



Solar Astronomy Outreach

**The Albuquerque
Astronomical Society**

Where is Timmy ?



www.taas.org/solar/solar-cal.html

163 Outreach events

**26,000+ adults & children
so far in 2014**

SOLAR GLASSES



SOLAR TELESCOPE

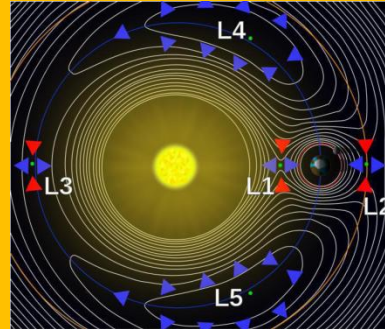


CAUTION

SAFE SOLAR VIEWING

It is dangerous to look at the SUN without proper protection for your eyes. You risk immediate, permanent damage to your eye.

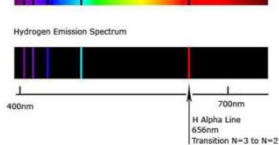
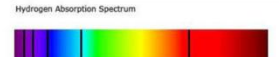
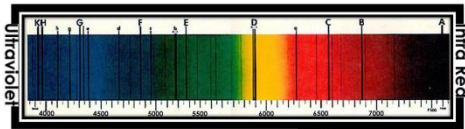
Never look directly at the SUN without special solar glasses (not regular sunglasses); filtered telescopes or binoculars; or specially designed solar telescopes.



How we observe the sun

Full Spectrum Hydrogen -alpha Calcium K spectral line Space Based Telescopes

Solar Filters – It's All About the Wavelength!

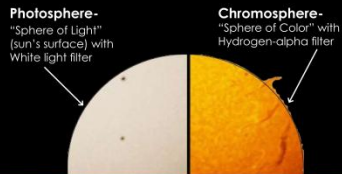


Hydrogen Alpha (H-α)
This filter only passes the red light emitted by the hydrogen atoms in the sun's atmosphere.

For more information about the Sun:



Each filter shows features in a slightly different layer of the sun and its atmosphere



Corona- Sun's atmosphere

Features to Look for in Hydrogen-alpha Light

- Granulation:** caused by the wave motion of plasma as it rises
- Active Region:** areas where the sun's magnetic field is stronger and more energetic. Sunspots and flares form here.
- Sunspot:** magnetic disturbances in the plasma. Caused by entangled magnetic field lines. Color indicates cooler temperatures, often seen as black.
- Prominence:** Loops of plasma pulled into space along magnetic field lines, seen along the edge of the sun for hours to days. Results from out-gassing of elements in the plasma and heats as it is pushed into the corona.
- Filament:** Same structure as a prominence but seen in front of the sun's disk. Both can be thousands of mile long and extend thousands of mile above the surface.
- Plage:** bright networks of moving plasma extending from an active region

Projection



Jim Kaminsky



1



2



3



**White light, Natural light
Full Spectrum filters**



**White
light
filtered
telescope**

**Hydrogen
-alpha
telescope**



White light filtered telescope with Canon Rebel camera and attached HD monitor



**AR12192
and
23 Oct
Eclipse**



Specially designed Rainbow Symphony
solar viewing glasses



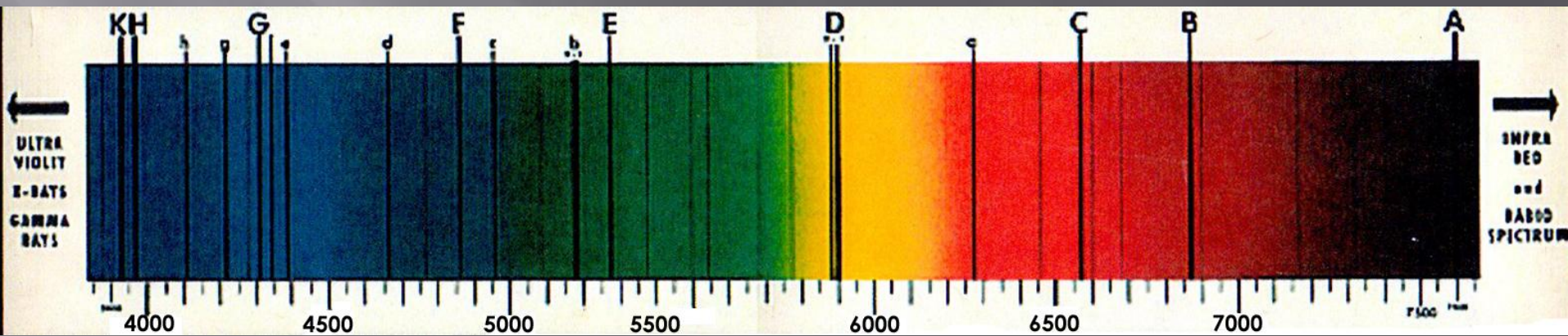
Timmy Telescope supports
Observing in Hydrogen- α



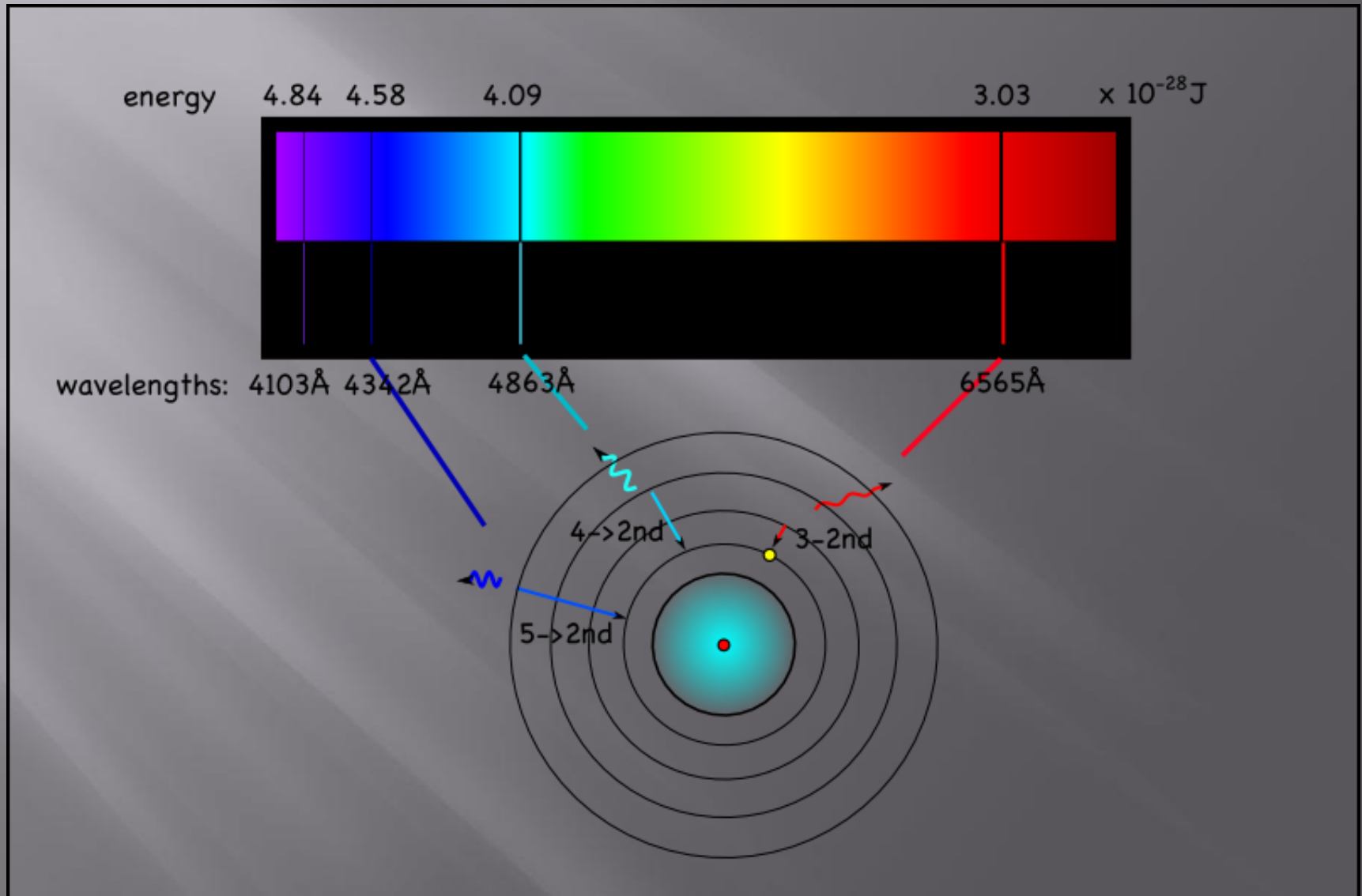
Full spectrum

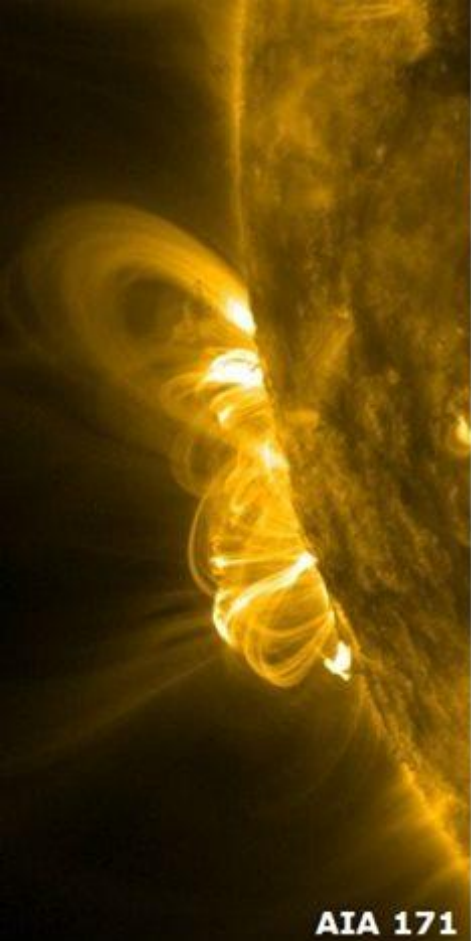


Hydrogen-alpha (processed)

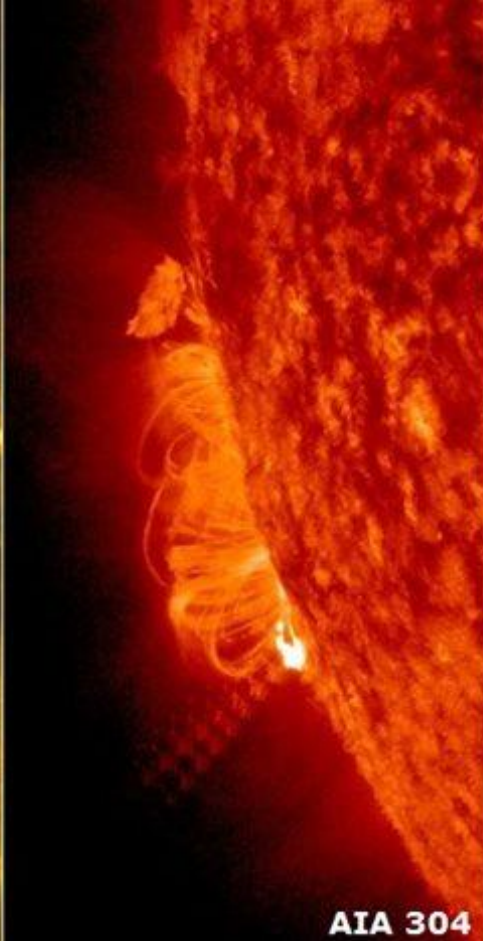


Hydrogen-alpha wavelength

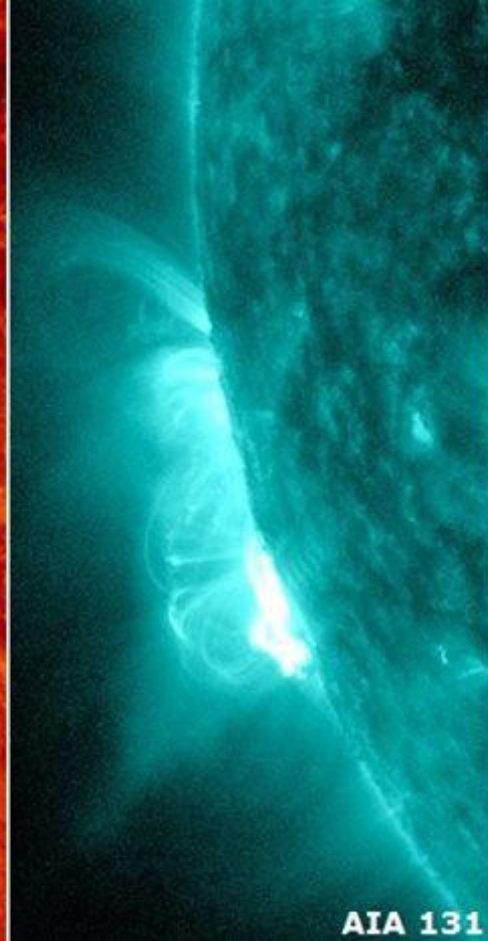




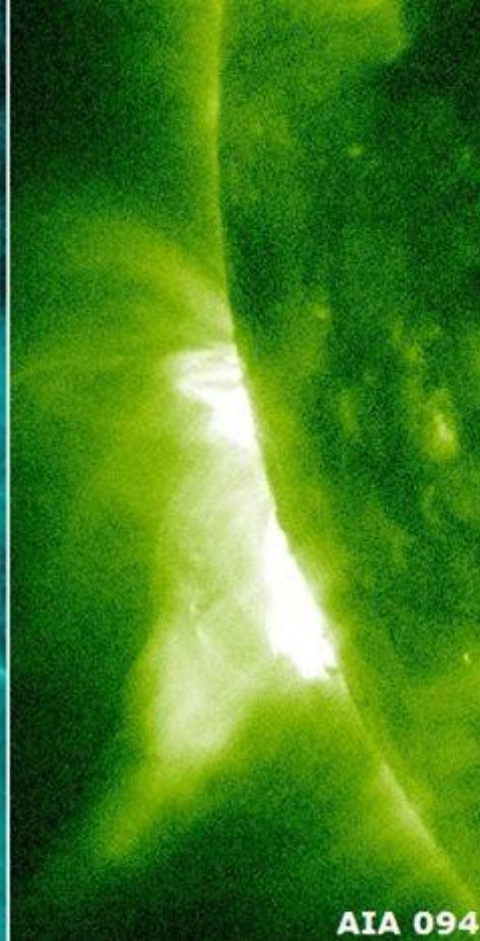
AIA 171



AIA 304

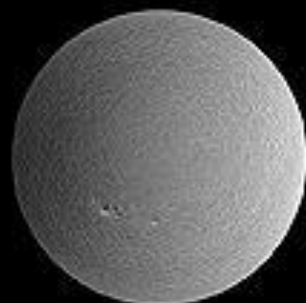


AIA 131

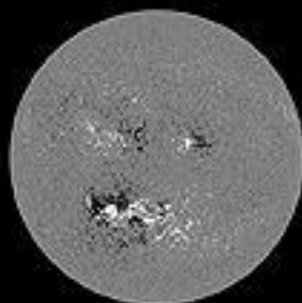


AIA 094

**Different spectral filters
give additional information**



HMI Dopplergram
Surface movement
Photosphere



HMI Magnetogram
Magnetic field polarity
Photosphere



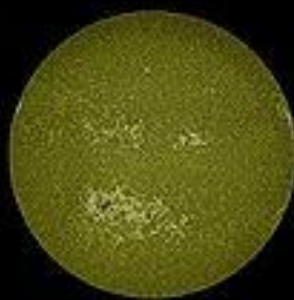
HMI Continuum
Matches visible light
Photosphere



AIA 1700 Å
4500 Kelvin
Photosphere



AIA 4500 Å
6000 Kelvin
Photosphere



AIA 1600 Å
10,000 Kelvin
Upper photosphere/
Transition region



AIA 304 Å
50,000 Kelvin
Transition region/
Chromosphere



AIA 171 Å
600,000 Kelvin
Upper transition
Region/quiet corona



AIA 193 Å
1 million Kelvin
Corona/flare plasma



AIA 211 Å
2 million Kelvin
Active regions



AIA 335 Å
2.5 million Kelvin
Active regions



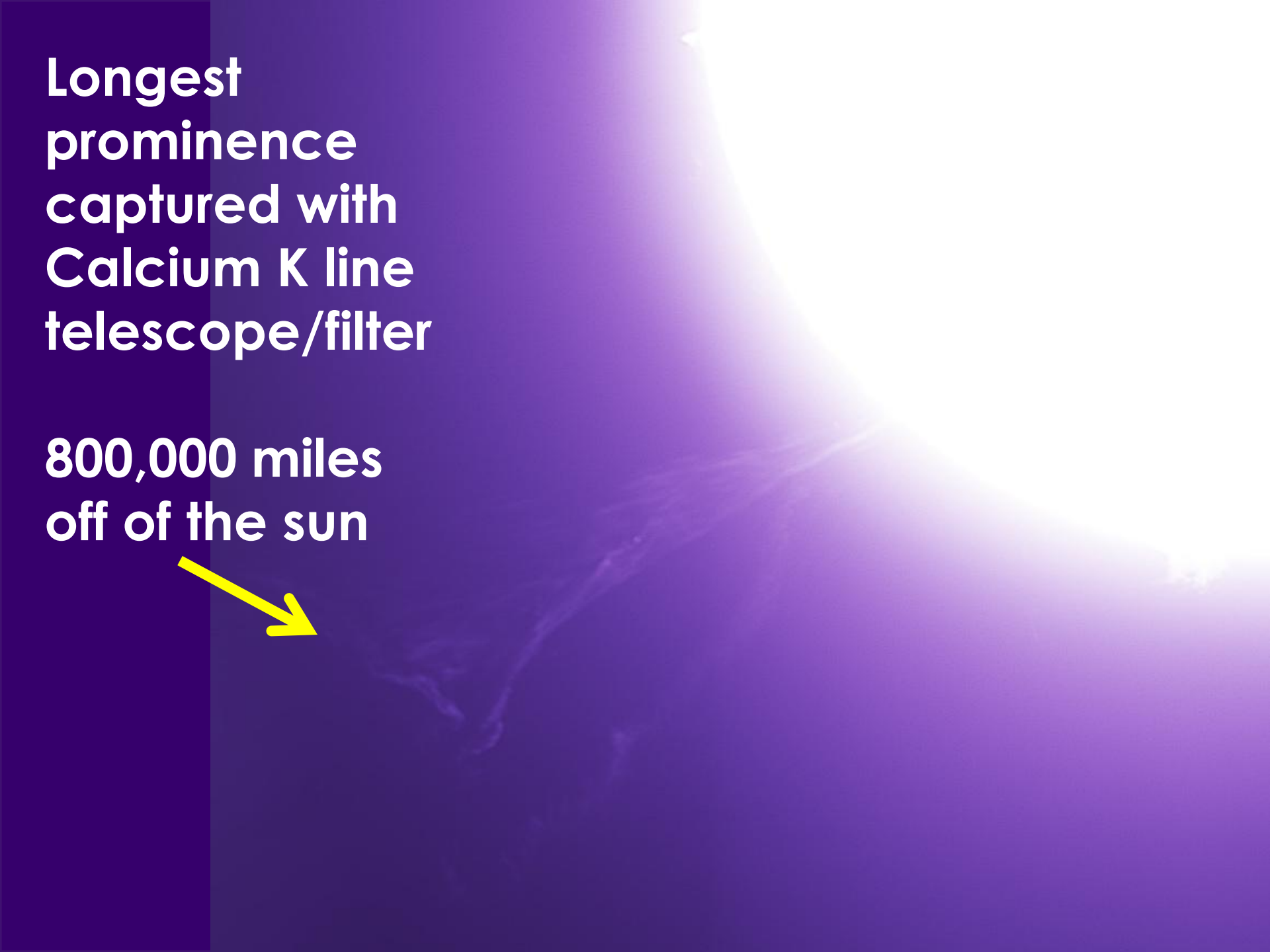
AIA 094 Å
6 million Kelvin
Flaring regions

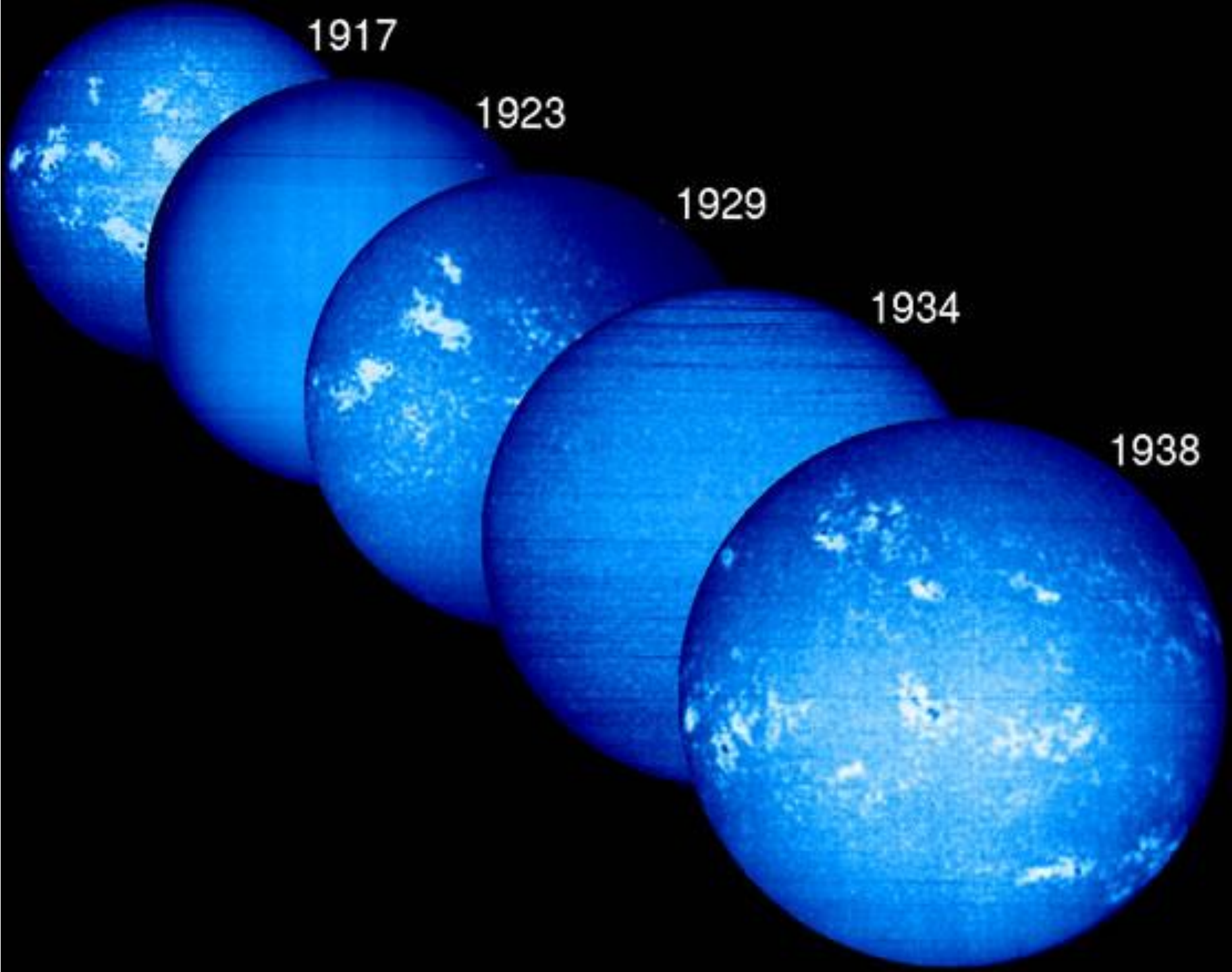


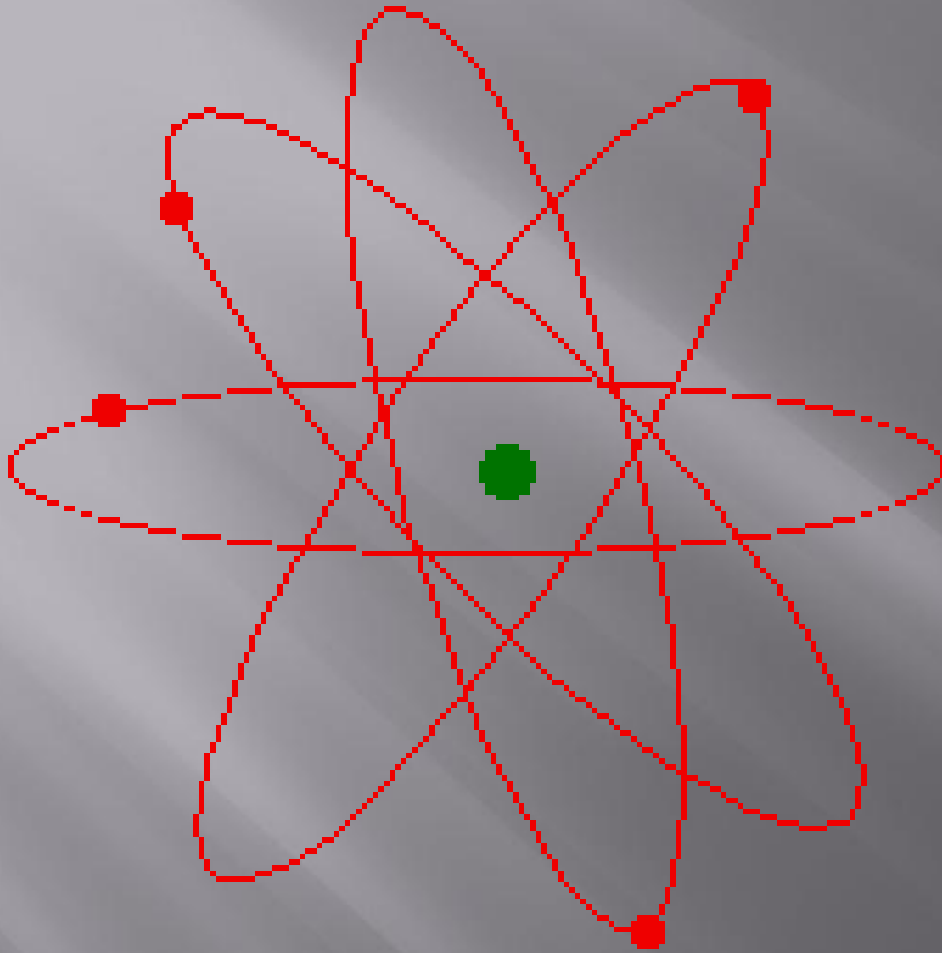
AIA 131 Å
10 million Kelvin
Flaring regions

**Longest
prominence
captured with
Calcium K line
telescope/filter**

**800,000 miles
off of the sun**







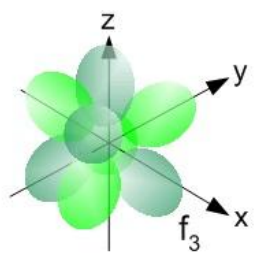
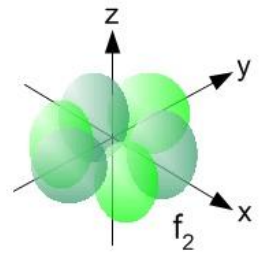
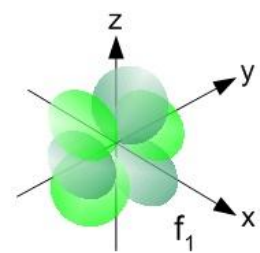
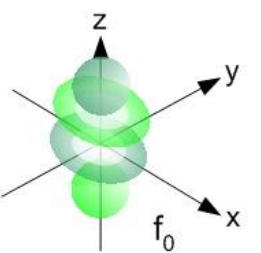
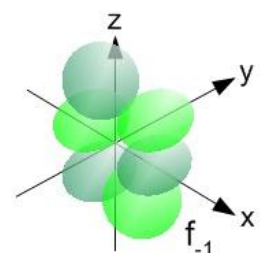
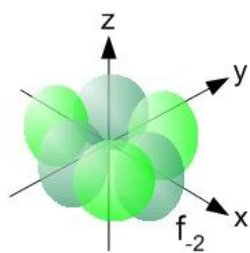
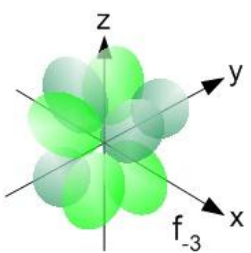
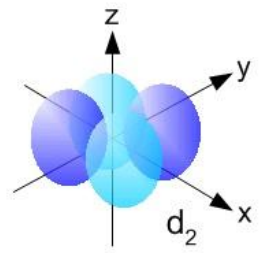
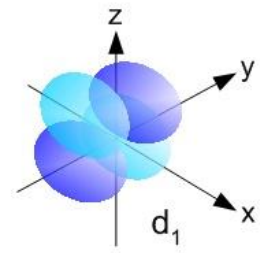
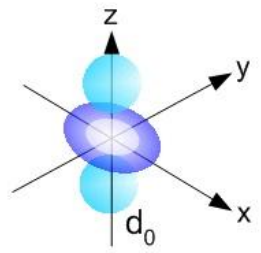
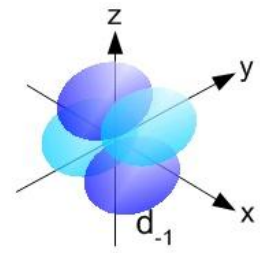
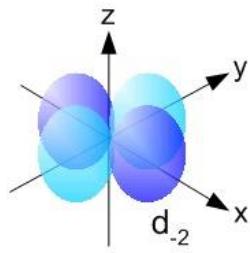
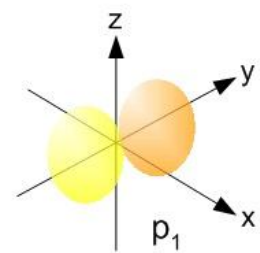
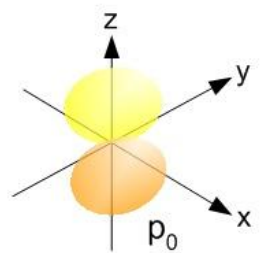
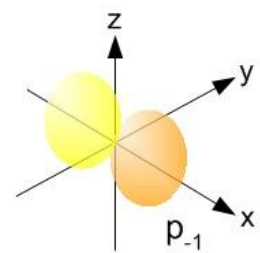
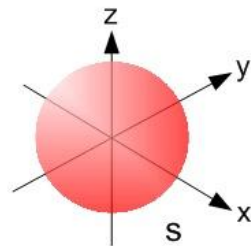
WRONG

WRONG

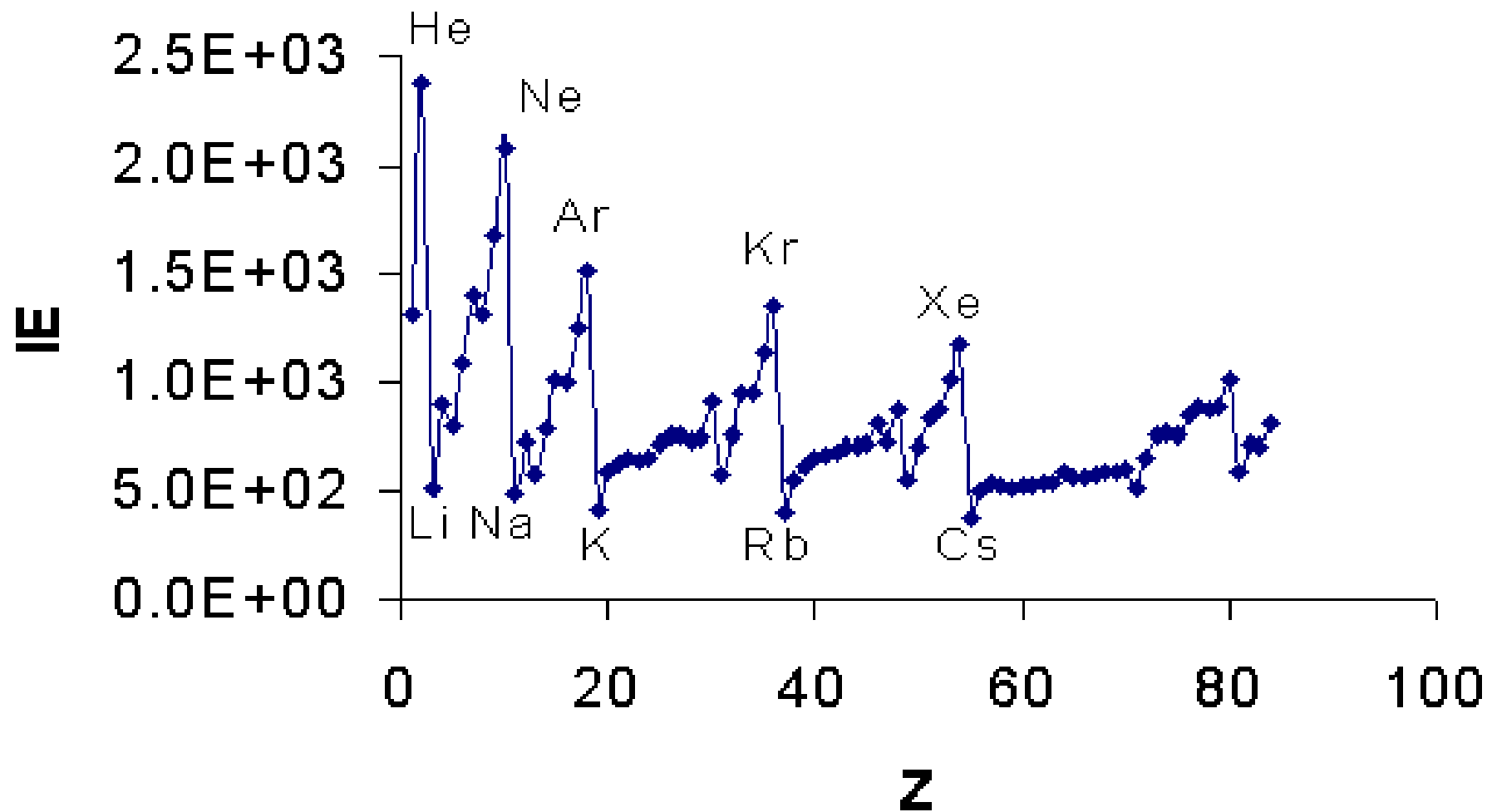
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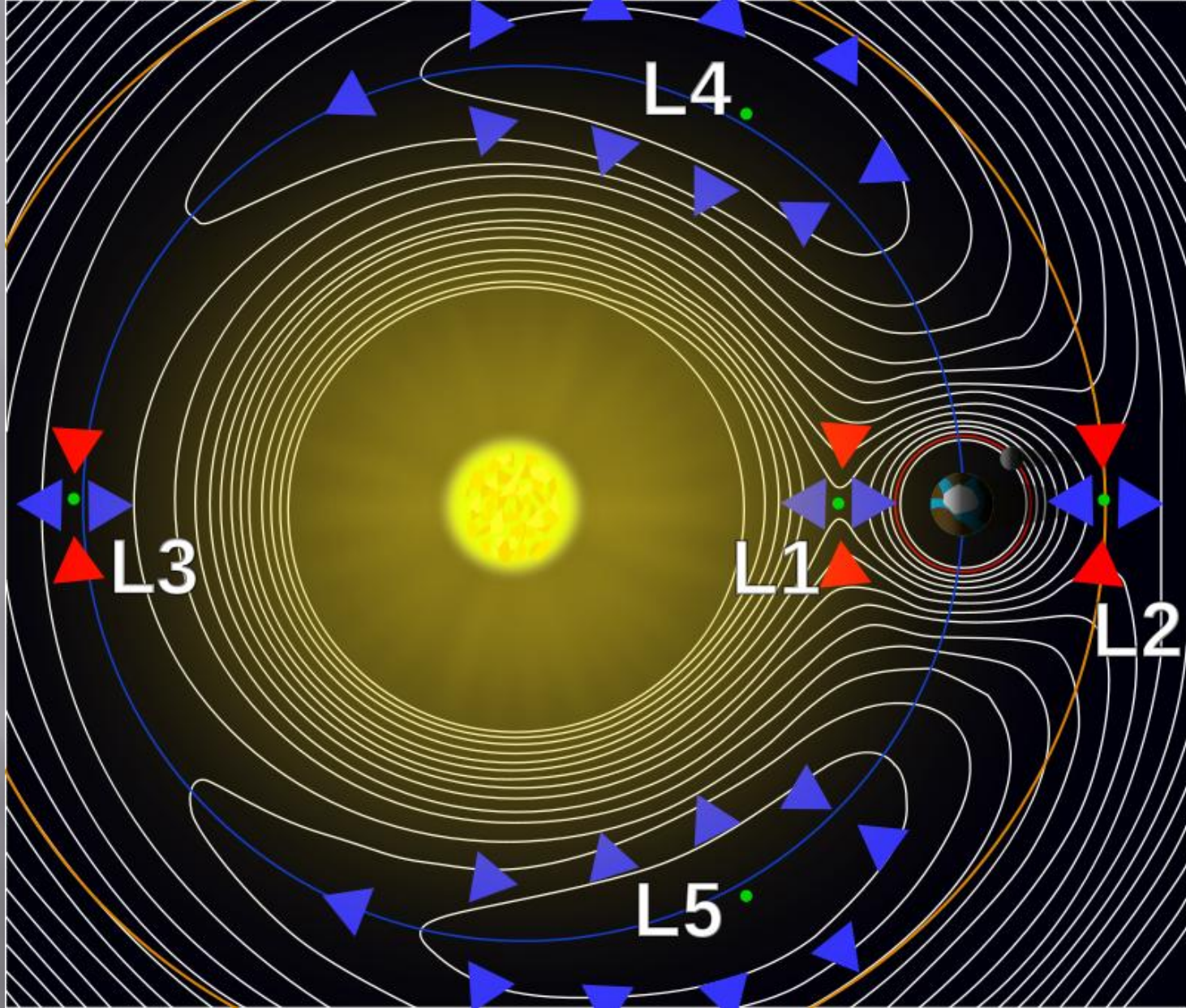
WRONG

WRONG



Ionization Energy vs. Atomic Number





SDO and other space based satellites

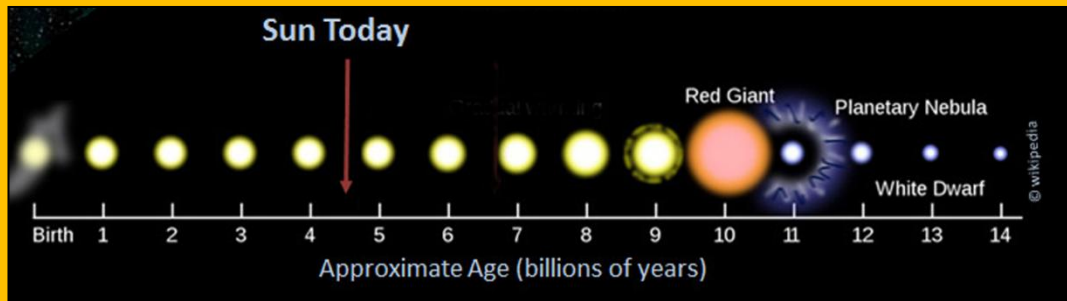
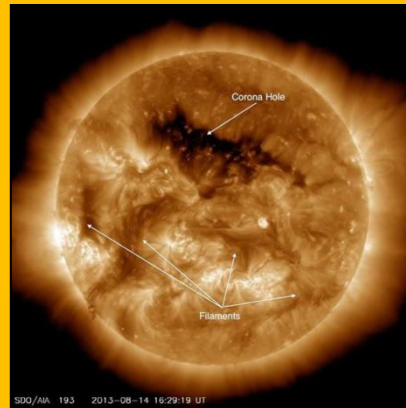
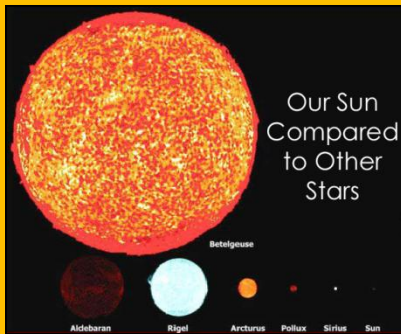
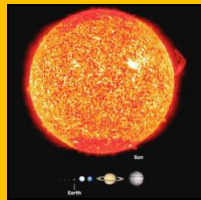
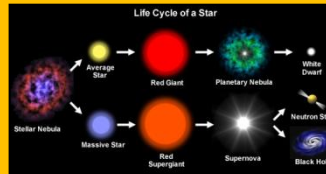
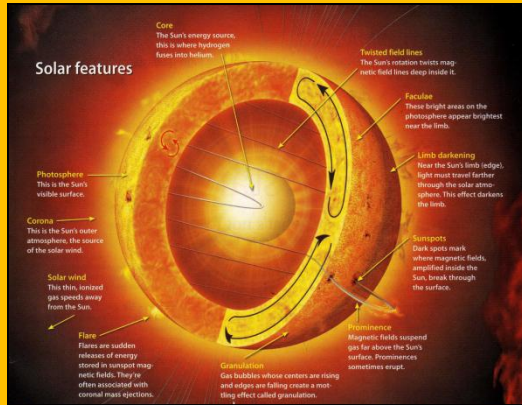
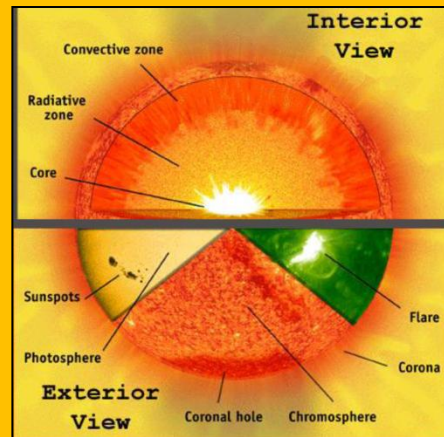
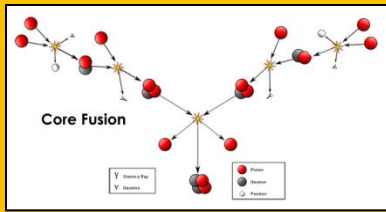
Solar Basics

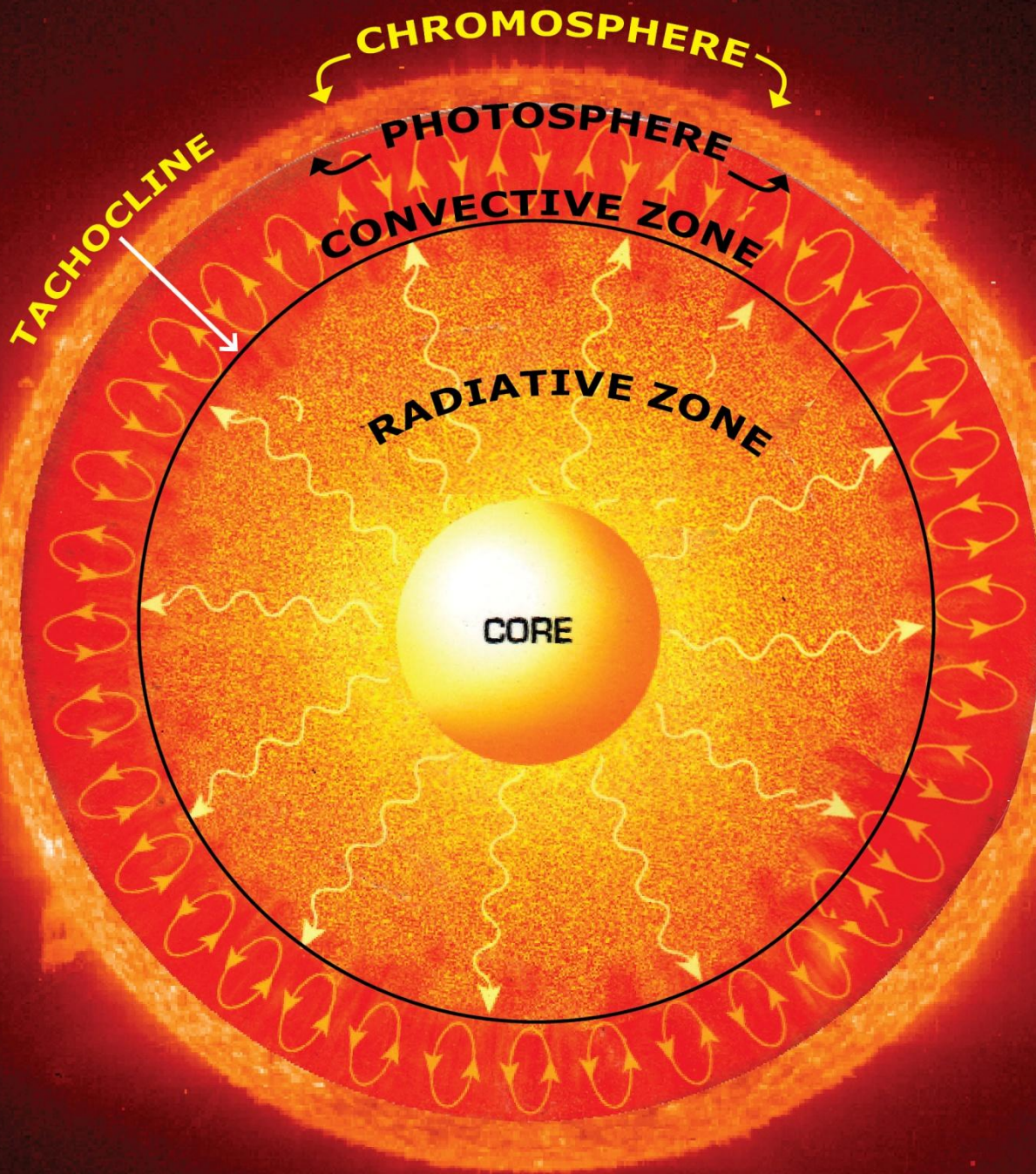
Structure

Fusion

Life cycle

Comparisons





Corona = gas,
millions of C°

Chromosphere =
gas and plasma,
ten of thousands
of C°

Photosphere =
plasma, real
surface, $5800 C^{\circ}$

Convective zone =
Emission of
magnetic field,
origin of sunspots

Tachocline =
Transition zone

Radiative zone =
stable, dark ,
photon re-
absorption

Solar Phenomena

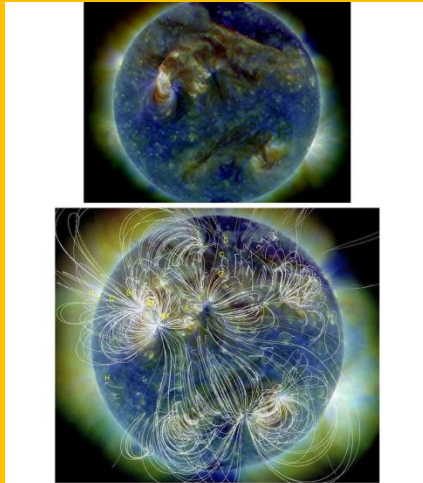
Solar Wind

Aurora

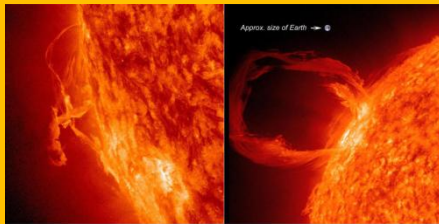
Prominences

Filaments

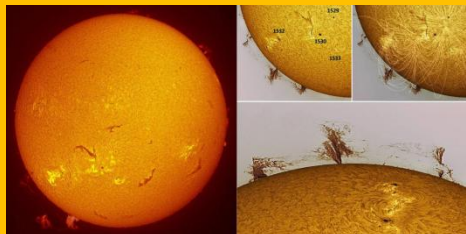
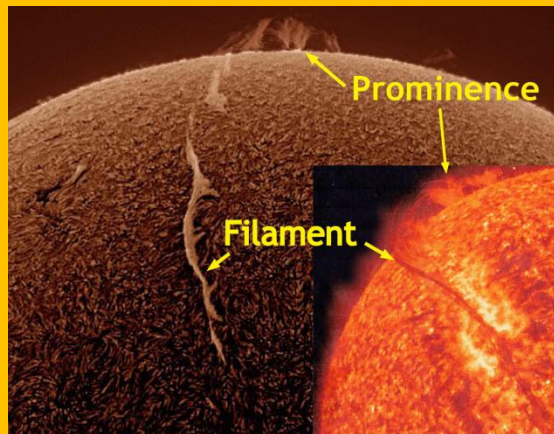
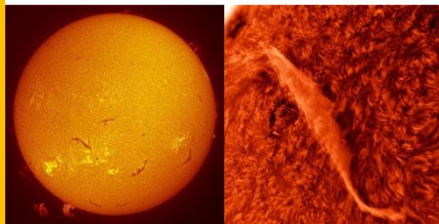
Magnetic
Field

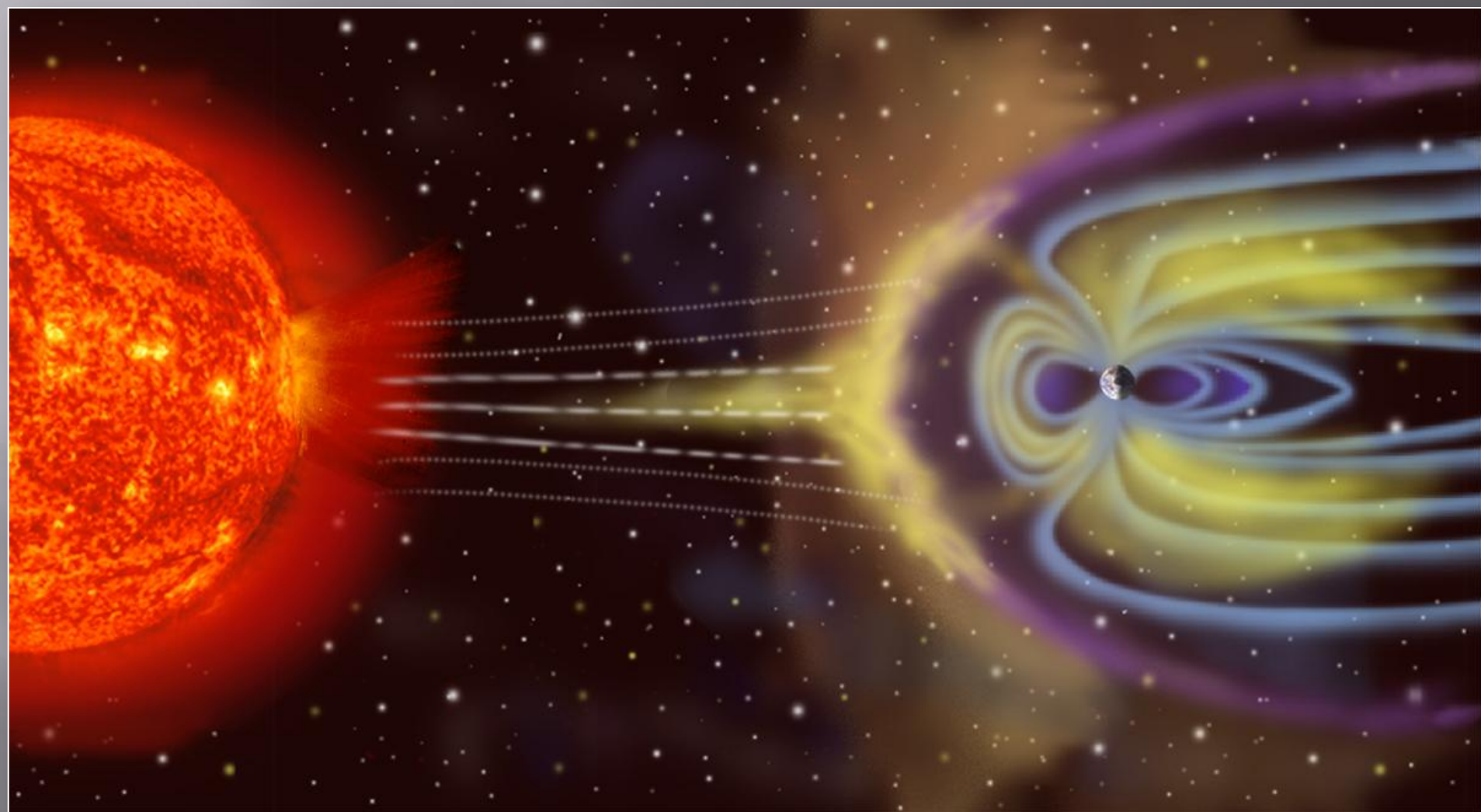


Solar eruptions affect the whole surface of the sun.
White lines indicate magnetic field lines.



Aurora Borealis





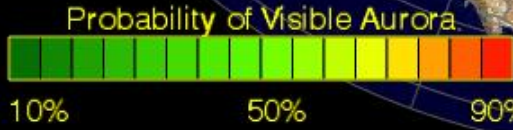
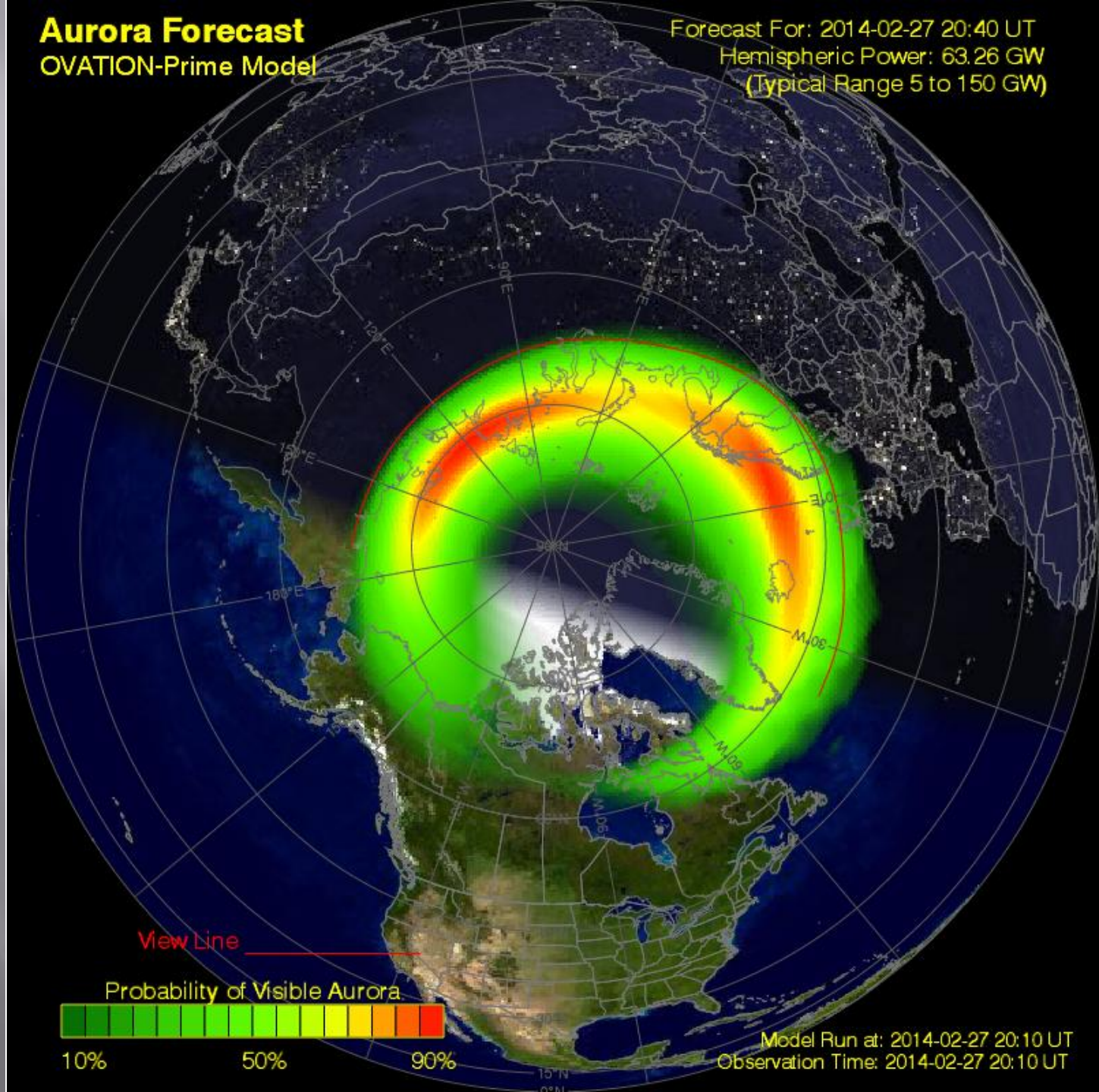


G. Olafsson, Iceland

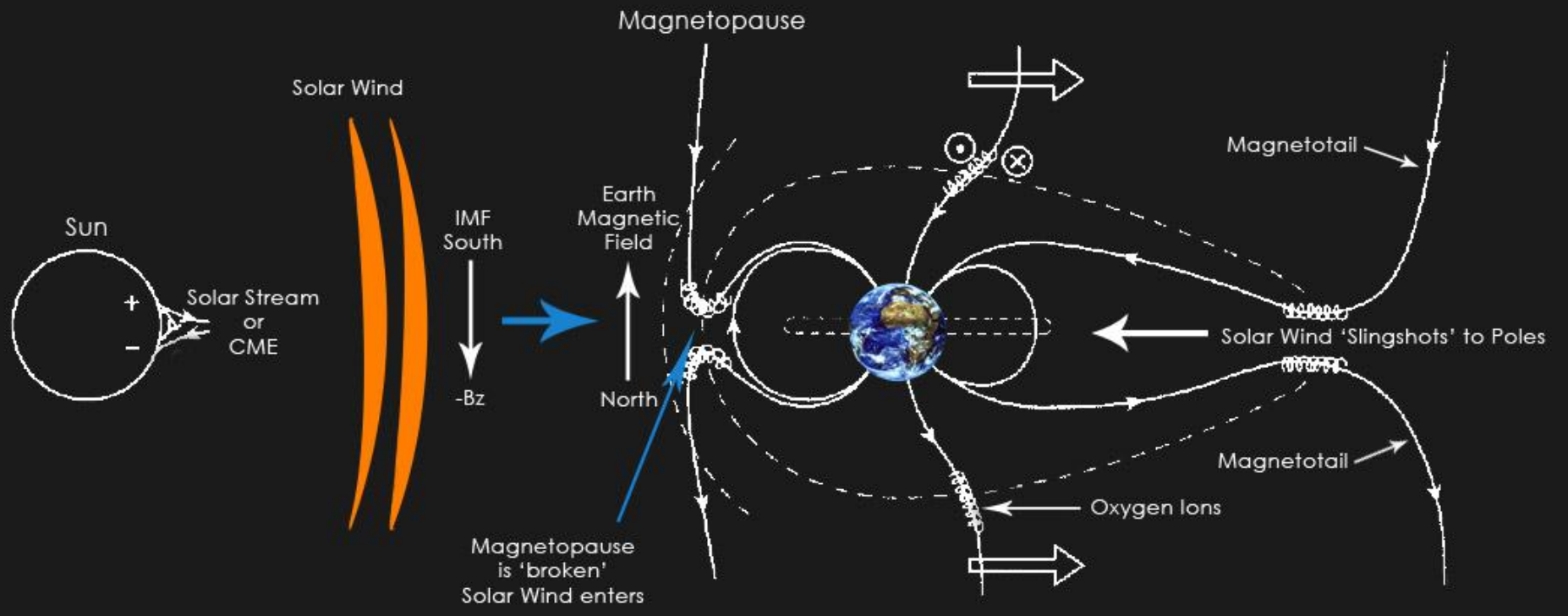
Aurora Forecast

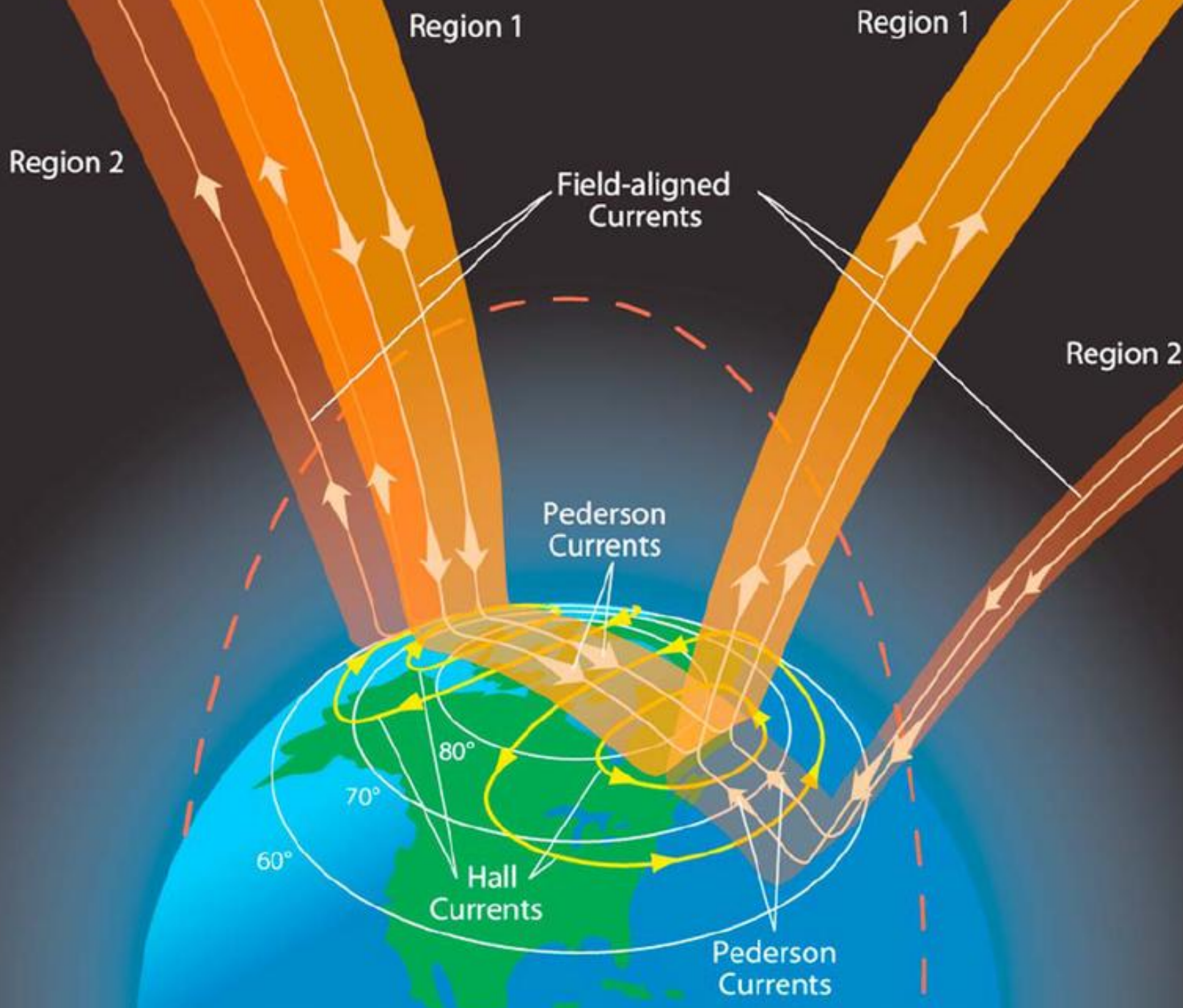
OVATION-Prime Model

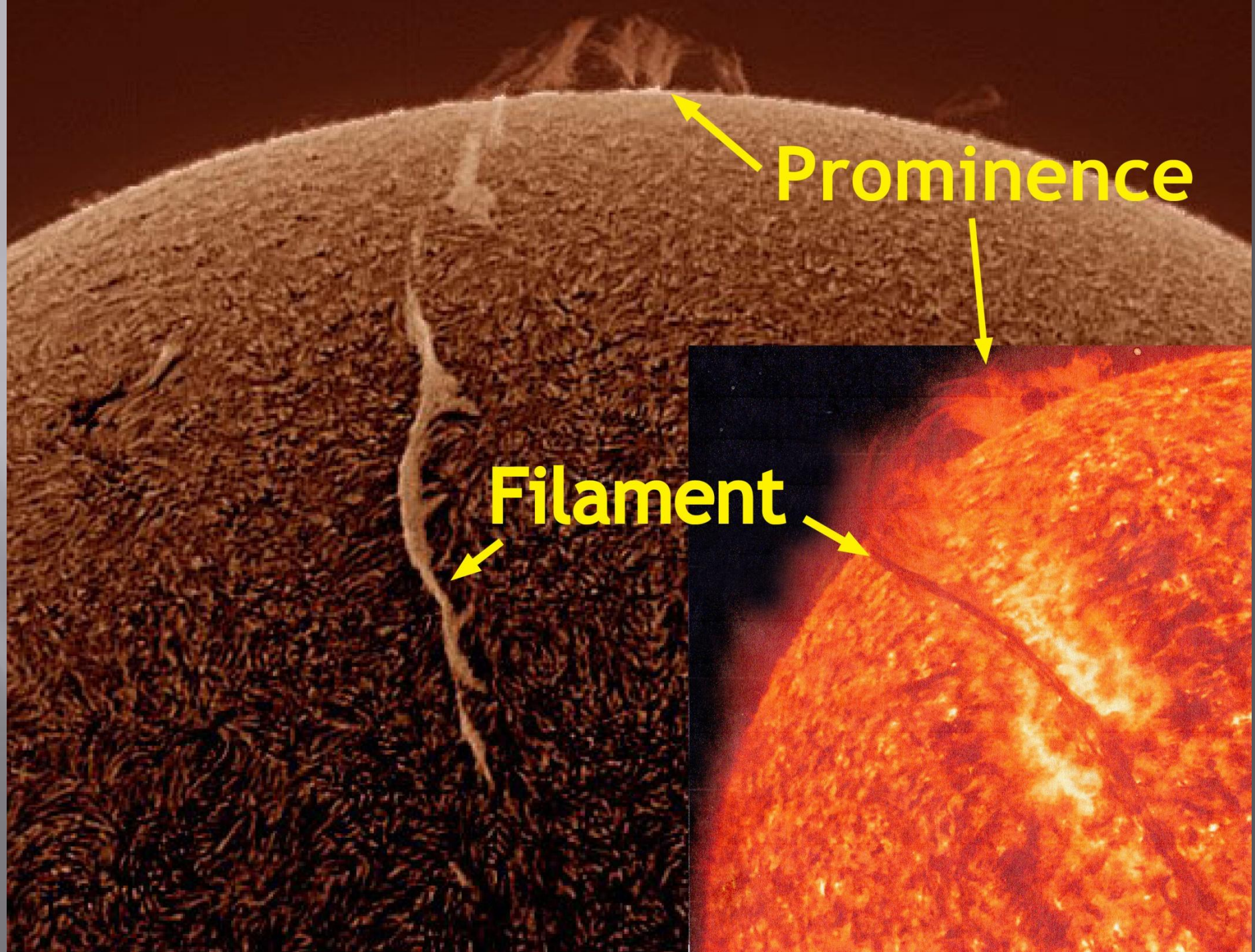
Forecast For: 2014-02-27 20:40 UT
Hemispheric Power: 63.26 GW
(Typical Range 5 to 150 GW)



Model Run at: 2014-02-27 20:10 UT
Observation Time: 2014-02-27 20:10 UT

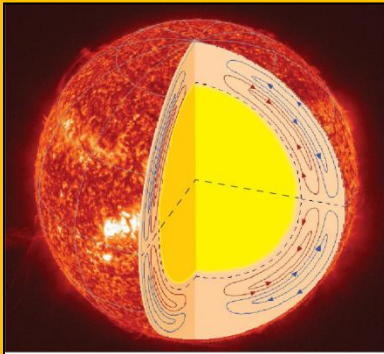
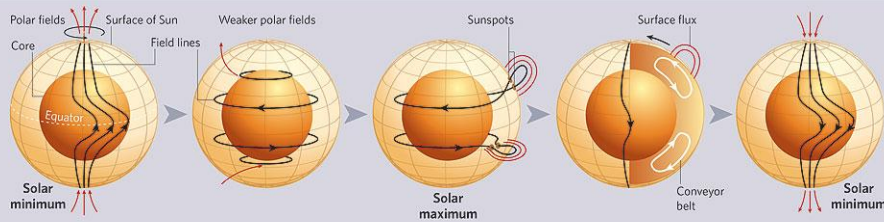




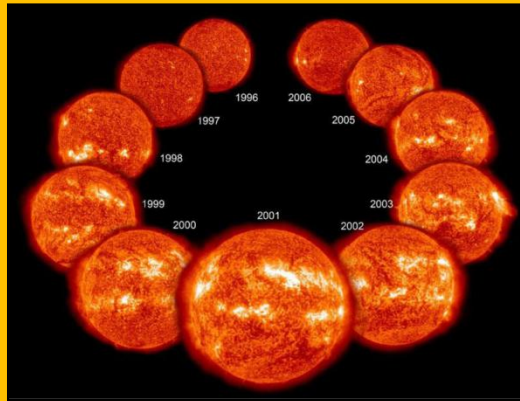


THE SOLAR CYCLE

How the Sun uses a 'conveyor belt' of plasma to recycle sunspots



Convection causes sunspots to appear at the equator and move to the poles. This also explains why there is a sunspot cycle.

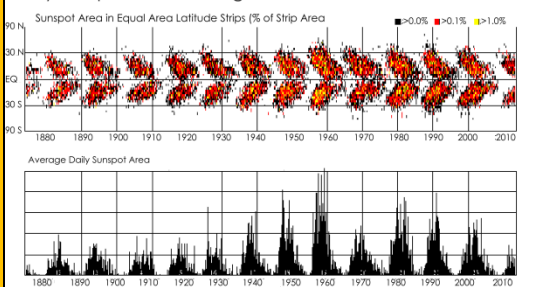


Solar Cycles

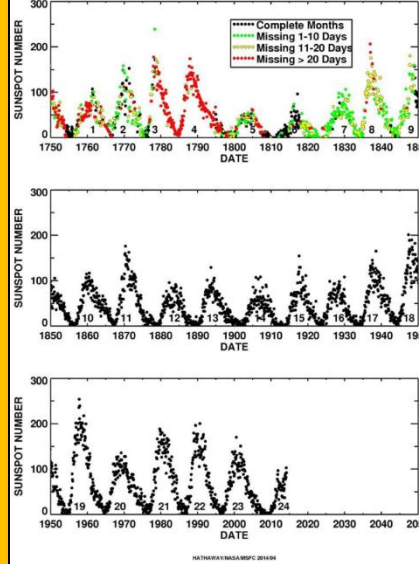
Magnetic Field Convection

Sun Spots

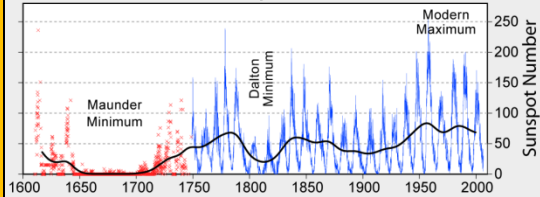
Daily Sunspot Area Averaged Over Individual Solar Rotations



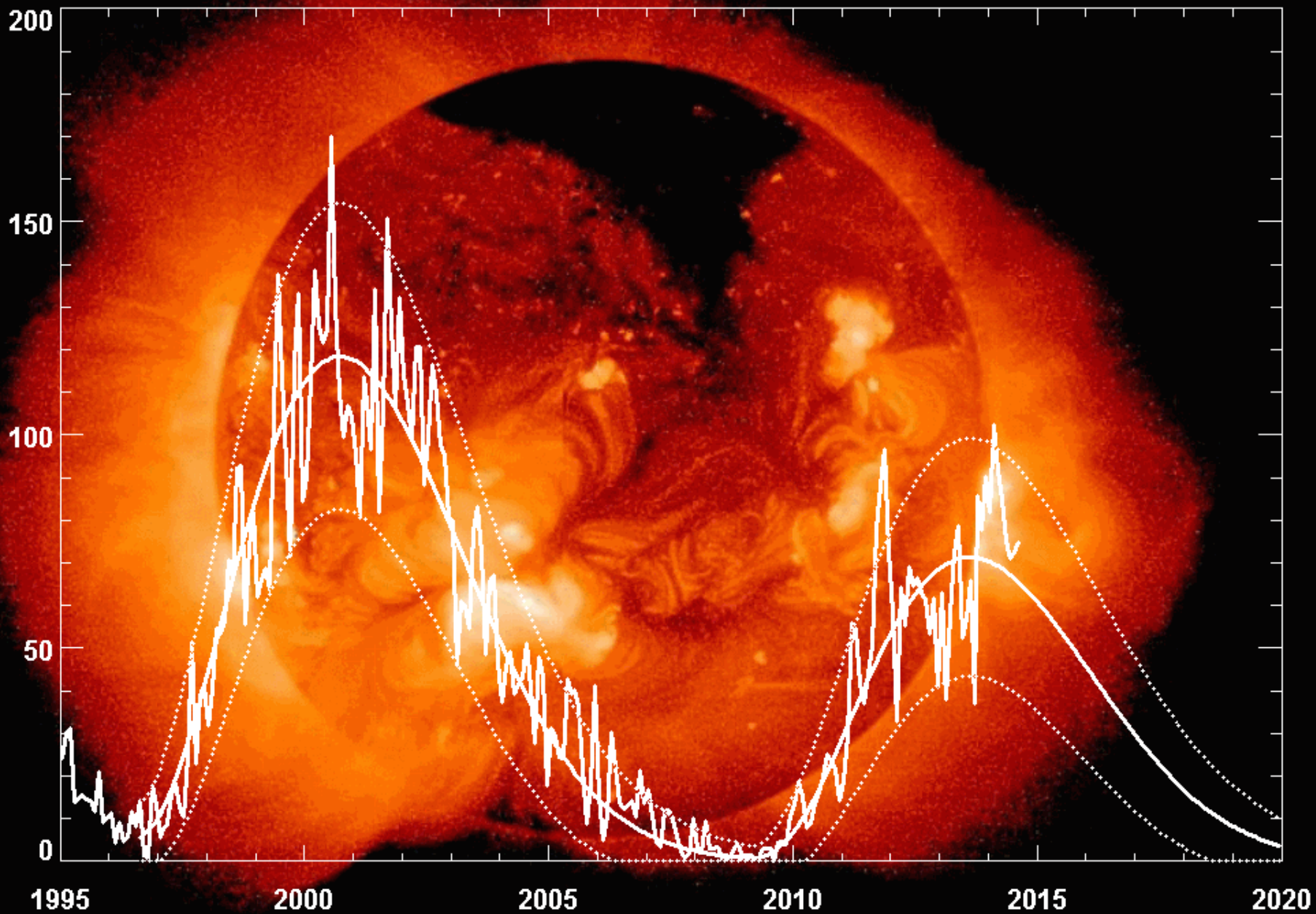
Monthly Averaged Sunspot Numbers

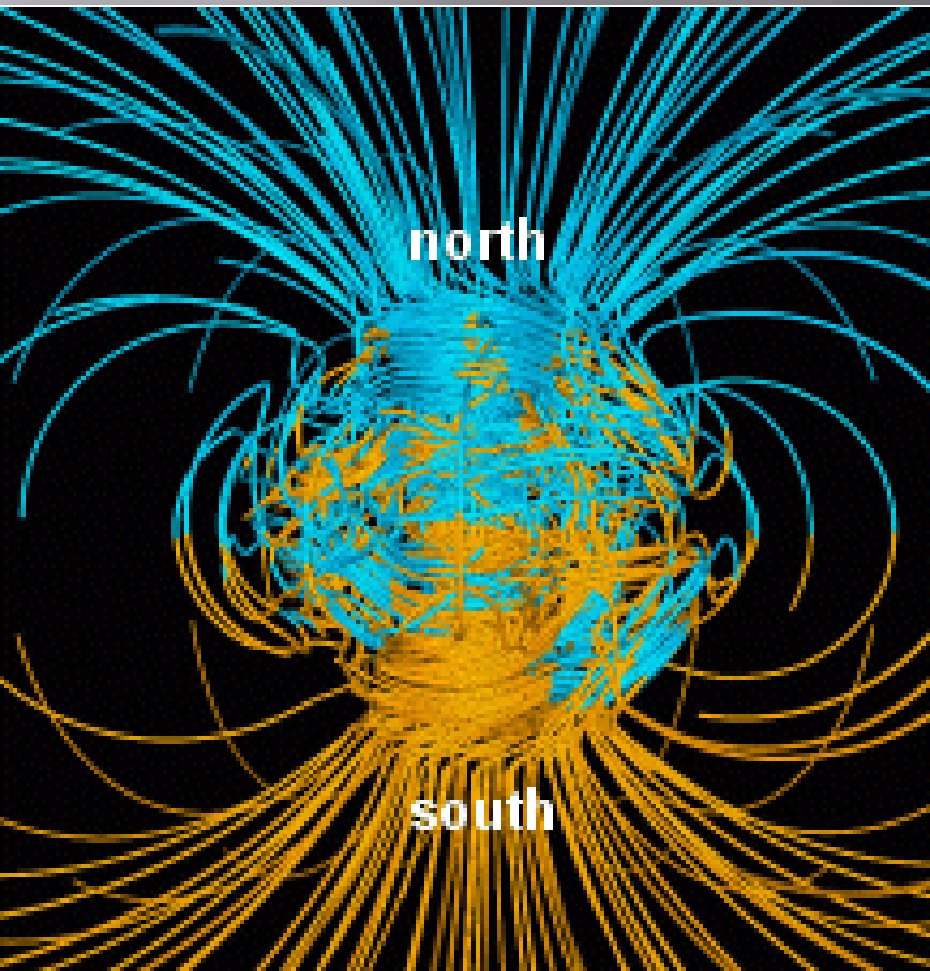


400 Years of Sunspot Observations

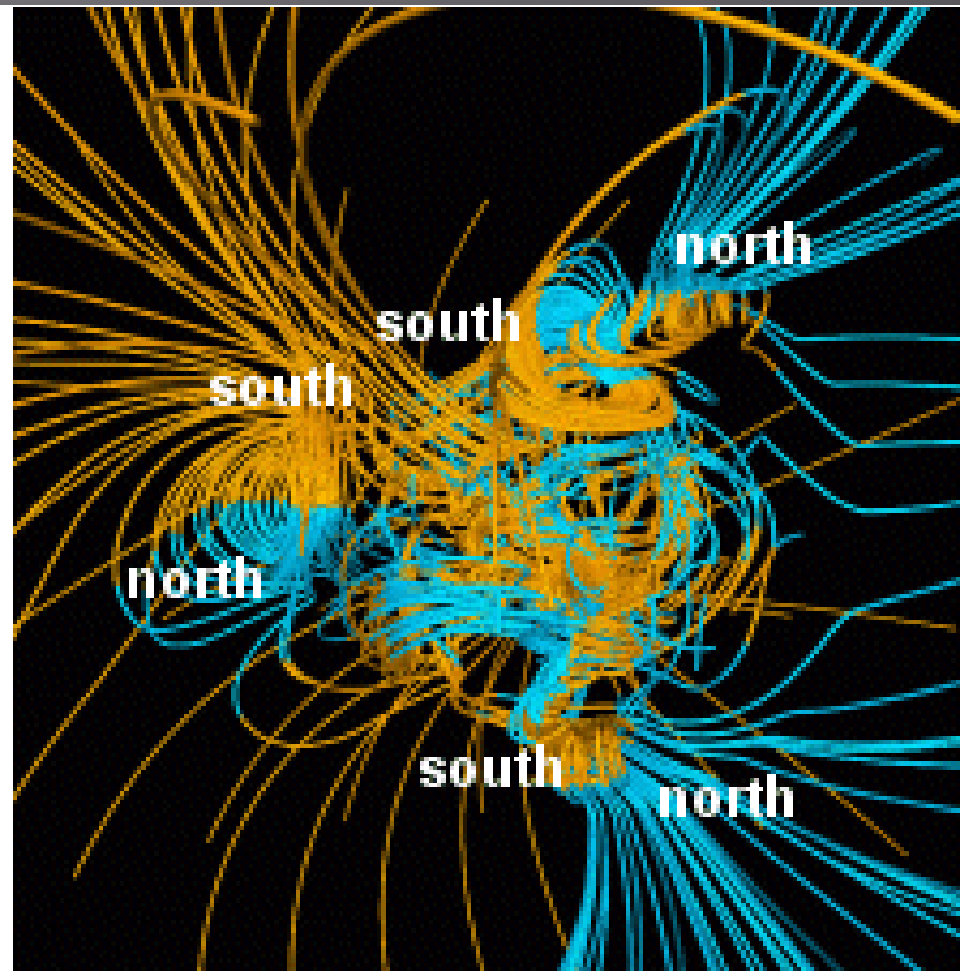


Cycle 24 Sunspot Number Prediction (2014/09)



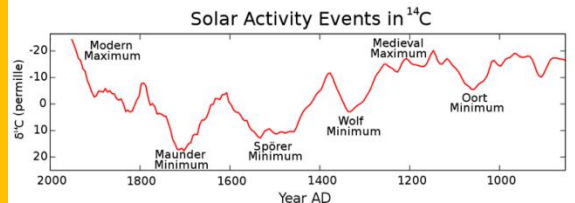
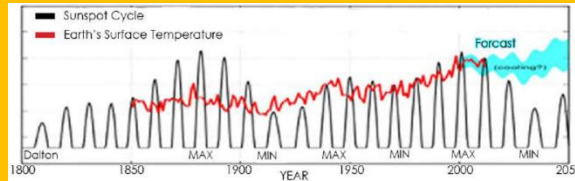
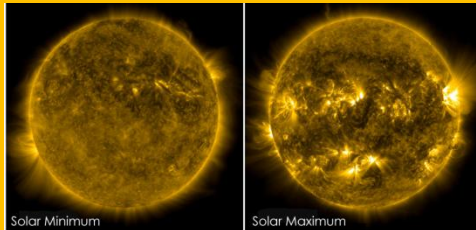
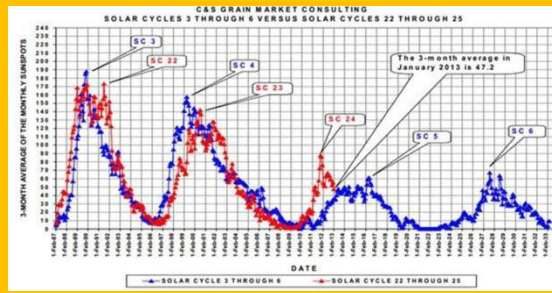
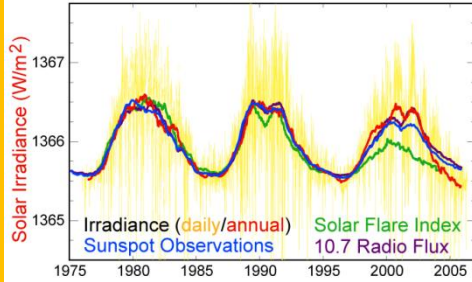


between reversals

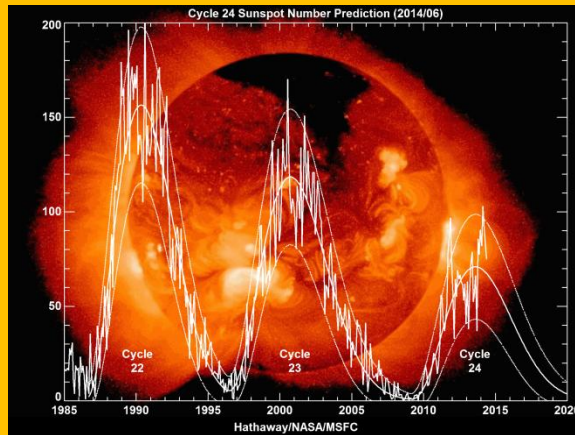


during a reversal

Solar Cycle Variations



Position of the Sun at Noon throughout the year- Anamemma



Solar Cycles

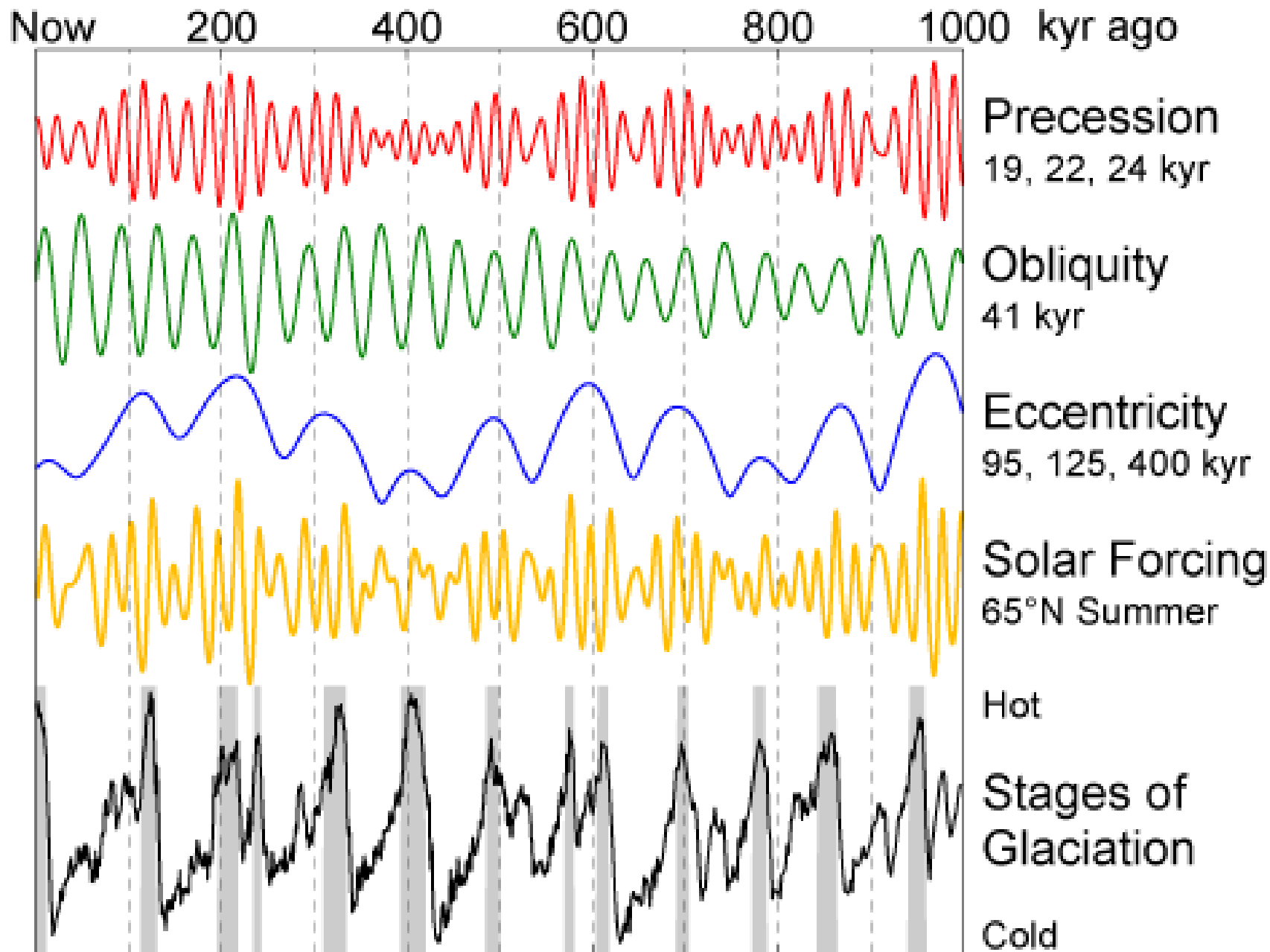
Anamemma

Irradiance

Sunspots

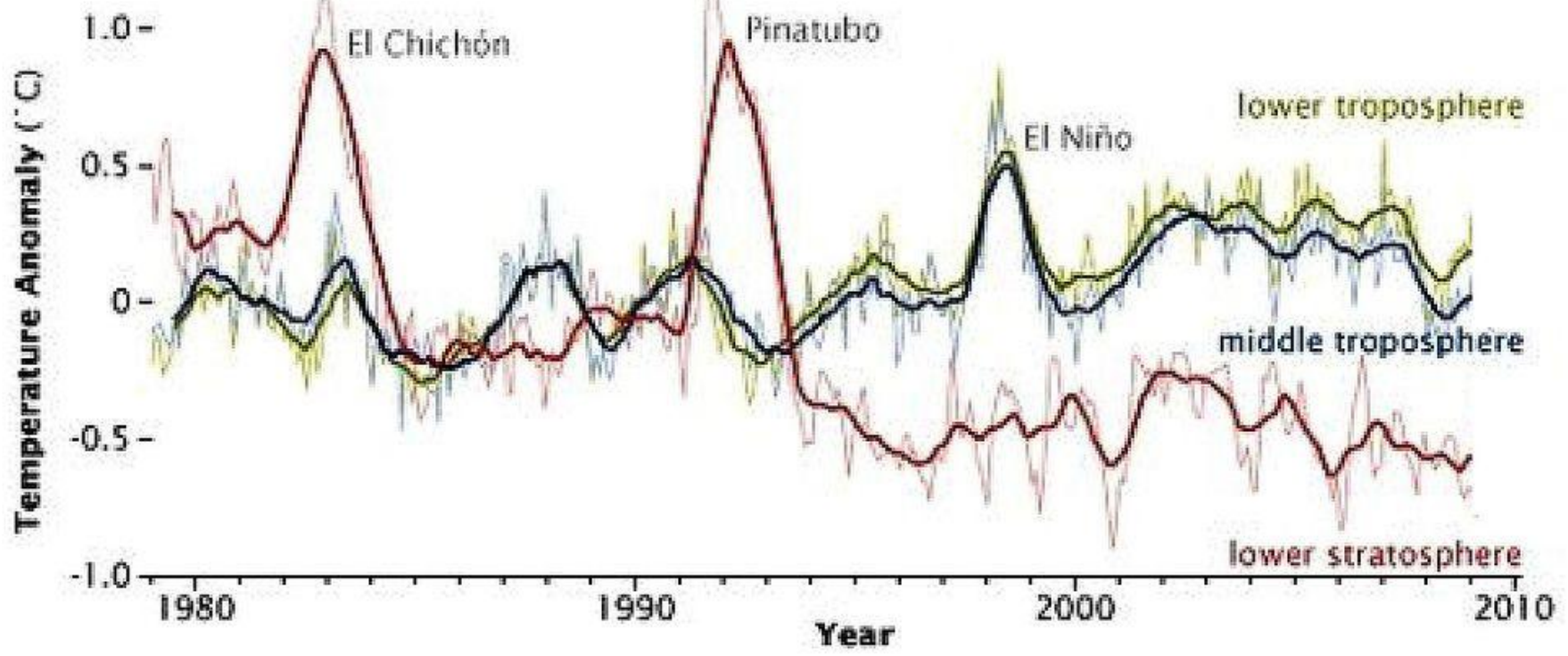
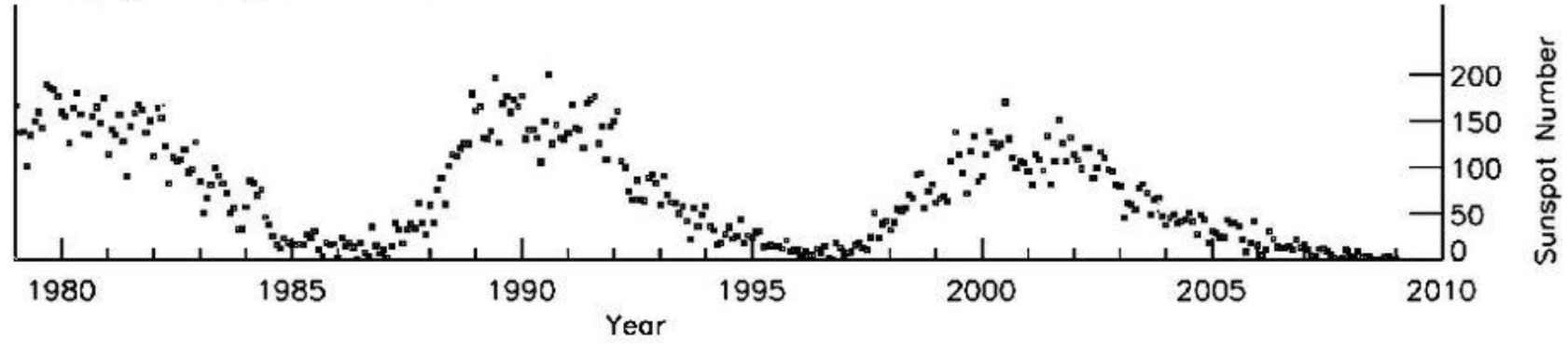
Maximums

Minimums



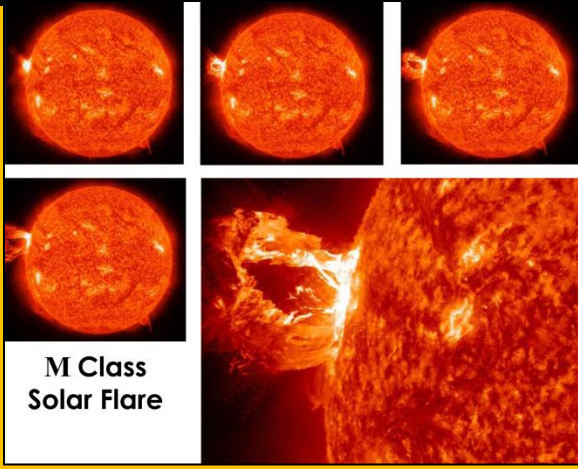
Milankovitch variations

Monthly Sunspot Number

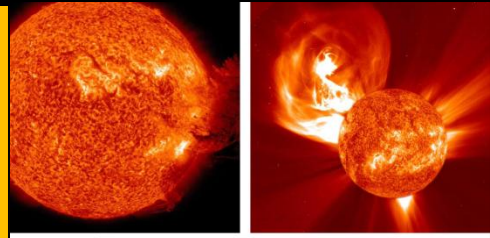


Solar Eruptions

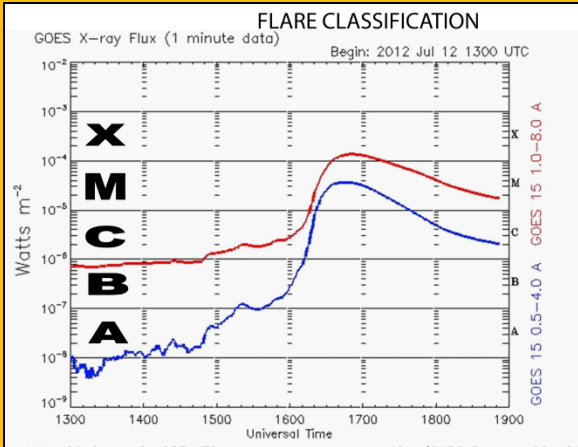
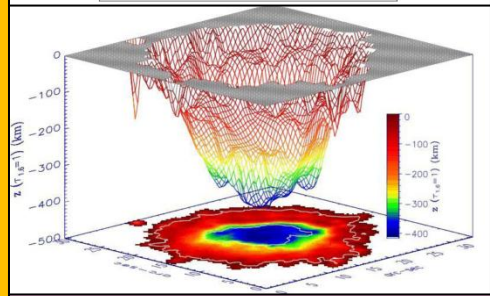
CMEs
Sunspots
Erupting
Filaments
Flares
Coronal Heating



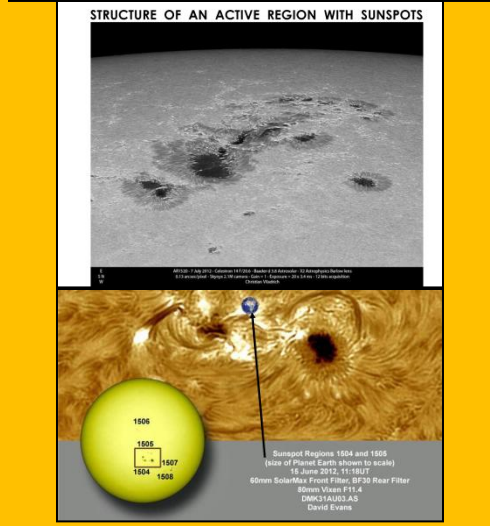
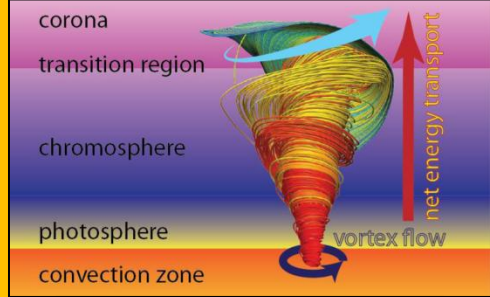
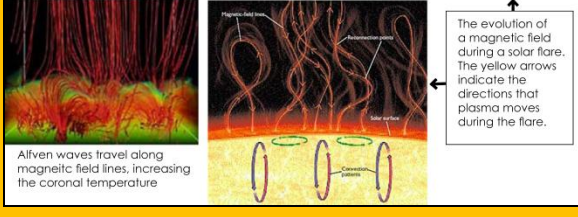
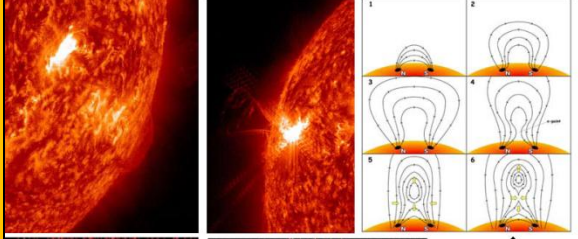
M Class Solar Flare

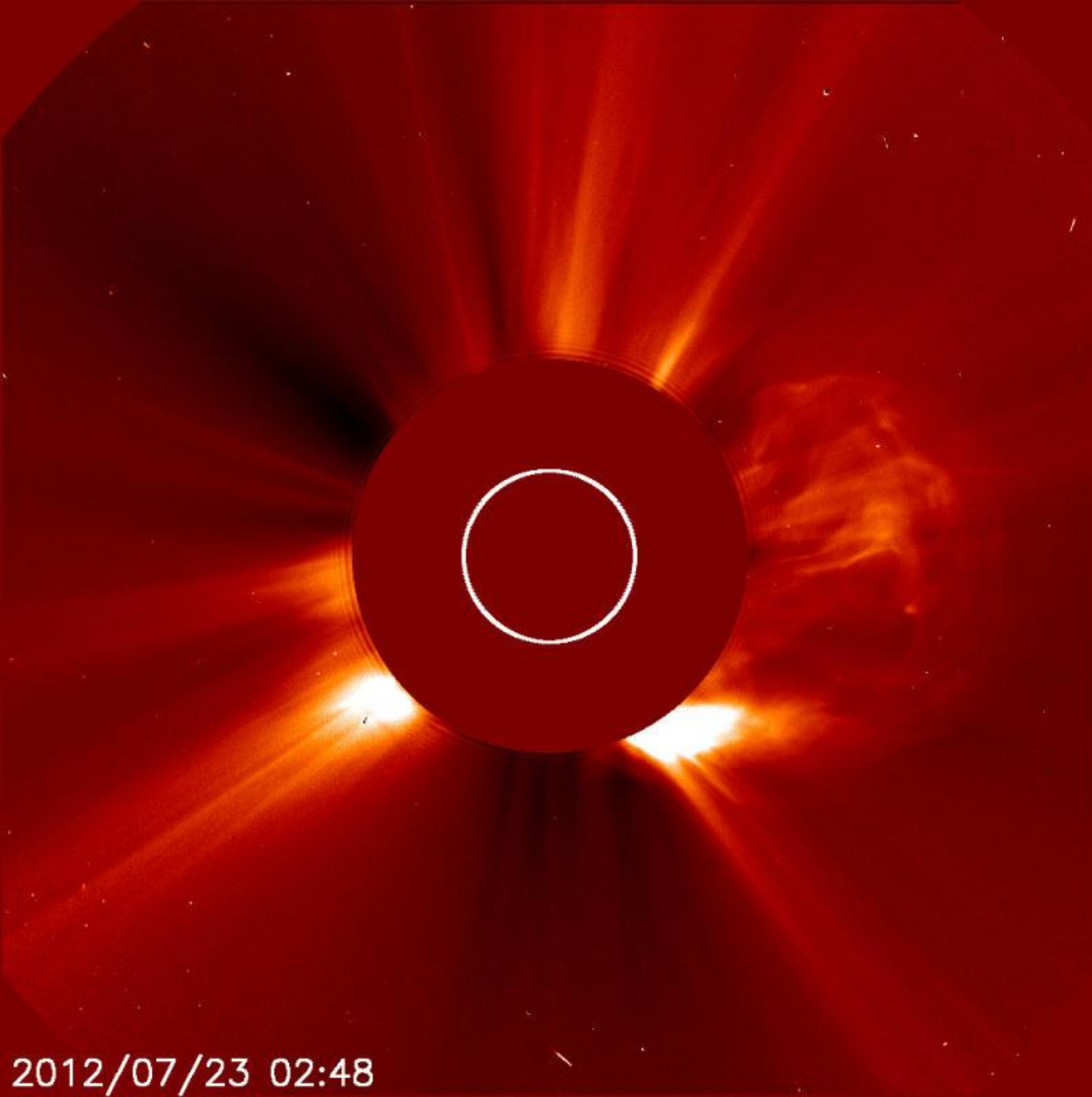


Coronal Mass Ejection: CME



Updated 2012 Jul 12 1853 UTC NOAA/SWPC Boulder, CO USA

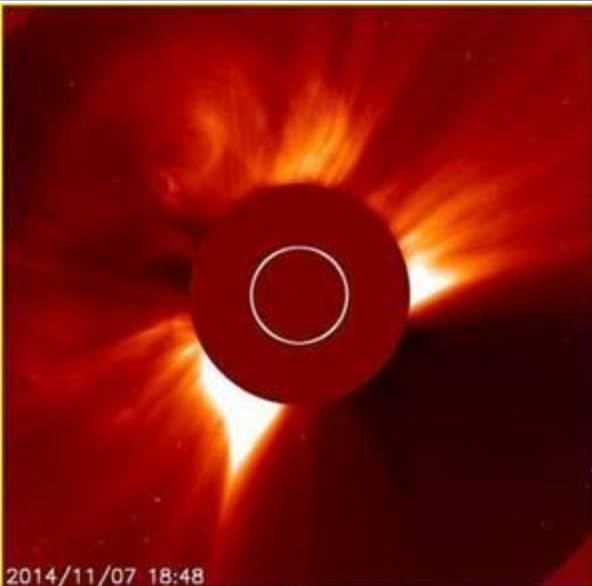




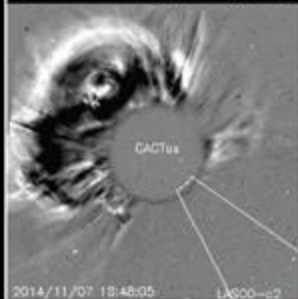
Coronal Mass Ejection

CME

2012/07/23 02:48



X1.6 Class Flare (AR2205)
Coronal mass ejection (CME)



2014/11/07 18:48:05 LASCO-c2

Start Time: 2014-11-07 18:08:34
End Time: 2014-11-07 21:12:10
Radial Lin. Vel.: 809 701 km/s
Angular Width: 360 deg

CME originated from AR 2205X 1.6 flare
Ejecta north-east direction



AIA 171
AIA 304

2014-11-07 17:23:11
2014-11-07 17:22:43

Active Regions

Plage

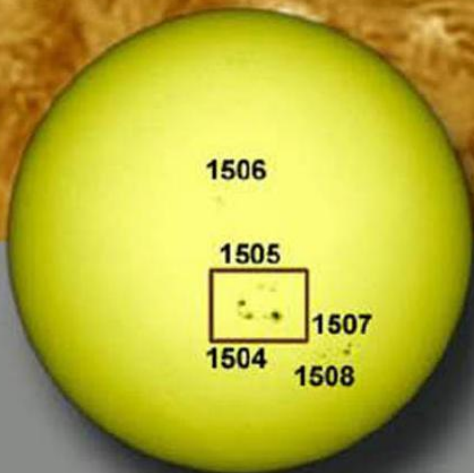
Granulation

Filament

Sunspot

Umbra

Penumbra



Sunspot Regions 1504 and 1505
(size of Planet Earth shown to scale)

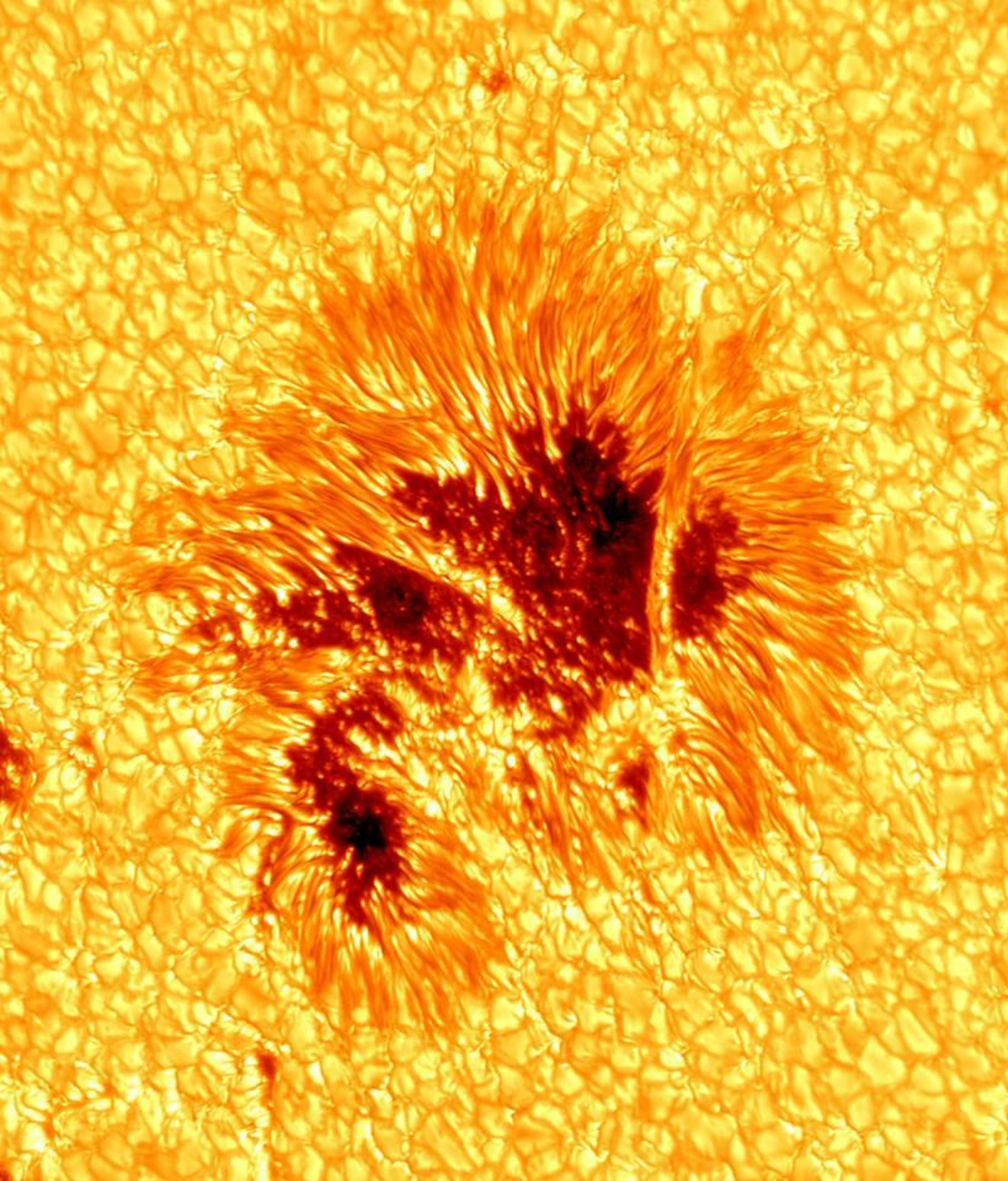
15 June 2012, 11:18UT

60mm SolarMax Front Filter, BF30 Rear Filter

80mm Vixen F11.4

DMK31AU03.AS

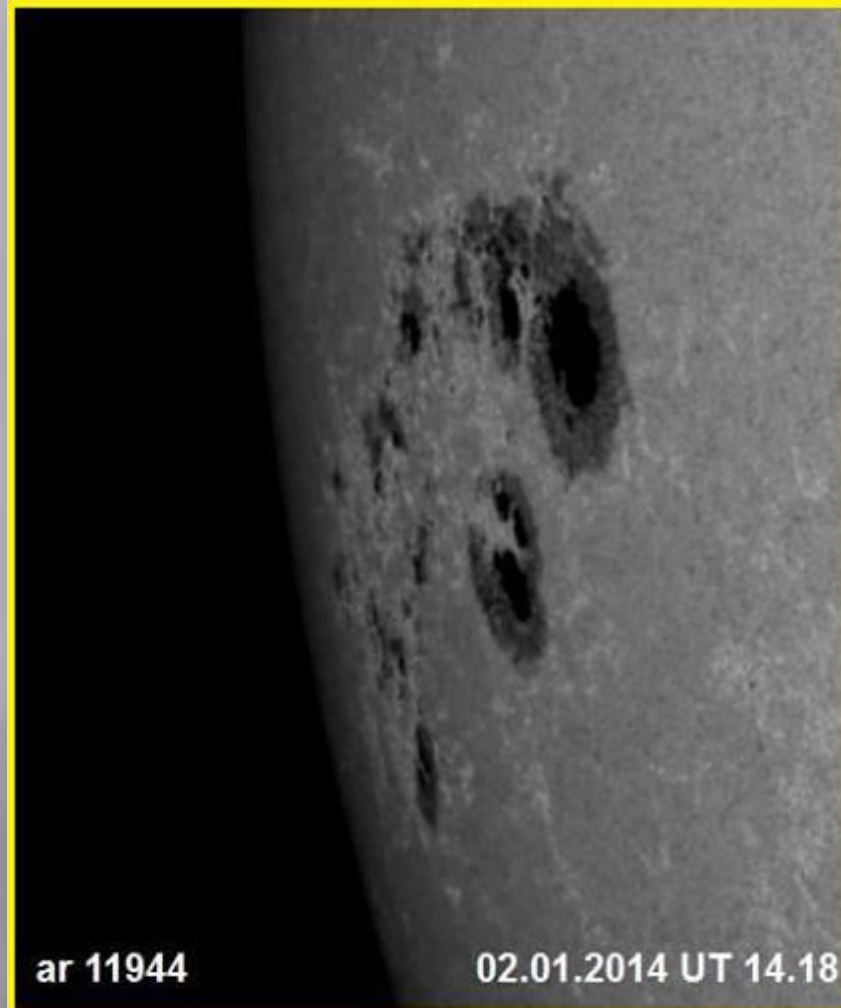
David Evans



Granulation =
“Texas” sized
convection cells.

Heat and magnetic
field emerge from
center, cool and
plunge down at edge.

Sunspots form at
edge of cell.



ar 11944

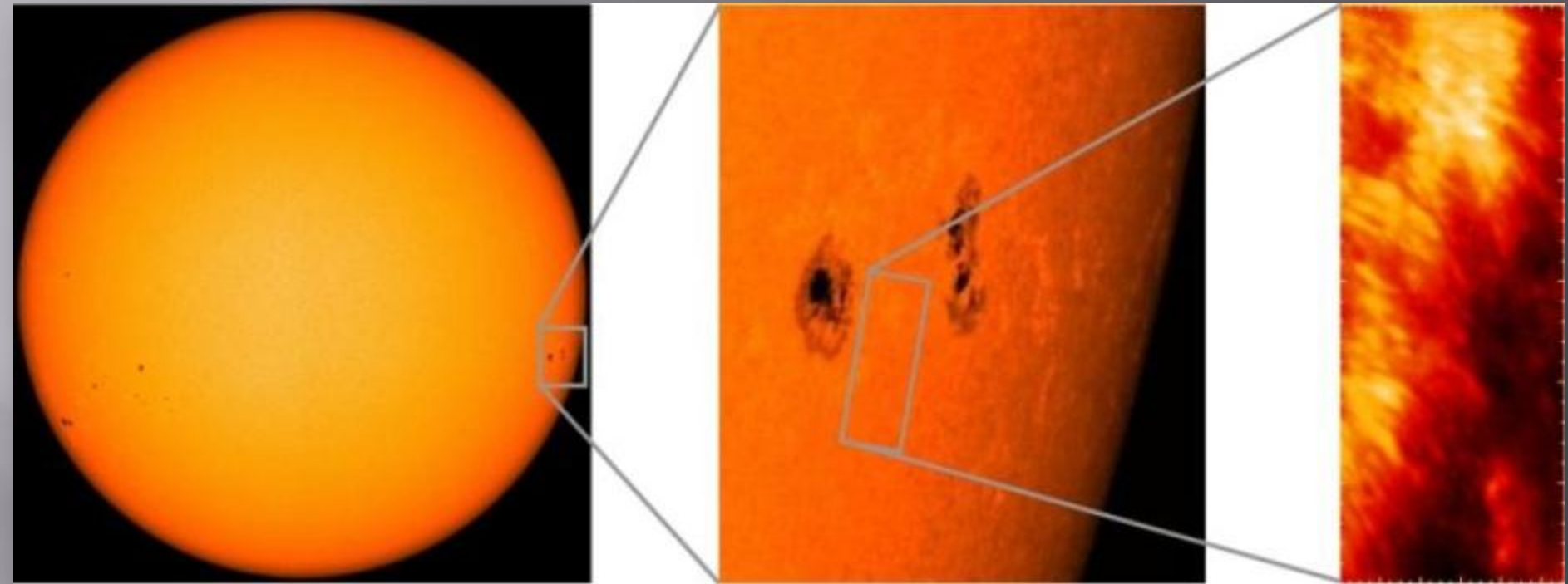
02.01.2014 UT 14.18



ar 11967

28.01.2014 UT 14.54

Numbering of sunspots involves a new Carrington rotation cycle and magnetic field flux intensity even though we now can/could follow evolution “behind” the sun’s rotation.



Full H- α disc

**Sunspot
structure**

**Plage
region**

Biggest Sunspot in 2 Solar Cycles
Largest since Nov. 1990!!!!

12195

12193

12187

12192

12194



Jupiter



Earth

NASA SOHO/MI

Erupting Filament



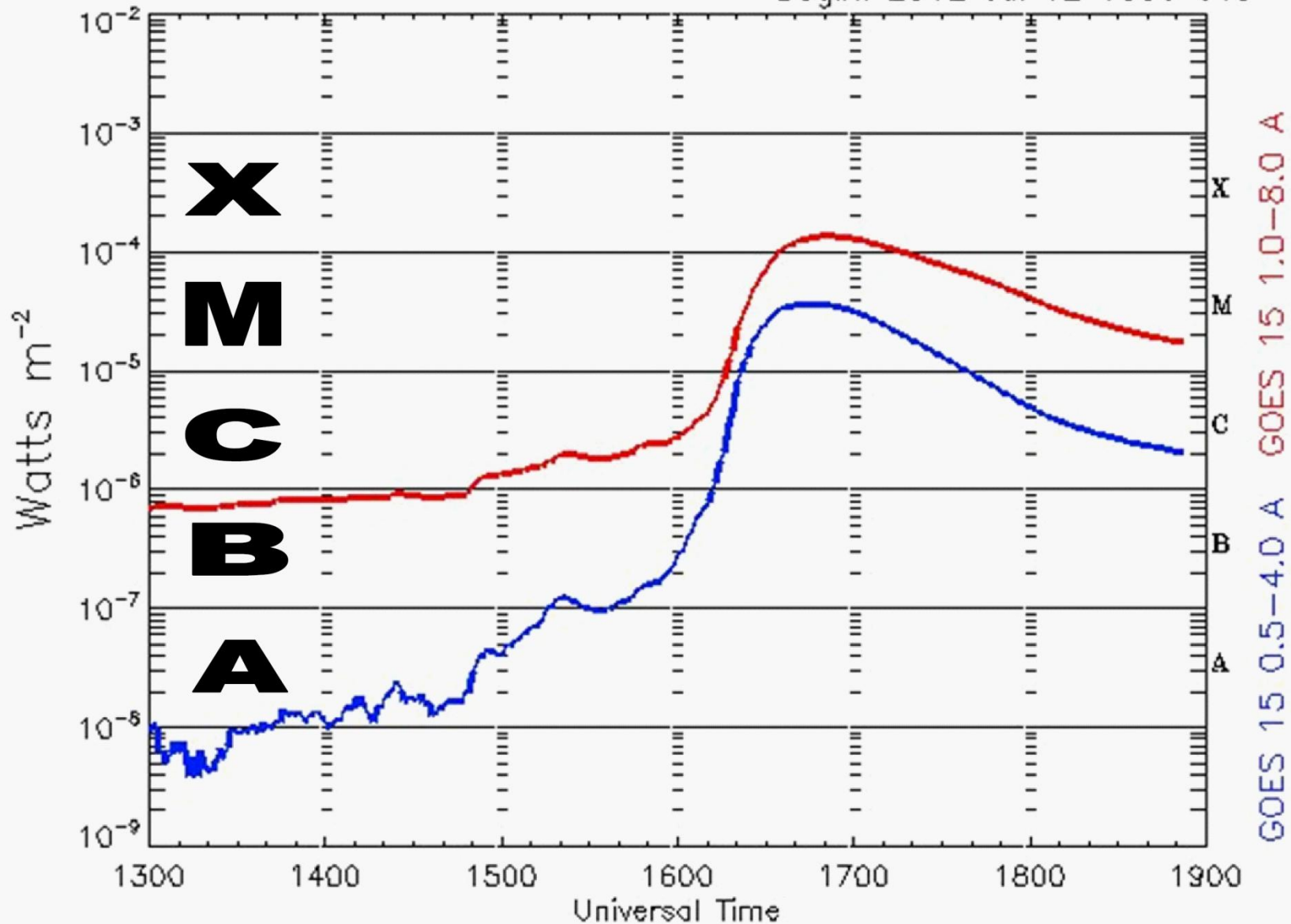
Earth
For scale



FLARE CLASSIFICATION

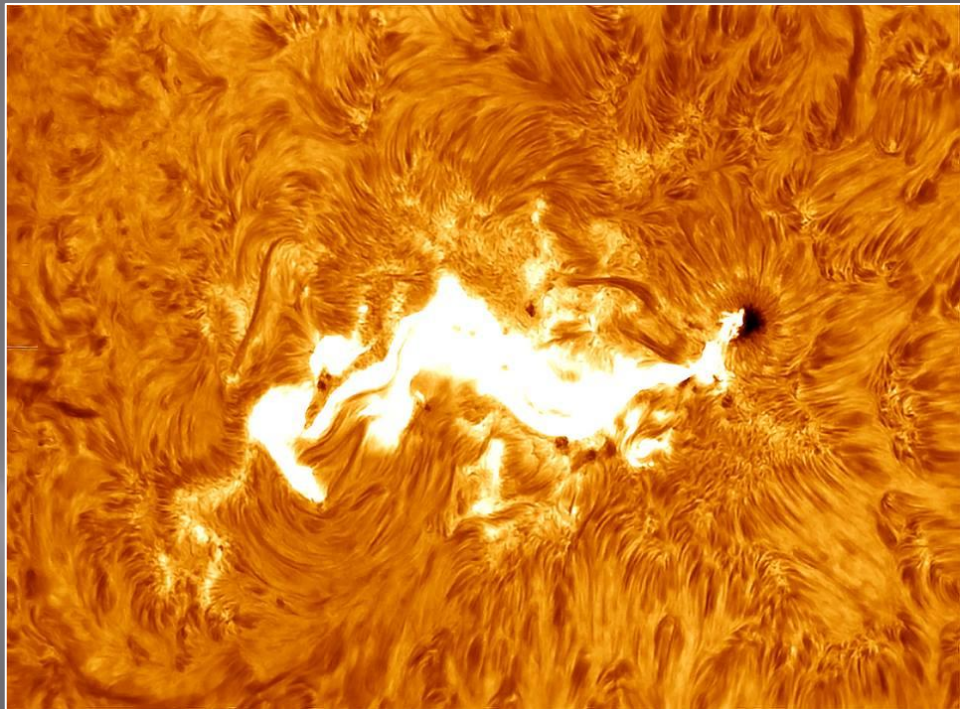
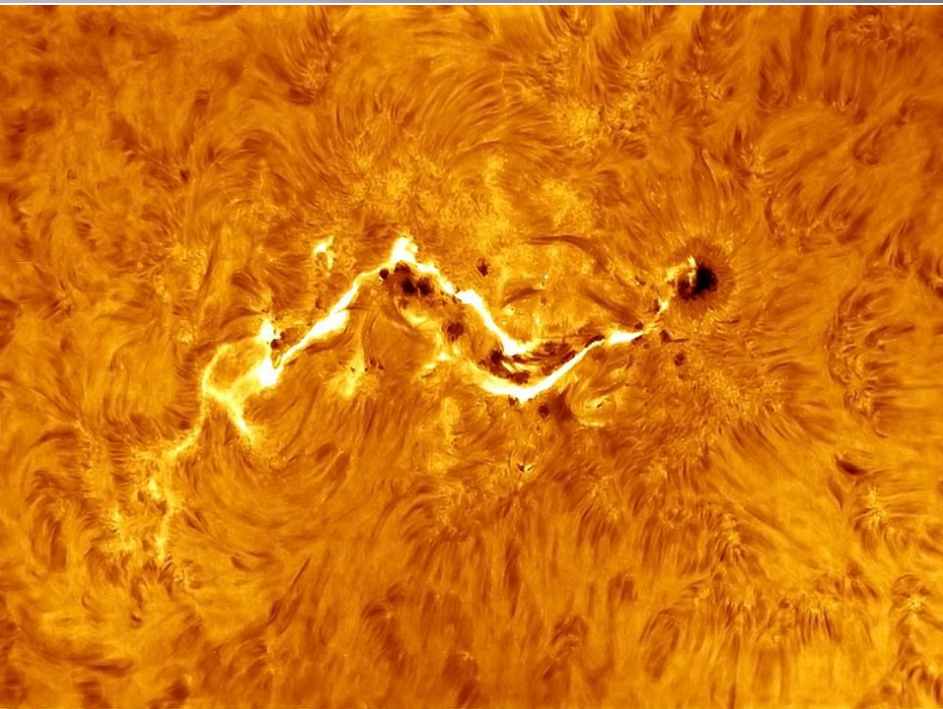
GOES X-ray Flux (1 minute data)

Begin: 2012 Jul 12 1300 UTC



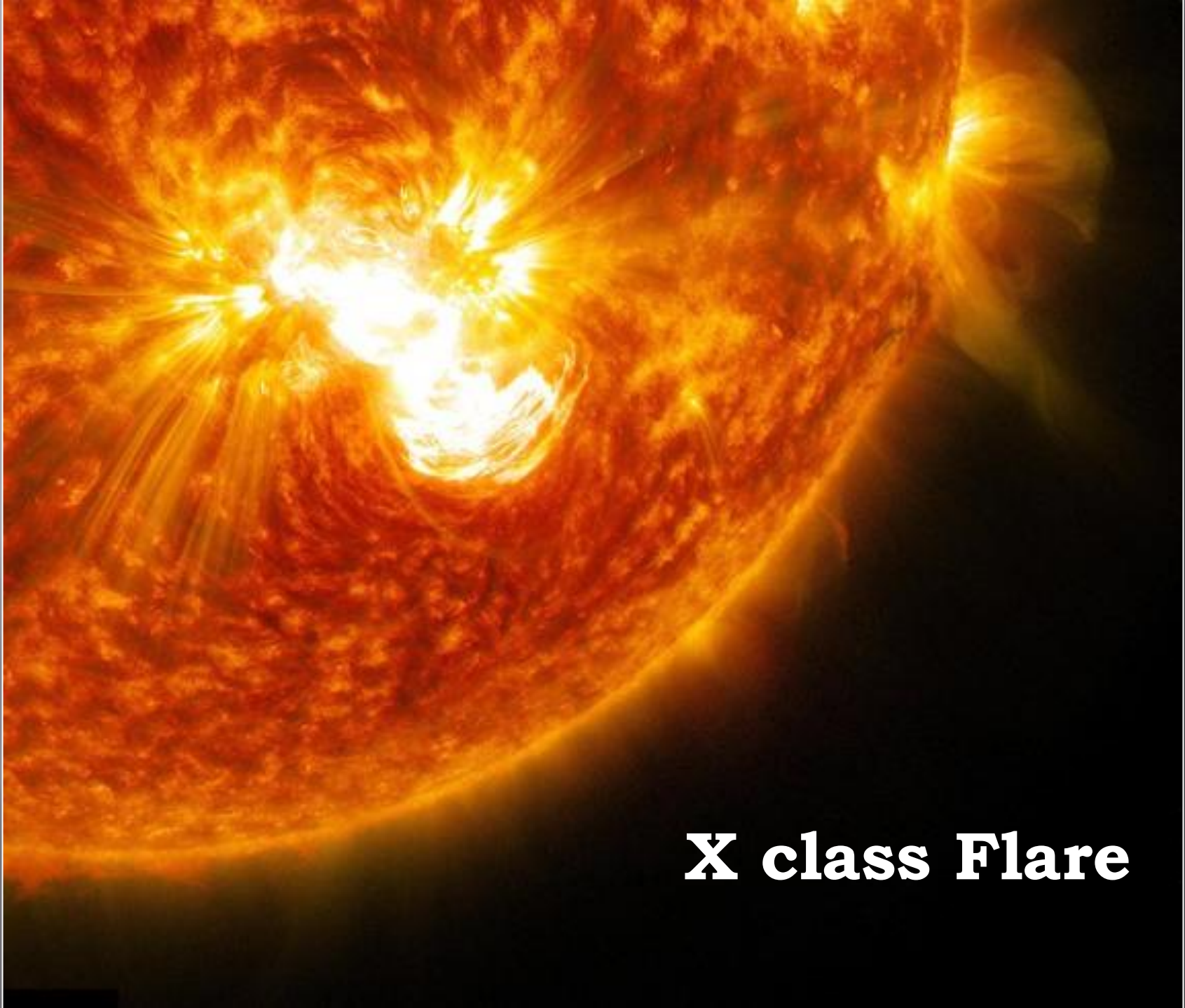
Updated 2012 Jul 12 1853 UTC

NOAA/SWPC Boulder, CO USA



Randy Shivak

**Flaring activity from AR 12205,
start to peak**



X class Flare

The Energy of a Solar Flare

The average power output of an X1 solar flare is 10^{20} watts (Joules per second)

That is equivalent to 1 million trillion 100 watt lightbulbs

1 million trillion = 1,000,000,000,000,000,000

The total energy released is about 10^{25} joules and equal to:

250 magnitude 9 earthquakes, or

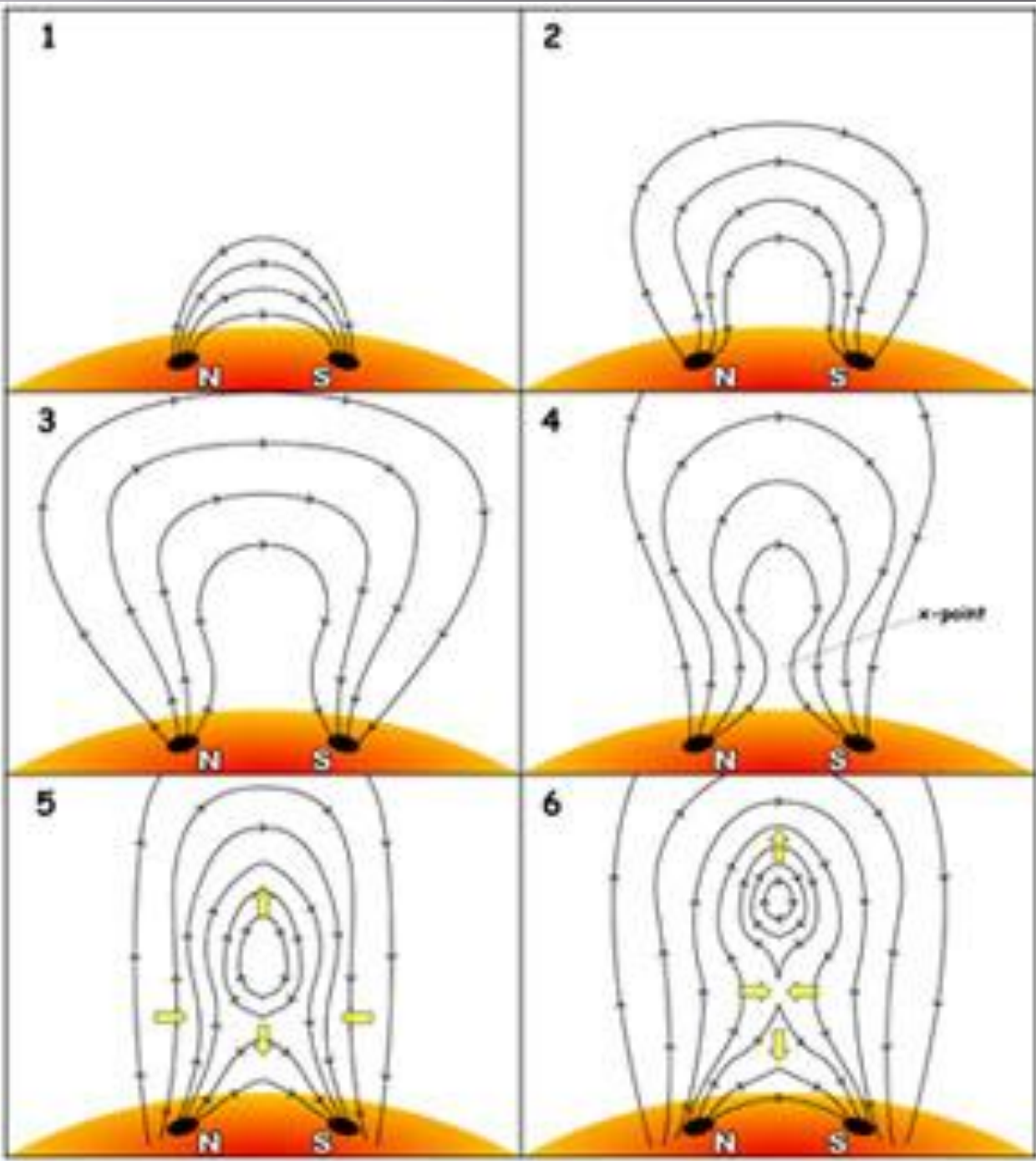
500 hurricanes, or

20,000 times world energy consumption (yearly), or

10 million volcanic eruptions, or

10,000 trillion lightning bolts, or

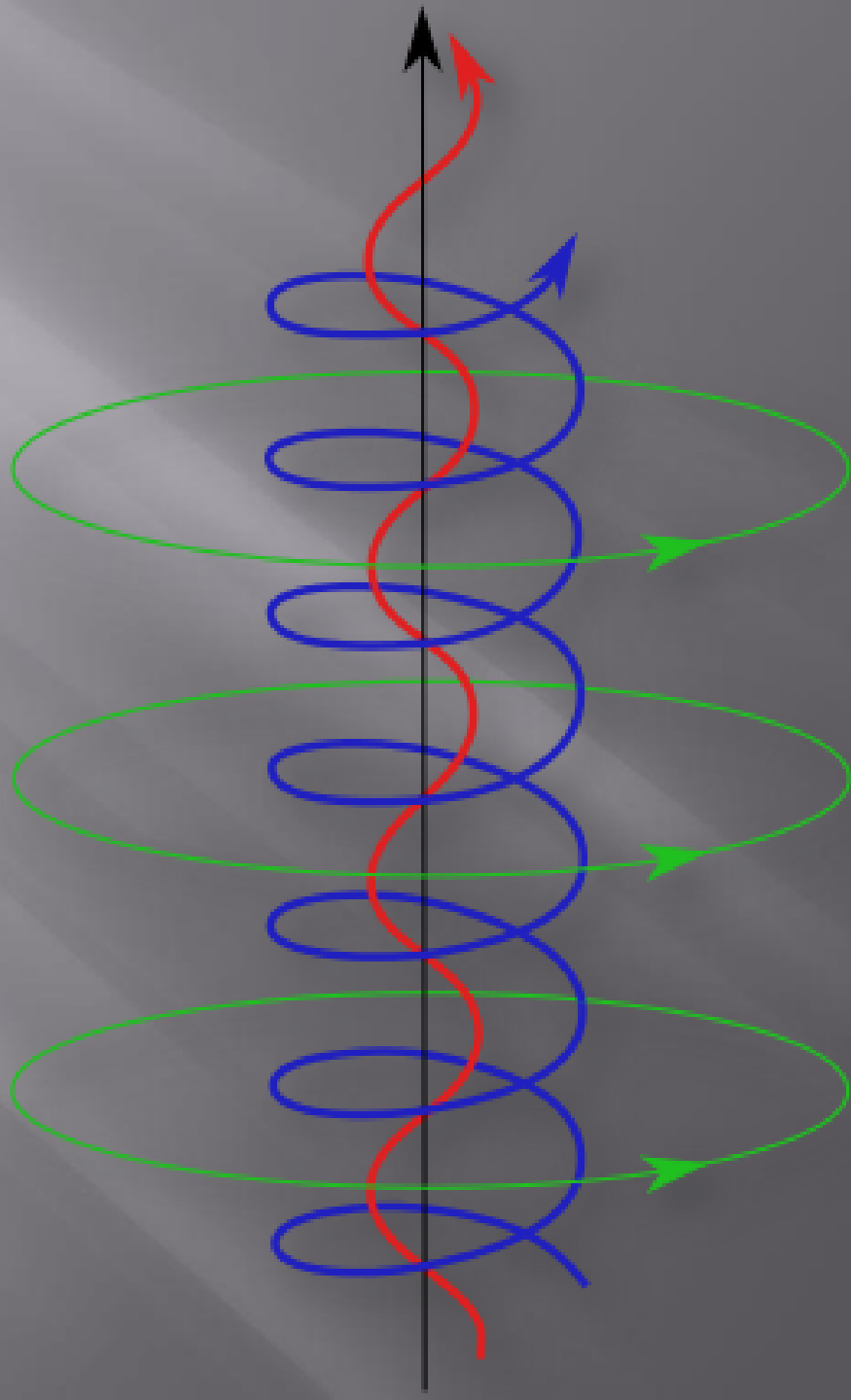
1 hundredth of the sun's output (every second)



Theory of Reconnection

Alfven waves
 (Hannes Alfven 1970 Nobel Prize in plasma physics)

Birkeland energy
 (Kristian Birkeland)



1. If magnetic field loops begin to pinch together...

2. ... the field lines of adjacent loops can reconnect, causing a release of energy.

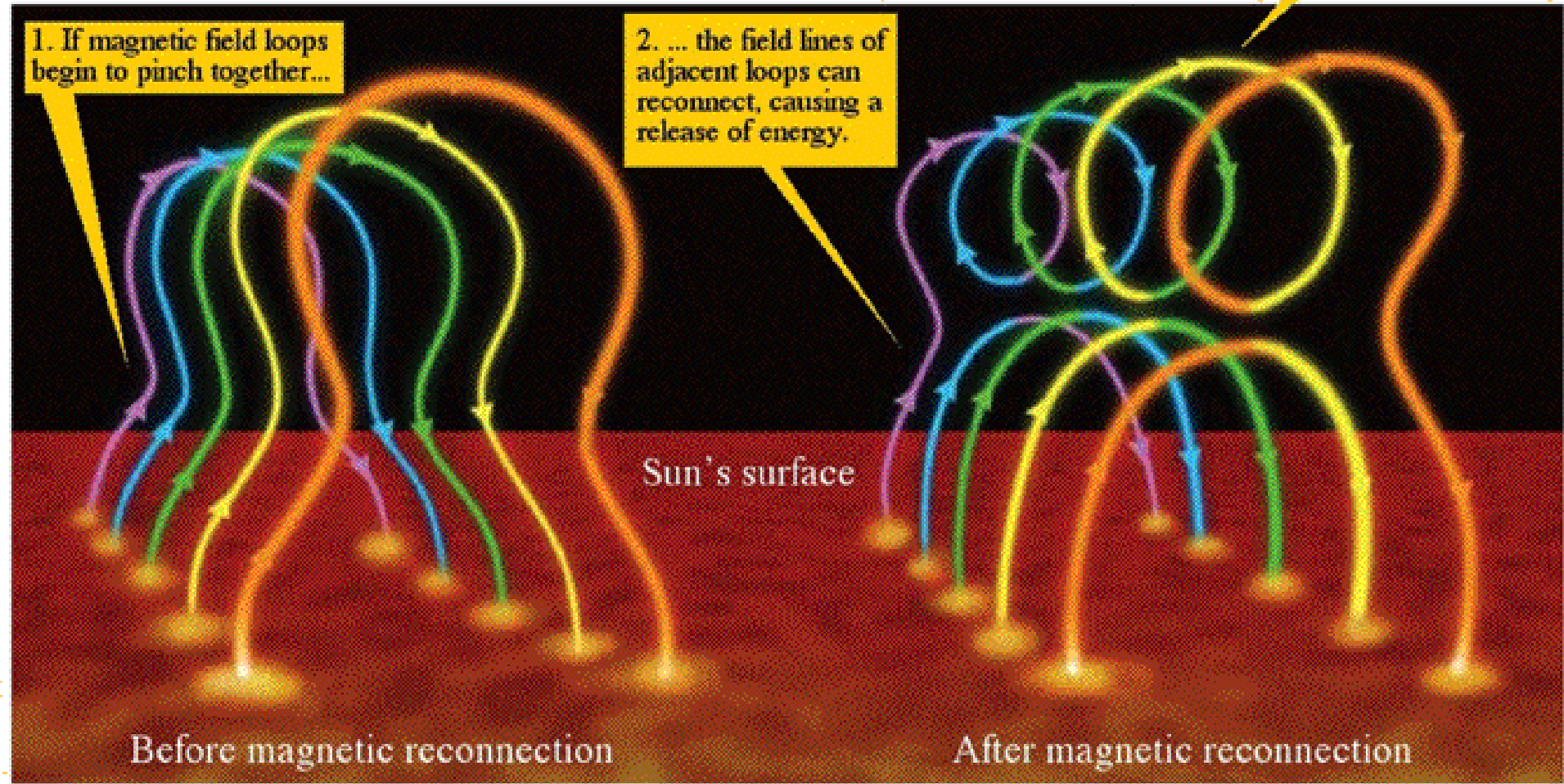
3. The upper helix or "coil" of magnetic field can break loose, carrying material with it into space.

Sun's surface

Before magnetic reconnection

After magnetic reconnection

Figure 16-25b
Universe, Eighth Edition
© 2008 W. H. Freeman and Company



Coronal Heating

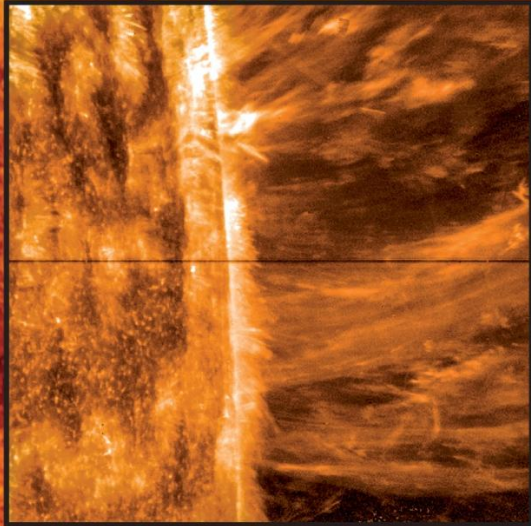
Why is the
Corona hotter
than the surface ?

Nanoflares

Alfven waves

Spicules

Exotic ionization
states



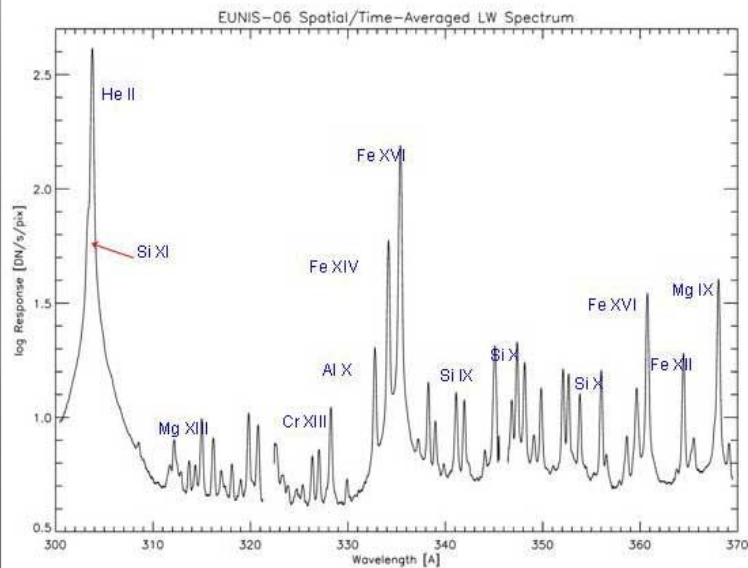
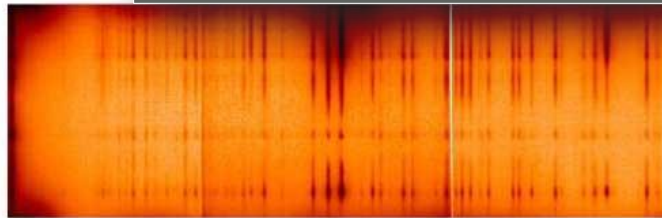
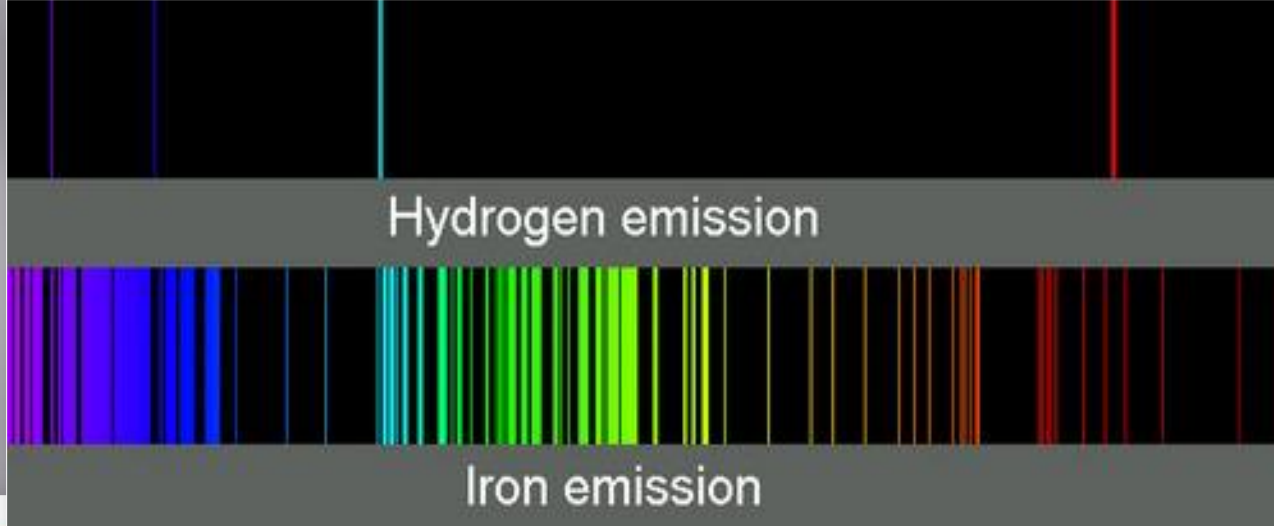


**The Rapid Acquisition
Imaging Spectrograph
Experiment, or RAISE**

**The Very high Angular
resolution Ultraviolet
Telescope, or VAULT**

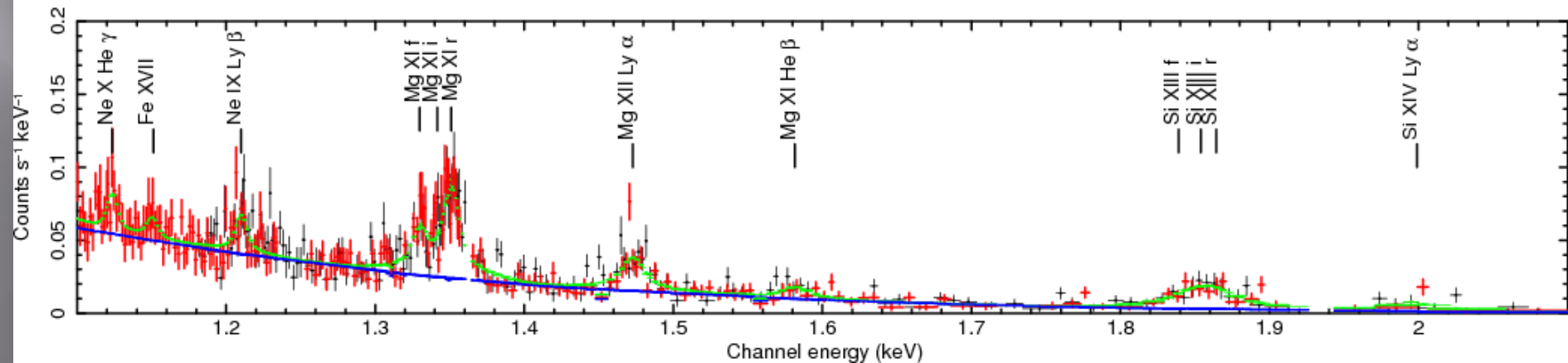
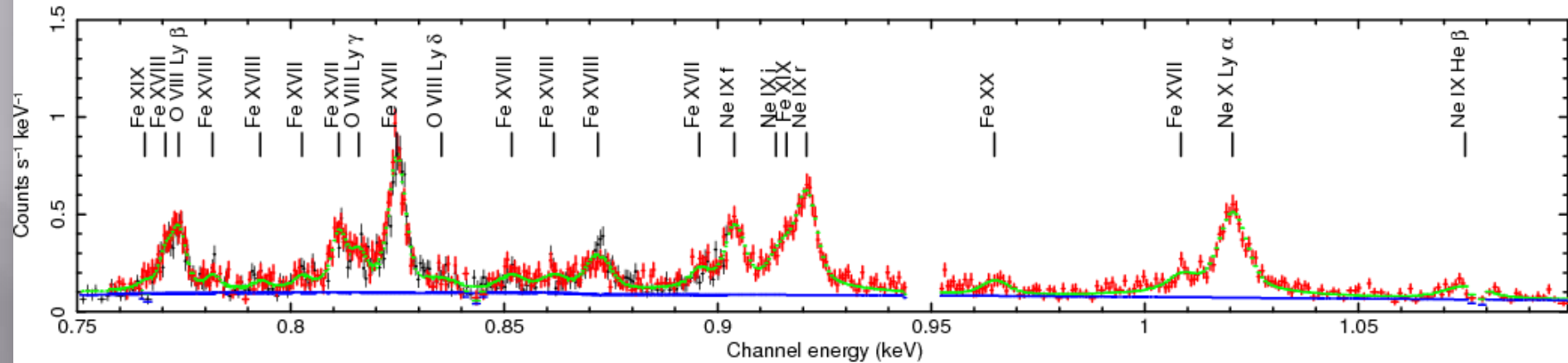
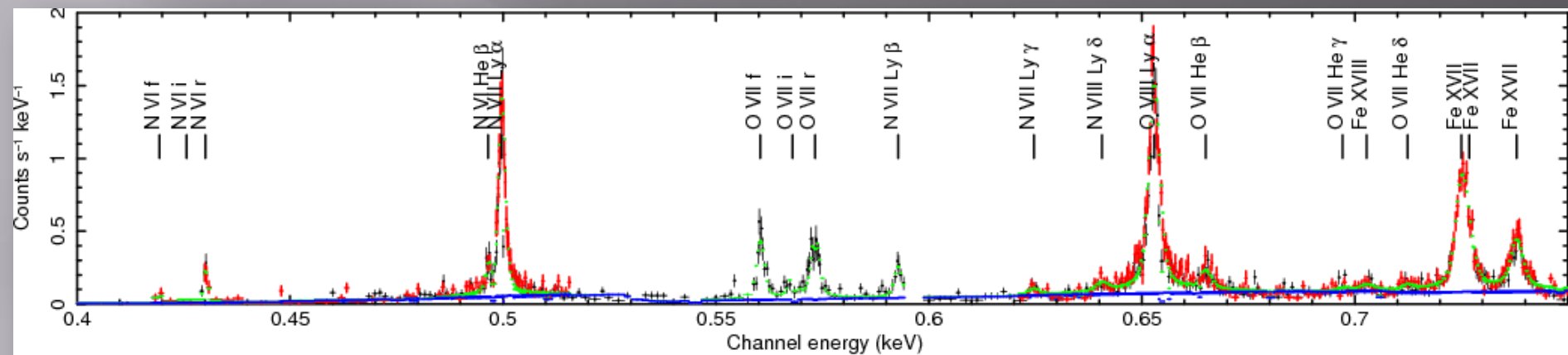


**Extreme Ultraviolet
Normal Incidence
Spectrograph, or EUNIS**



300 – 370 Å

Observational
evidence of
high energy ion
states of iron



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www.taas.org/solar.html

www.facebook.com/groups/TimmyTelescope/

**EXPERIENCE
the**



**WOW!
FACTOR**

