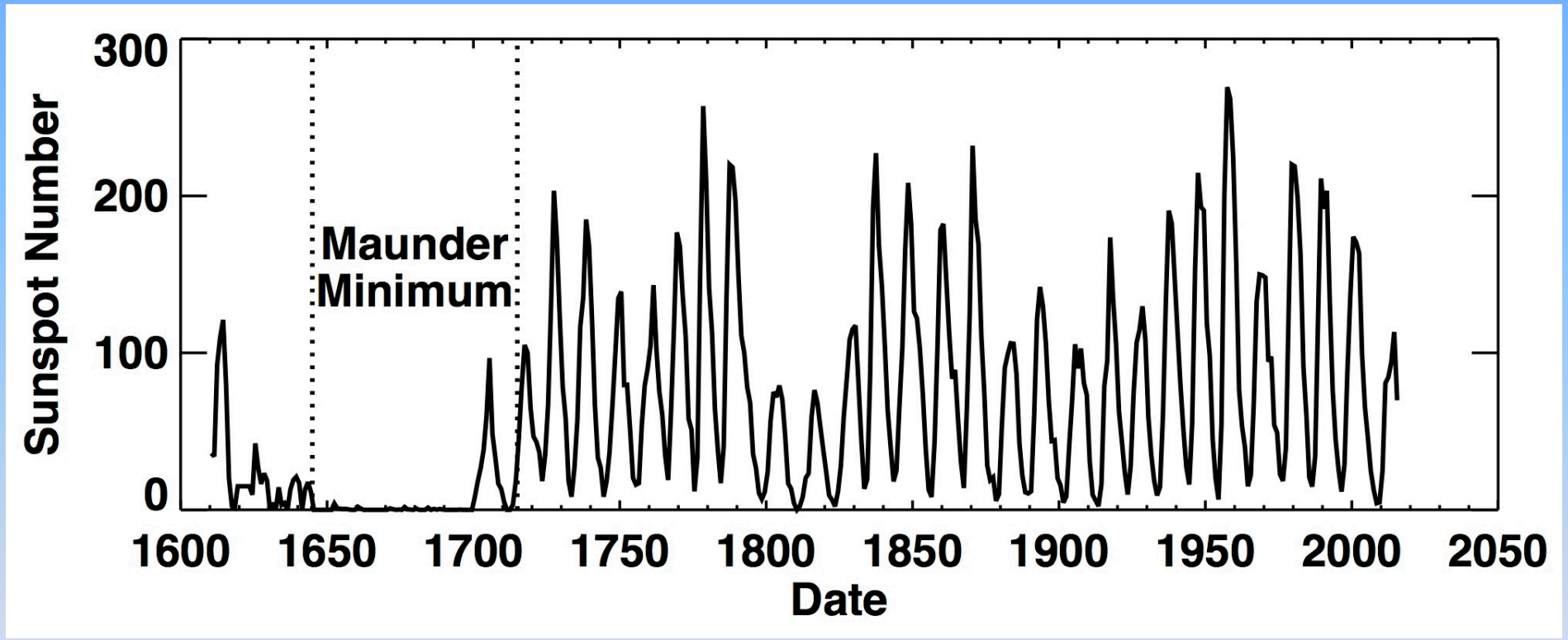


Image via SolarCycleScience.com

Meridional Flow

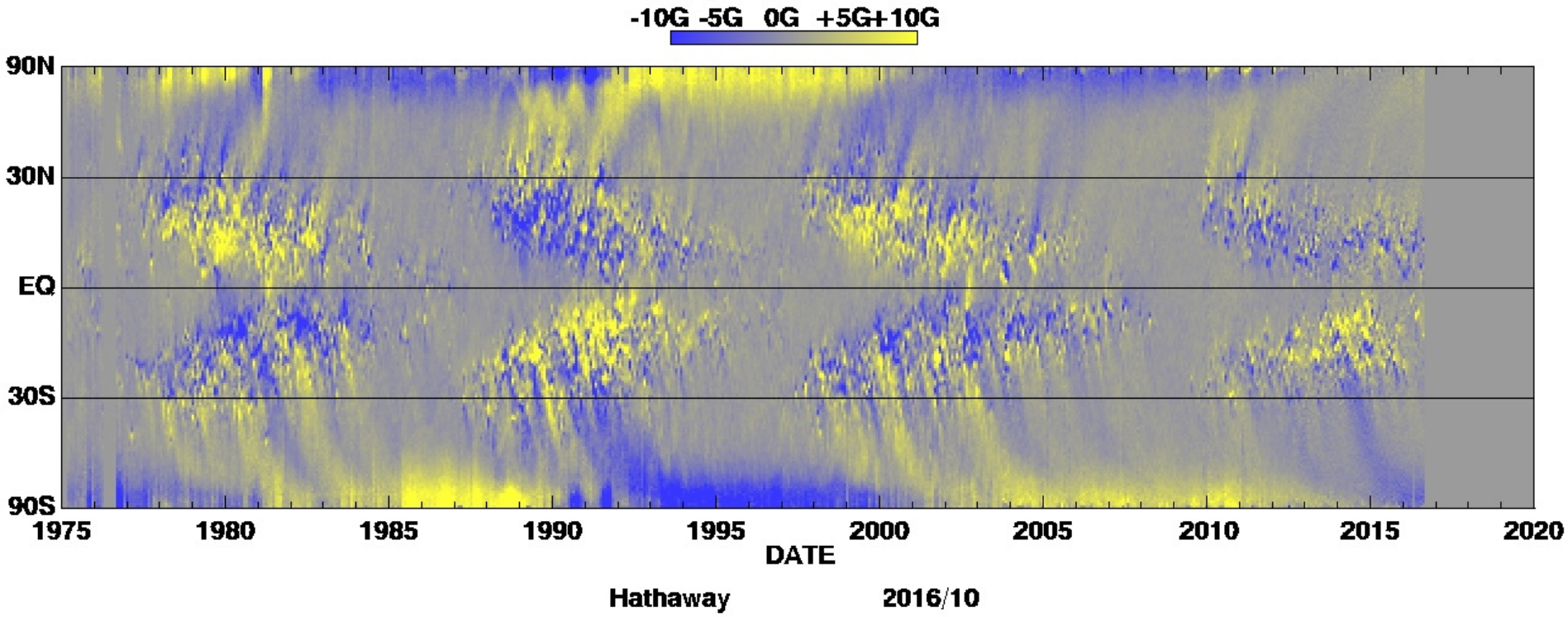
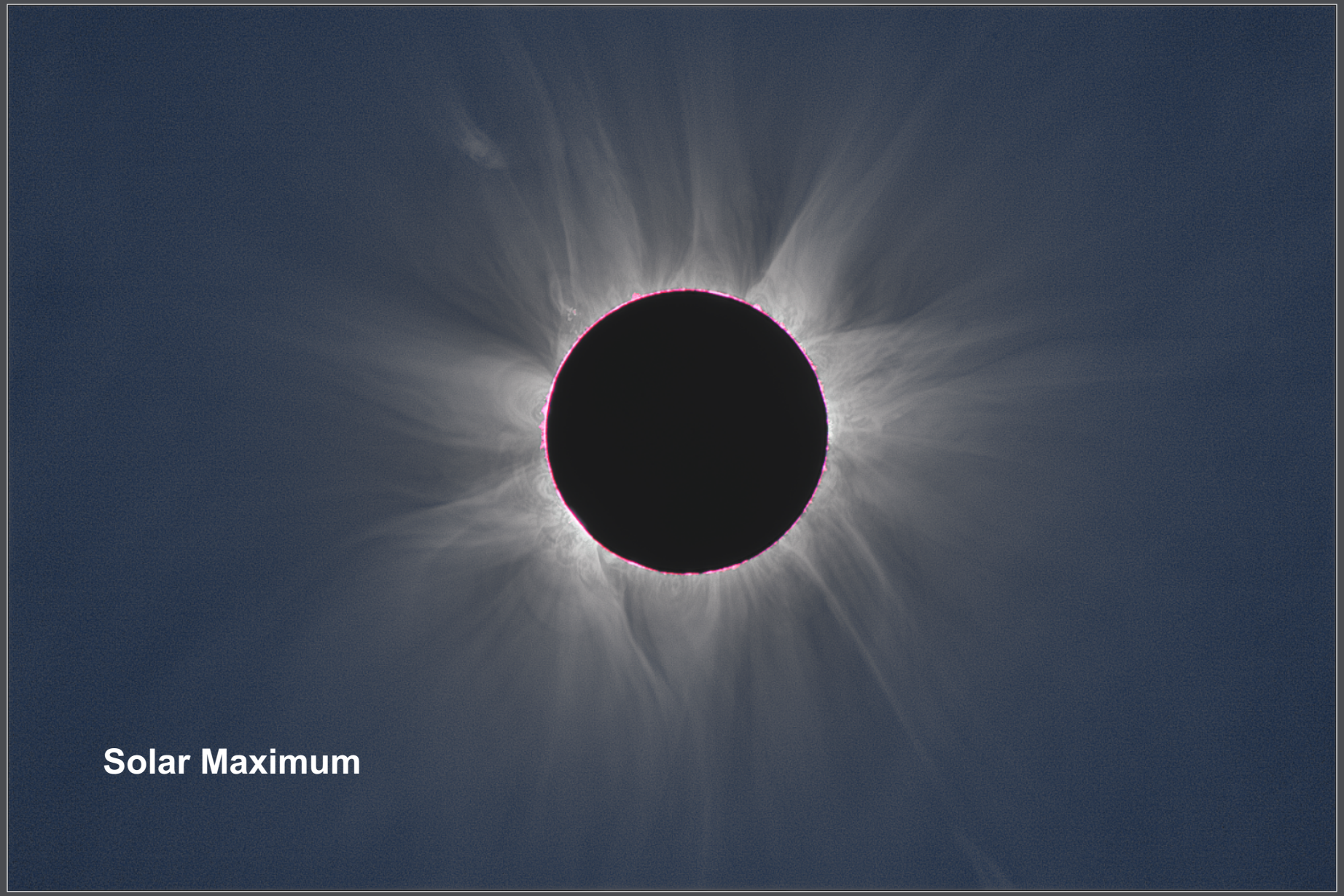
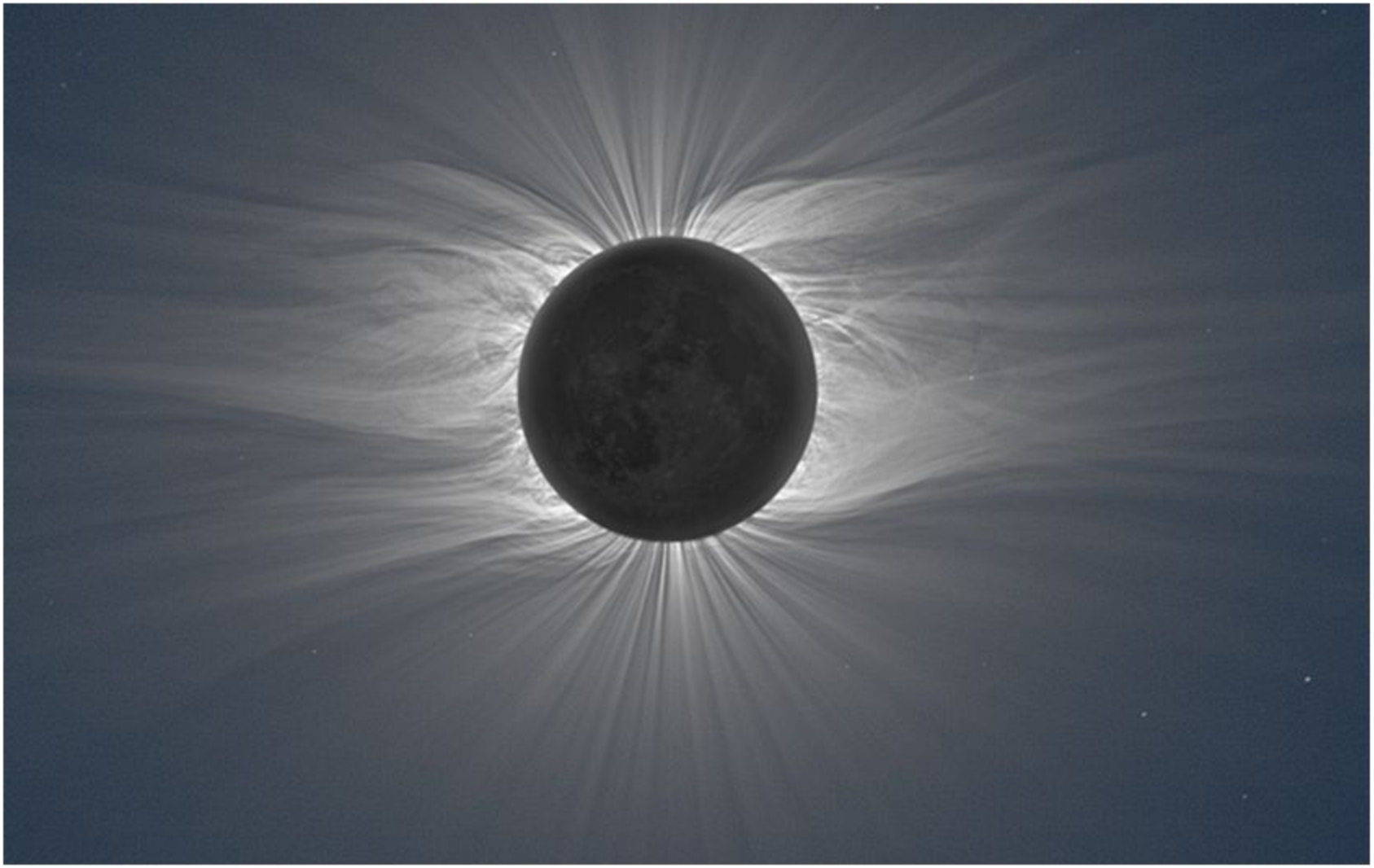


Image by David Hathaway via SolarCycleScience.com

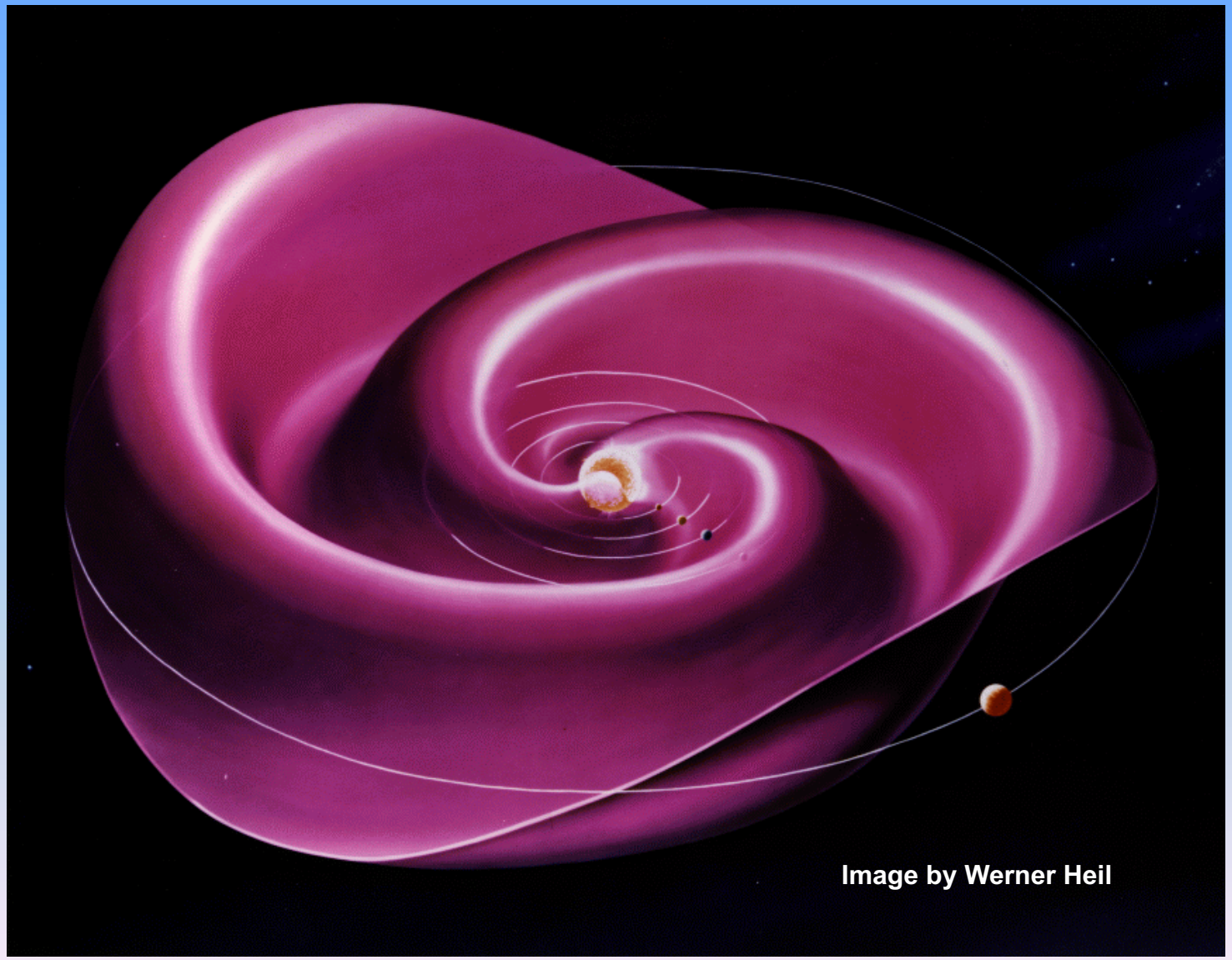


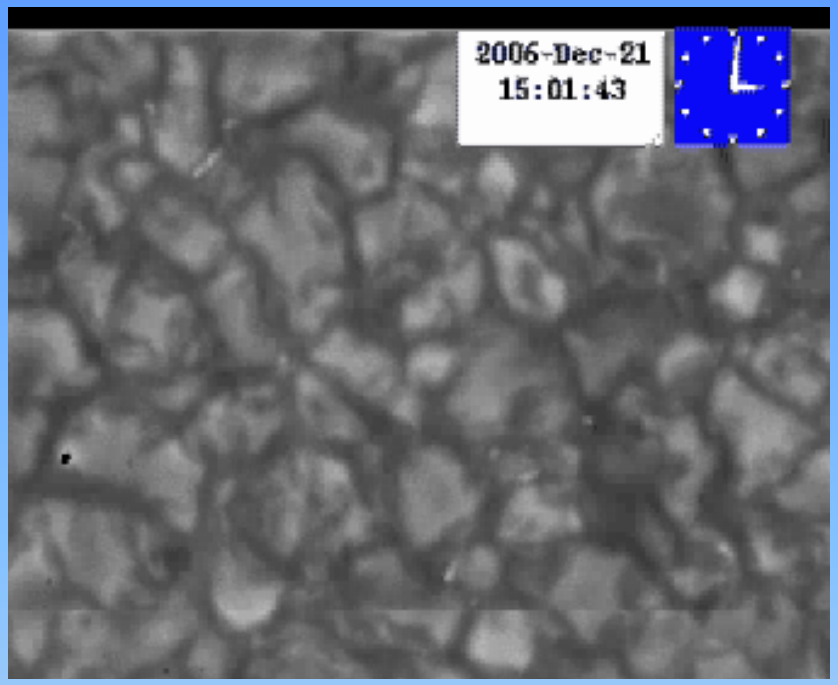
Solar corona during the recent deep solar minimum: 2009 solar eclipse



M. Druckmuller, Brno Observatory, Czech Rep. 2009 July 22

Heliospheric Current Sheet

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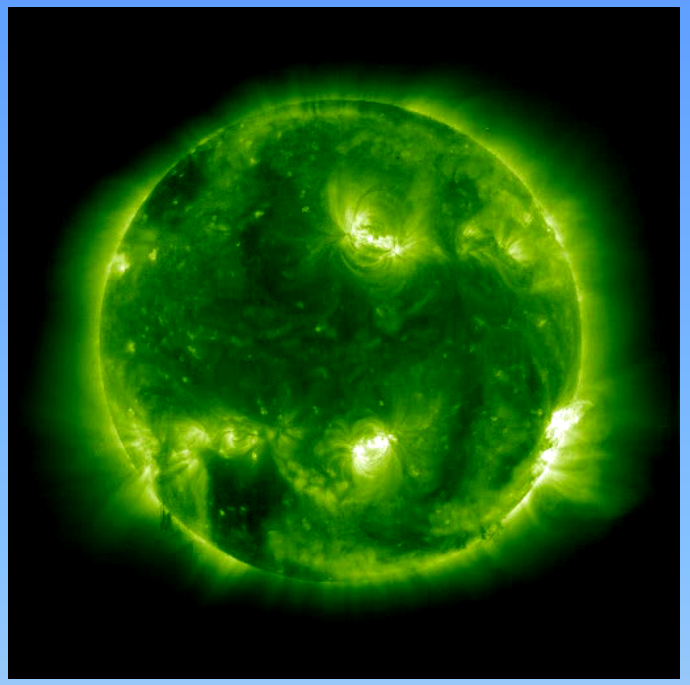

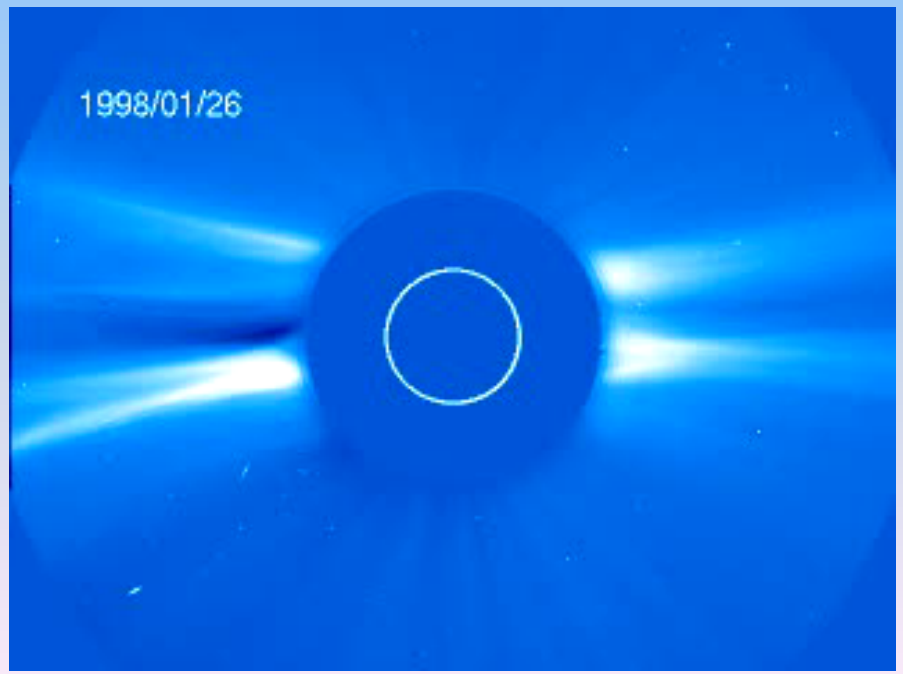
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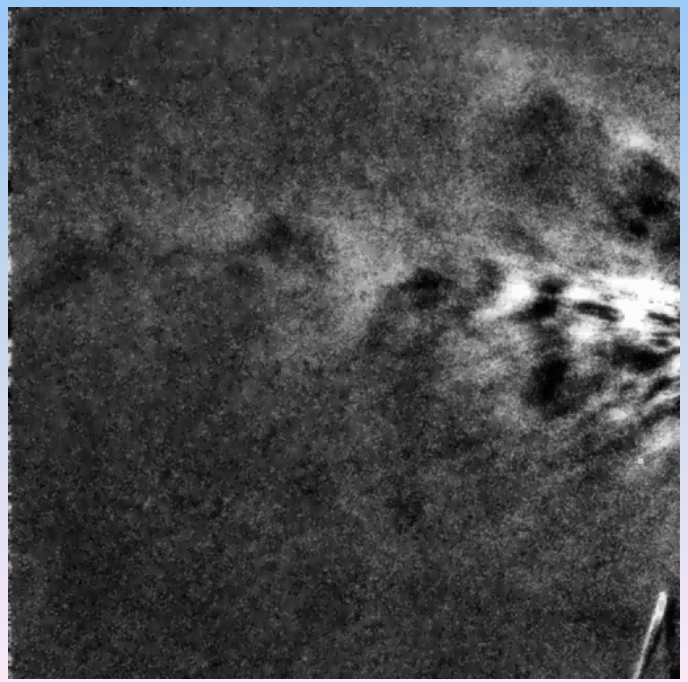
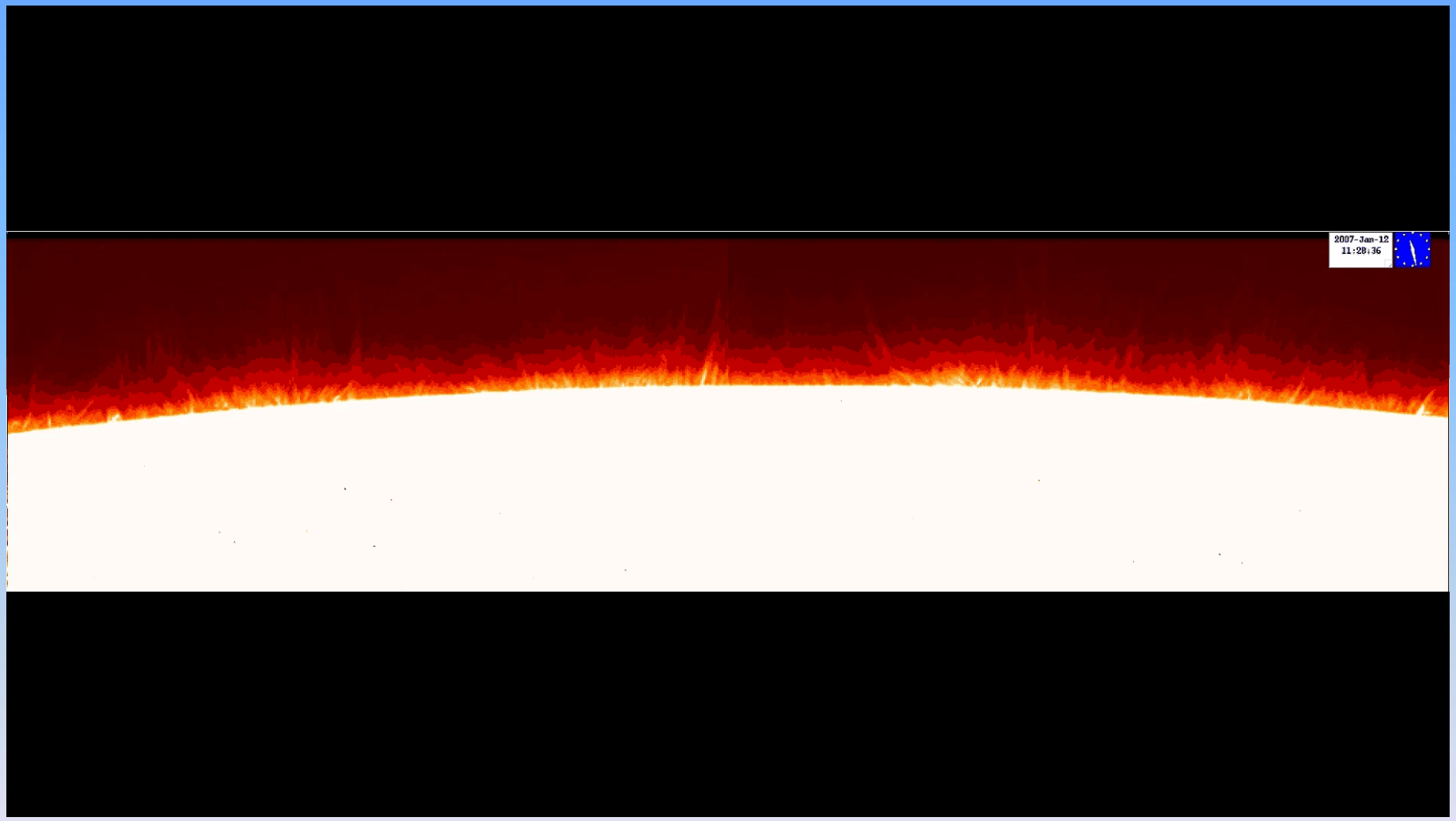
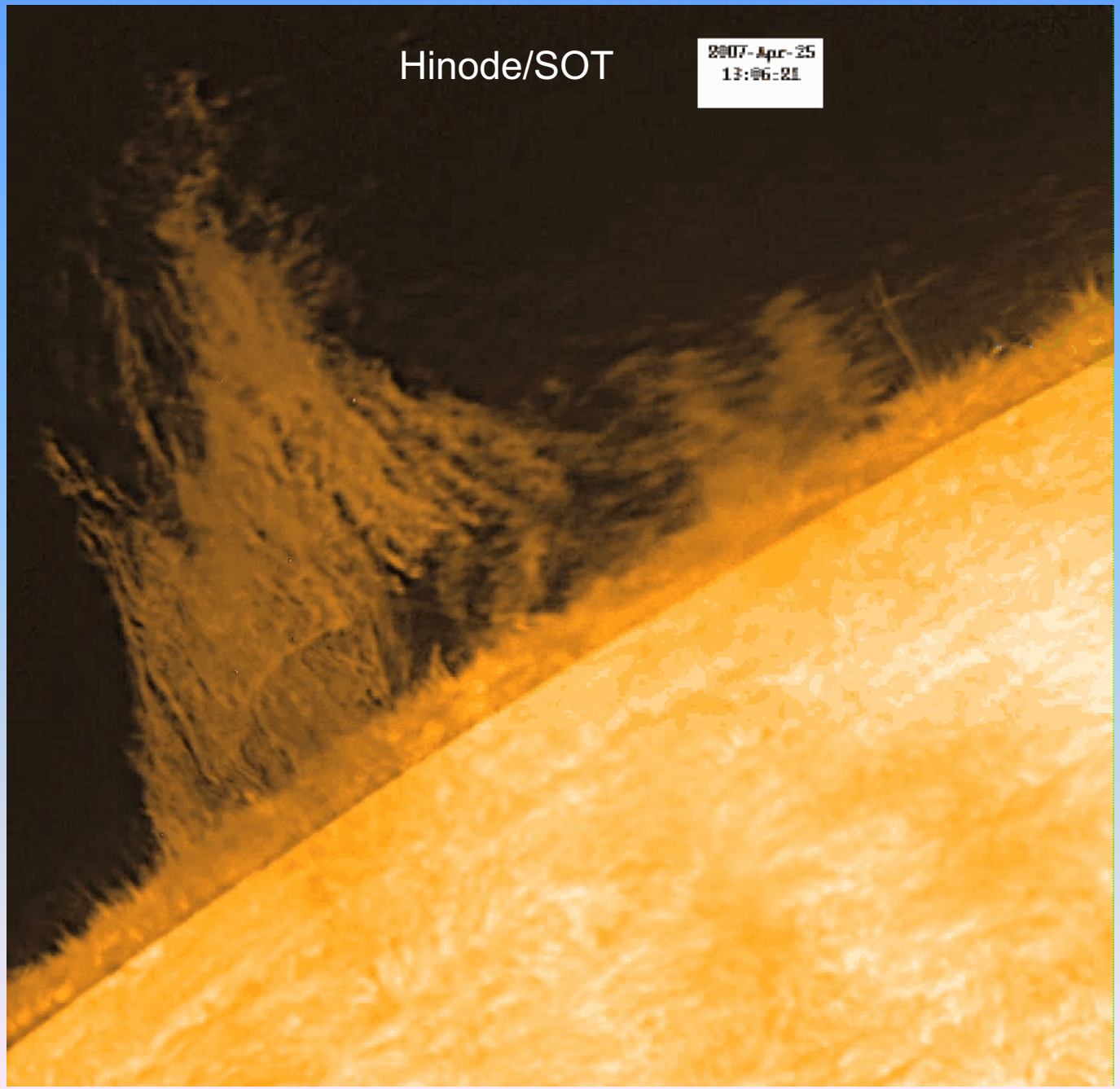
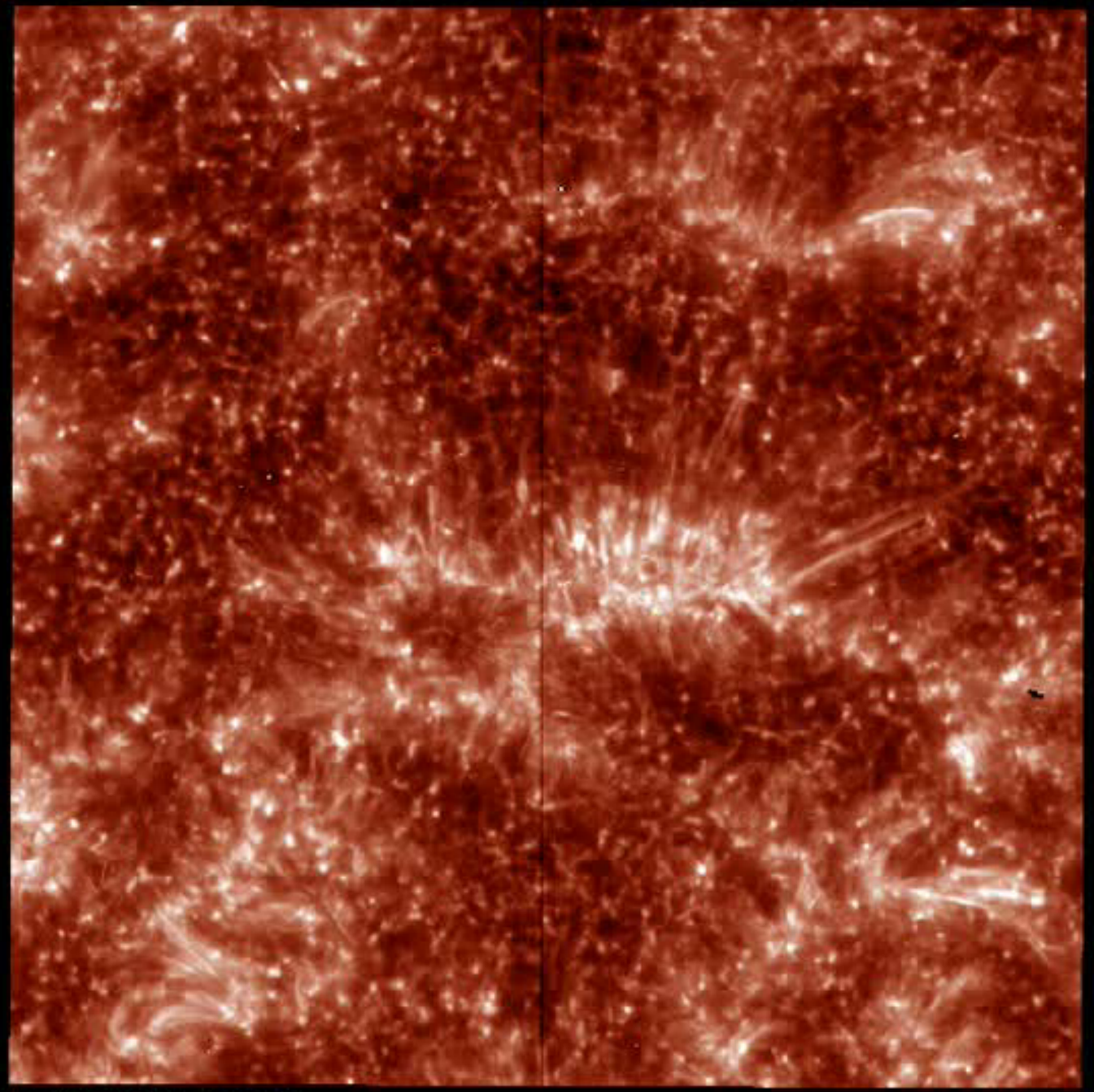


Hinode/SOT - North Pole Limb



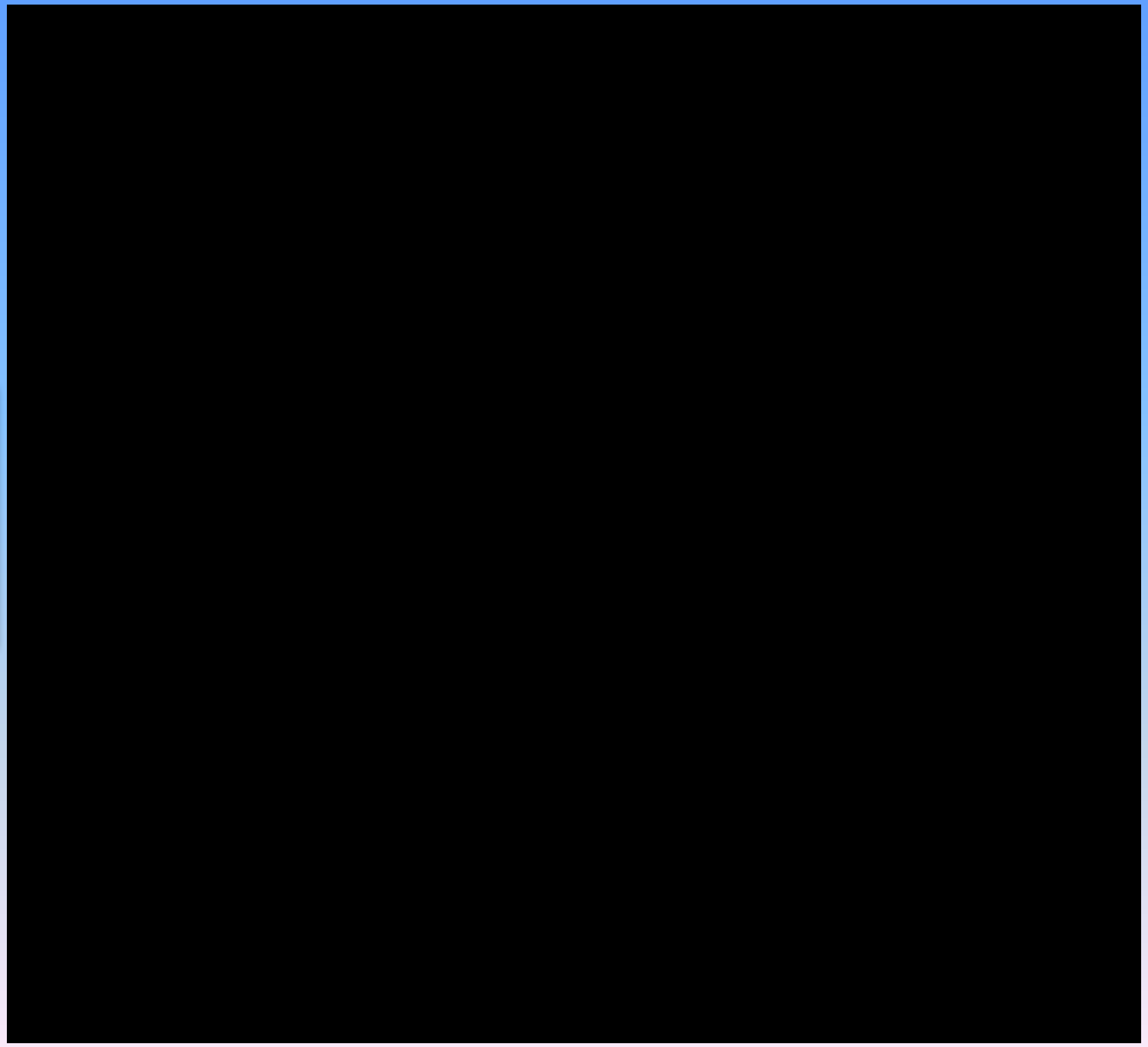

Hinode/SOT
2007-Apr-25
13:06:21



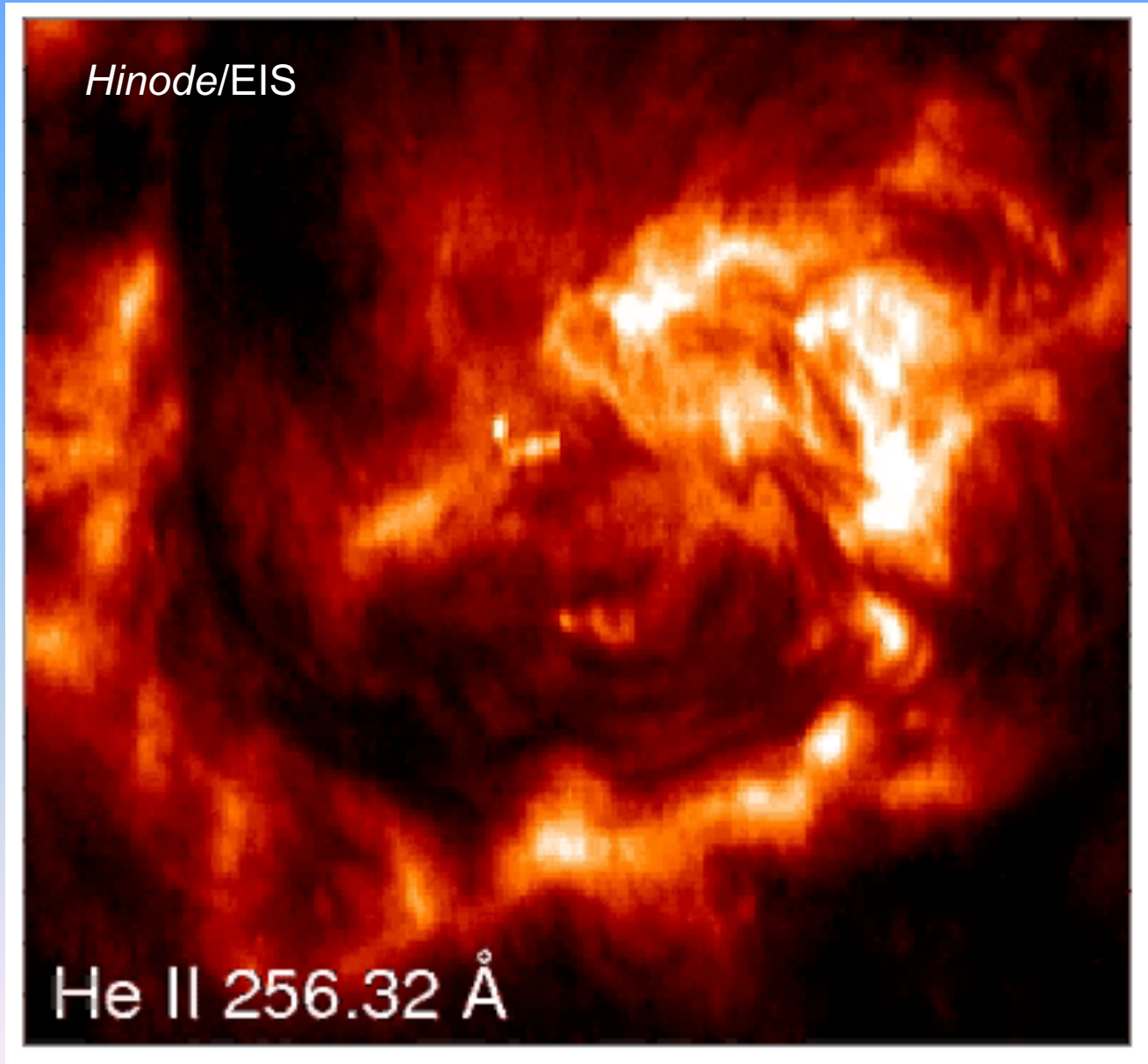
Si IV (65,000 K) from the Interface Region Imaging Spectrograph

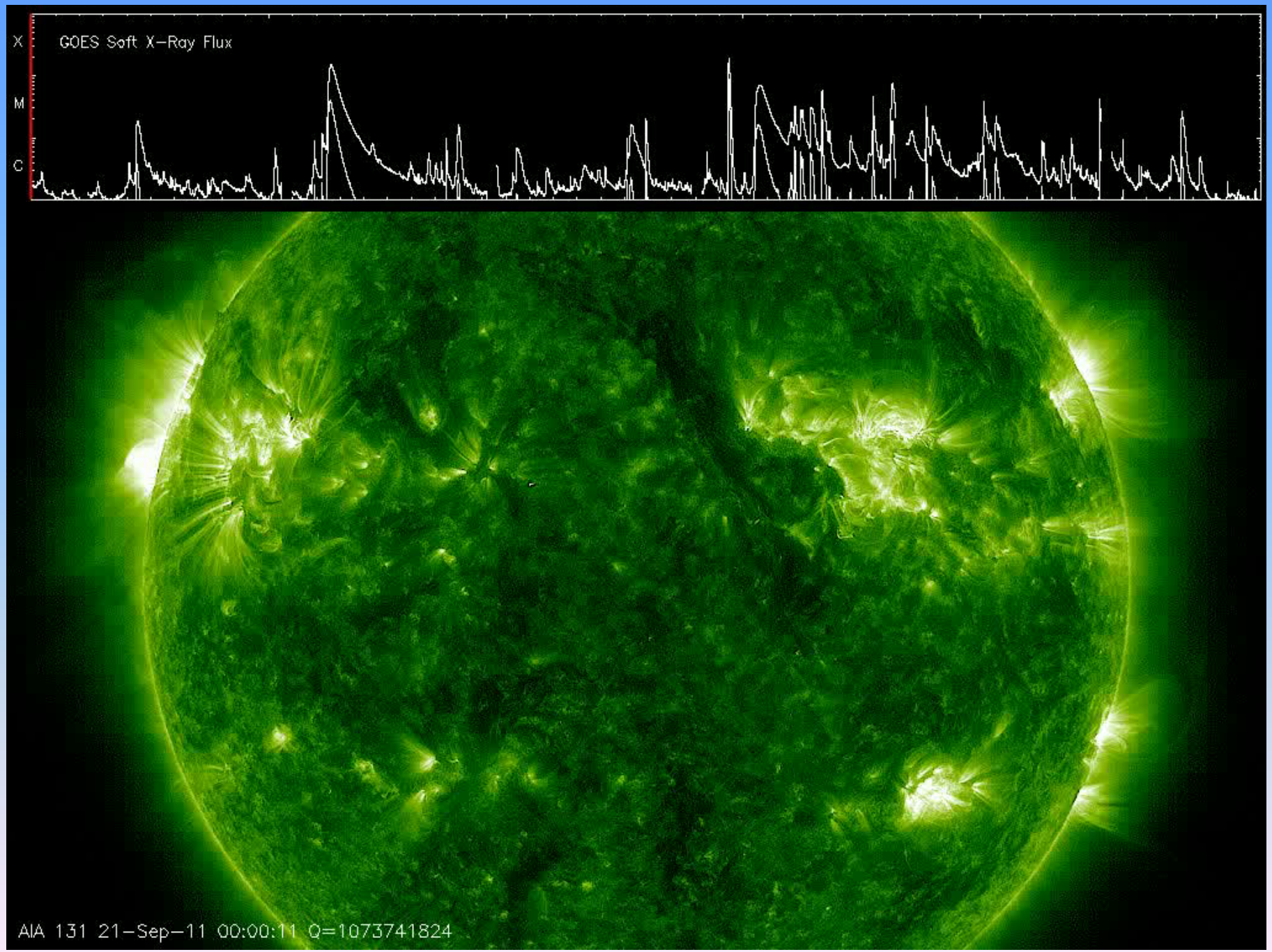
The Sun's atmosphere at 100,000 K. Everthing is moving!

NASA *Solar Dynamics Observatory*

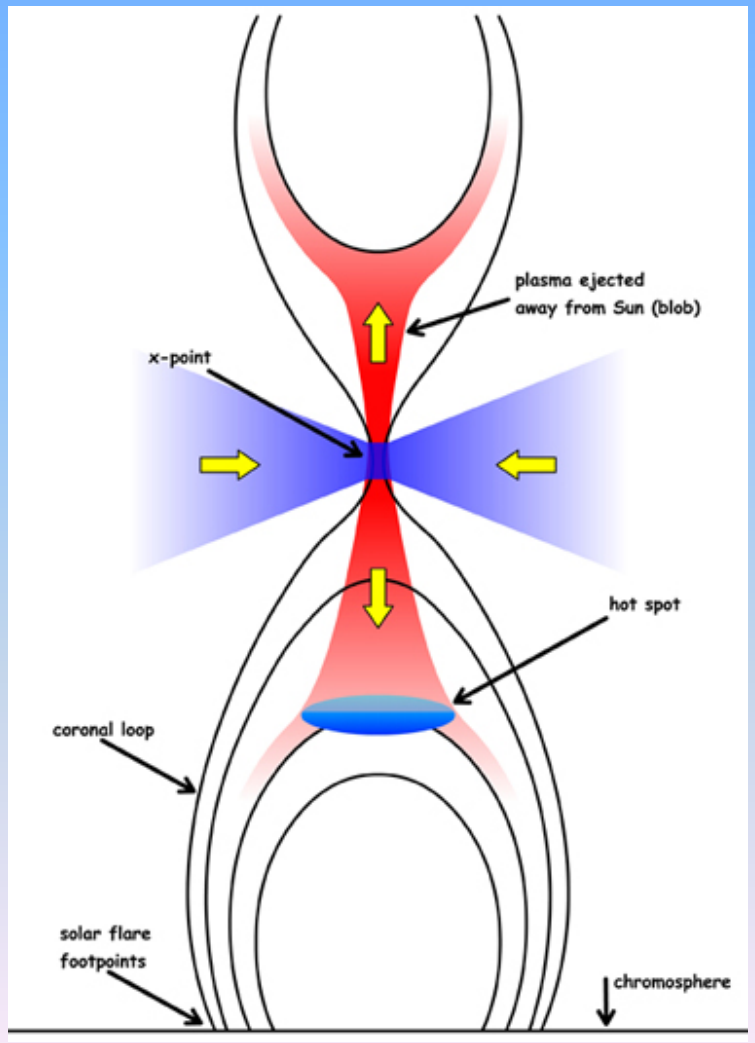


An active region at different temperatures

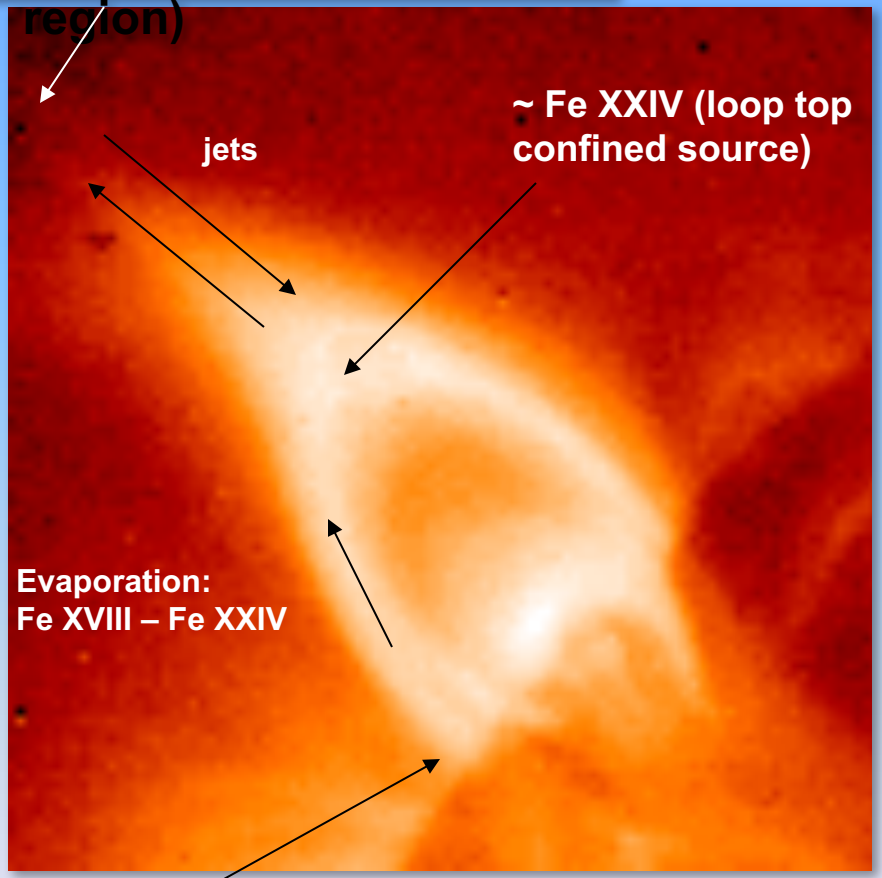



GOES Soft X-Ray Flux
X
M
C
AIA 131 21-Sep-11 00:00:11 Q=1073741824

Solar Flares: The Standard Reconnection Model

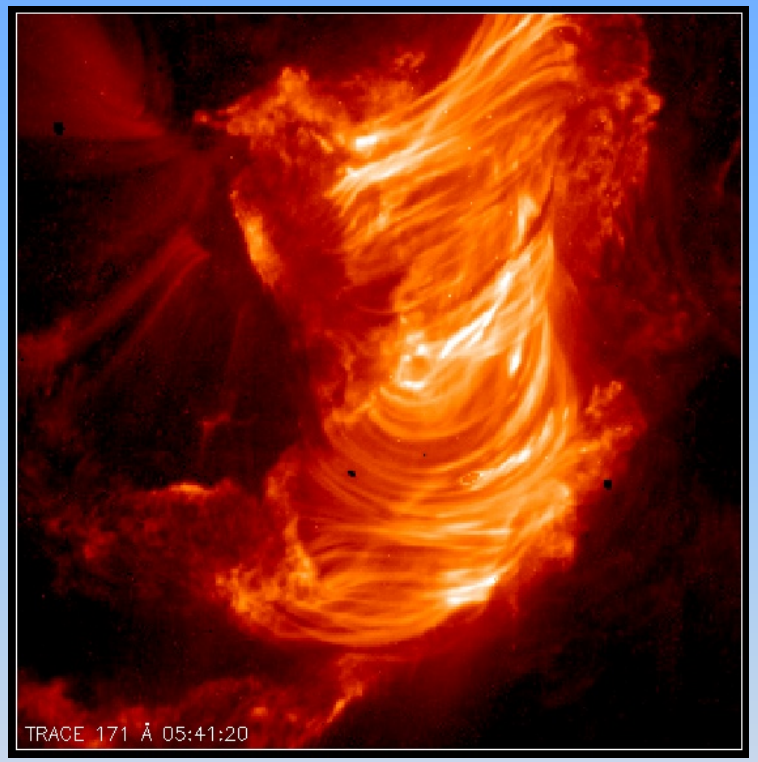


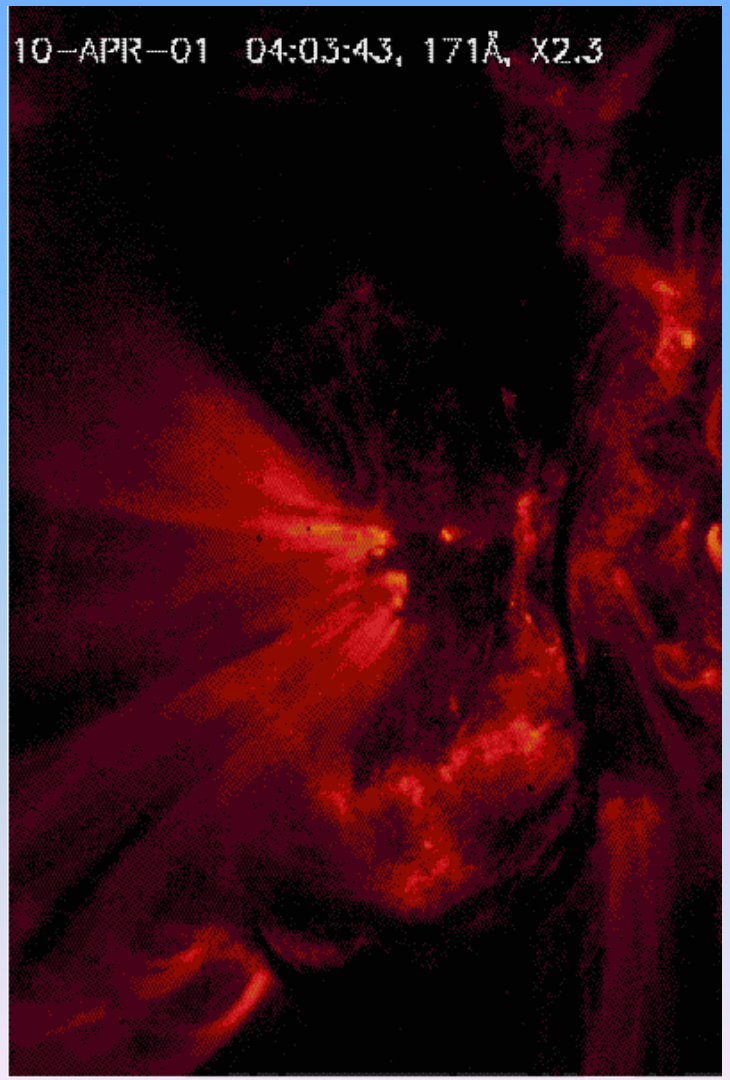
~ Fe XII (inflows into the reconnection region)



He II loop footpoints

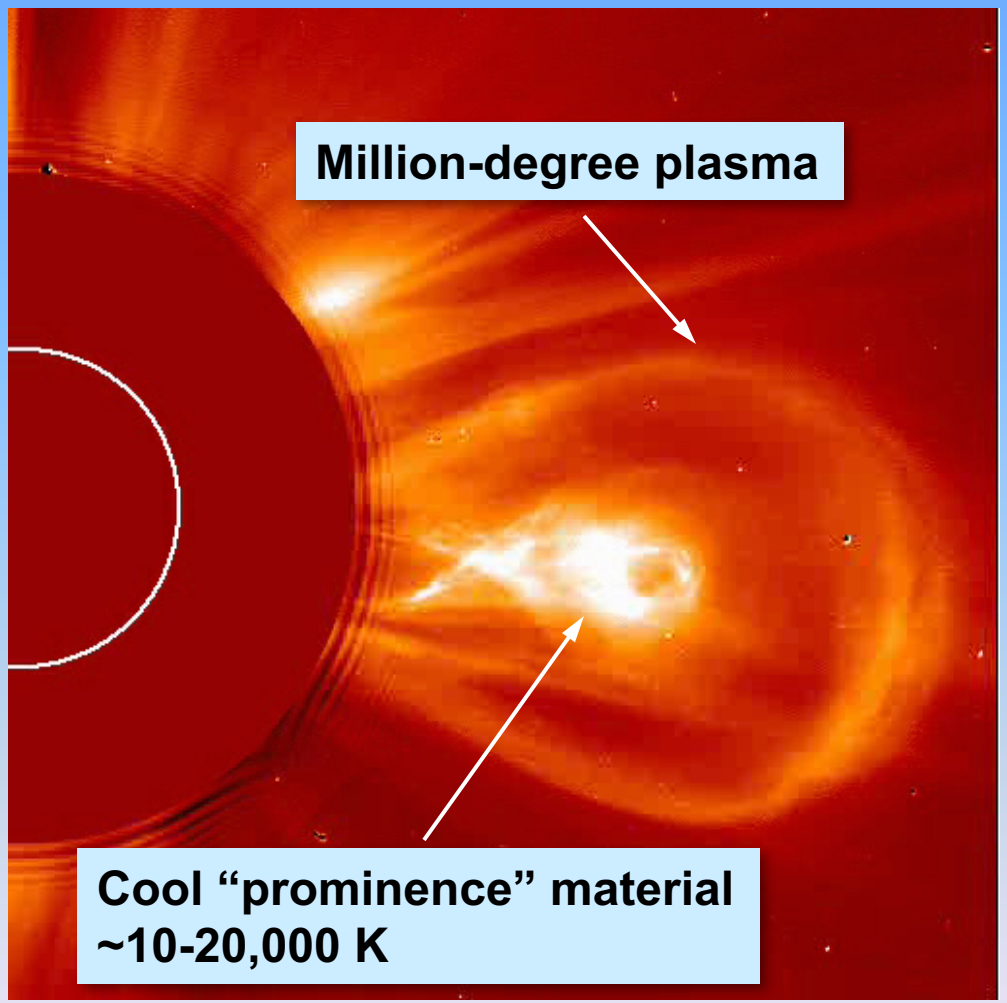
Typical Large Flare Morphology and Evolution



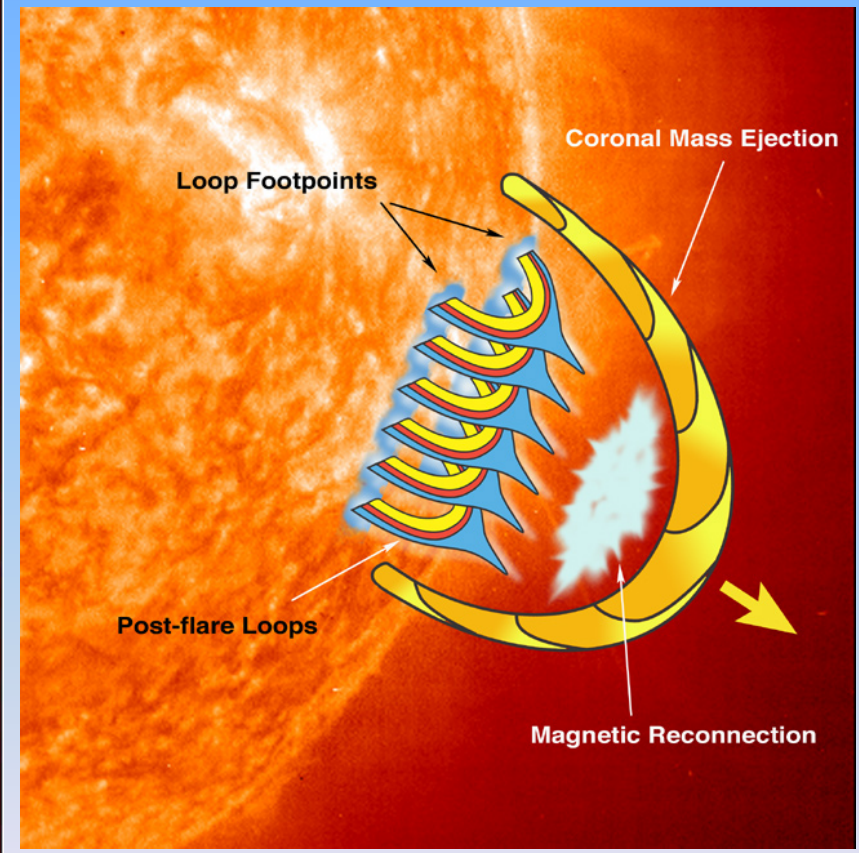


Flares show a rising arcade of soft X-ray emitting loops.

Coronal Mass Ejections (CMEs)

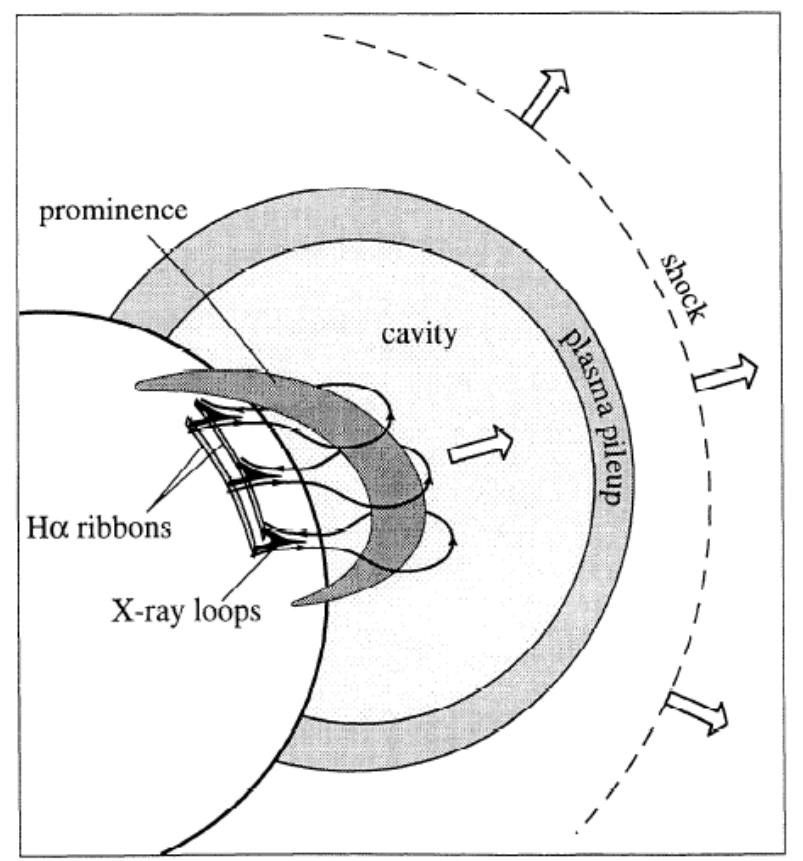


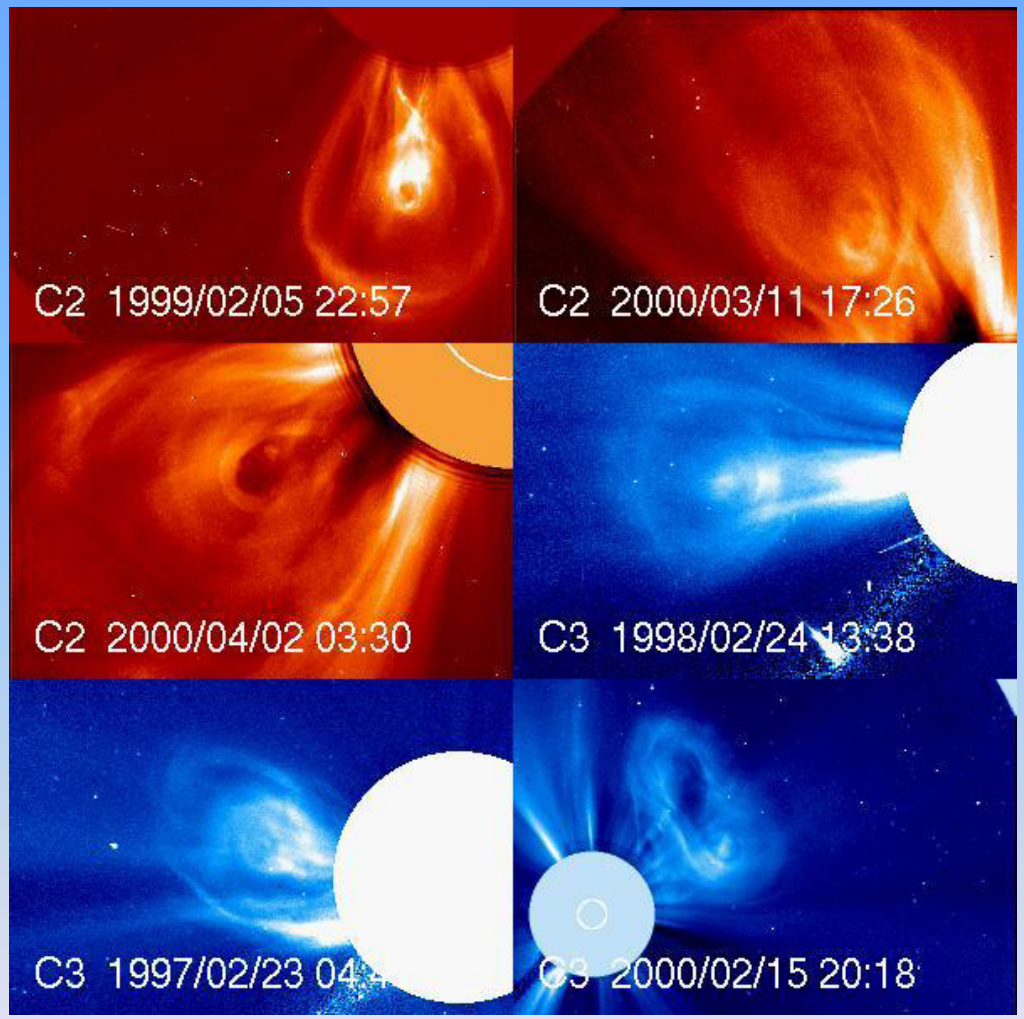
SOHO/LASCO; *STEREO*/SECCHI



Geometry and Examples of CMEs

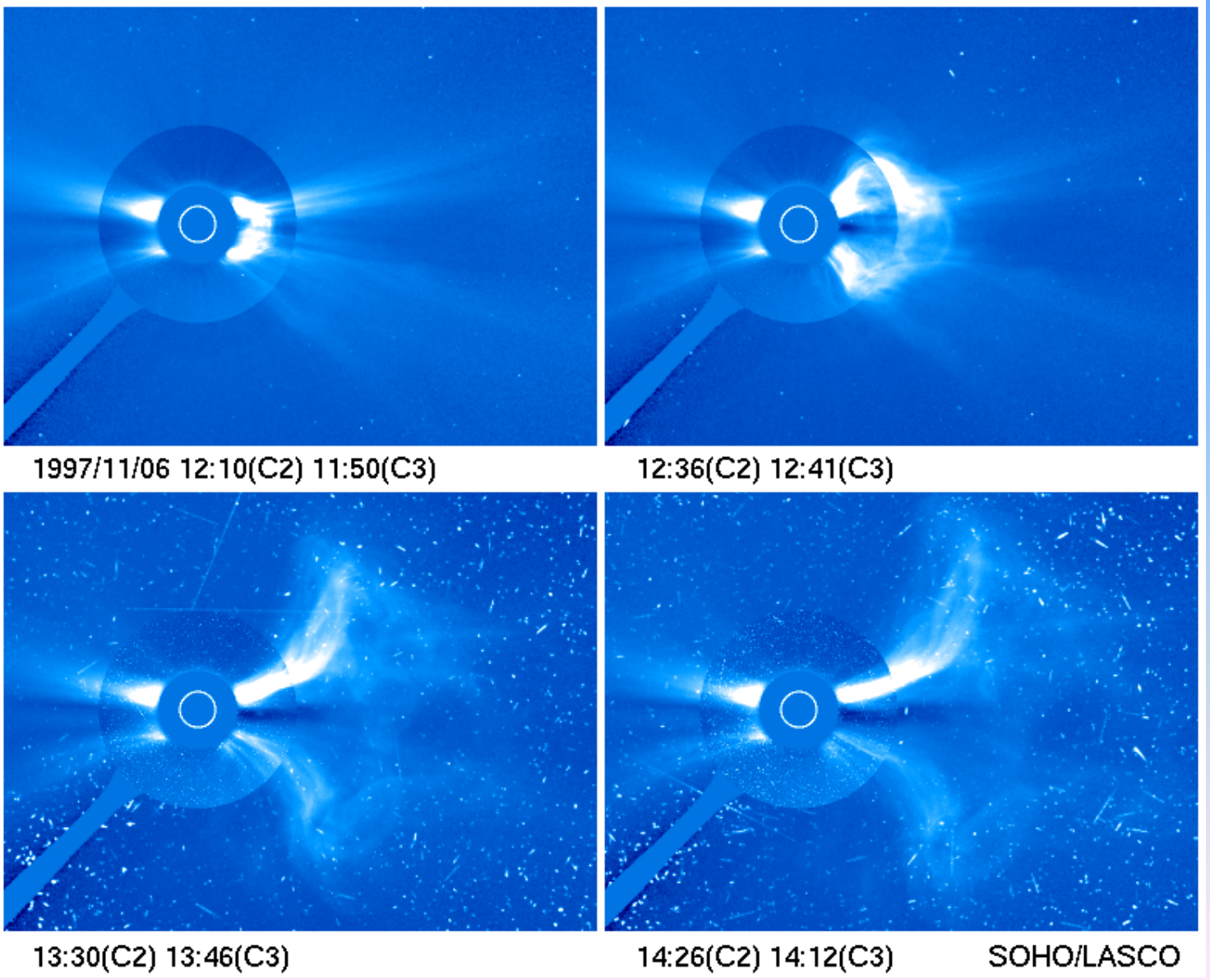
SOHO/LASCO; *STEREO*/SECCHI



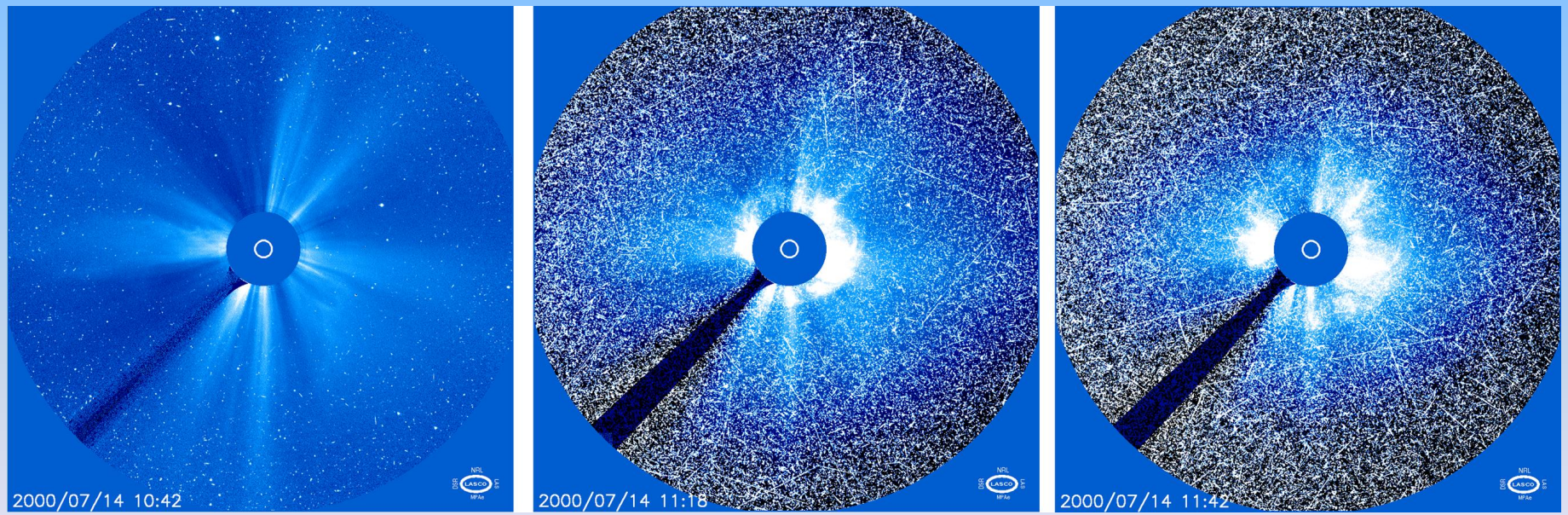


Most CMEs have flux rope structures

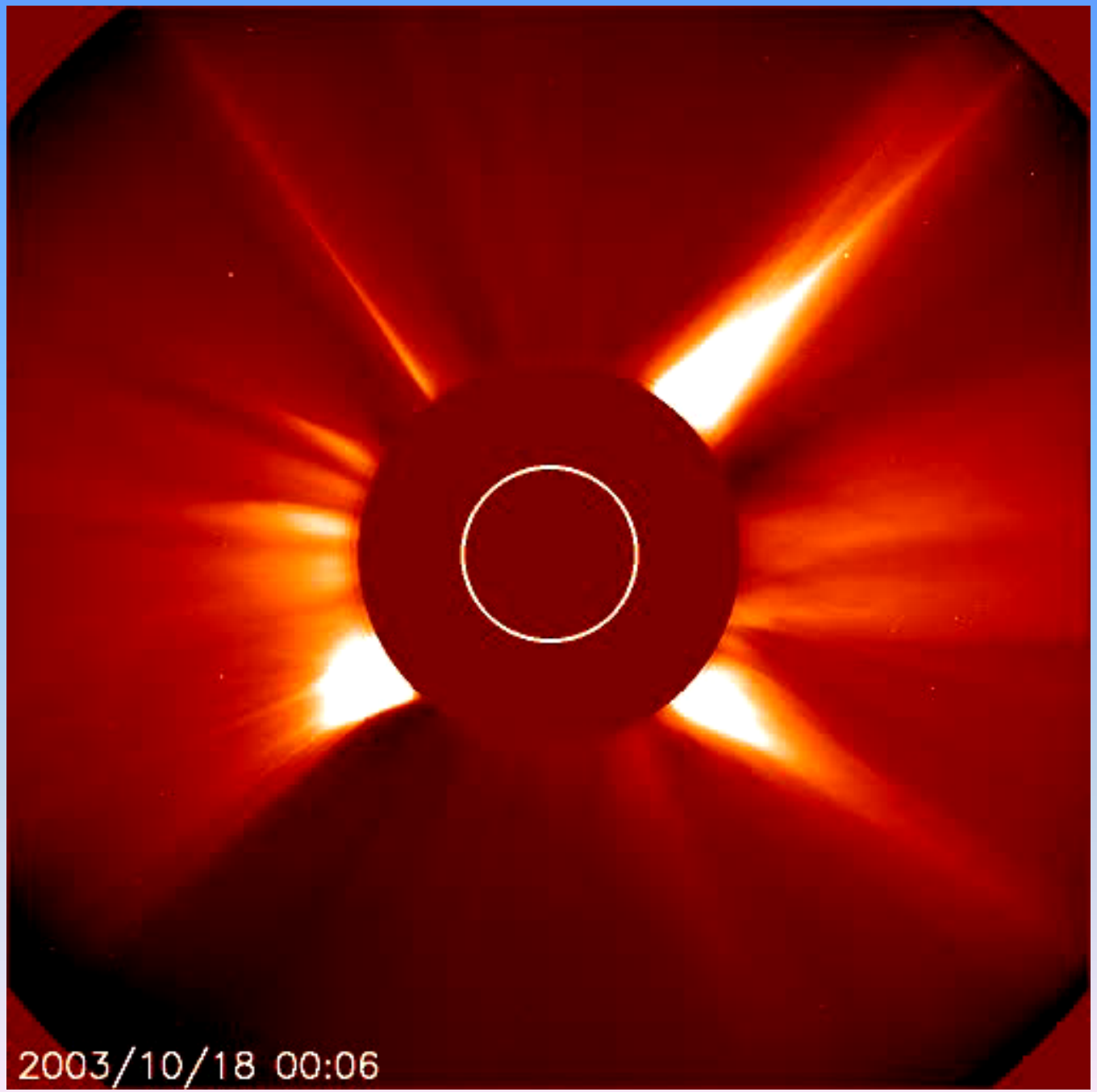
Coronal Mass Ejection (LASCO)



Solar Flare and Coronal Mass Ejection - LASCO



LASCO C2 coronagraph on the *Solar & Heliospheric Observatory* (*SOHO*)



The Big Questions of Solar Astrophysics

- What heats the solar corona?
- What role does the Sun's magnetic field play in causing solar flares and coronal mass ejections?
- How is the solar wind accelerated?
- How does the solar magnetic dynamo really work?
- Do we completely understand the solar interior?

What are Possible Energy Sources for Producing and Maintaining the Sun's Atmosphere?

- Mechanical energy from the convection zone
- Heating by magnetic reconnection (nanoflares)
- Wave heating (Alfvén waves?)
- Mass and energy transfer from the chromosphere into the corona

Where Can You Stay Informed About Solar Activity?

- www.solarmonitor.org
  - Solar images, X-ray data
- www.Jhelioviewer.org
  - Images from the NASA *Solar Dynamics Observatory*
  - You can run movies of current and past solar activity
- NOVAC (Northern Virginia Astronomy Club) – www.novac.com
  - Learn how to observe the Sun
  - And learn how to observe all the other stars and the rest of the Universe, too!

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Space Science Division
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