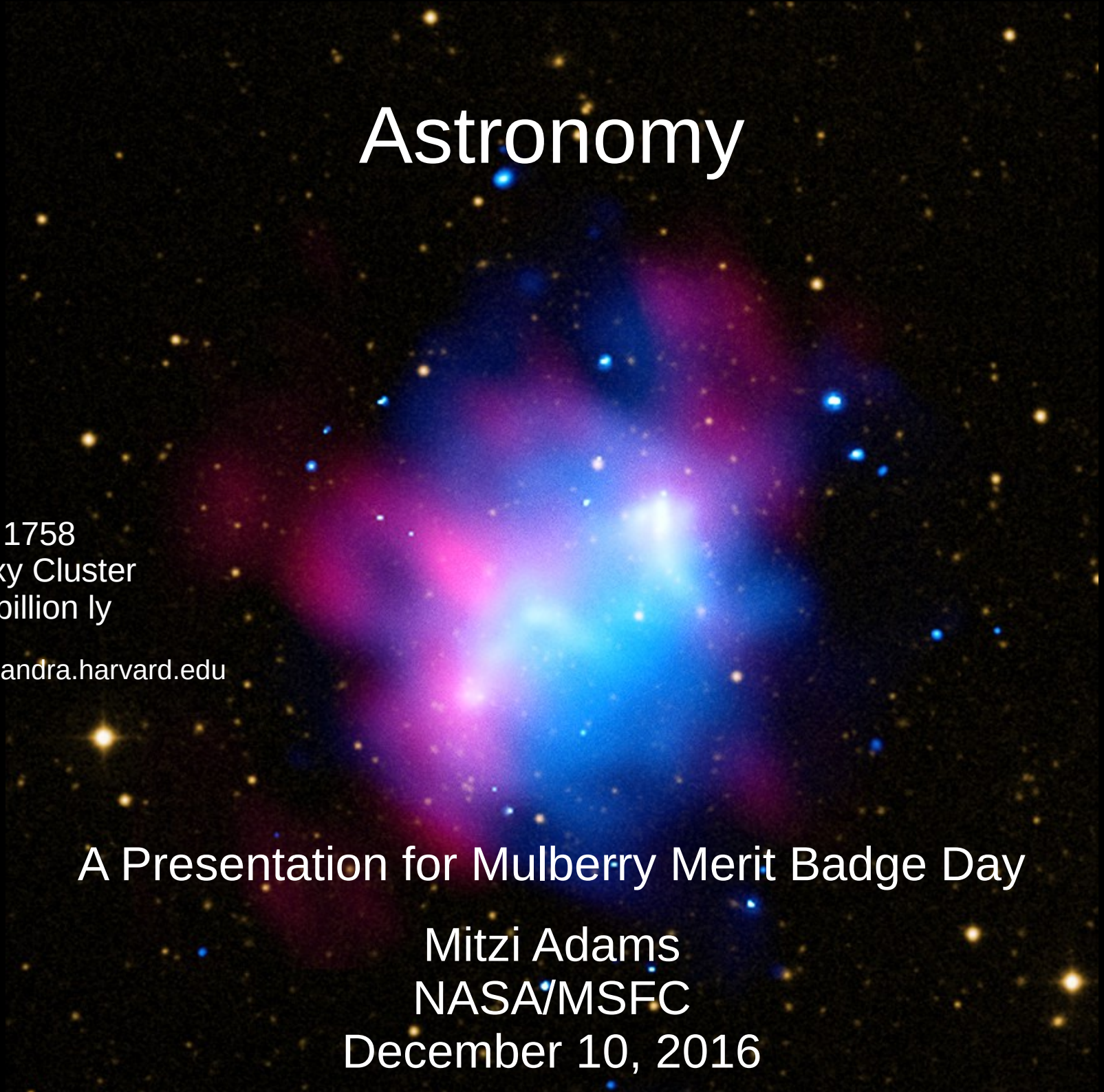
Astronomy



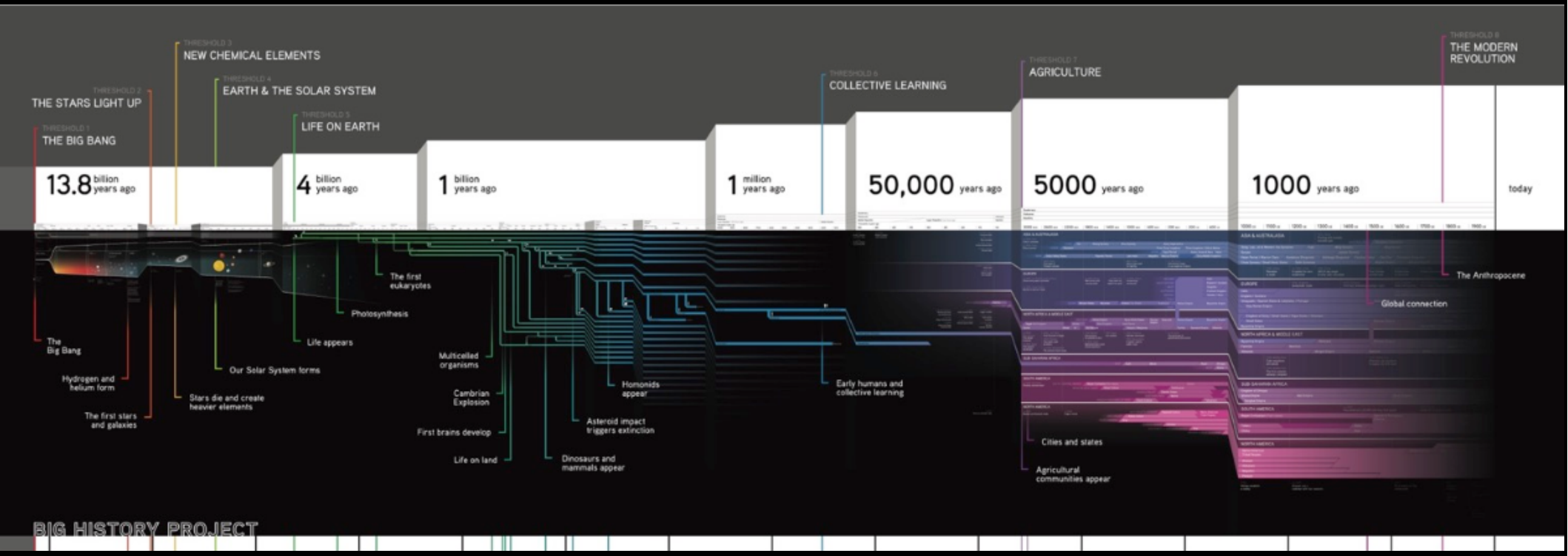
Abell 1758
Galaxy Cluster
~3.2 billion ly

From http://chandra.harvard.edu

A Presentation for Mulberry Merit Badge Day

Mitzi Adams
NASA/MSFC
December 10, 2016

Putting it into Context
Astronomical Scales



Time, Distance Size

How big is a million, a billion, 13.8 billion ?

Count numbers, consider each number as one second.

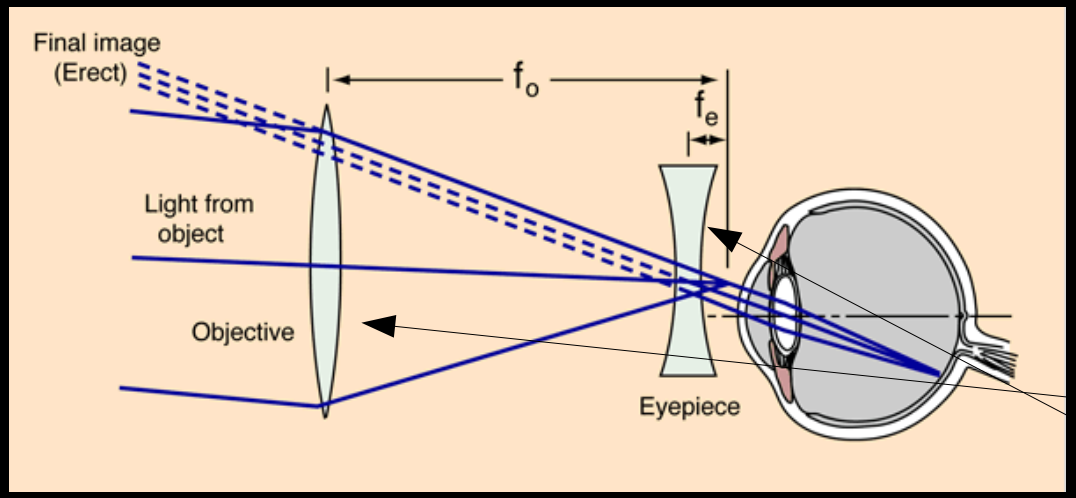
Count to one million -- 11.6 days

Count to one billion -- Multiply 11.6 days by 1000 = 32 years

Count to 13.8 billion --> 439 years

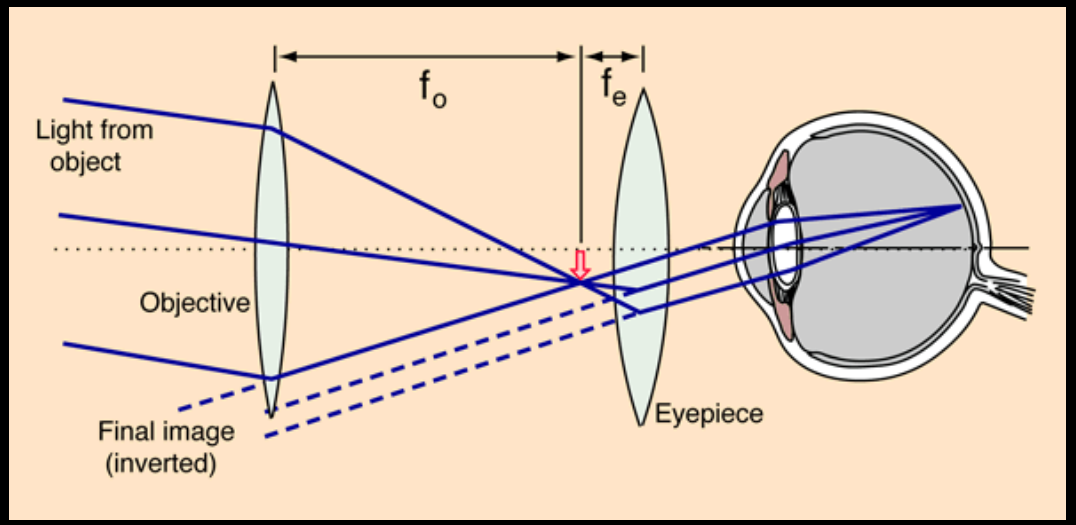
Optical Telescopes

Refractor
First Used by Galileo to do Astronomy



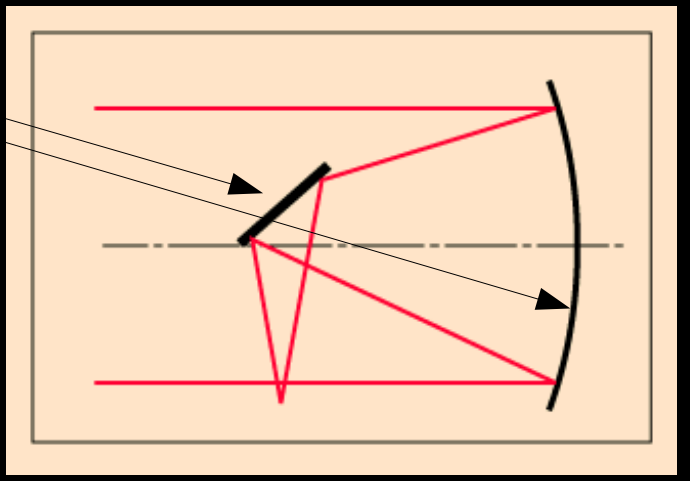
Lenses

Astronomical

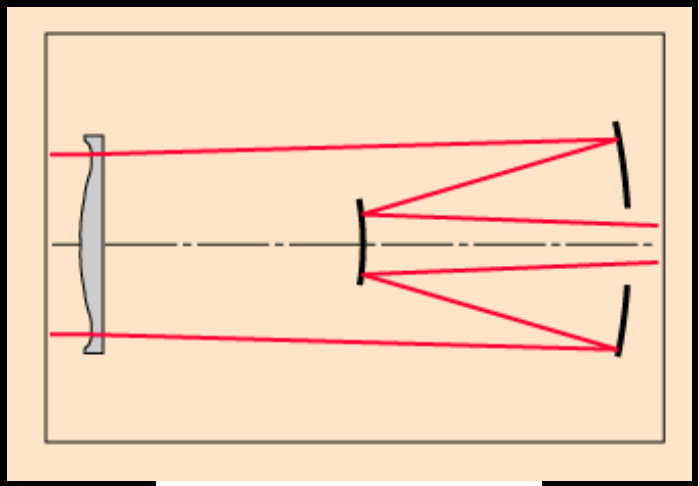


Mirrors

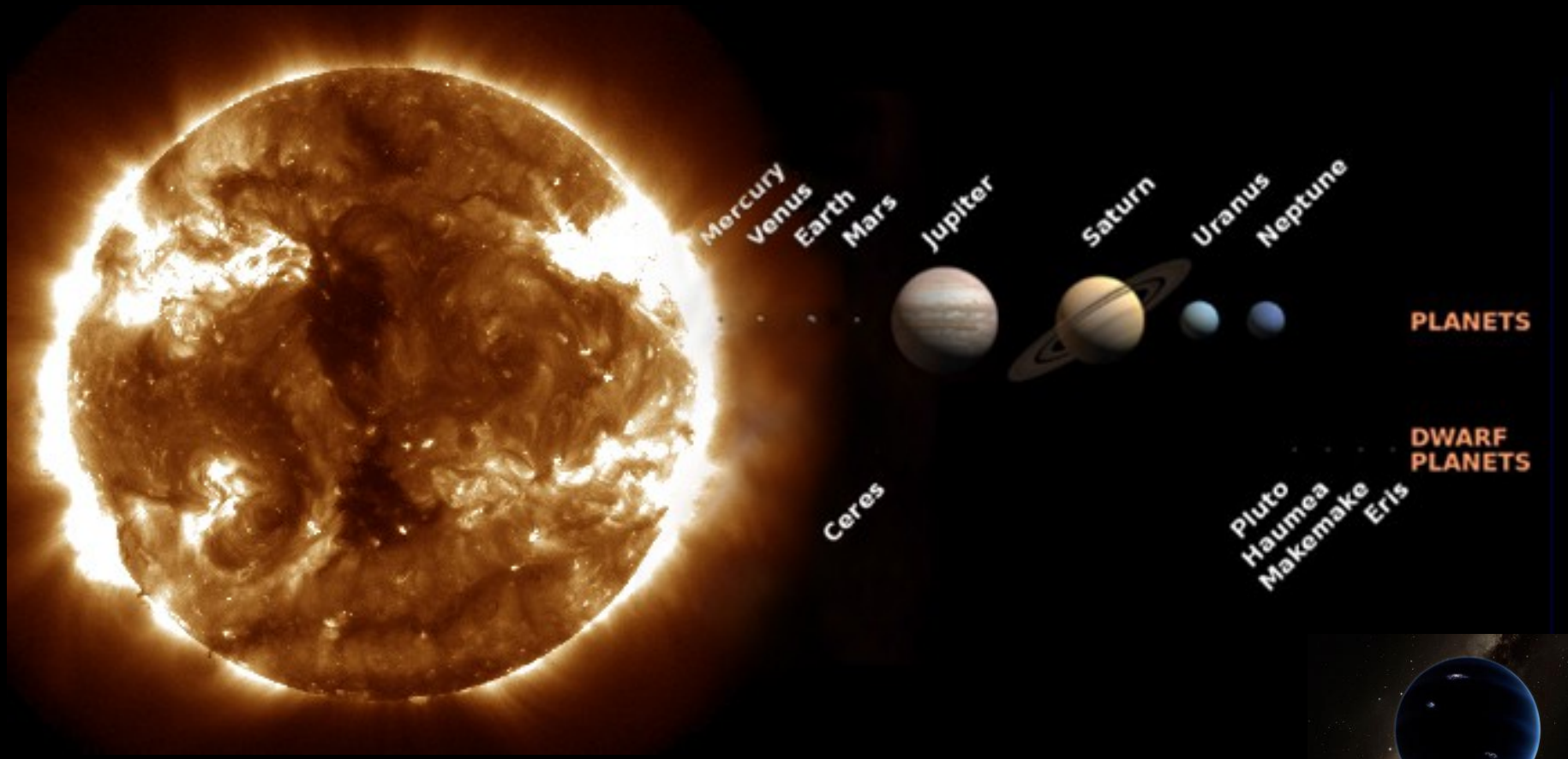
Reflector
Newtonian



Schmidt-Cassegrain



Our Dynamic Sun: A Star at the Center of the Solar System

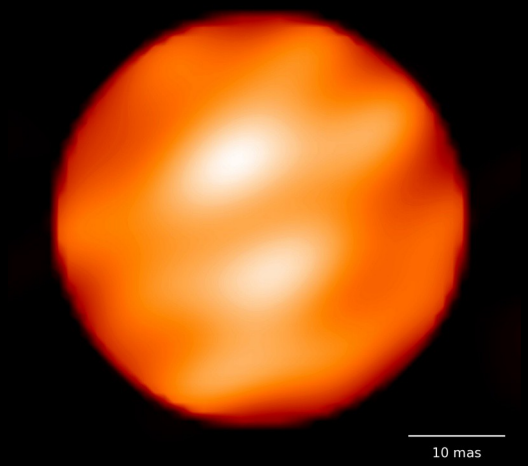


Planet Nine?

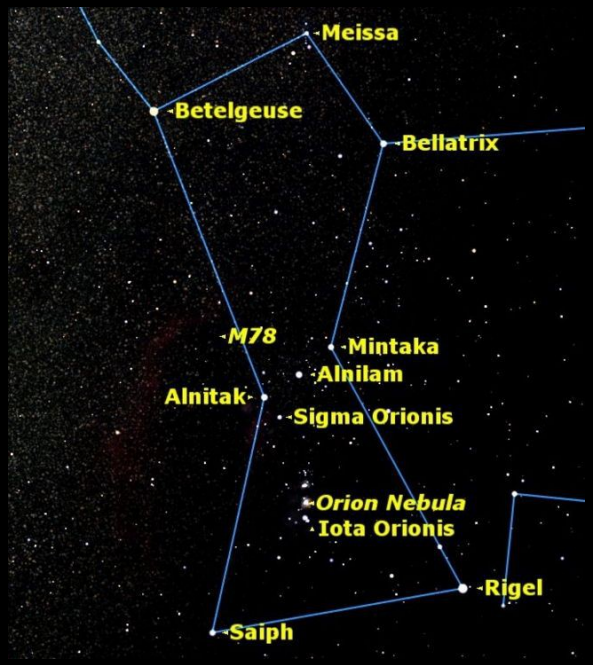
What is a Star?

What is a Star?

A star is an astrophysical body that produces its own light by thermonuclear reactions in its core.



Betelgeuse: A red giant star, about 600 ly away, 3500 K, 1,180 $R_\odot$, 7.7 $M_\odot$.

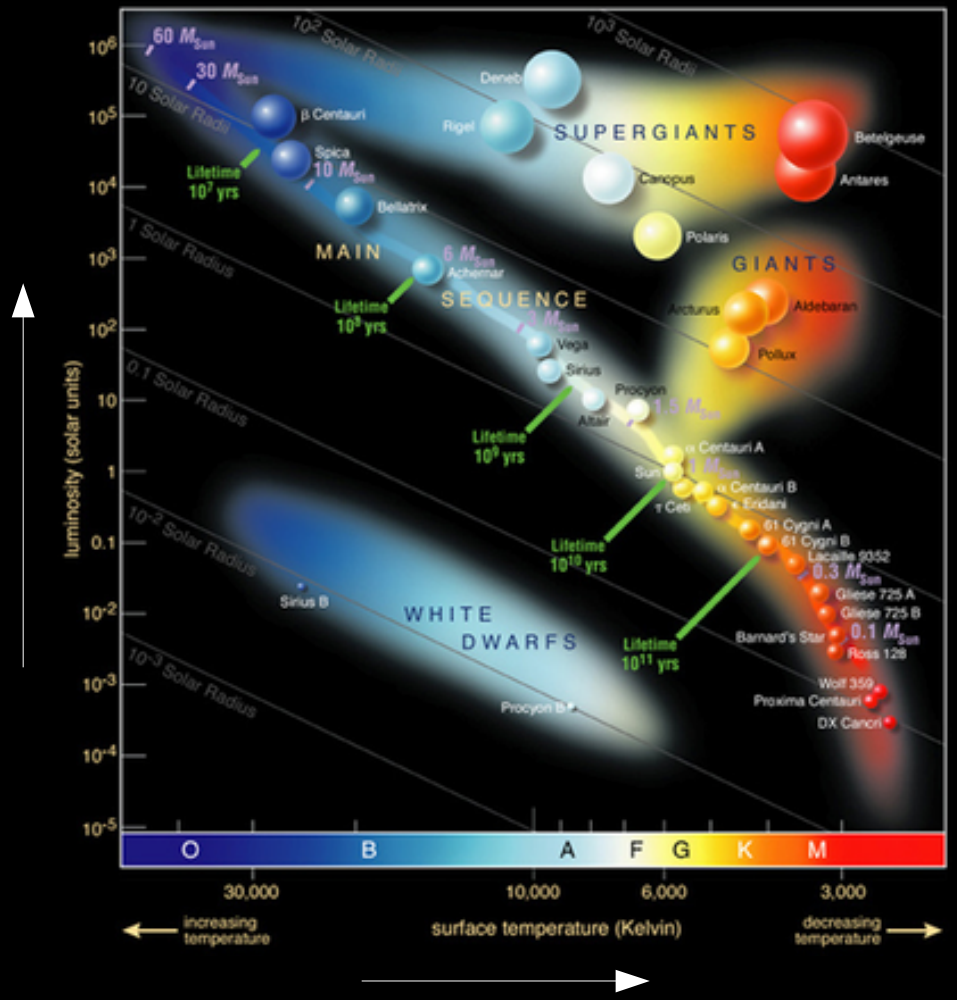


To produce energy, hydrogen converts to Helium

Rigel: A blue-white star, about 770 ly away, 11,000 K, 80 $R_\odot$, 20 $M_\odot$.

Stars Classified According to Color (Temperature)

Brighter



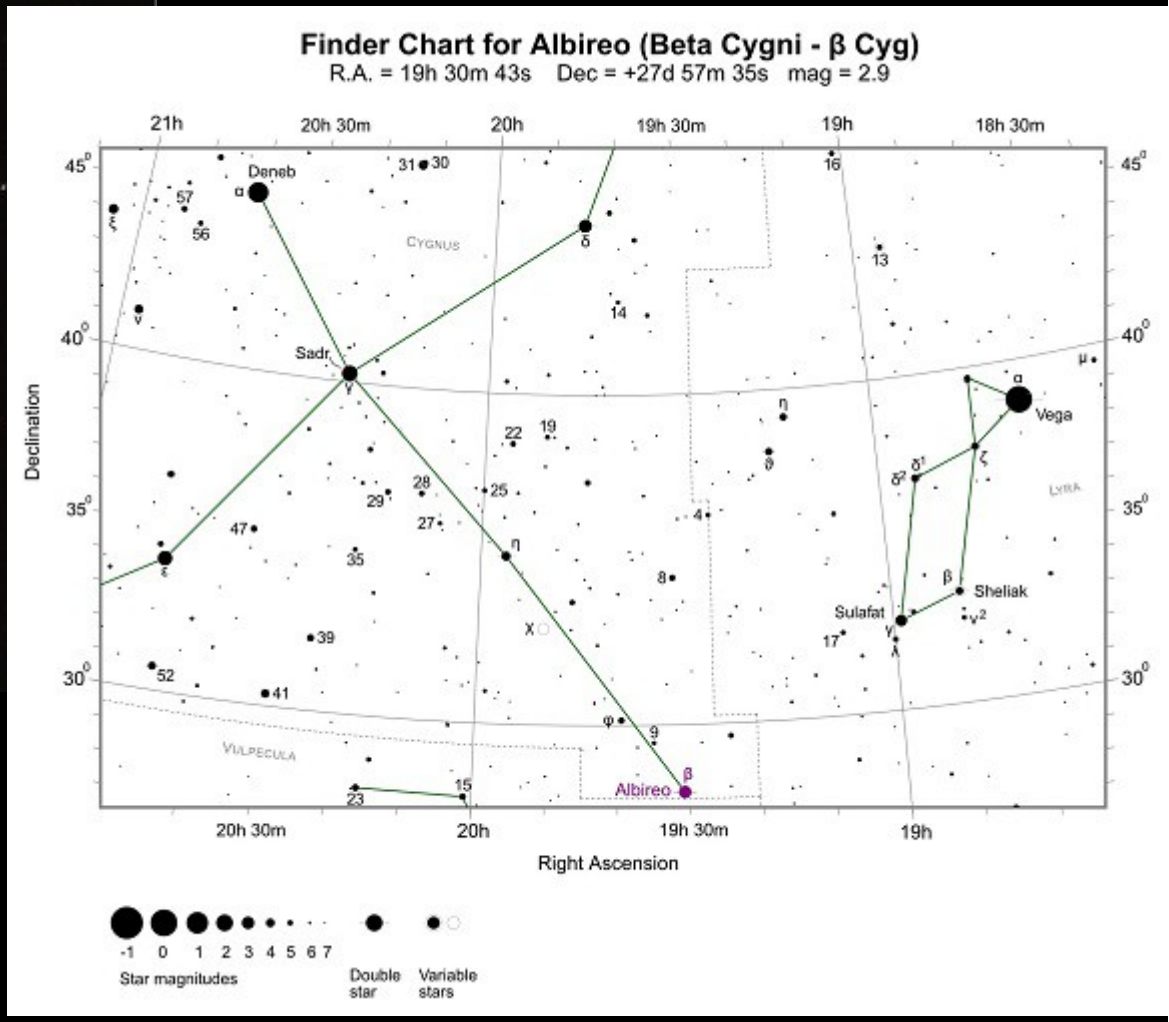
Cooler

OBAFGKM

Overseas Broadcast A Flash, Godzilla Kills Mothra

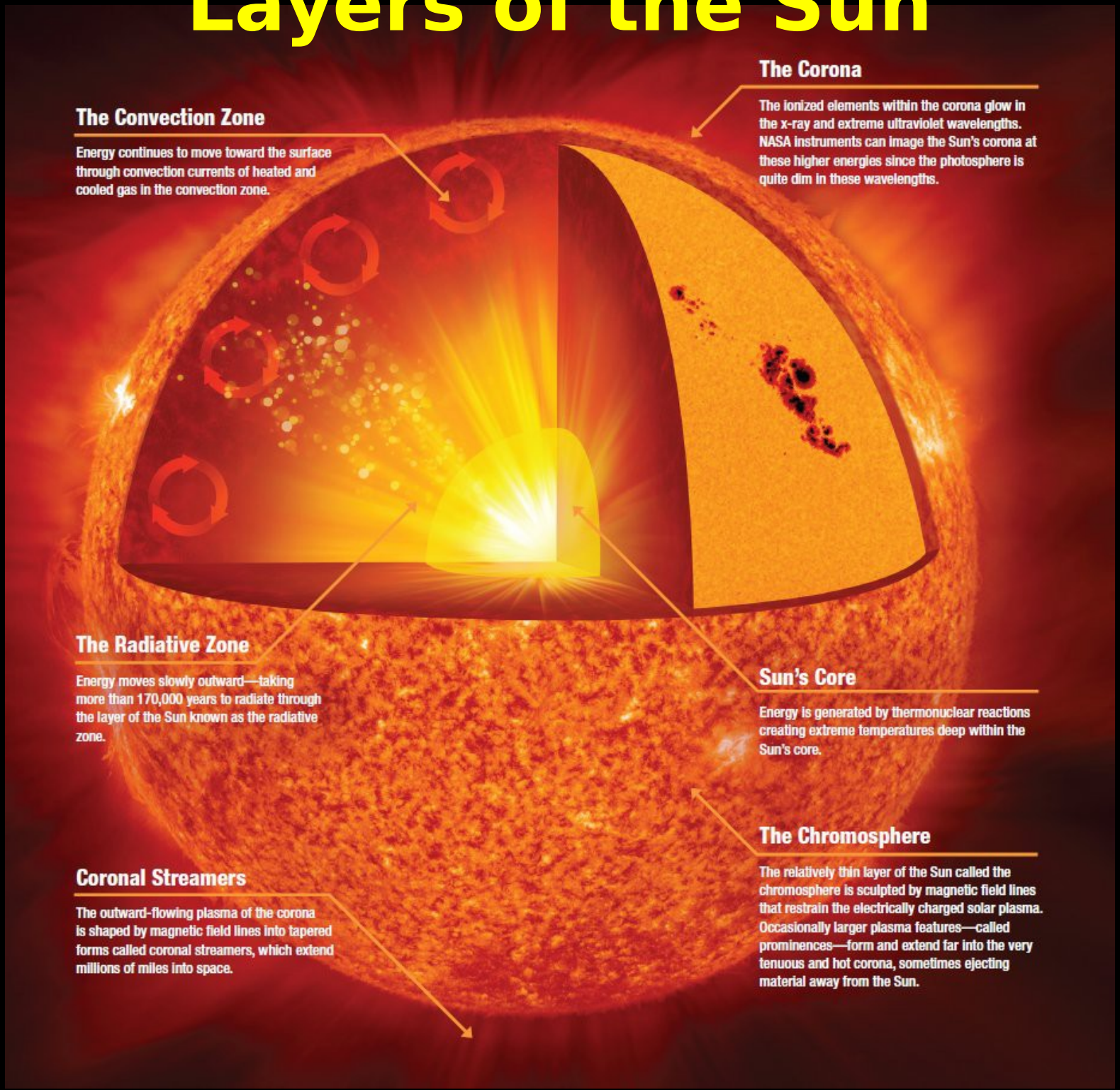
A Beautiful Binary Star System
Albireo

430 ly away
Look for Cygnus in summer

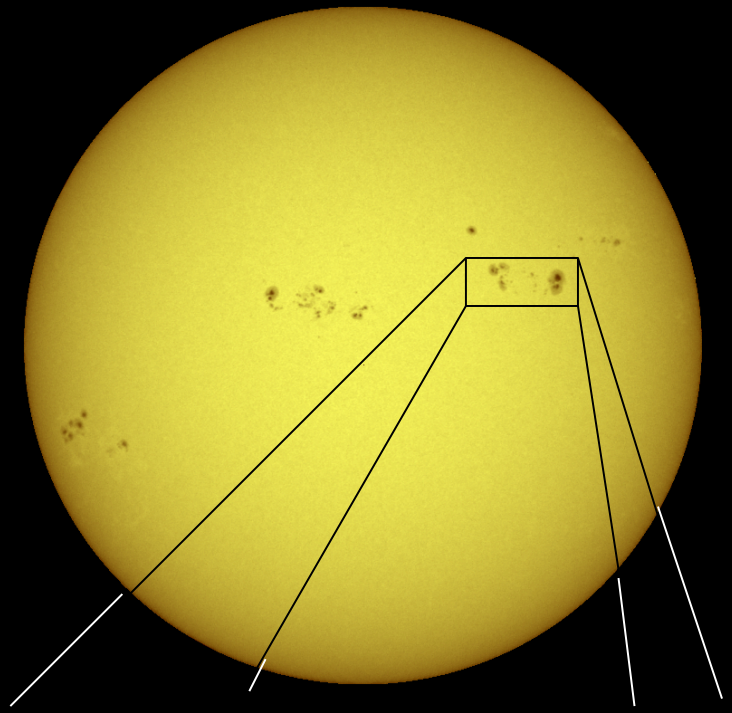


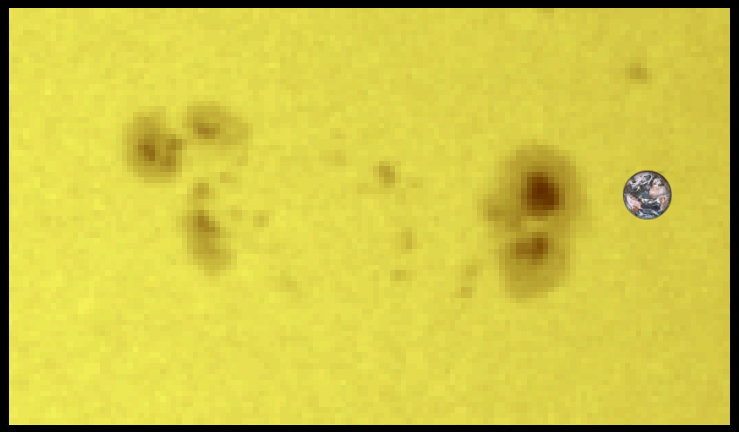
Albireo A is a binary, the yellowish color comes from a star with spectral type, K2, temperature ~ 4000 K
Albireo B is blue, type B8, temperature ~13,000K

Layers of the Sun



Sunspots

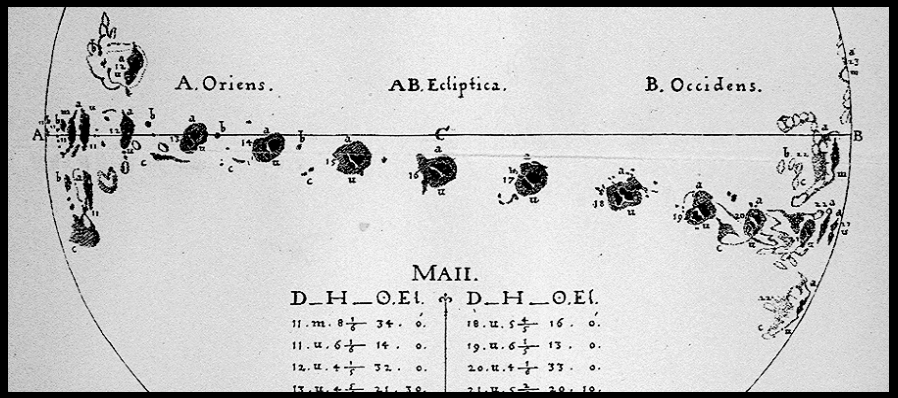




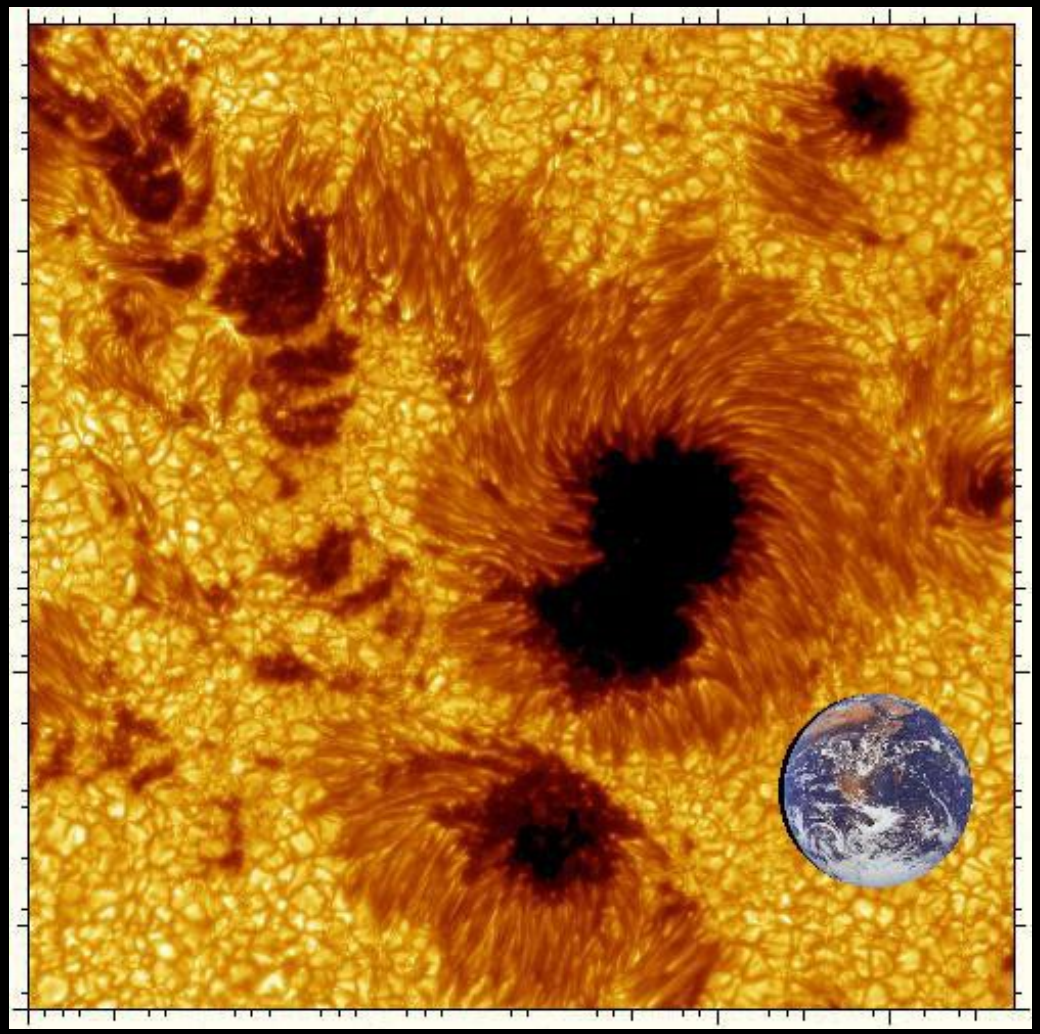
Sunspots are dark (and cooler) regions on the surface of the Sun. They have a darker inner region (the Umbra) surrounded by a lighter ring (the Penumbra).

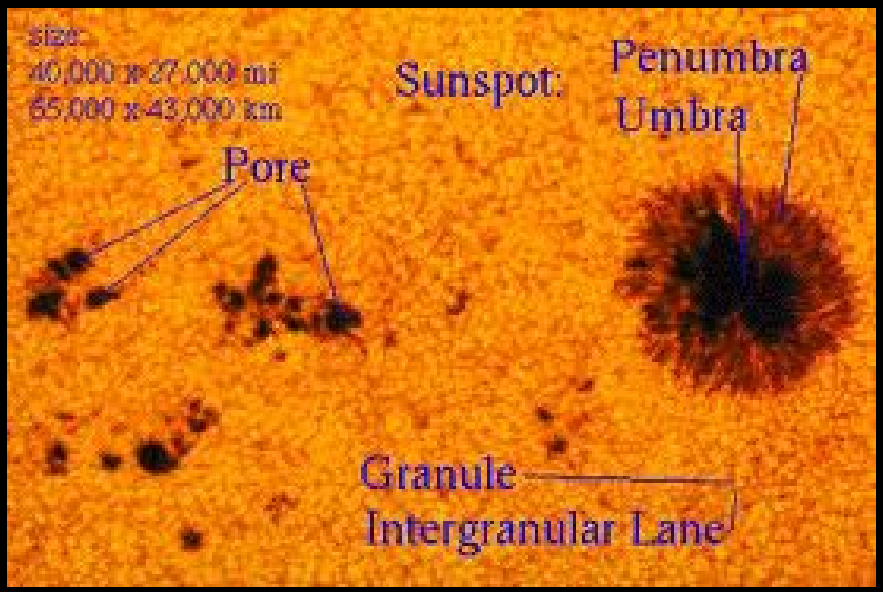
Sunspots usually appear in groups that form over hours or days and last for days or weeks.

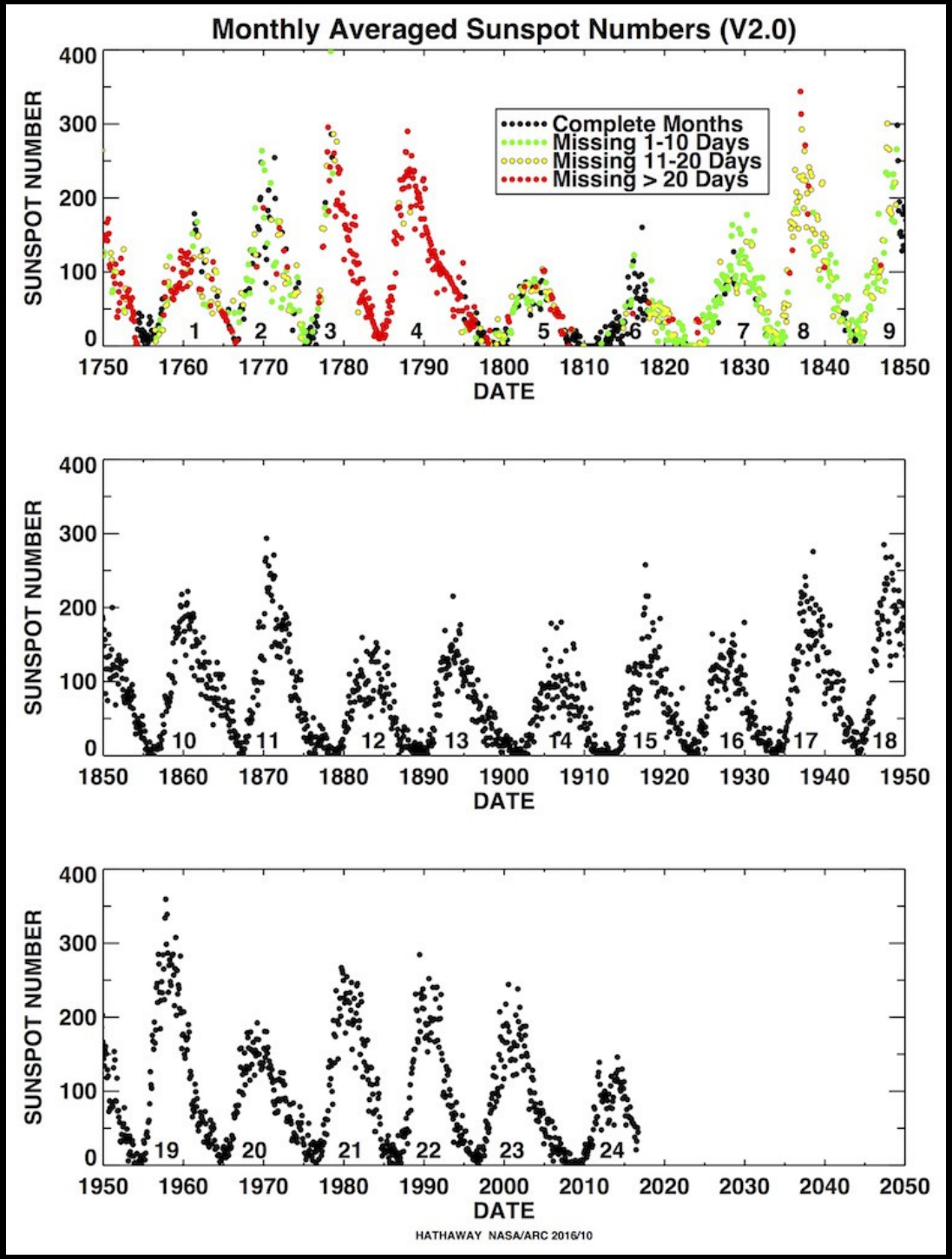
The earliest sunspot observations (c. 1609) indicated that the Sun rotates once in about 27 days.



Sunspots
Examples







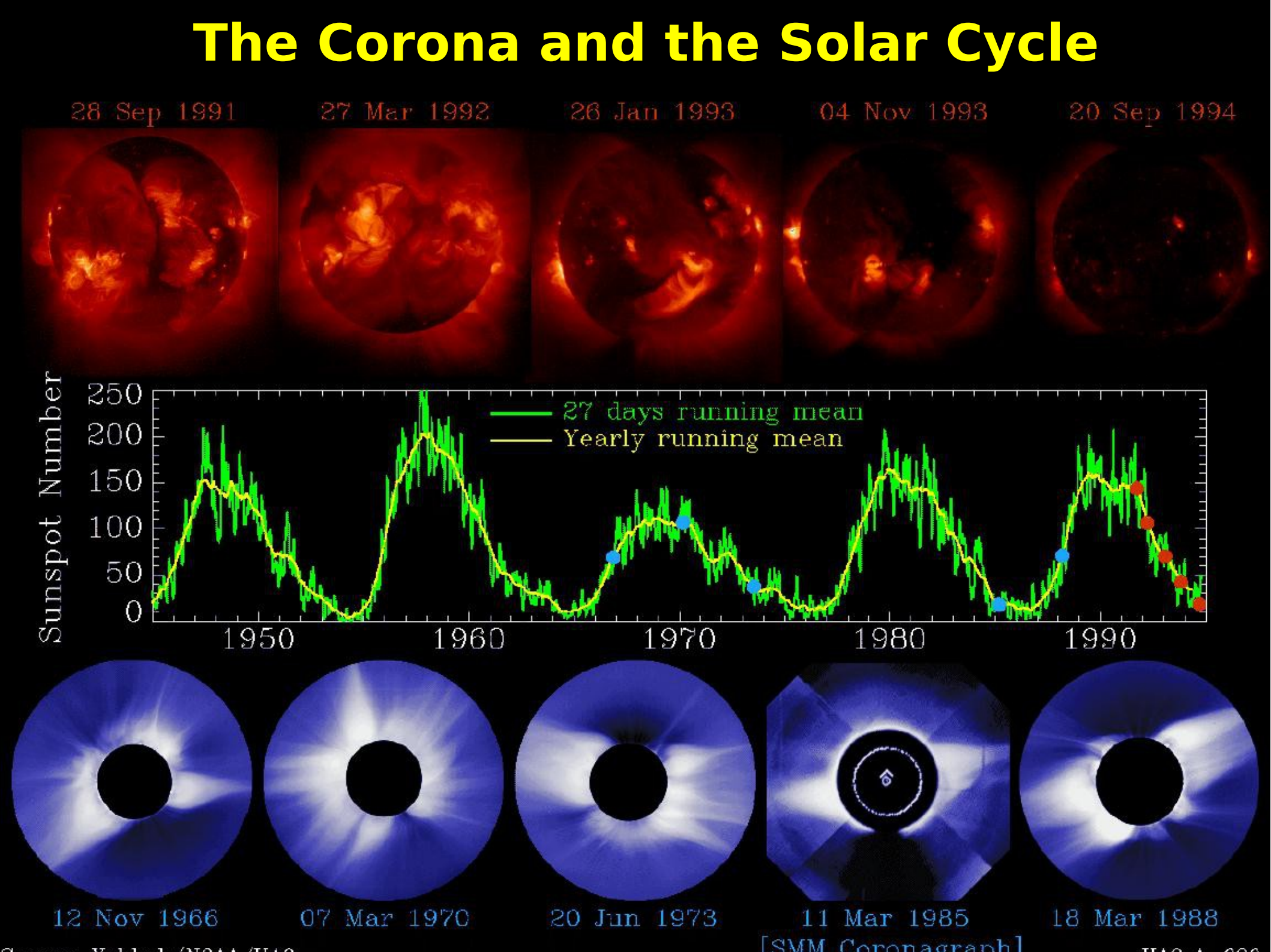
23 Full Cycles

Heinrich Schawbe discovered (1844) there was a cycle of sunspot number.

The average cycle lasts about 11 years, but ranges from 9 to 14.

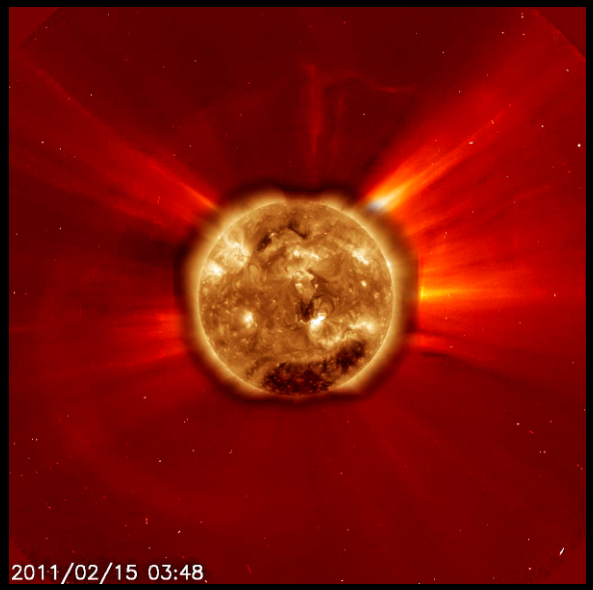
The average maximum number is about 100, but ranges from 50 to 200.

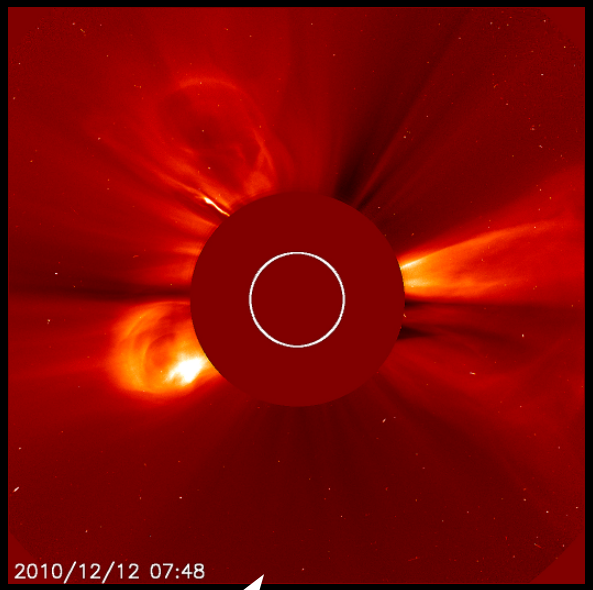
The Corona and the Solar Cycle

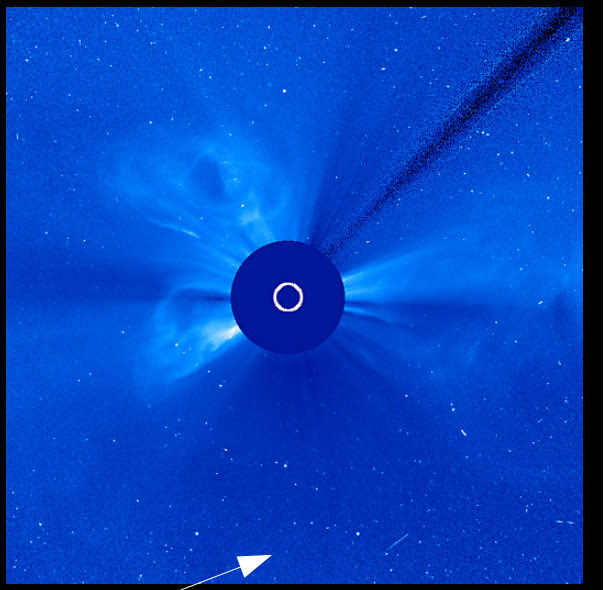


Solar Eruptions

Solar Flares and Coronal Mass Ejections (CMEs)







This combo of SDO and Soho C2 shows X2-flare and a halo CME

Three distinct CMEs: First to right, second from north pole, third from far side of Sun. All three eruptions happened within hours of each other.

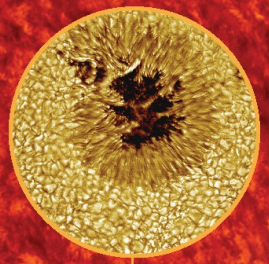
Animations!
c2_halloween_2003.mpg, c3_halloween_2003.mpg, X2_C2_combo_best.mpg

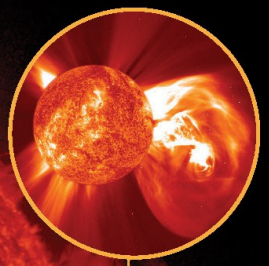
Space Weather

Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space-based and ground-based technological systems, as well as endanger life or health. Just like weather on Earth, space weather has its seasons, with solar activity rising and falling over an approximate 11 year cycle.

Sunspots

Sunspots are comparatively cool areas at up to 7,700° F and show the location of strong magnetic fields protruding through what we would see as the Sun's surface. Large, complex sunspot groups are generally the source of significant space weather.





Coronal Mass Ejections (CMEs)

Large portions of the corona, or outer atmosphere of the Sun, can be explosively blown into space, sending billions of tons of plasma, or superheated gas, Earth's direction. These CMEs have their own magnetic field and can slam into and interact with Earth's magnetic field, resulting in geomagnetic storms. The fastest of these CMEs can reach Earth in under a day, with the slowest taking 4 or 5 days to reach Earth.

Solar Wind

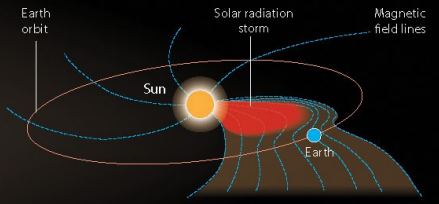
The solar wind is a constant outflow of electrons and protons from the Sun, always present and buffeting Earth's magnetic field. The background solar wind flows at approximately one million miles per hour!

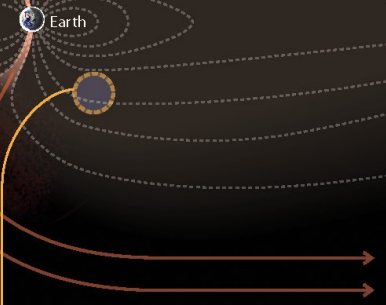
Sun's Magnetic Field

Strong and ever-changing magnetic fields drive the life of the Sun and underlie sunspots. These strong magnetic fields are the energy source for space weather and their twisting, shearing, and reconnection lead to solar flares.

Solar Radiation Storms

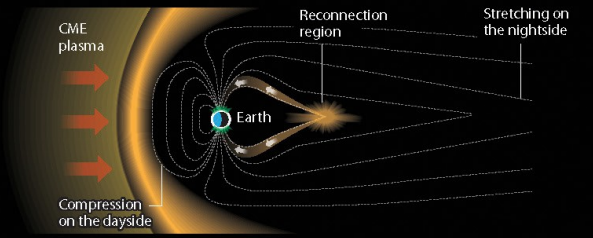
Charged particles, including electrons and protons, can be accelerated by coronal mass ejections and solar flares. These particles bounce and gyrate their way through space, roughly following the magnetic field lines and ultimately bombarding Earth from every direction. The fastest of these particles can affect Earth tens of minutes after a solar flare.

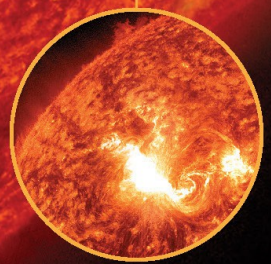




Geomagnetic Storms

A geomagnetic storm is a temporary disturbance of Earth's magnetic field typically associated with enhancements in the solar wind. These storms are created when the solar wind and its magnetic field interacts with Earth's magnetic field. The primary source of geomagnetic storms is CMEs which stretch the magnetosphere on the nightside causing it to release energy through magnetic reconnection. Disturbances in the ionosphere (a region of Earth's upper atomosphere) are usually associated with geomagnetic storms.





Solar Flares

Reconnection of the magnetic fields on the surface of the Sun drive the biggest explosions in our solar system. These solar flares release immense amounts of energy and result in electromagnetic emissions spanning the spectrum from gamma rays to radio waves. Traveling at the speed of light, these emissions make the 93 million mile trip to Earth in just 8 minutes.

Earth's Magnetic Field

Earth's magnetic field, largely like that of a bar magnet, gives the Earth some protection from the effects of the Sun. Earth's magnetic field is constantly compressed on the day side and stretched on the night side by the ever-present solar wind. During geomagnetic storms, the disturbances to Earth's magnetic field can become extreme. In addition to some buffering by the atmosphere, this field also offers some shielding from the charged particles of a radiation storm.

Source images: NASA, NOAA.

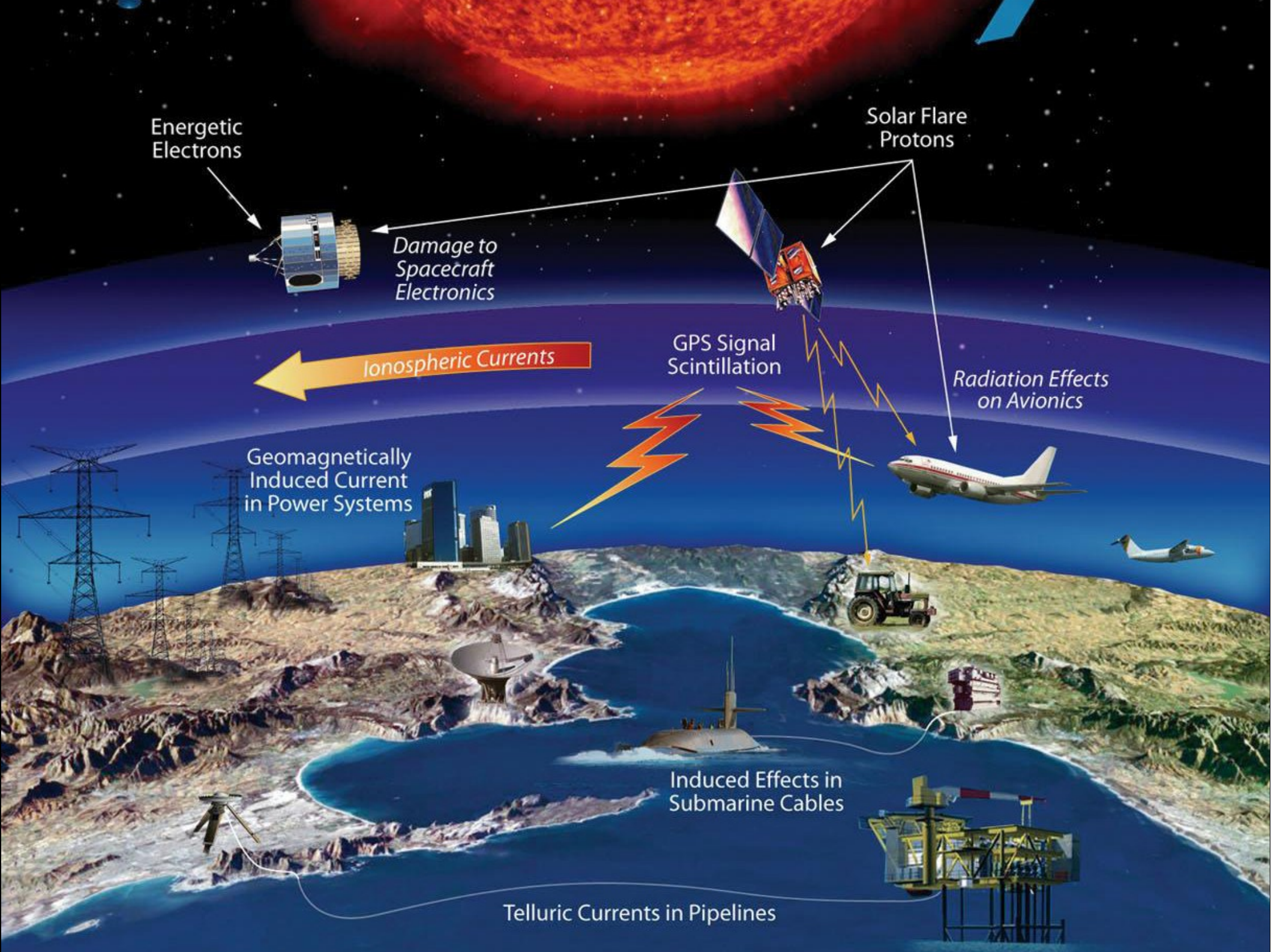
NOAA Space Weather Prediction Center – www.spaceweather.gov

Aurorae

Seen mostly at high latitudes, aurorae are produced when Earth's magnetosphere is disturbed.

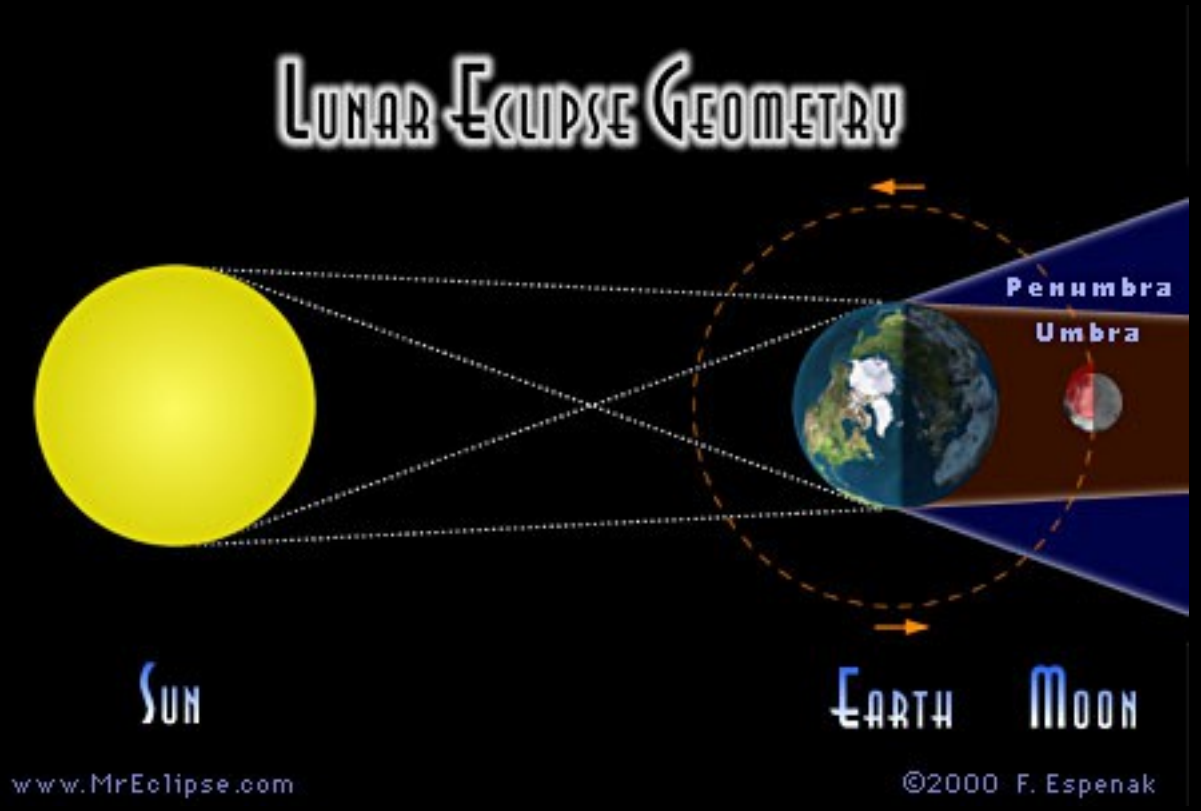
Plasma from the magnetosphere precipitates into the upper atmosphere.

Reds are from oxygen
Greens are from lower in atmosphere.


Energetic Electrons
Solar Flare Protons
Damage to Spacecraft Electronics
Ionospheric Currents
GPS Signal Scintillation
Radiation Effects on Avionics
Geomagnetically Induced Current in Power Systems
Induced Effects in Submarine Cables
Telluric Currents in Pipelines

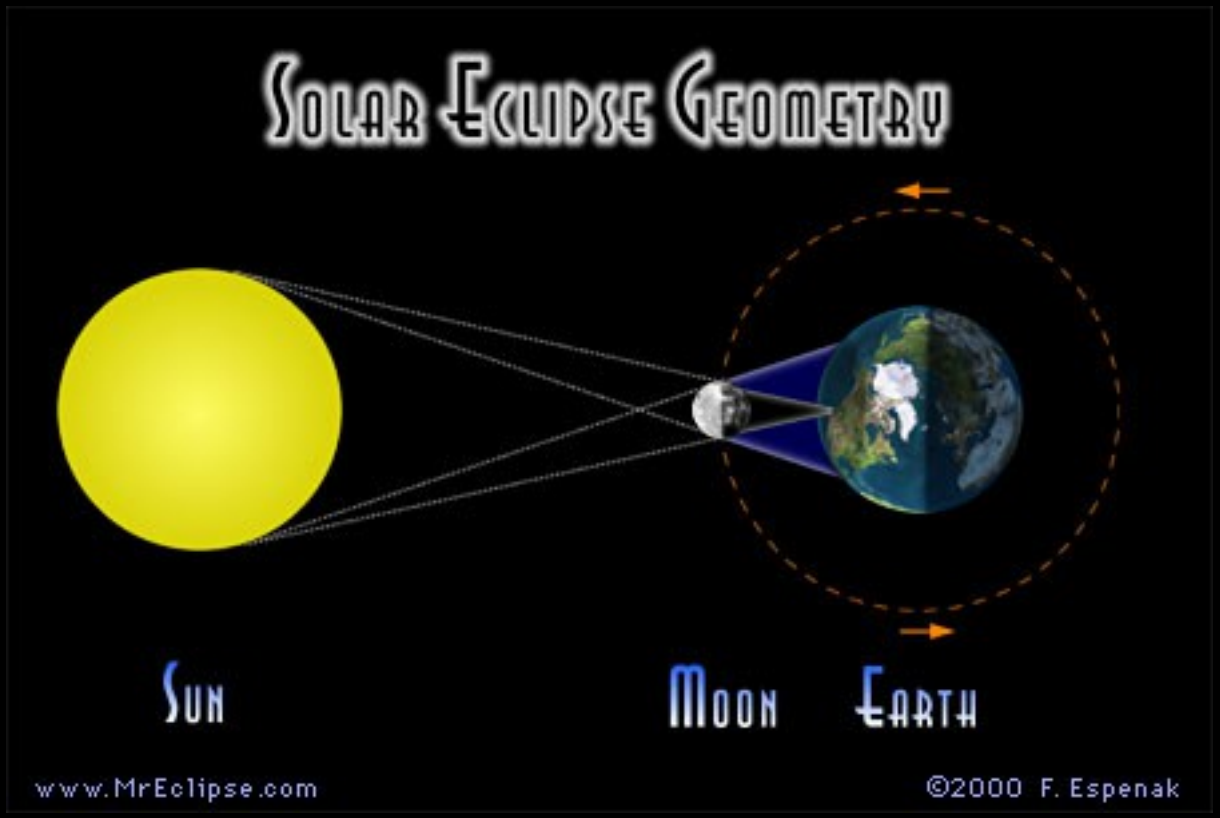
What Is an Eclipse?

An eclipse happens when one object blocks light from falling onto another object. The shadow of the eclipsed object falls onto the other object.



Images Used With Permission

Solar Eclipses



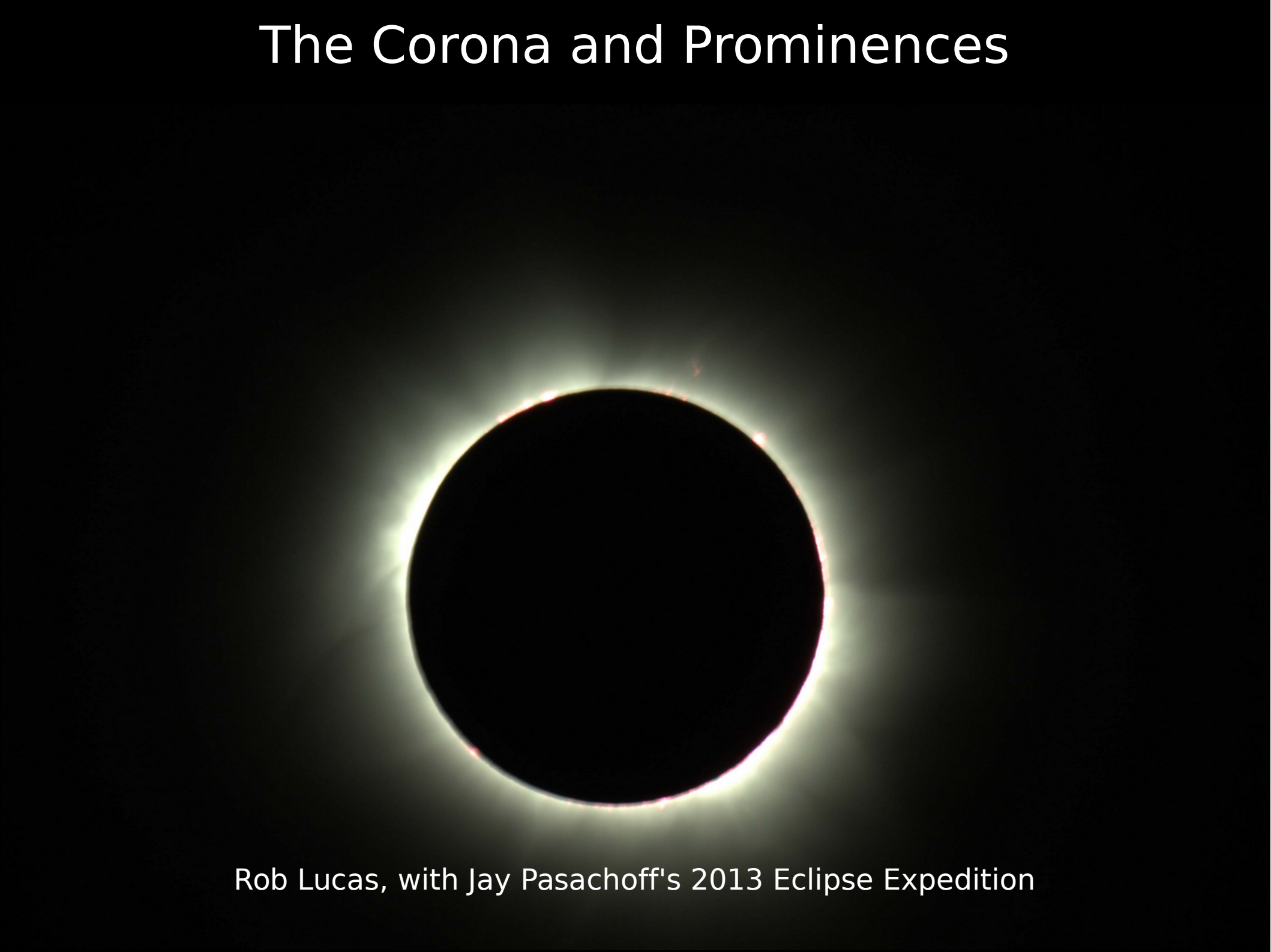
Images Used With Permission

What You Can See

Image Used With Permission

Zophia Edwards wide-angle view, from Jay Pasachoff's Eclipse 2013 page

The Corona and Prominences



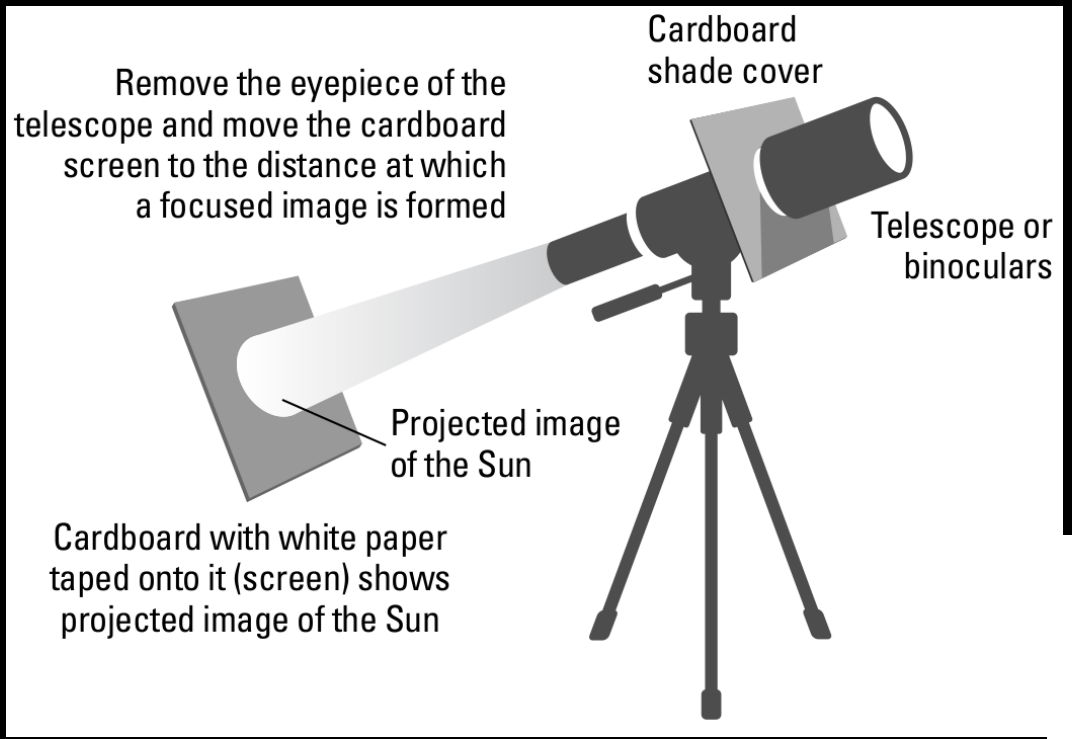
Rob Lucas, with Jay Pasachoff's 2013 Eclipse Expedition

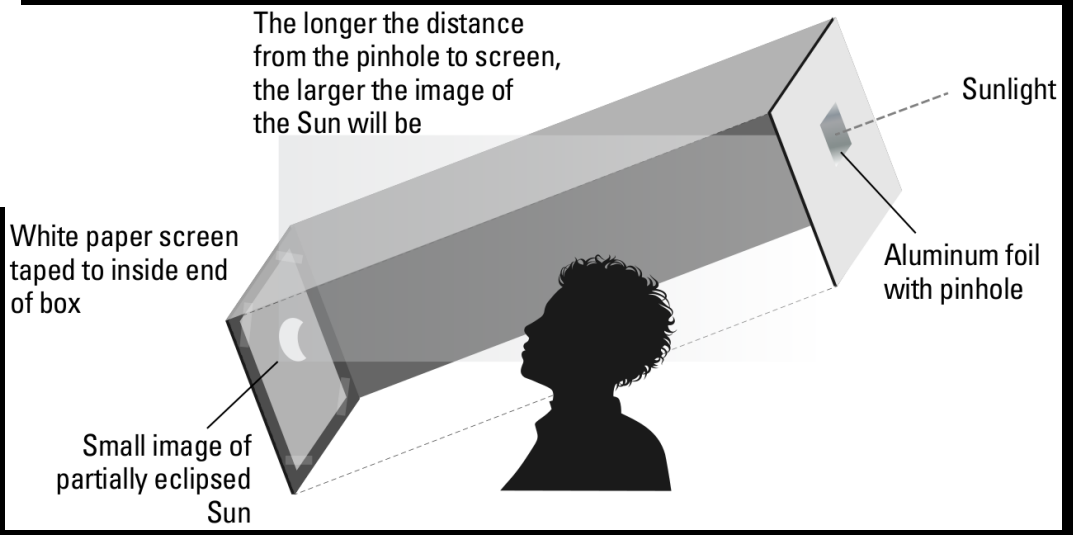
How to Safely Observe An Eclipse

No Special Rules for Lunar Eclipses

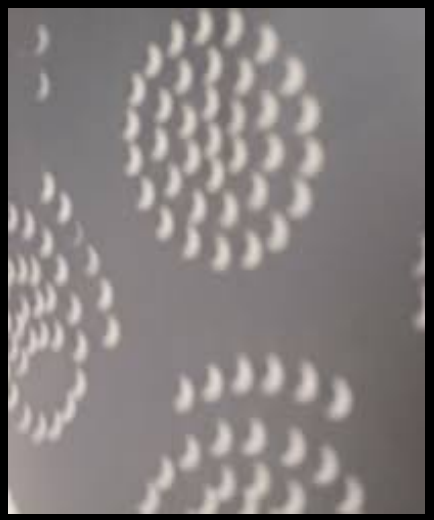
For Solar Eclipses:

- Projection
- Special Telescope Filters
- Eclipse Glasses
- Number 14 Welder's Glass

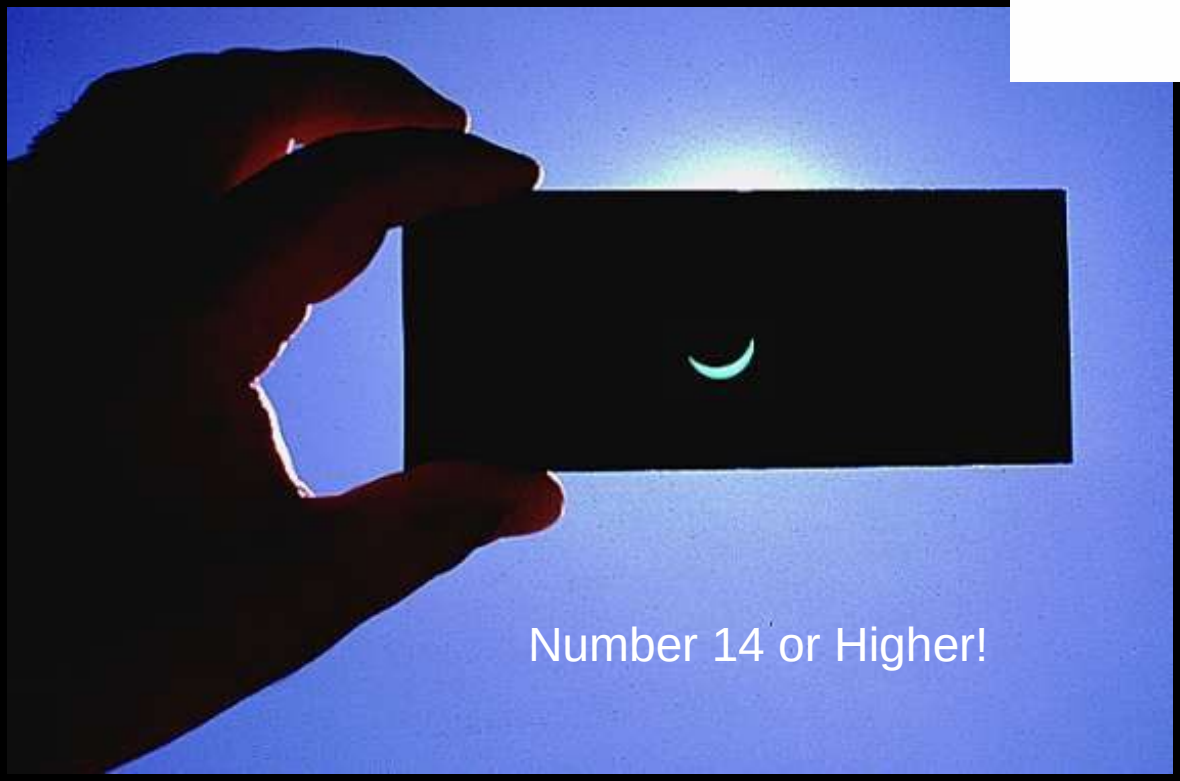




Use a Kitchen Colander For Partial Phases



Eclipse Glasses and Welder's Glass



Eclipse Across America

August 21, 2017

National Aeronautics and Space Administration

What is a Solar Eclipse?

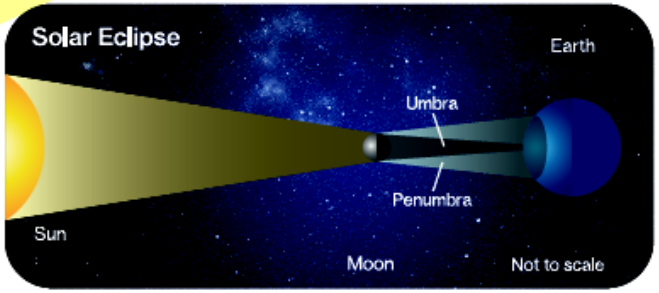
A **solar eclipse** happens when the Moon, as it orbits Earth, fully or partially blocks the light of the Sun, thus casting its shadow on Earth.

Observers within the path of totality can expect to see something like the image below. bservers outside the path of totality will see the Sun partially eclipsed as a crescent Sun (with safe filters).

Greatest Eclipse

Time	Location
10:17 a.m. PDT	Lincoln Beach, OR Depoe Bay, OR
11:26 a.m. MDT	Lime, ID
1:19 p.m. CDT	Valley View, MO Bloomsdale, MO
1:28 p.m. CDT	Calistia, TN
2:47 p.m. EDT	Bethera, SC

After the 2017 solar eclipse, the next **total solar eclipse** visible over the continental United States will be on **April 8, 2024**.



If the Sun is scaled to about 10 cm (3.9 In), Earth would be about 10 meters away (33 feet).

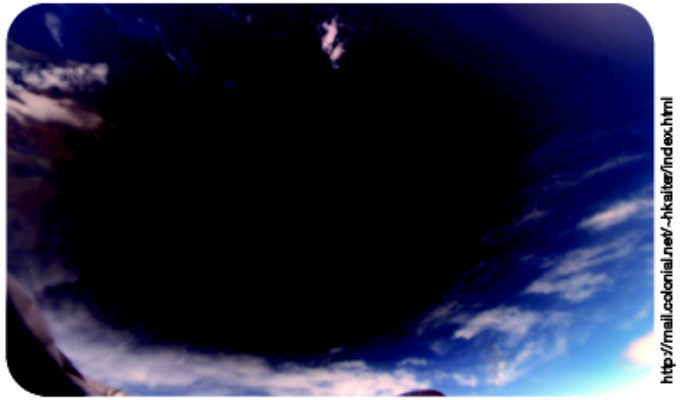
The predicted path of the August 21, 2017 solar eclipse

Duration of Greatest Eclipse:
2 min 40 sec
(18:25 UT=13:25 CDT or 1:25 p.m. CDT)

Location Greatest Eclipse:
36 deg 58 min N; 87 deg 40 min W
(between Princeton and Hopkinsville, KY)

Path Width: **approximately 115 km**

Eclipse Predictions by Fred Espenak, GSFC, NASA-emeritus



Never look directly at the Sun unless you have filters that you know are safe.

For more information: http://eclipse/gsfc.nasa.gov/SEhelp/safety.html

For more information about solar eclipses: http://eclipse.gsfc.nasa.gov/solar.html
http://eclipsewise.com/solar
http://eclipsewise.com/solar/SEnews/TSE2017/TSE2017.html
http://eclipse2017.nasa.gov/

The NASA image above shows the Moon's umbral shadow as seen from the International Space Station during the total solar eclipse on 29 March 2006.

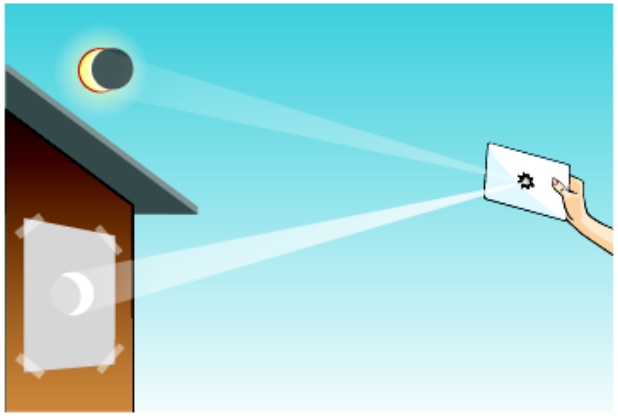
Mitzi Adams • *mitzi.adams@nasa.gov* • **256–961–7626**

www.nasa.gov

FL-2016-10-122-MSFC G–248081

Safely Observing the Sun

WARNING: Never look directly at the Sun without proper eye protection. You can *seriously* injure your eyes.



Mirror in an Envelope

Slide a mirror into an envelope with a ragged hole cut into the front. Point the mirror toward the Sun so that an image is reflected onto a screen at least 5 meters (about 15 feet) away. The longer the distance, the larger the image.

Do not look at the mirror, only at the screen.

Local Area Eclipse Details

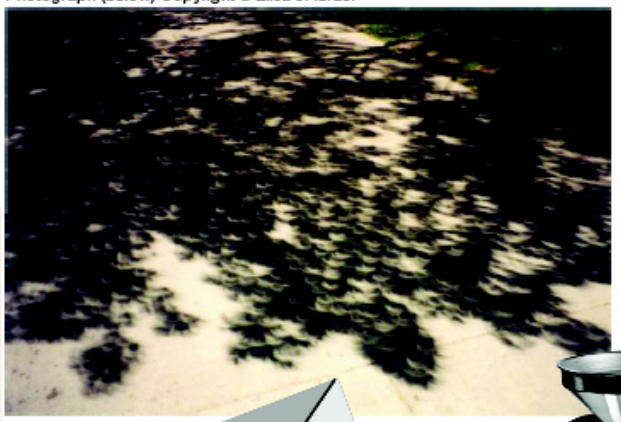
Location	% Covered	Start (CDT)	Max (CDT)	End (CDT)
Nashville, TN	100.0%	11:58AM	1:28PM	2:54PM
Totality begins 1:27PM • Totality ends 1:29PM				
Brentwood, TN	100.0%	11:58AM	1:28PM	2:54PM
Totality begins 1:28PM • Totality ends 1:29PM				
Franklin, TN	99.9	11:58AM	1:28PM	2:54PM
Fayetteville, TN	98.2	11:59	1:30	2:56
Ardmore, AL/TN	97.3	11:59	1:29	2:55
Florence, AL	95.9	11:57	1:28	2:54
Athens, AL	96.7	11:59	1:29	2:56
Decatur, AL	96.1	11:59	1:30	2:56
Hartselle, AL	95.8	11:59	1:30	2:56
Madison, AL	96.7	11:59	1:30	2:56
USSRC	96.8	11:59	1:30	2:56
Huntsville, AL	97.0	11:59	1:30	2:56
VBAS	97.1	12:00NOON	1:30	2:56
Arab, AL	96.0	12:00	1:31	2:57
Gurley, AL	97.1	12:00	1:31	2:57
Guntersville, AL	96.4	12:01	1:31	2:57
Scottsboro, AL	97.4	12:01	1:31	2:57
Bridgeport, AL	98.6	12:01	1:32	2:57

JAVA Script Solar Eclipse Explorer
http://eclipse.gsfc.nasa.gov/JSEX/JSEX-NA.html

Strange Shadows!

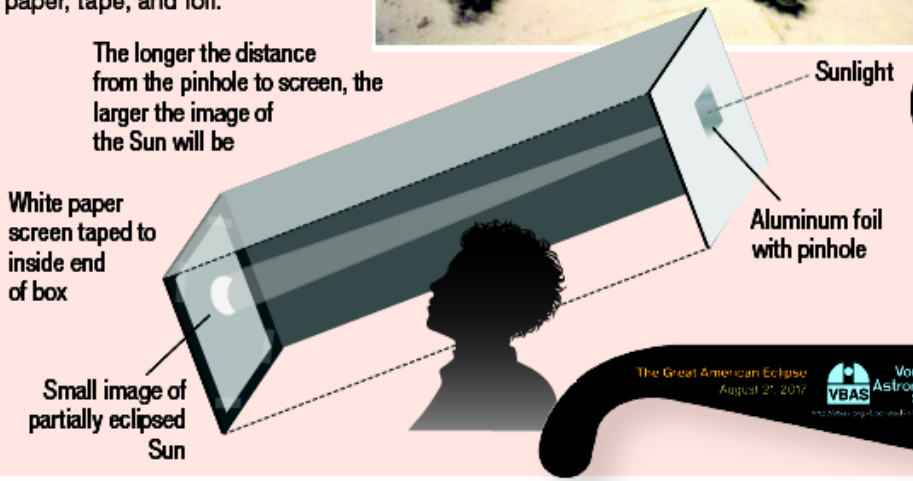
Sunlight through trees produces projected crescents during partial phases.

Photograph (below) Copyright © Elisa J. Israel



Go Stick Your Head in a Box

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



Sun Funnel

Make this device for your telescope with simple instructions at: www.astrosociety.org/tov/Build_a_Sun_Funnel.pdf

Cool in the Shades

Visit the Von Braun Astronomical Society (or your local astronomical society) and pick up a pair of these special Eclipse Sunglasses!

www.vbas.org

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