Solar Eclipses: What They Are, Front Line Experiences, and Some Science

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NASA/MSFC

Today's Discussion:

- Overview of eclipses.
- The 21 August 2017 total solar eclipse.
- Eye safety.
- A couple of experiences from the "front line" of past eclipses.
- The motivation for doing solar eclipse studies (just an outline…).
- Things you can do.

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- One body falls into the shadow of another.

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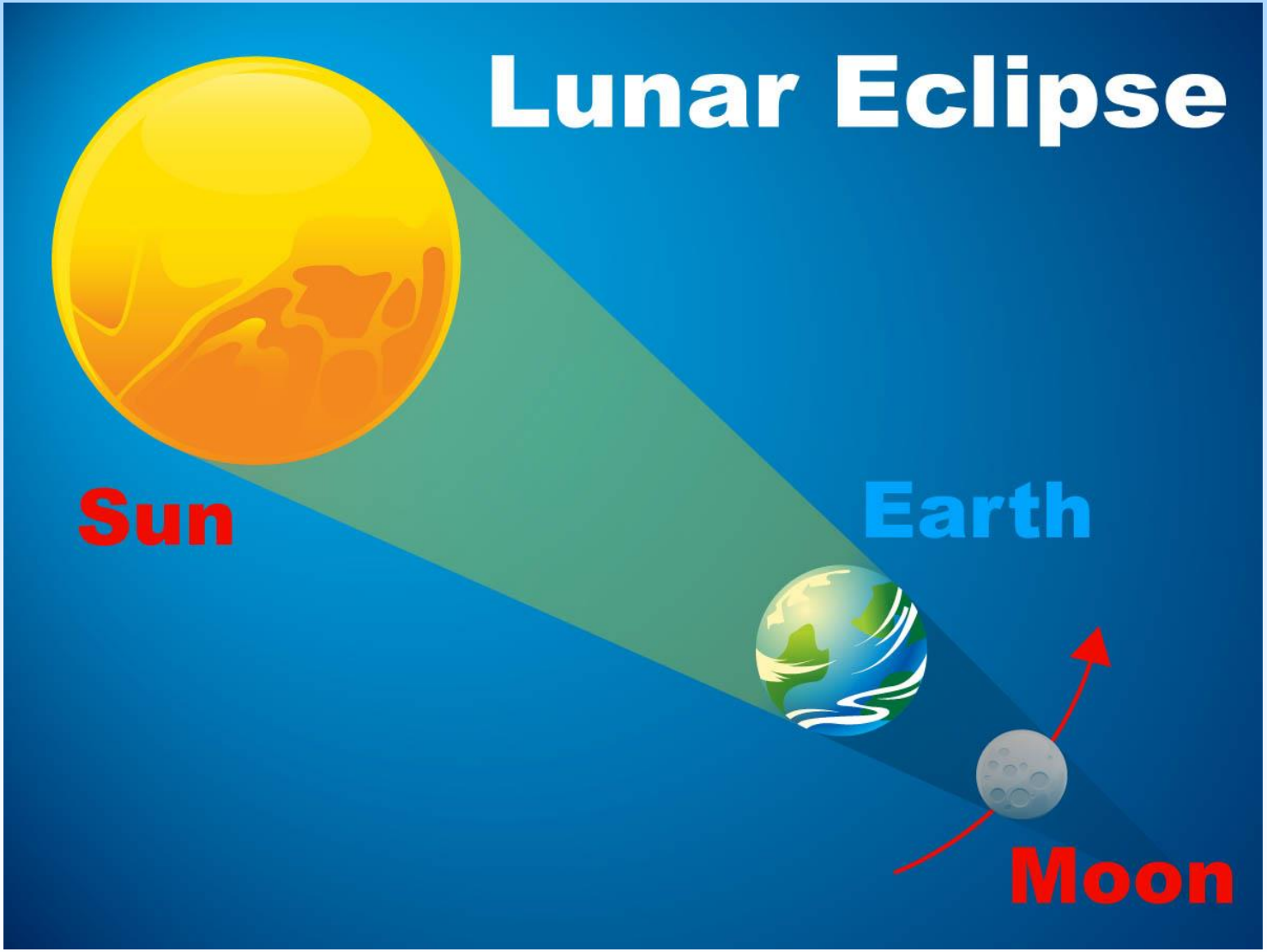
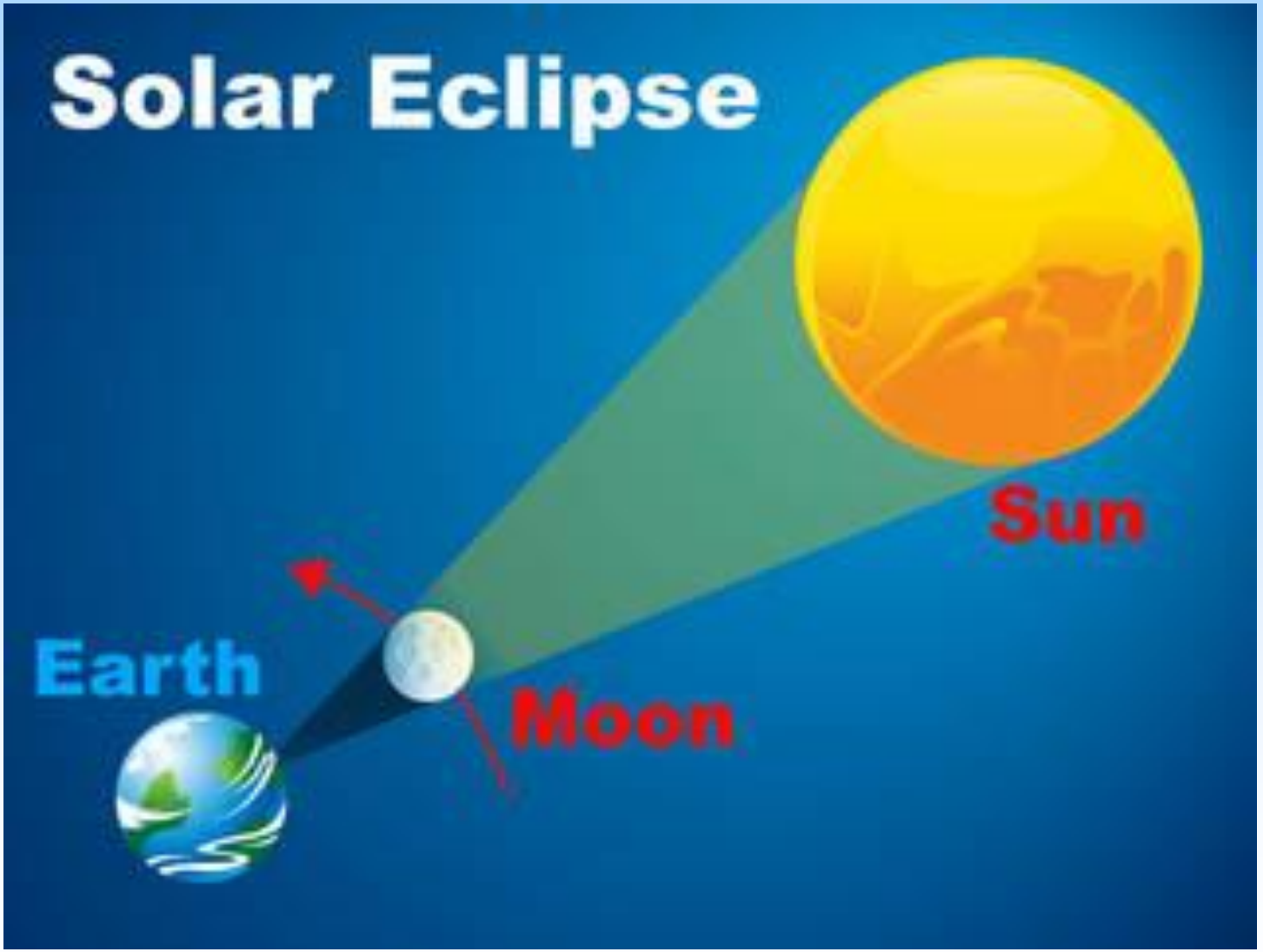

Lunar Eclipse
Sun
Earth
Moon

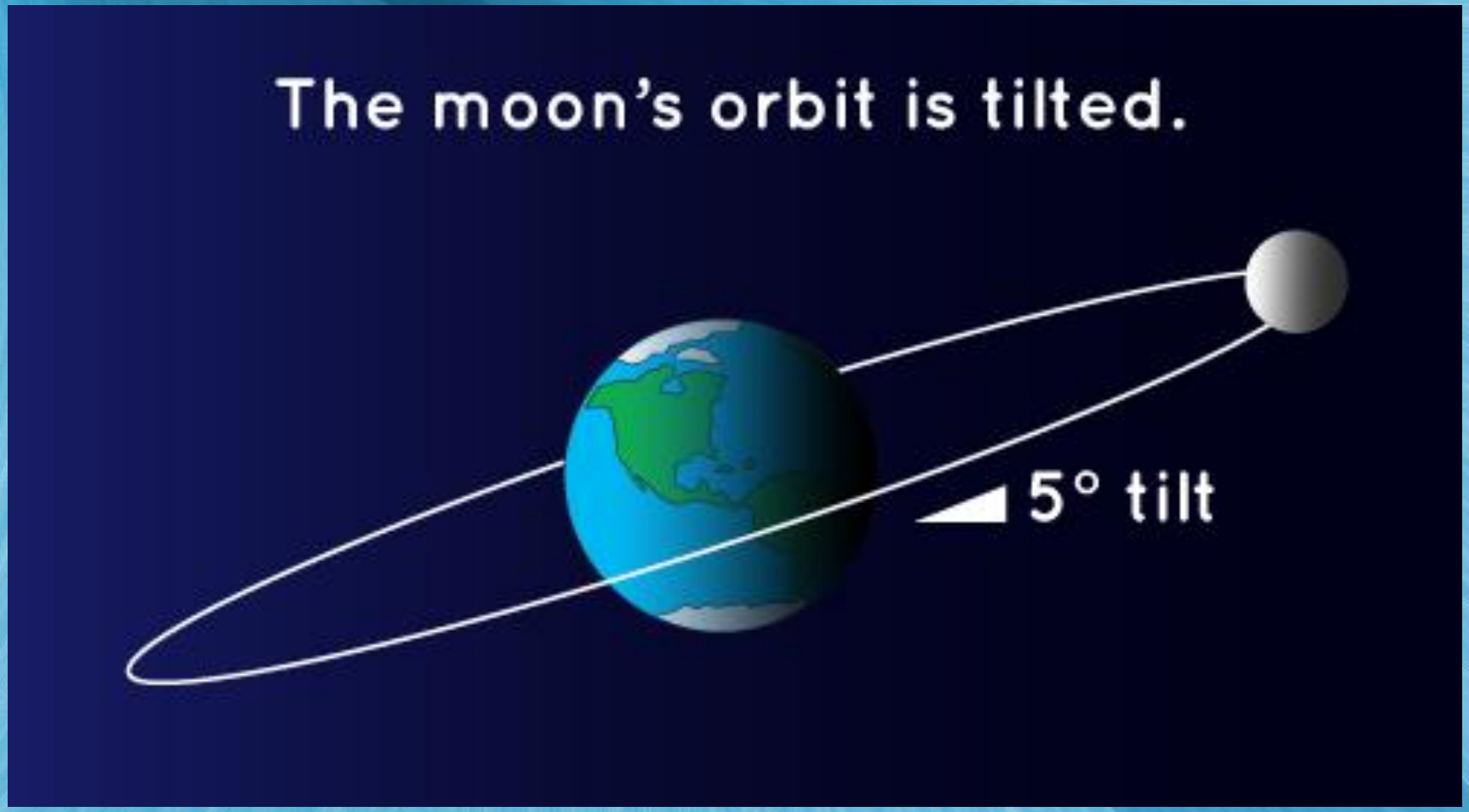
What are Eclipses?

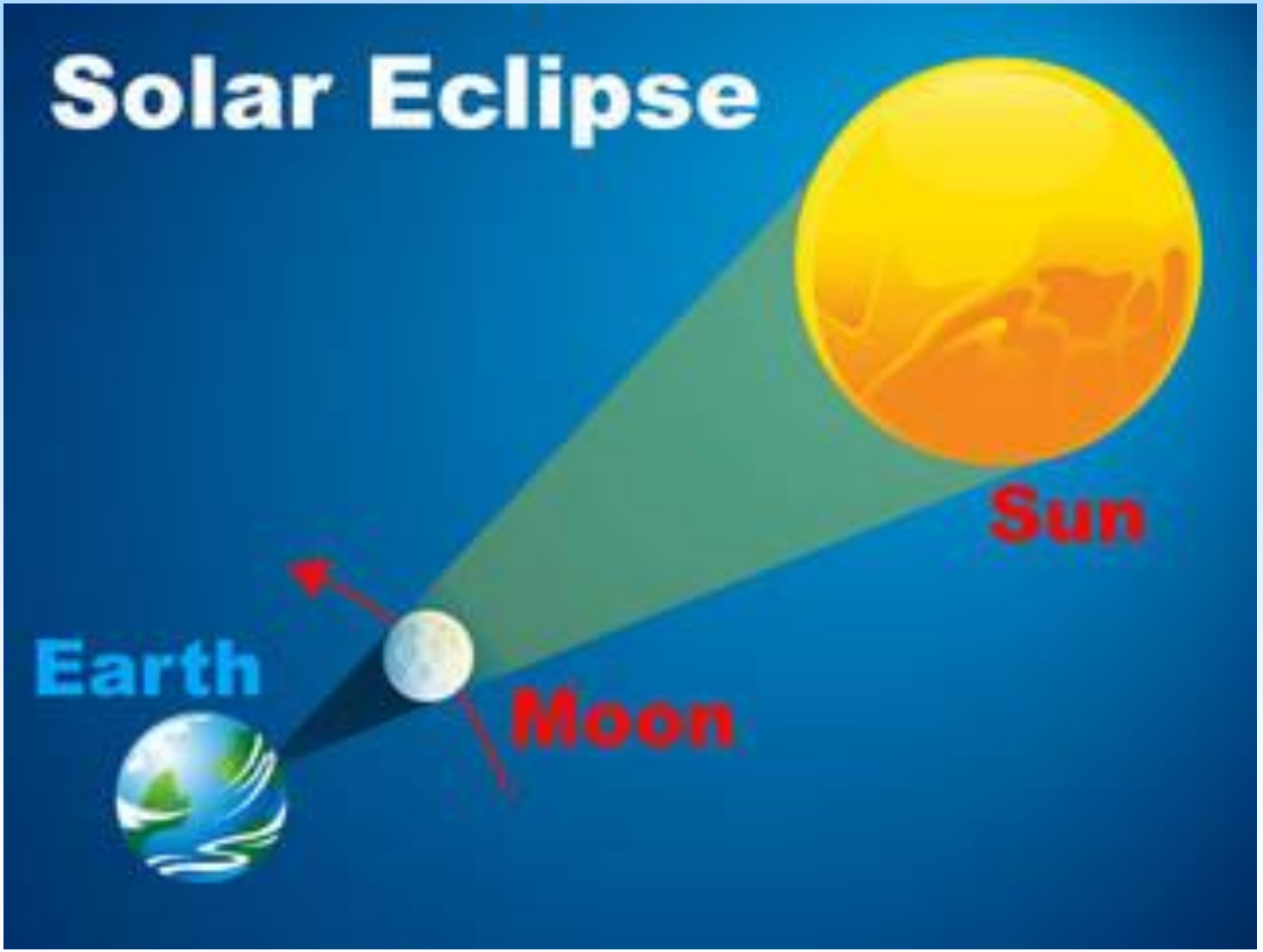
- One body falls into the shadow of another.
- Lunar eclipses.
- Solar eclipses.

What are Eclipses?

- One body falls into the shadow of another.
- Lunar eclipses.
- Solar eclipses.
  - Partial.
  - Annular.
  - Total.

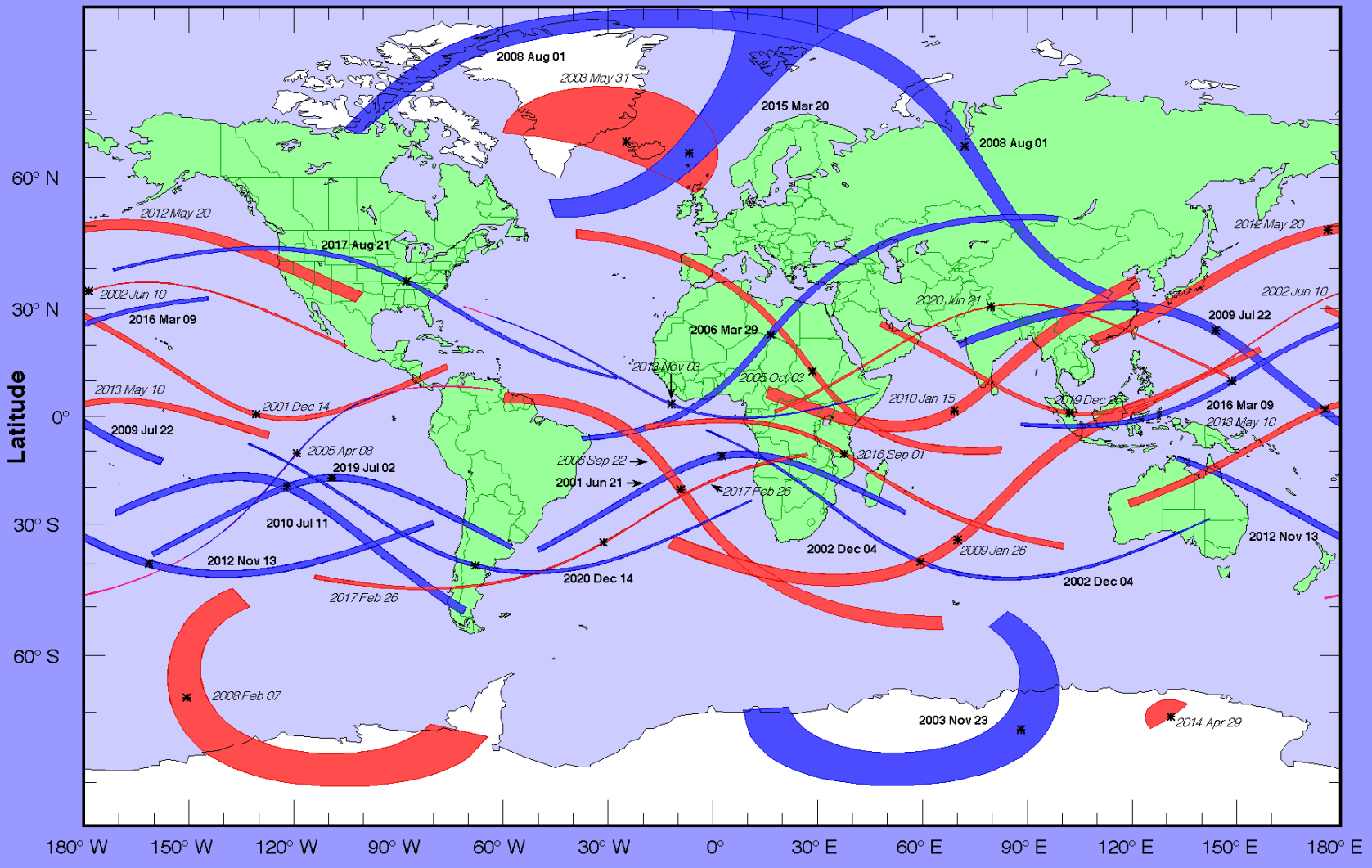

Solar Eclipse
Sun
Earth
Moon


The moon's orbit is tilted.
5° tilt


Solar Eclipse
Sun
Earth
Moon


20 May 2012 22:35:02 UT

Total and Annular Solar Eclipse Paths: 2001 – 2020

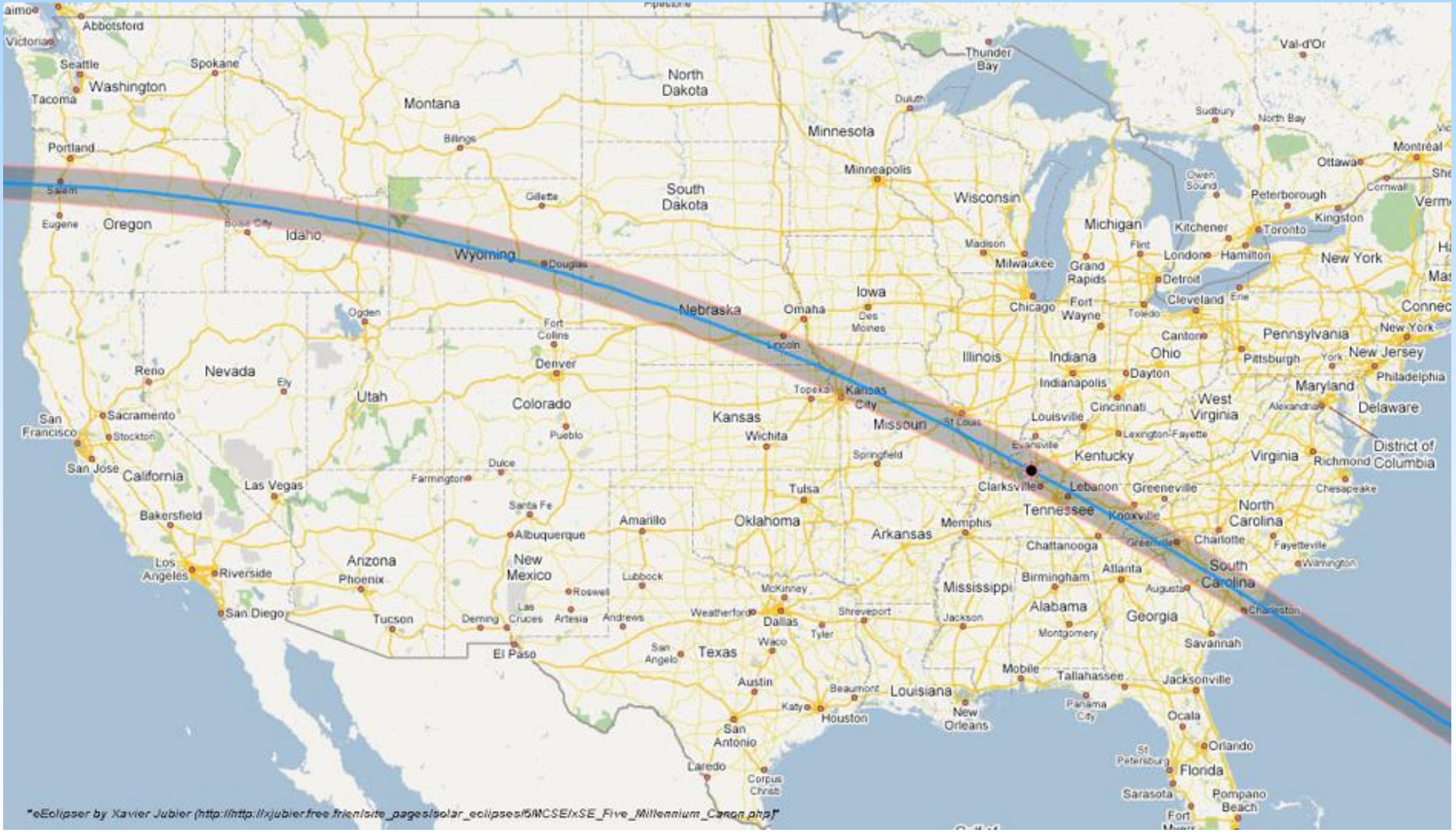


sunearth.gsfc.nasa.gov/eclipse/eclipse.html

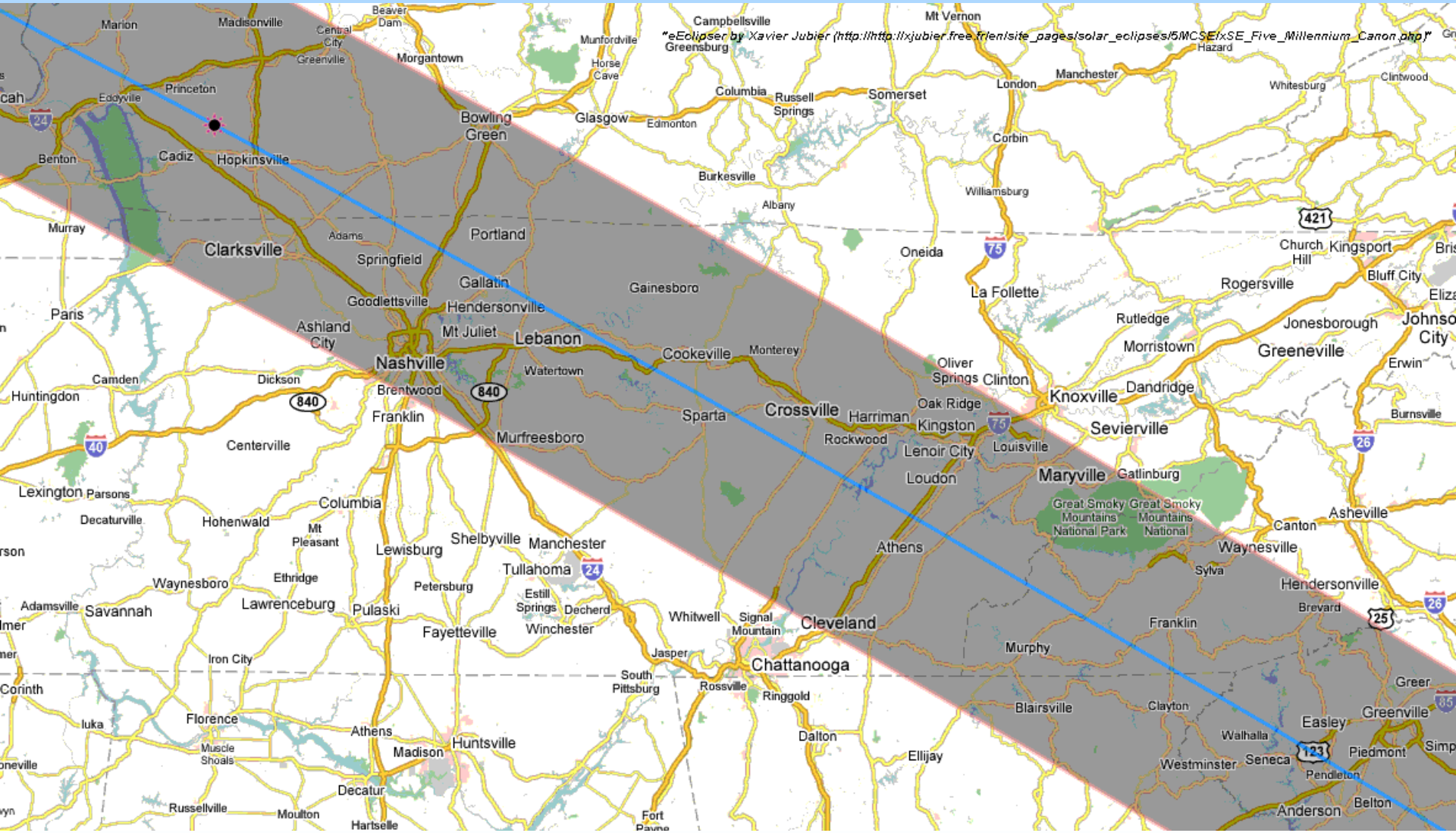
Fred Espenak, NASA/GSFC - 2002 July

The 21 August 2017 Total Solar Eclipse

August 21, 2017 Total Solar Eclipse Path



August 21, 2017 Total Solar Eclipse Path



Do not Risk Your Precious Eyes!!

- Do ***not*** look at the partial phases of the eclipse directly without certified eye protection!!
- There's no point to staring at partial phases….

- Look without protection only if you're in the totality path, and then only during totality! (About 2 minutes.)

Viewing Eclipses (partial phases)

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- Eclipse glasses:

(https://eclipse.aas.org/resources/solar-filters)

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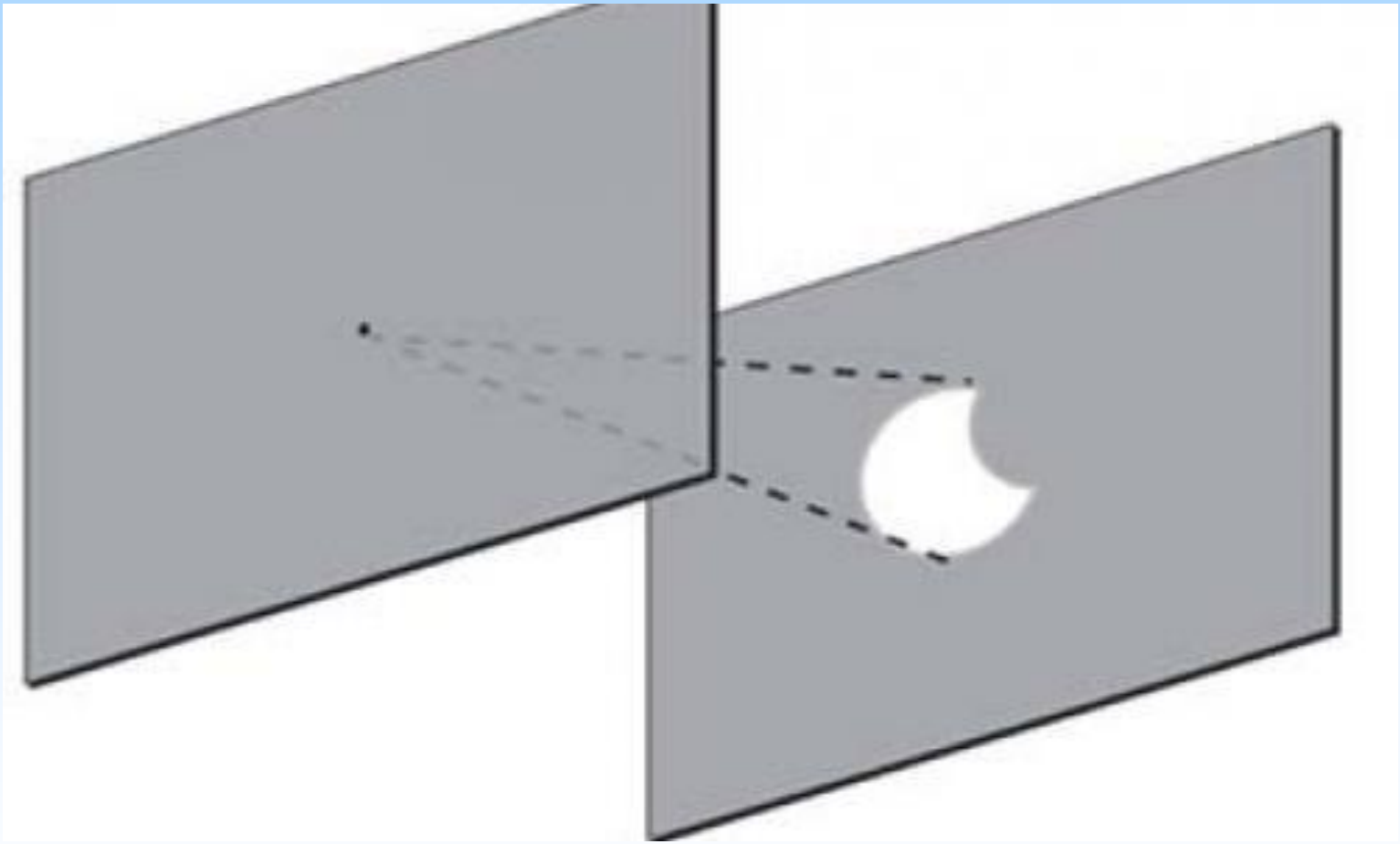
  - Pinhole projection



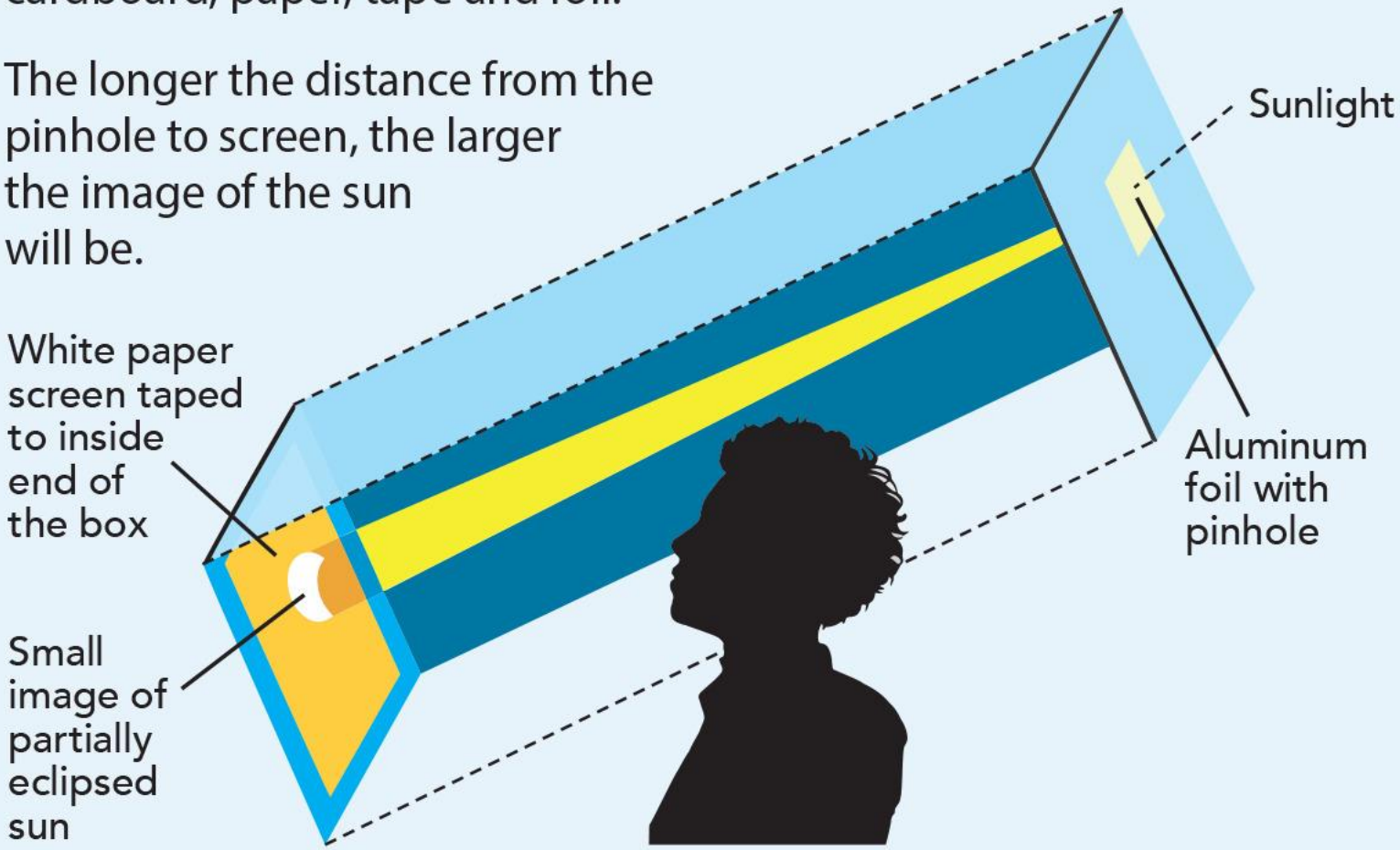
Viewing Eclipses (partial phases)

- Eclipse glasses
- Welder's glass (#14)
- Indirect methods
  - Pinhole projection
  - Box projection

MAKE YOUR OWN CARDBOARD PROJECTOR

You can make this simple eclipse projector with some cardboard, paper, tape and foil.

The longer the distance from the pinhole to screen, the larger the image of the sun will be.



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  - Box projection
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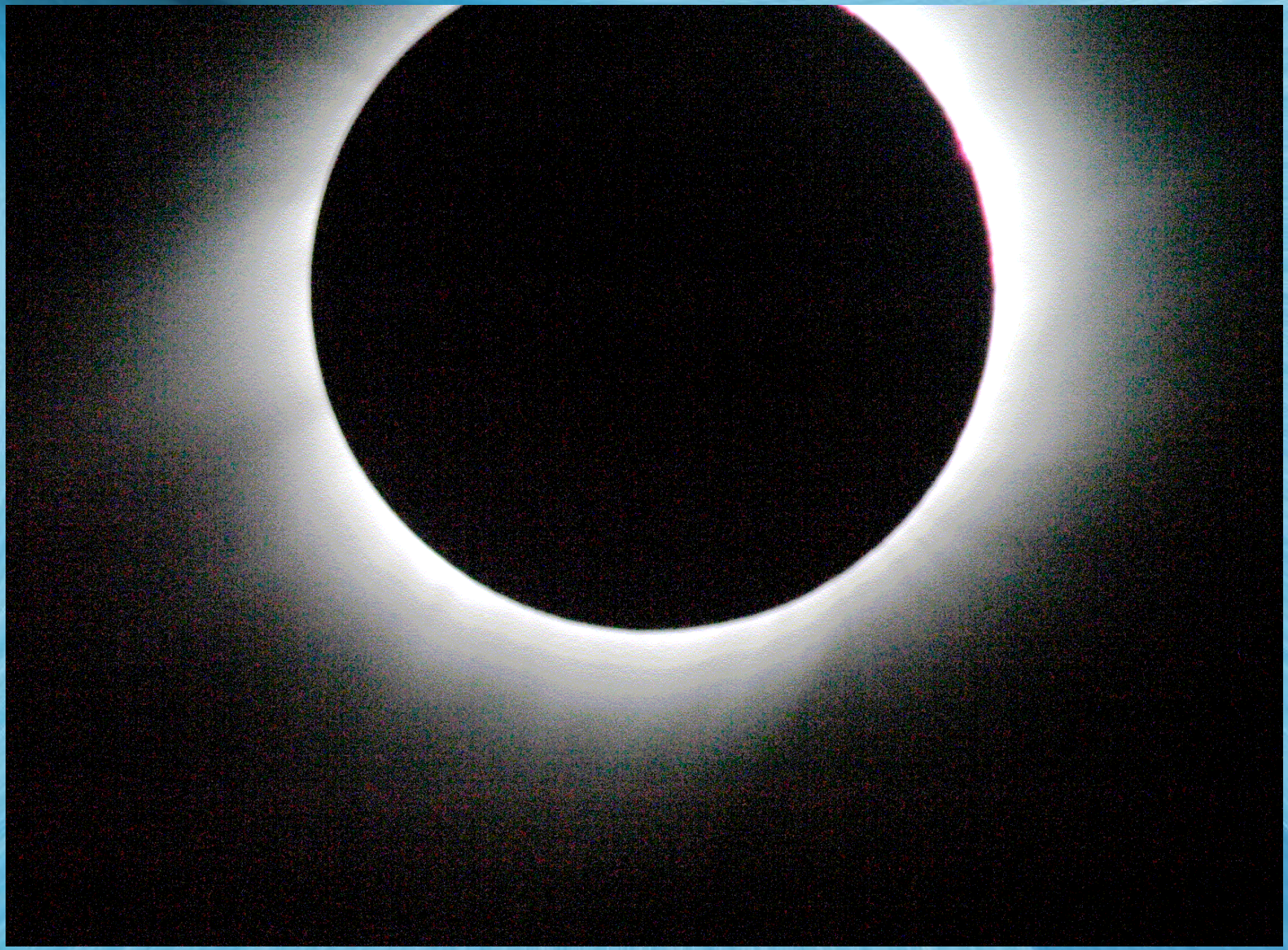
  - Almost-anything projection!

Eclipse Science

How *Not* to do Eclipse Science! Ghana 2006 Version

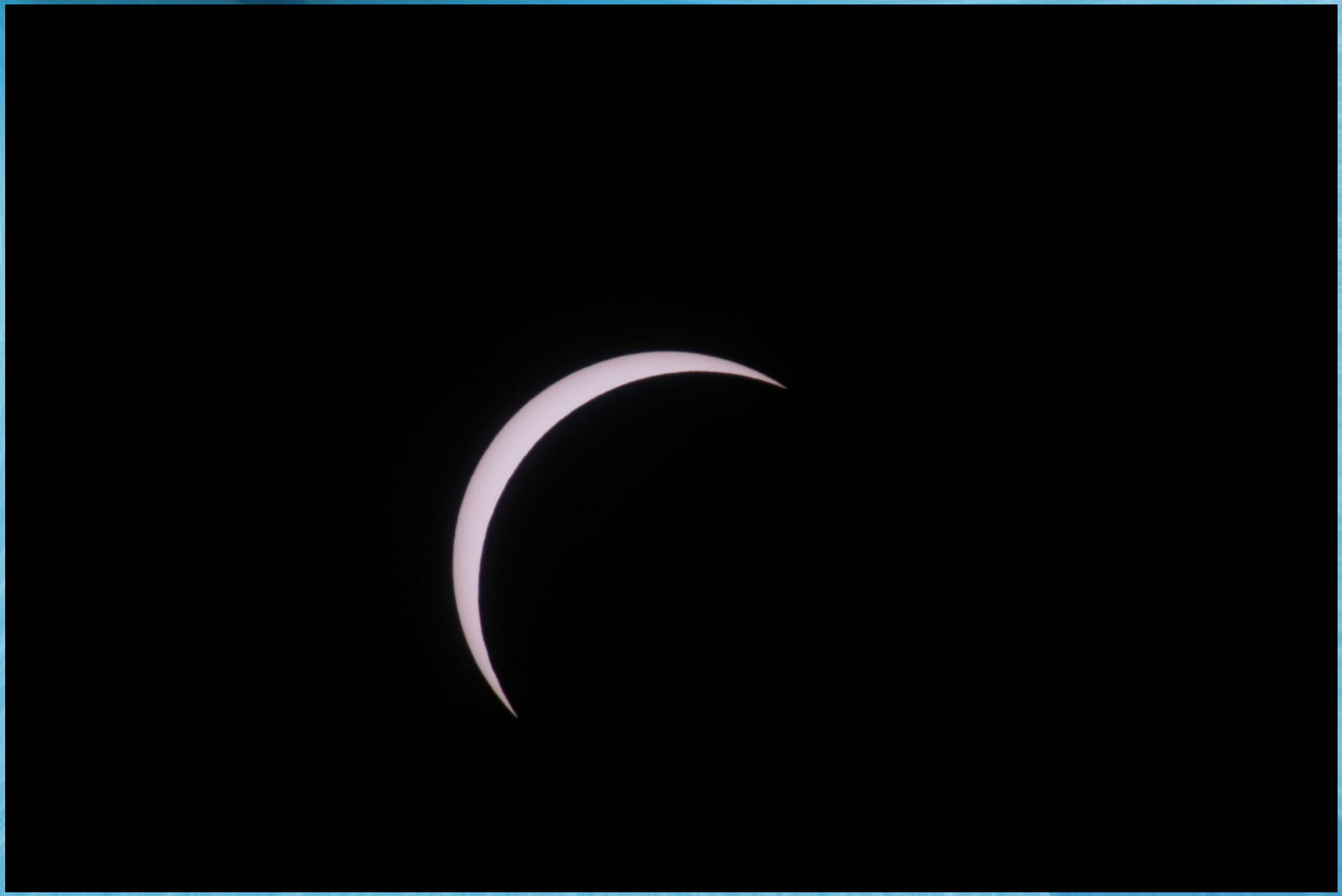
(Useful information for picture takers too.)



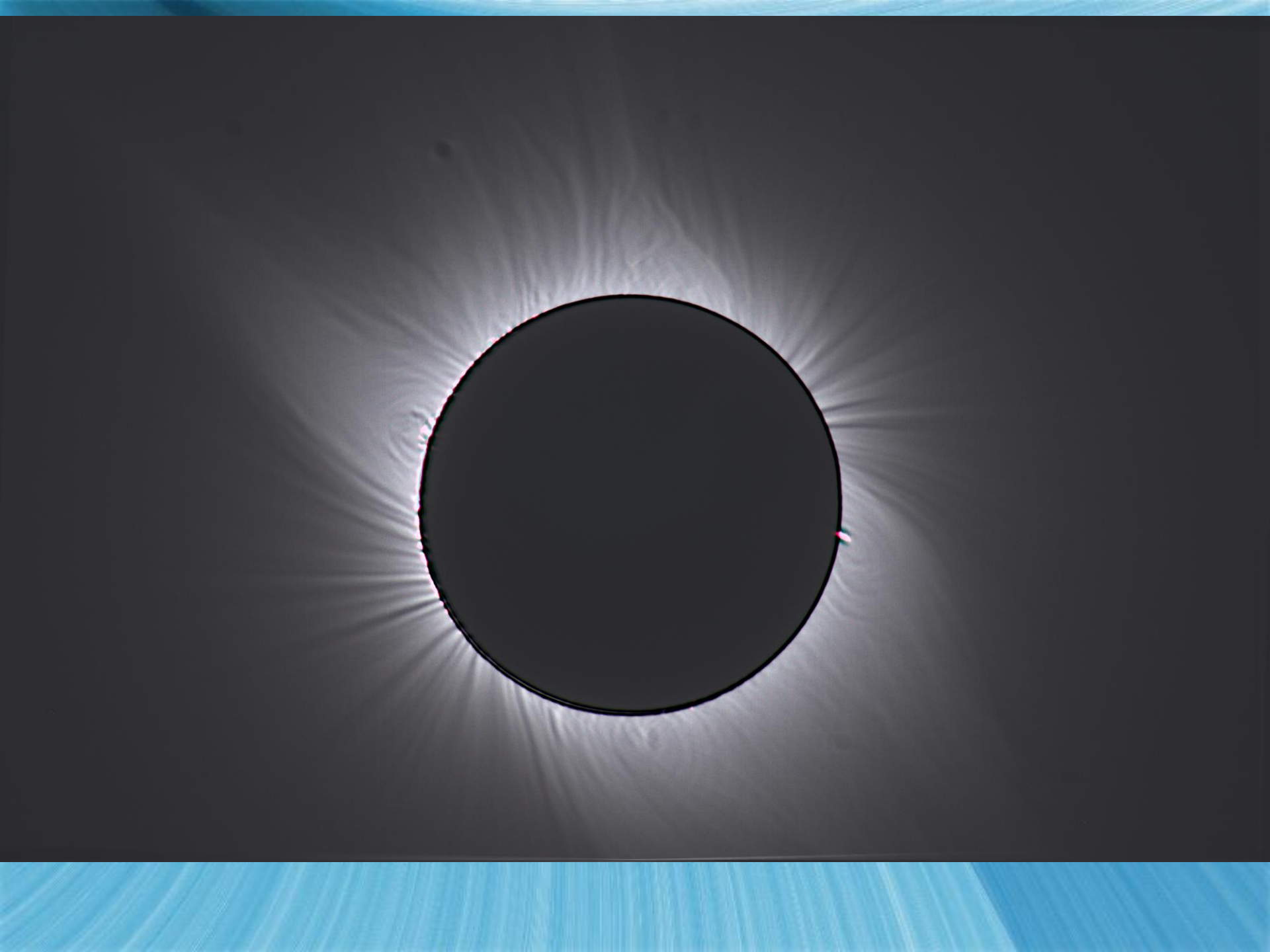
Lessons Learned (Science at Eclipses)

- No new equipment.
- Consider carefully before moving after setting up.
- Practice, practice, practice!

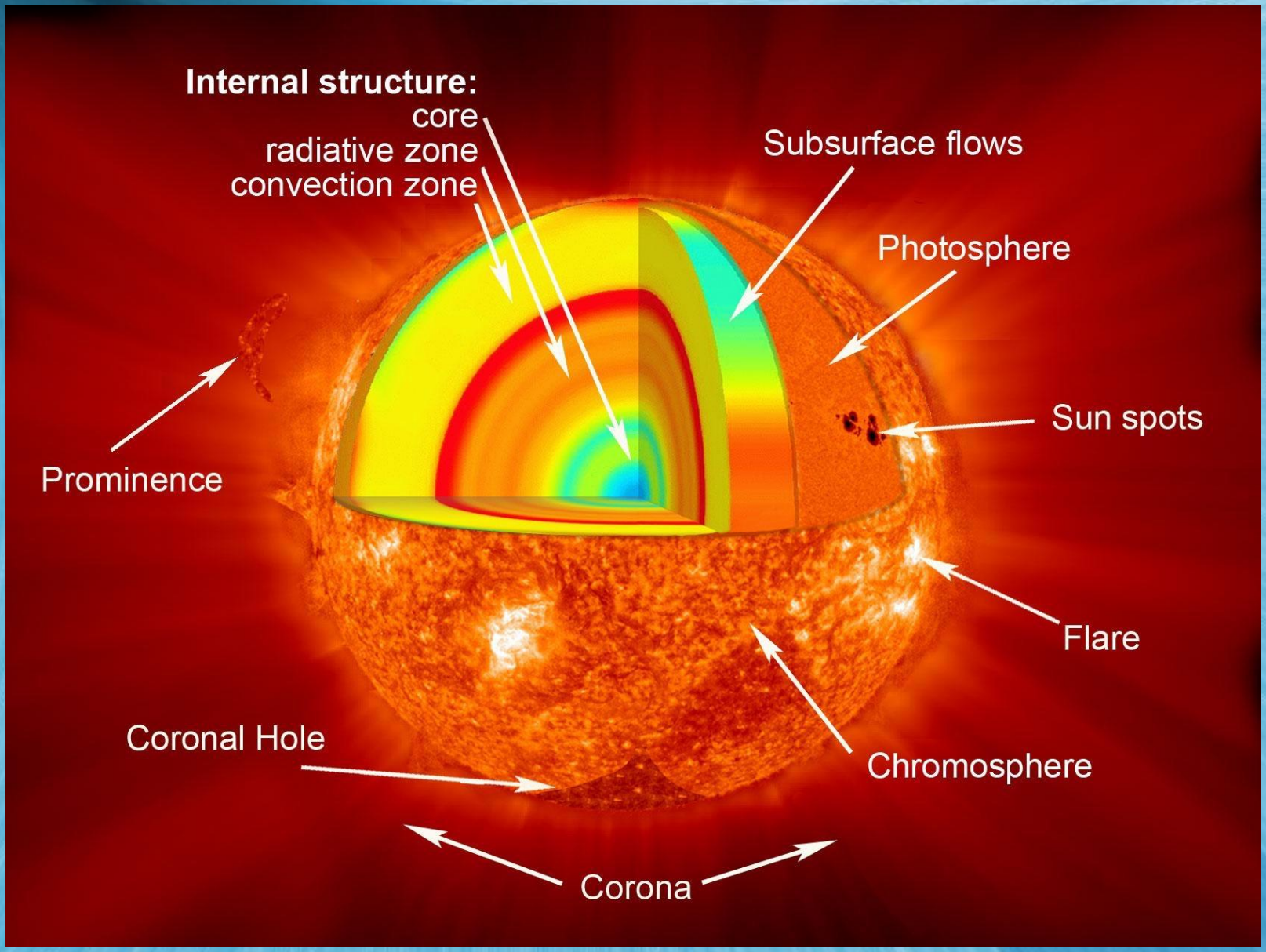
Gansu Province, China, 2008

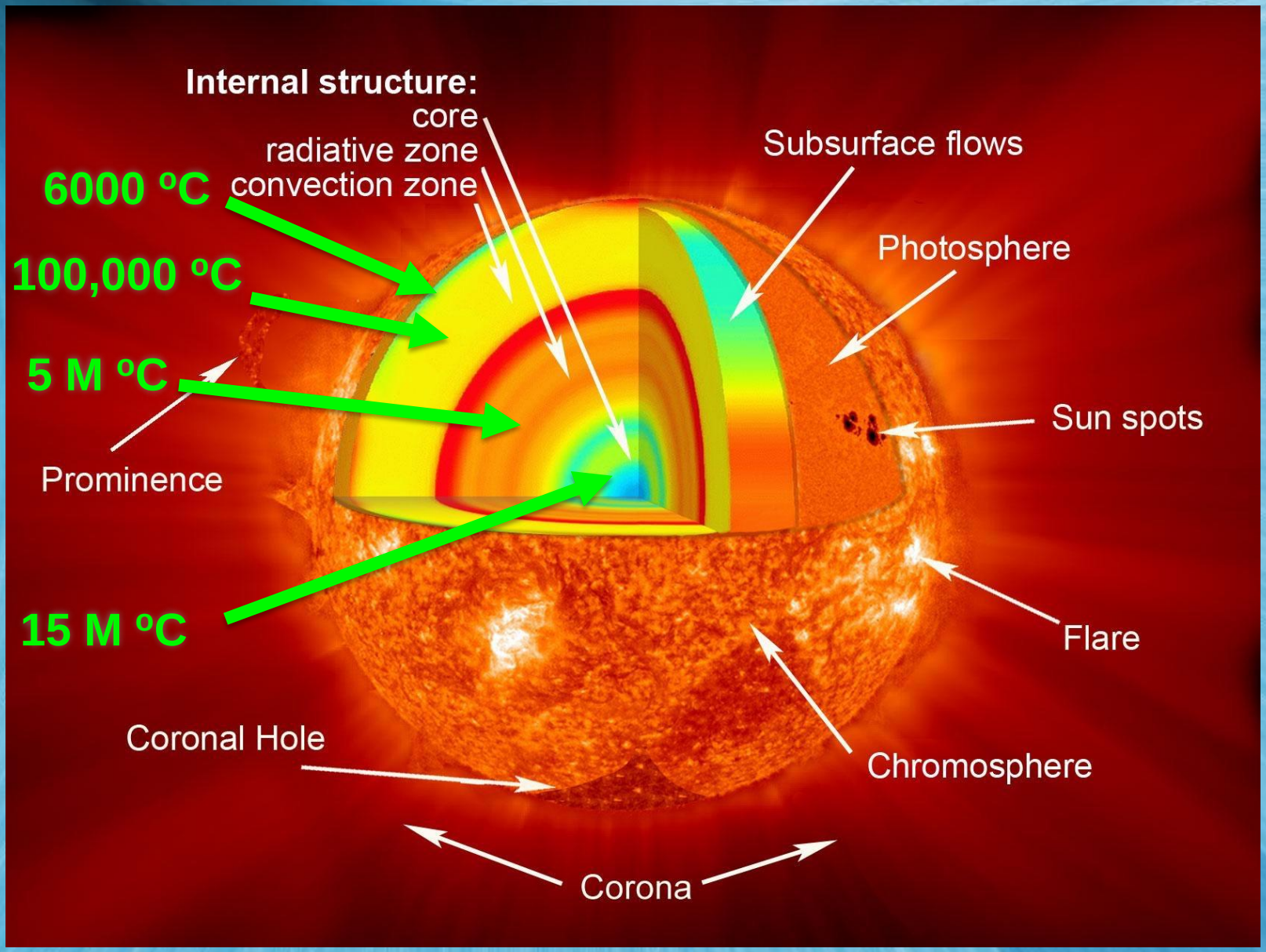



KONA HAWAII



Science of the Sun. A key Problem: The Temperature of the Corona


Internal structure:
core
radiative zone
convection zone
Subsurface flows
Photosphere
Sun spots
Prominence
Flare
Coronal Hole
Chromosphere
Corona


Internal structure:
core
radiative zone
convection zone
6000 °C
100,000 °C
5 M °C
15 M °C
Prominence
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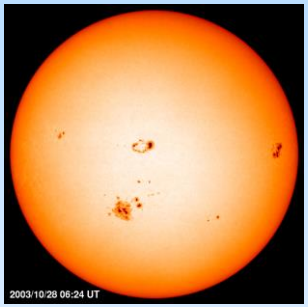
Corona

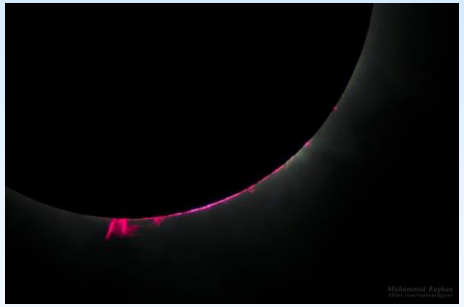
The Solar Atmosphere

The Outer layers (Atmospheres) of the Sun:

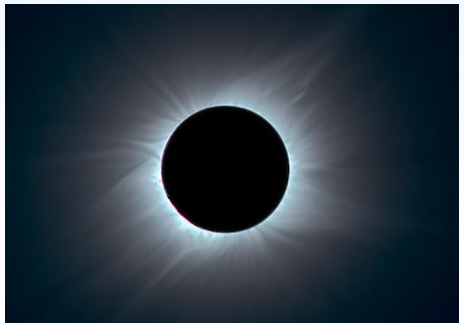
•Photosphere



• Chromosphere



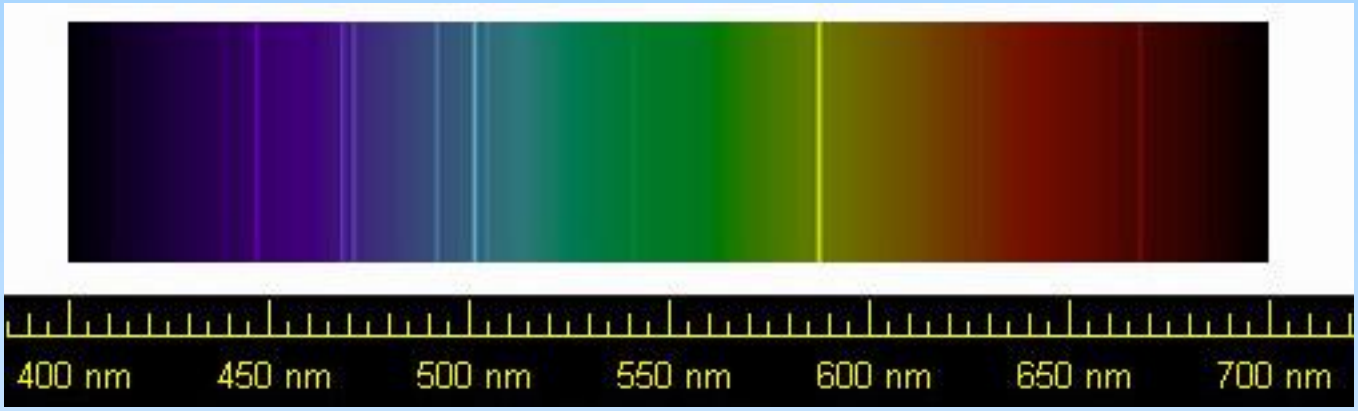
•Corona



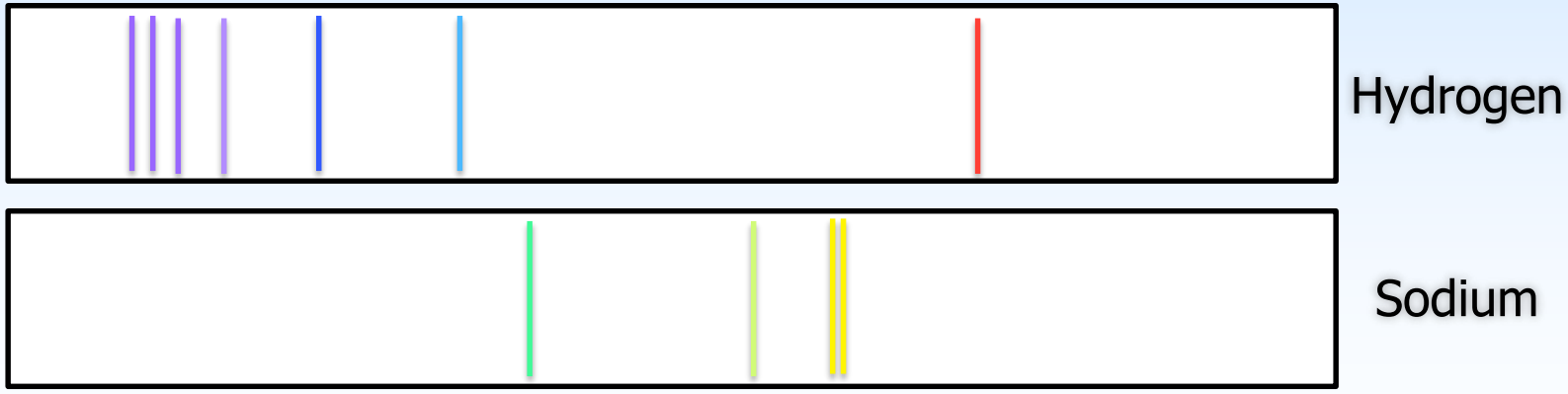
But….

- A “problem” resulted from 1869 eclipse observations of the corona.
- Used a recently developed instrument - the “spectroscope,” to study the corona.

Spectra



- Breaks light into “rainbow” colors, with lines.
- Different elements produce different lines.
- So these lines are like “fingerprints” for elements.



- Hence, spectra can be used to determine the composition of far-away objects, like the corona.

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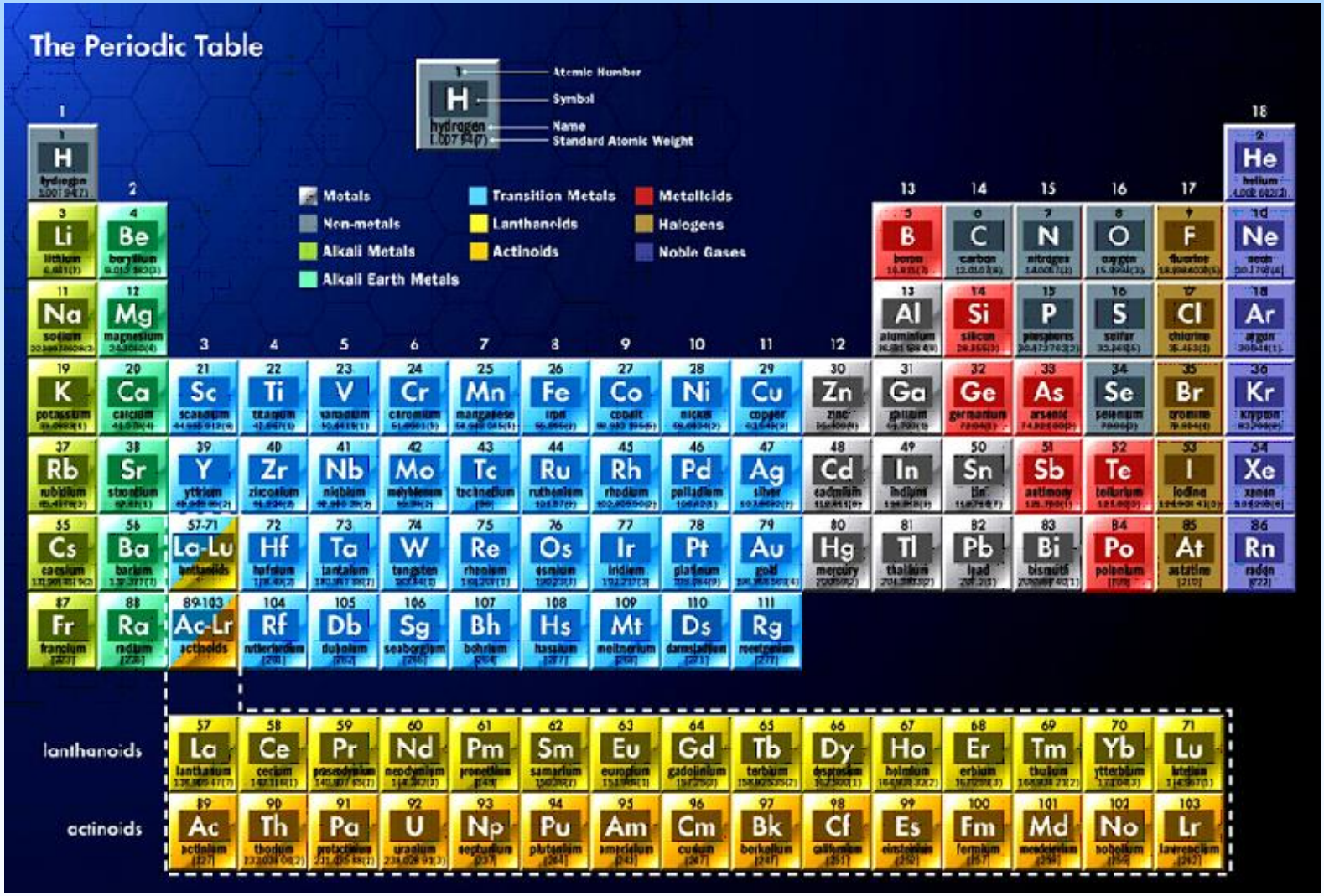
But this didn’t work....


The Periodic Table
Atomic Number
Symbol
Name
Standard Atomic Weight
Metals
Non-metals
Alkali Metals
Alkali Earth Metals
Transition Metals
Lanthanoids
Actinoids
Metalloids
Halogens
Noble Gases
lanthanoids
actinoids

NASA/CXC/SAO

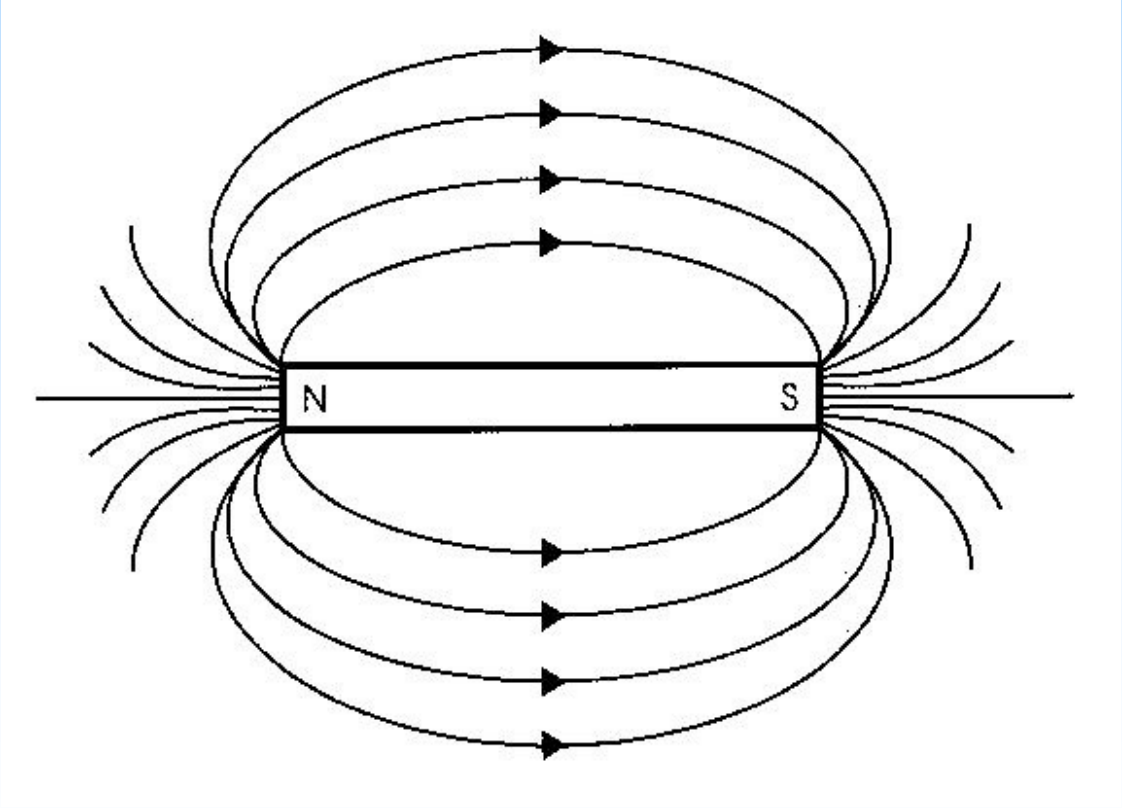
The Corona: Continued...

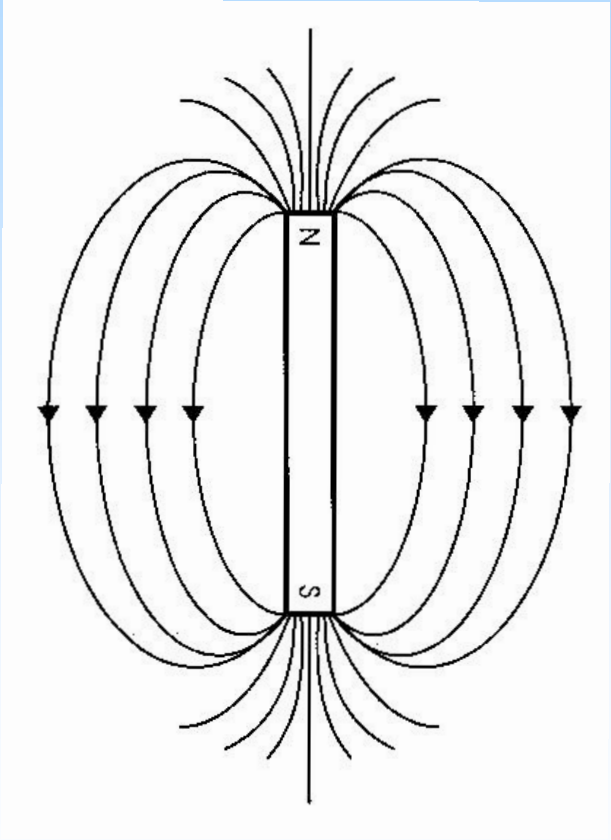
- The mystery spectral lines found to be due to very hot ("highly-ionized") familiar elements ~1940.

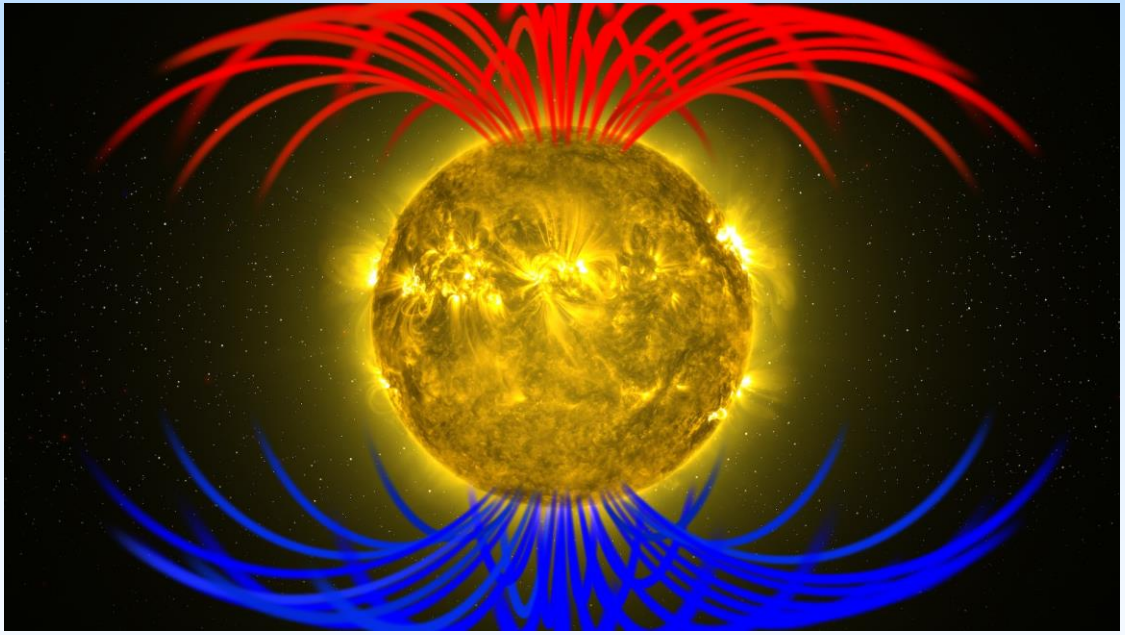
  So this was a sloooow process: 1869 eclipse observations, and 1939~1943 explanation!!

- Structure of the corona: late 1960s and 1970s observations from balloons, Skylab, etc.
- This structure due to the magnetic field.

Magnetism is the key to why the corona is hot. (It is also responsible for many of the changing features of the Sun.)




N
S



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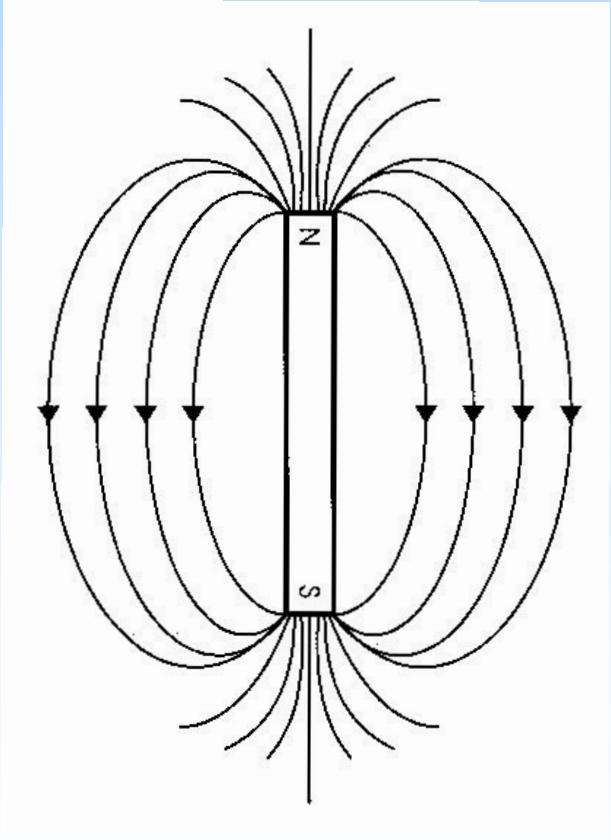

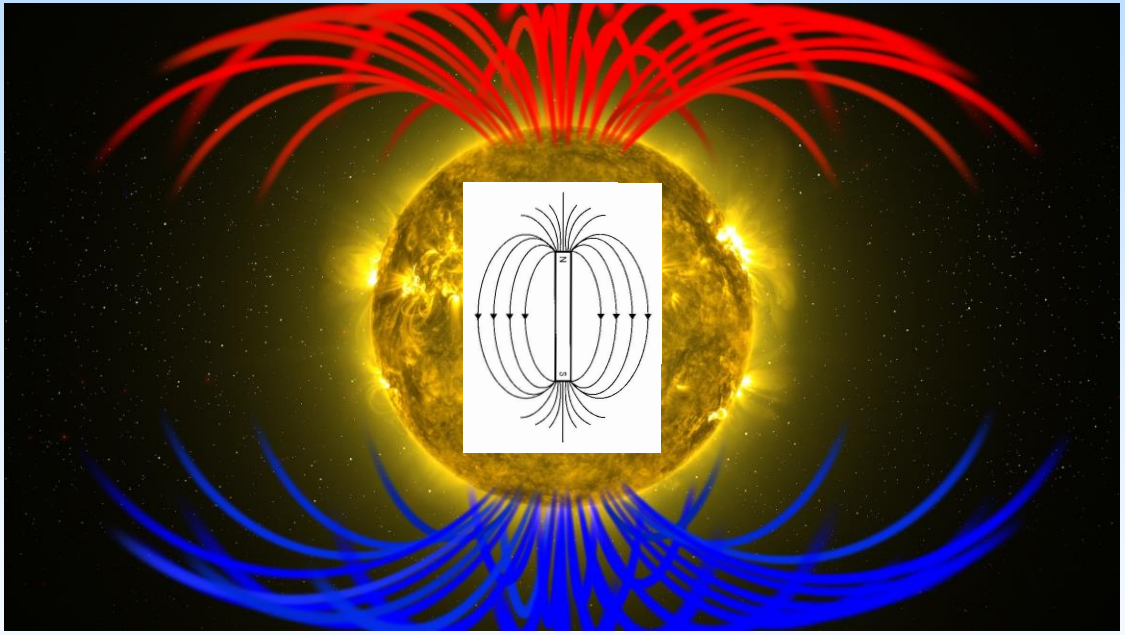

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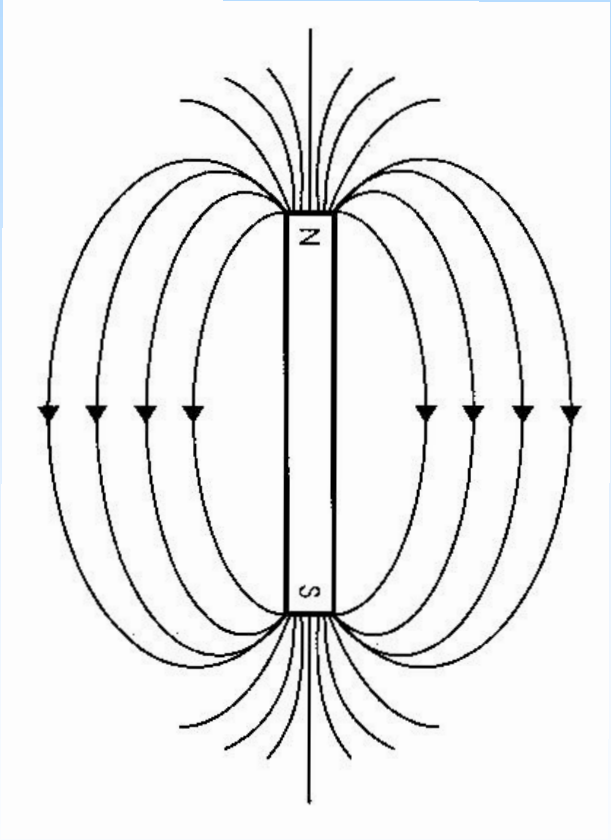

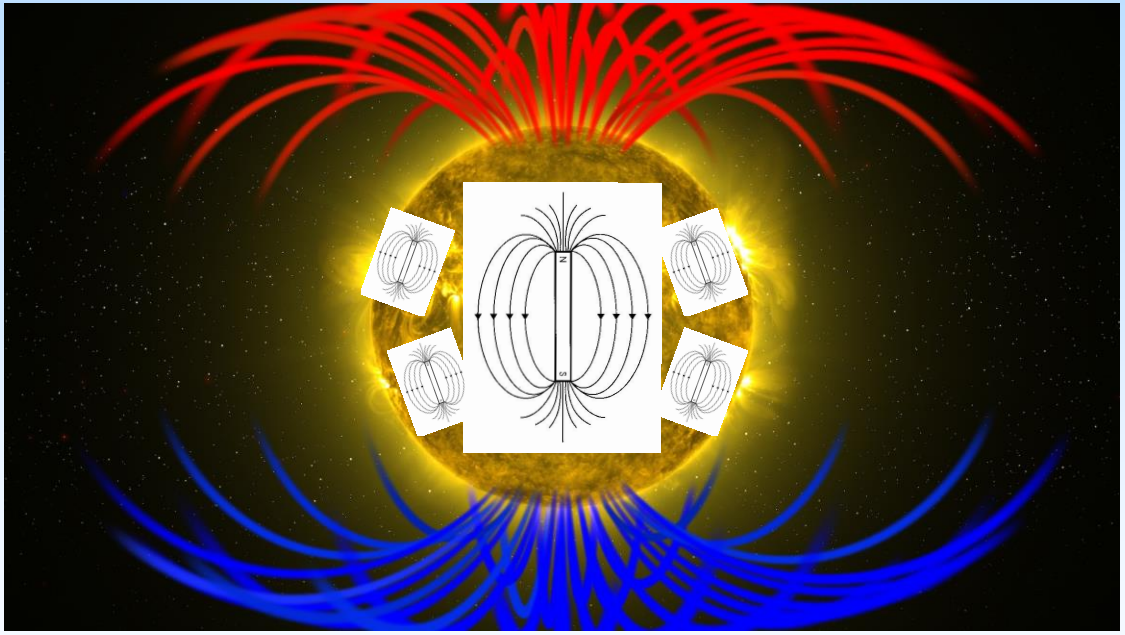

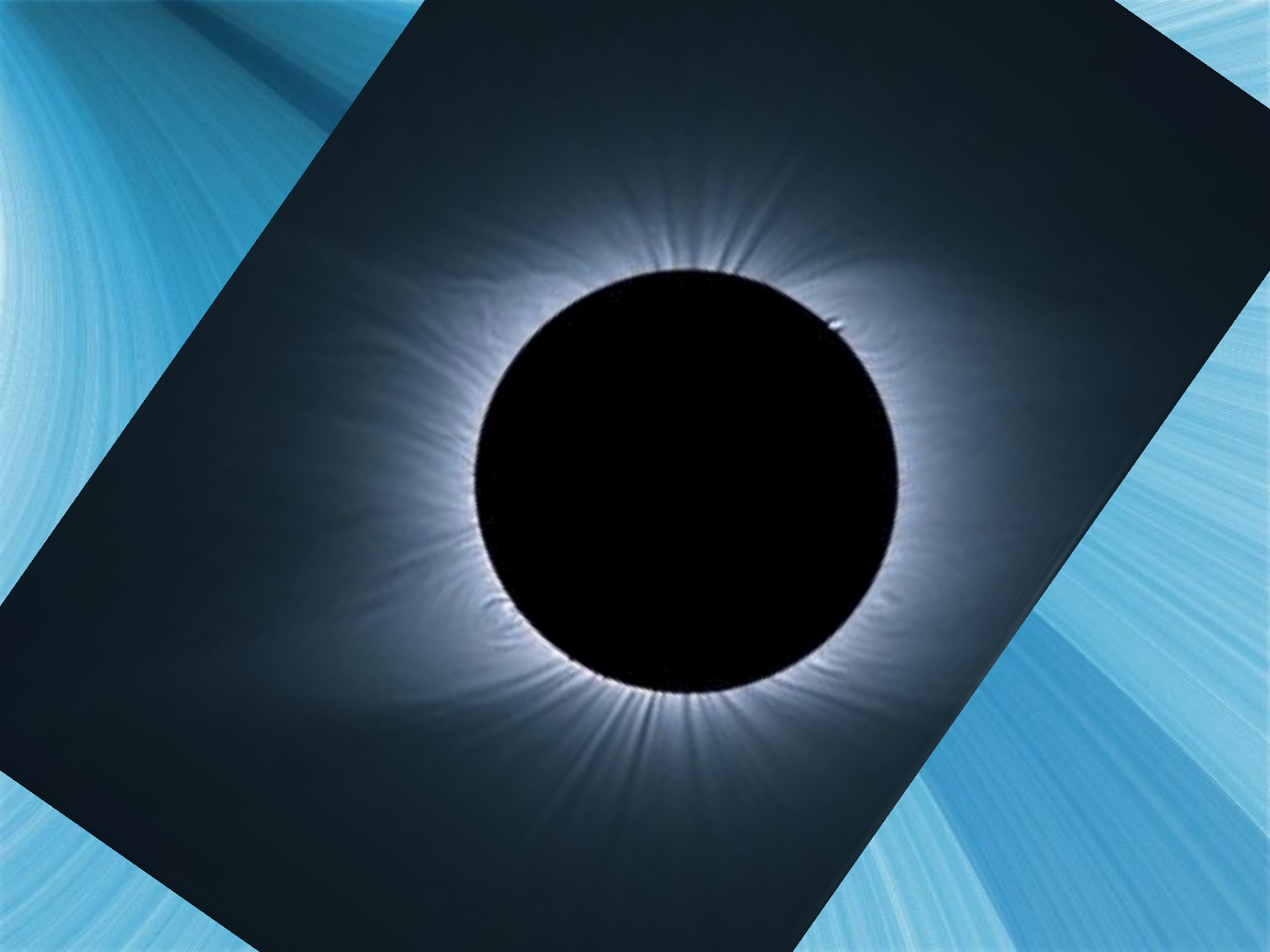

A Key Objective of Solar Physics:

Unravel details of how the magnetic field heats the corona!

- This is one goal (direct or indirect) of many eclipse studies.
- Also, many other stars have hot coronae, and thus understanding the heating of the Sun's corona tells us about other stars too.

Fun Things to Do:

- Temperature changes at different locations.
- Shadow bands, just near totality. Try taking pictures of them. (In path of totality.)
- Pictures of sharpening shadows. [To do “seriously”: Record time accurately (within a few seconds), your precise location (GPS coordinates?), use a standard surface (e.g., white sheet), sky conditions (may be hard unless clear).]
- Creative photography.

But maybe best of all…

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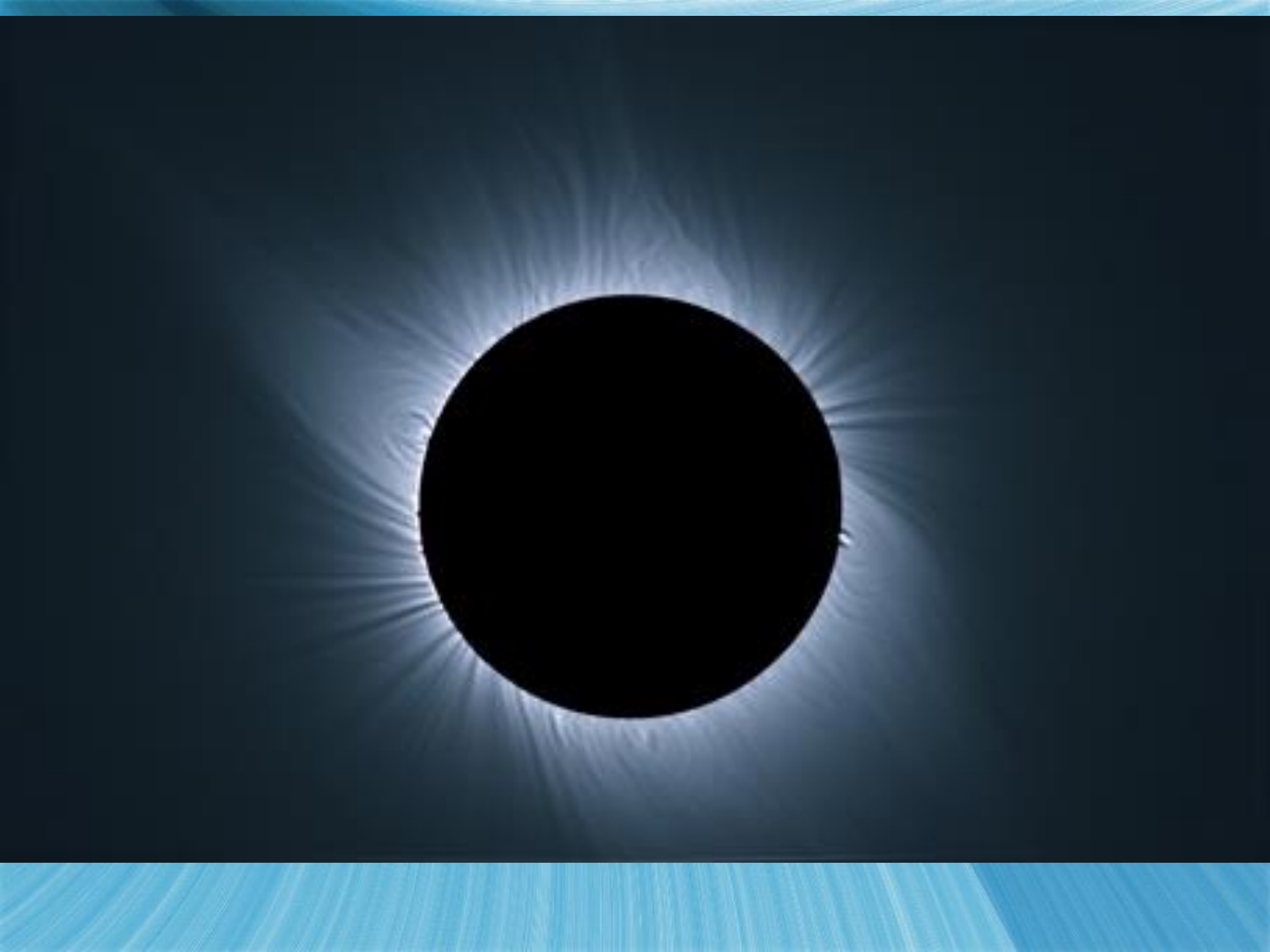
ENJOY IT!

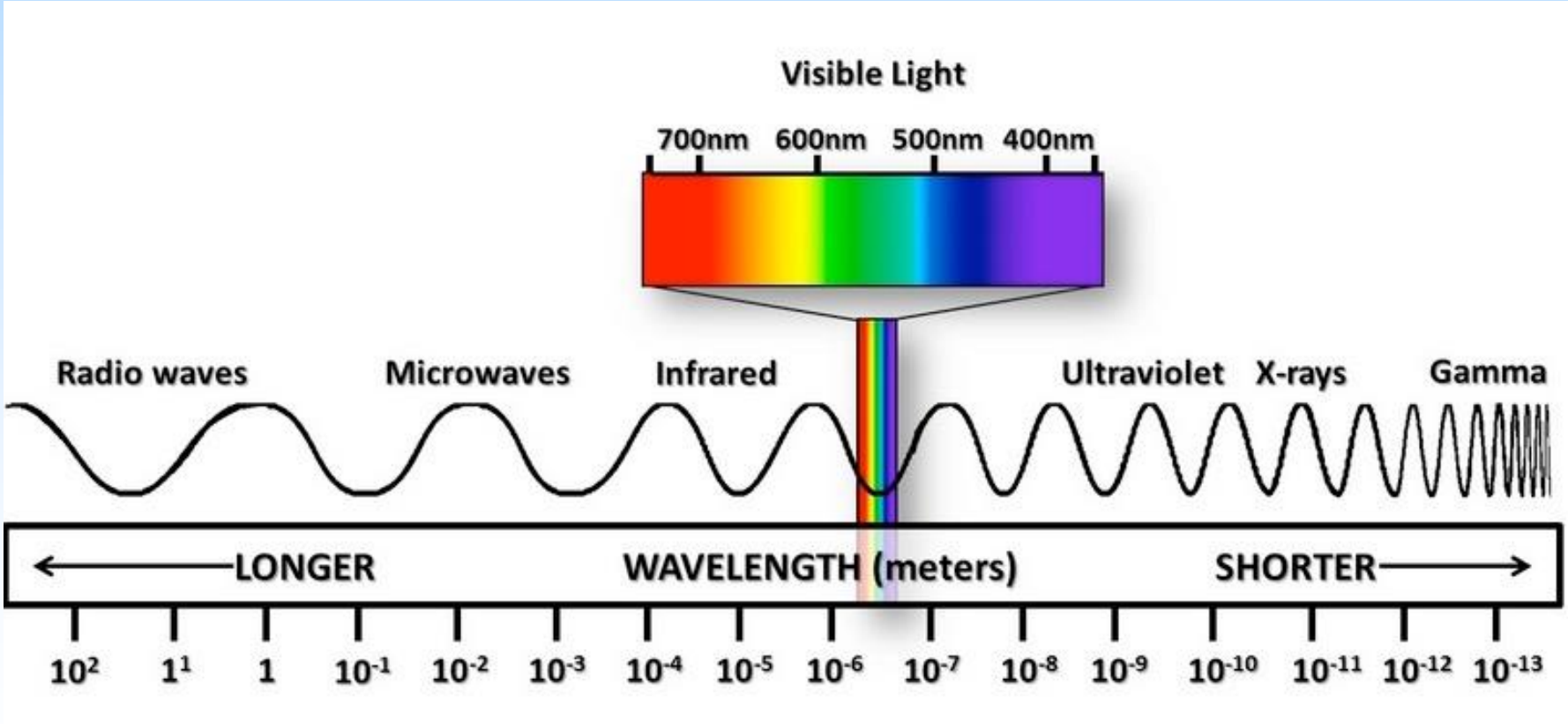

20 May 2012 22:35:22 UT

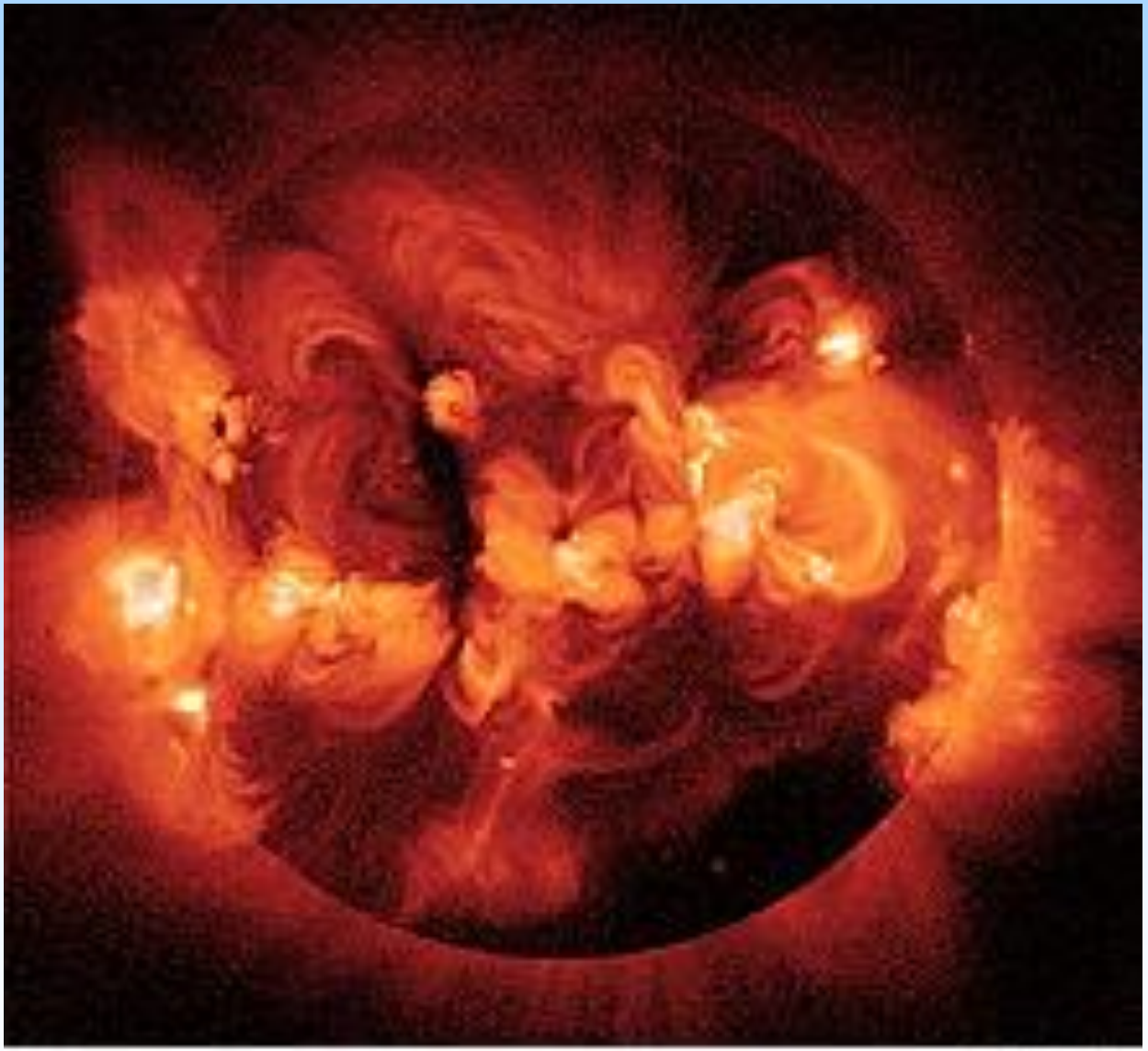

Volt


Rotella
OPEL

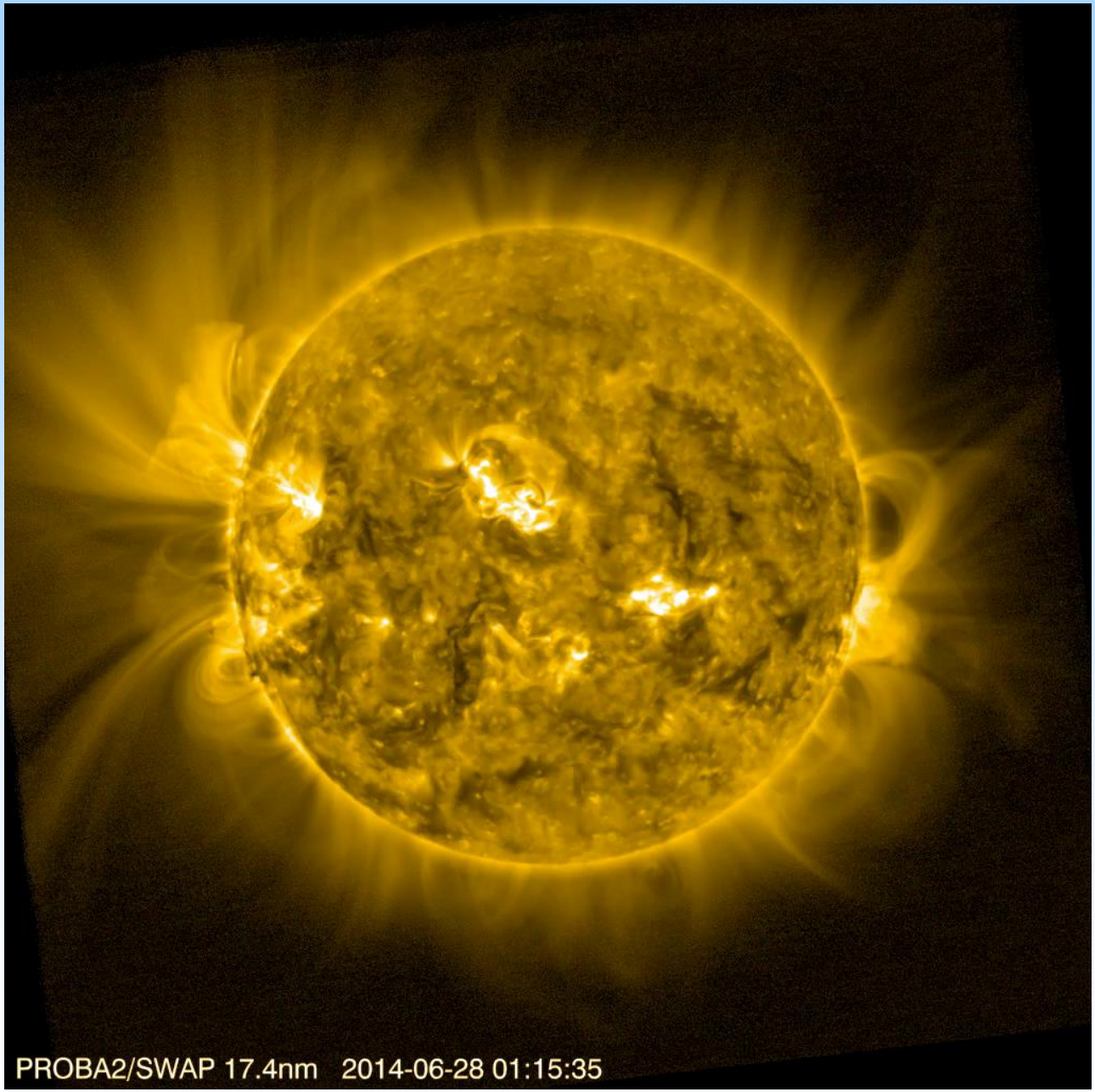


We have to go to ***space*** to see the Sun's outer atmosphere with regularity.





The Corona from Yohkoh/SXT


PROBA2/SWAP 17.4nm 2014-06-28 01:15:35

The Corona

- Expected to be cool, but found strange spectral lines, first during 1869 eclipse.

- Many explanations considered, including a “new” element: *coronium*.

- **But this didn’t work....**

Annular Eclipse (2012)