

The Sun and the Eclipse Across America

August 21, 2017

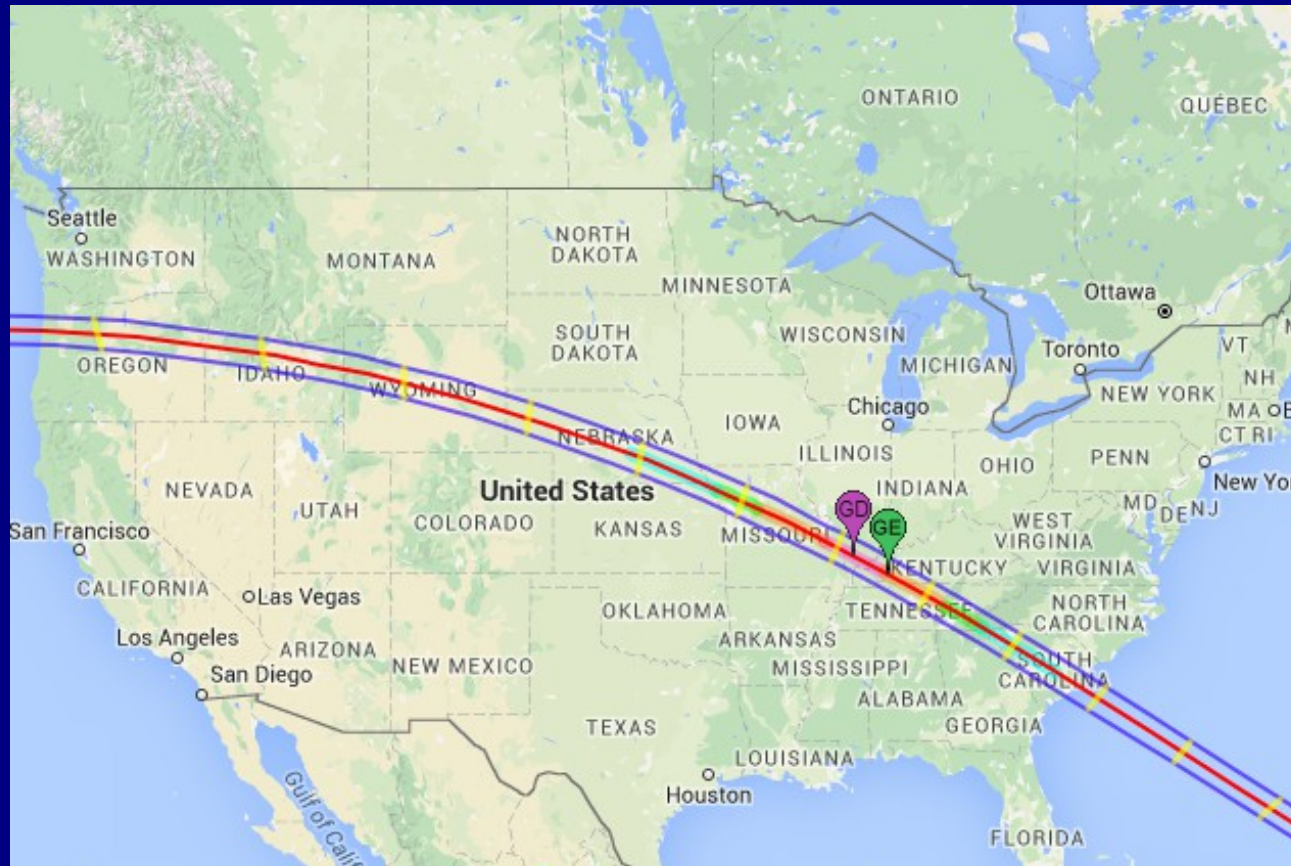
Mitzi Adams, Solar Scientist
ST13, NASA/MSFC



Image Courtesy of Dr. Alphonse Sterling, NASA/MSFC
August 1, 2008 Gansu Province, China

Eclipse Across America

August 21, 2017



Close to Hopkinsville, Kentucky (GE):

Start of partial eclipse	16:56 UT	11:56 a.m. CDT
Start of totality	18:24 UT	1:24 p.m. CDT
Maximum eclipse	18:25 UT	1:25 p.m. CDT
End of totality	18:26 UT	1:26 p.m. CDT
End of partial eclipse	19:51 UT	2:51 p.m. CDT

Eclipse Across America...in Tennessee

August 21, 2017



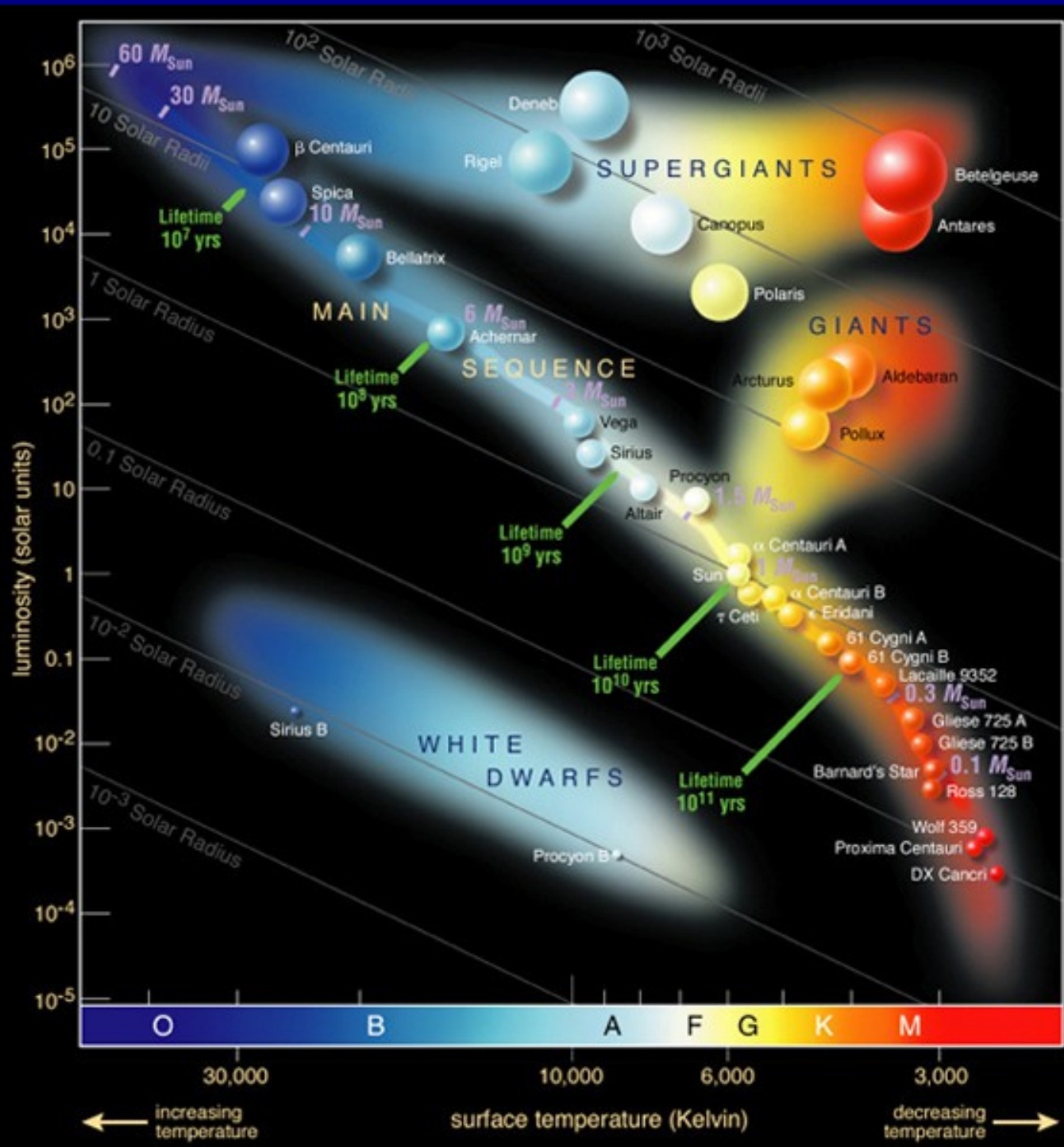
Eclipse Across America...in North Carolina

August 21, 2017



Location	Event	Time (EDT=UT-4)
Asheville 99.3%	Start of partial (C1) Max eclipse End partial (C4)	17:08:20 UT 18:37:51 20:01:30
Sylva 100%	Start of partial (C1) Start of total (C2) Max eclipse End of total (C3) End of partial (C4)	17:06:56 18:35:48 18:36:44 18:37:41 20:00:52
Andrews 100% on centerline	Start of partial (C1) Start of total (C2) Max eclipse End of total (C3) End of partial (C4)	17:05:45 18:34:28 18:35:47 18:37:06 20:00:16

What IS the Sun?



The Sun is a Star
Stars are Mostly Hydrogen Gas

α-Cen-A is G2,
α-Cen-B is K1,
Proxima (α-Cen-C) is M6,

the Sun is G2
8.5 light minutes away

Betelgeuse is M2
643 ly

Bellatrix is B2 Rigel is B8
250 ly 860 ly



Saiph is B0
650 ly

Layers of the Sun

The Convection Zone

Energy continues to move toward the surface through convection currents of heated and cooled gas in the convection zone.

The Corona

The ionized elements within the corona glow in the x-ray and extreme ultraviolet wavelengths. NASA instruments can image the Sun's corona at these higher energies since the photosphere is quite dim in these wavelengths.

The Radiative Zone

Energy moves slowly outward—taking more than 170,000 years to radiate through the layer of the Sun known as the radiative zone.

Sun's Core

Energy is generated by thermonuclear reactions creating extreme temperatures deep within the Sun's core.

Coronal Streamers

The outward-flowing plasma of the corona is shaped by magnetic field lines into tapered forms called coronal streamers, which extend millions of miles into space.

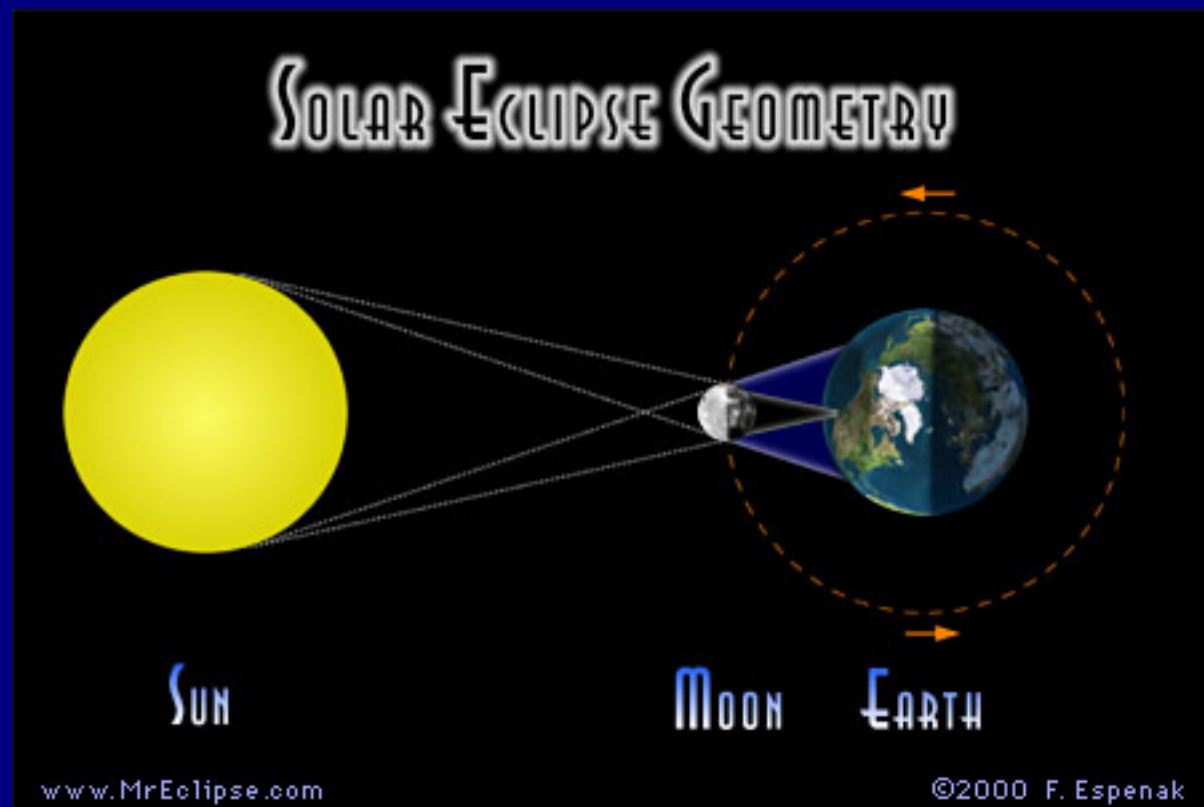
The Chromosphere

The relatively thin layer of the Sun called the chromosphere is sculpted by magnetic field lines that restrain the electrically charged solar plasma. Occasionally larger plasma features—called prominences—form and extend far into the very tenuous and hot corona, sometimes ejecting material away from the Sun.



What is an Eclipse?

An eclipse happens when one object blocks the light of another



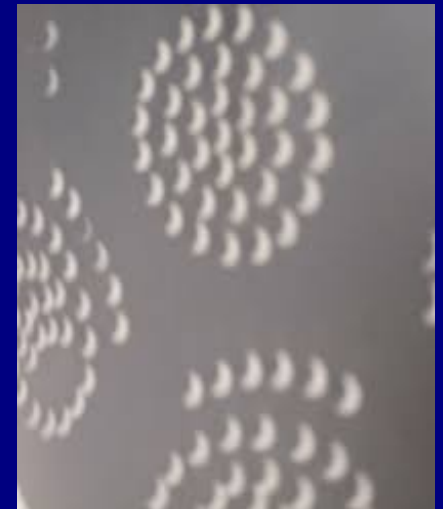
Images Used With Permission

What You Can See: Partial Eclipse

The entire United States will see a partial eclipse.



Use a Kitchen Colander or Trees For Partial Phases



Shadow Bands

Light shines through air, creating a wavy pattern similar to light through water in a pool



Total Eclipse: Diamond Ring and Bailey's Beads



What You Can See: Total Eclipse



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

Image Used With Permission

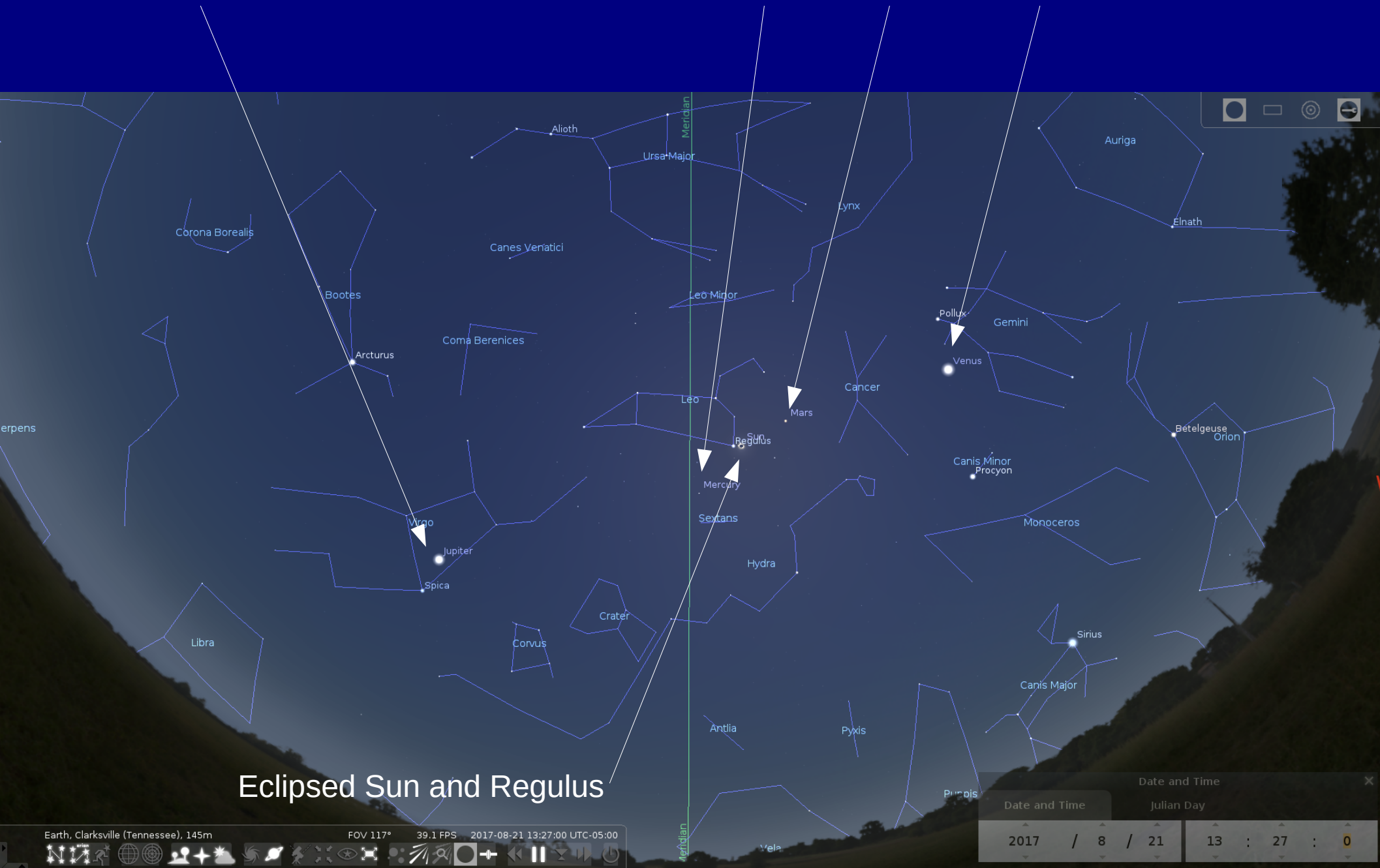
The Corona and Prominences



Rob Lucas, with Jay Pasachoff's 2013 Eclipse Expedition
Image Used With Permission

The Sky During Totality

Jupiter is to the east of the Meridian (left), Mercury, Mars, and Venus to the west.



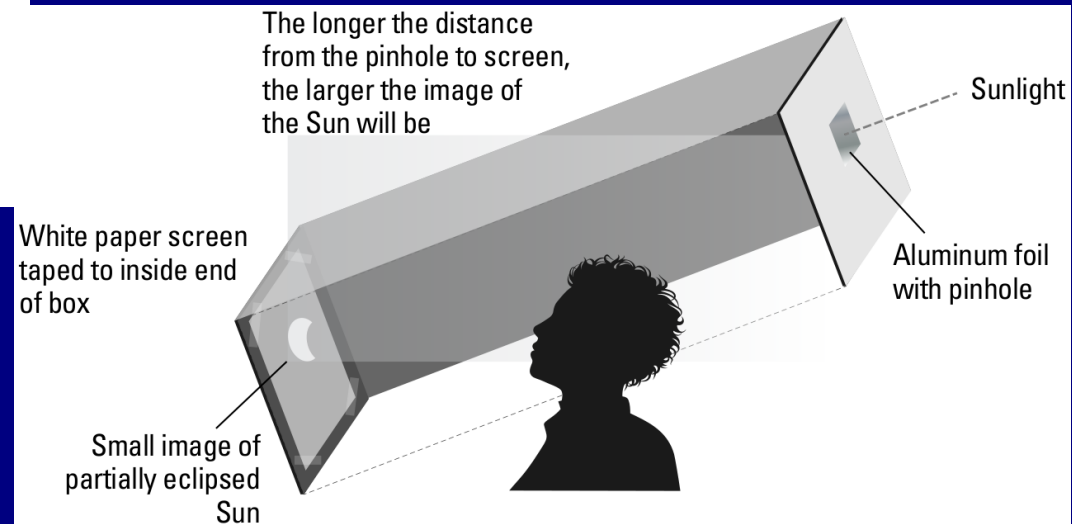
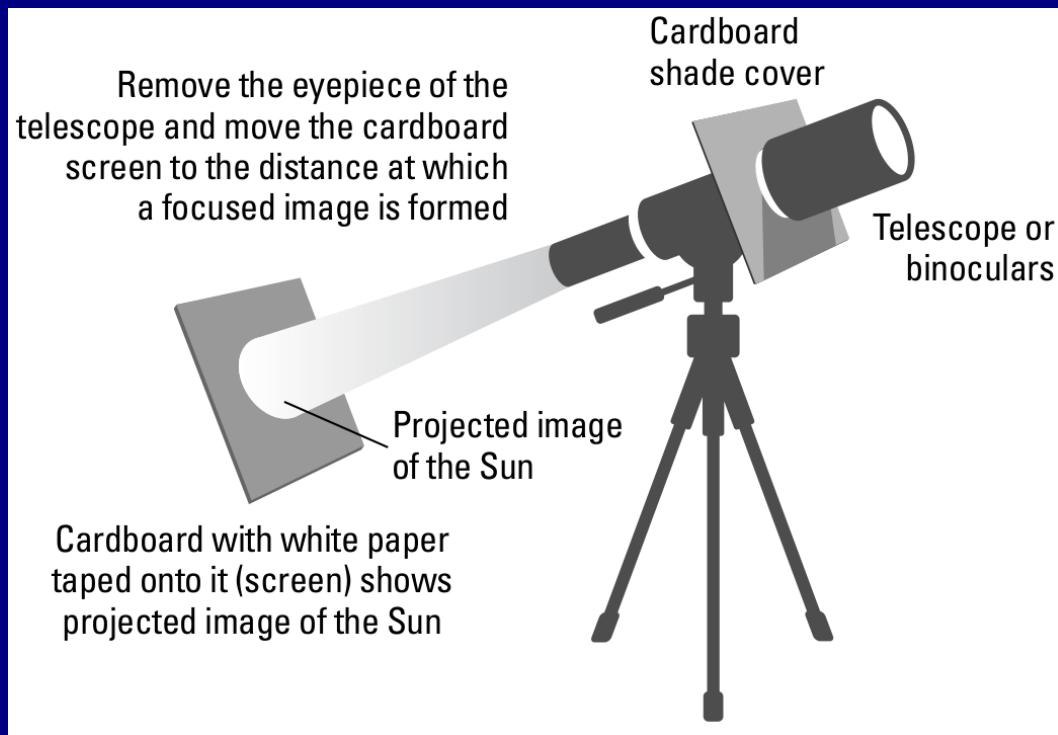
Safely Viewing an Eclipse

How to Safely Observe An Eclipse

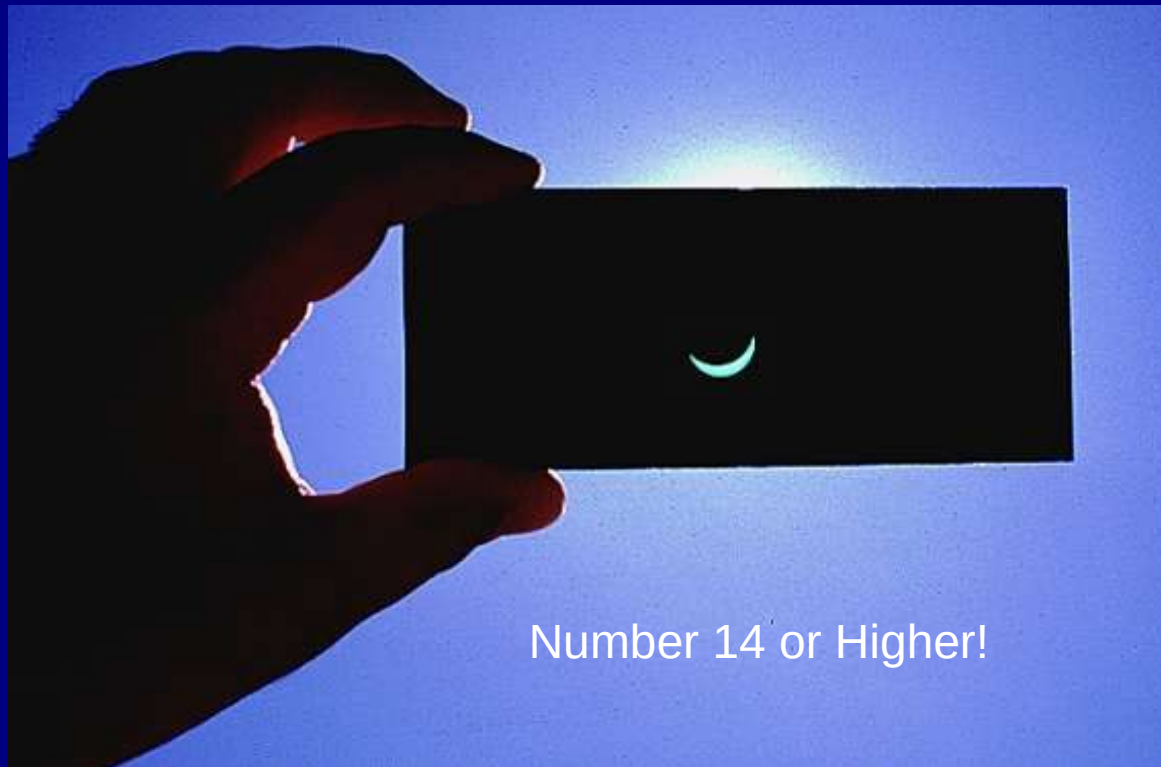
No Special Rules for Lunar Eclipses

For Solar Eclipses:

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



Eclipse Glasses and Welder's Glass



Number 14 or Higher!

Solar Filters for Telescopes



More Information

http://www.astrosociety.org/tov/Build_a_Sun_Funnel2.pdf



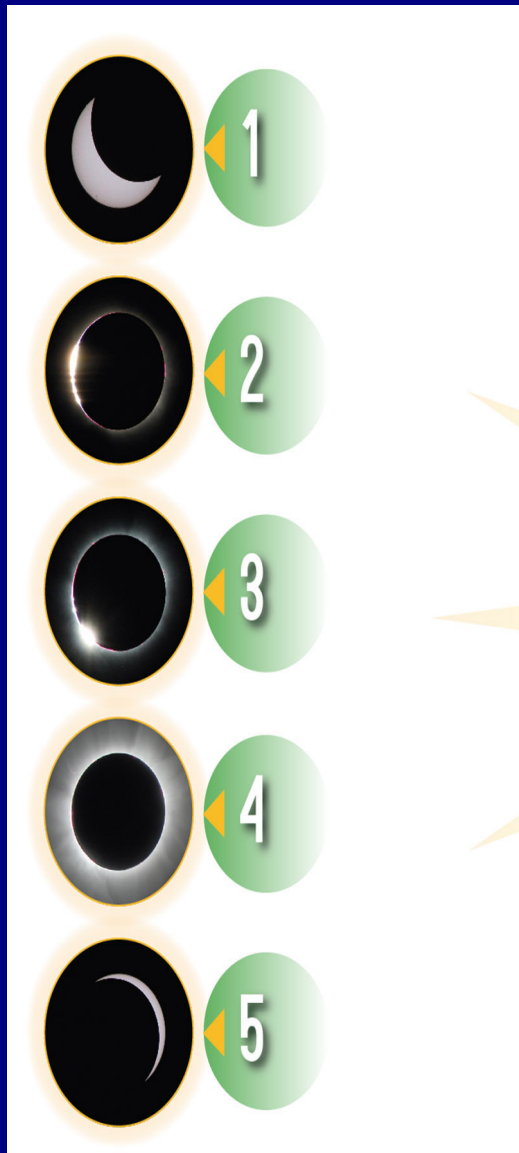
<http://www.nasa.gov/offices/education/about/index.html>

<http://www.greatamericaneclipse.com/>

<http://eclipse.gsfc.nasa.gov/SEgoogle/SEgoogle2001/SE2017Aug21Tgoogle.html>

EYE SAFETY: WHEN TO WEAR THE GLASSES

PRACTICE WITH YOUR AUDIENCES!!



PARTIAL ECLIPSE • GLASSES ON

The eclipse begins when the sun's disk is partially blocked by the Moon. This partial eclipse phase can last over an hour.

BAILY'S BEADS • GLASSES ON

As totality approaches, only the low-lying valleys on the Moon's edge allow sunlight through, forming bright spots of light called Baily's Beads.

DIAMOND RING • GLASSES ON

The last of the sunlight streaming through the Moon's valleys creates a single bright flash of light on the side of the Moon. This is known as the diamond ring effect, and it marks the last few seconds before totality begins.

TOTALITY • GLASSES OFF

Once the diamond ring disappears and the Moon completely covers the entire disk of the sun, you may safely look at the eclipse without a solar filter. Be careful to protect your eyes again before the end of totality—the total eclipse may last less than a minute in some locations.

FINAL STAGES • GLASSES ON

A crescent will begin to grow on the opposite side of the sun from where the Baily's Beads shone at the beginning. This crescent is the lower atmosphere of the sun, beginning to peek out from behind the Moon and it is your signal to stop looking directly at the eclipse. Make sure you have safety glasses back on—or are otherwise watching the eclipse through a safe, indirect method—before the first flash of sunlight appears around the edges of the Moon.

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. Observers outside the path of totality will see the Sun partially eclipsed as a crescent Sun (with safe filters).

Greatest Eclipse

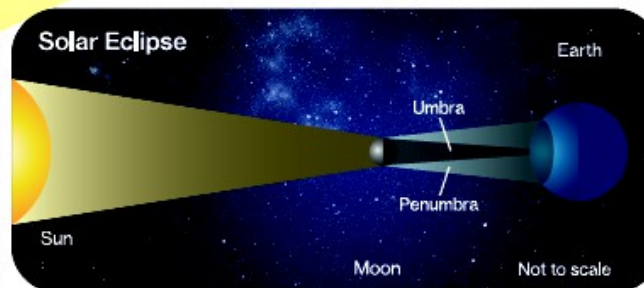
Time	Location
10:17 a.m. PDT	Lincoln Beach, OR Depoe Bay, OR
11:26 a.m. MDT	Lime, ID
1:19 p.m. CDT	Valley View, MO Bloomsdale, MO
1:28 p.m. CDT	Calistia, TN
2:47 p.m. EDT	Bethera, SC

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).



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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:

For more information about solar eclipses:

<http://eclipse.gsfc.nasa.gov/SEhelp/safety.html>

<http://eclipse.gsfc.nasa.gov/solar.html>

<http://eclipsewise.com/solar>

<http://eclipsewise.com/solar/SEnews/TSE2017/TSE2017.html>

<http://eclipse2017.nasa.gov/>



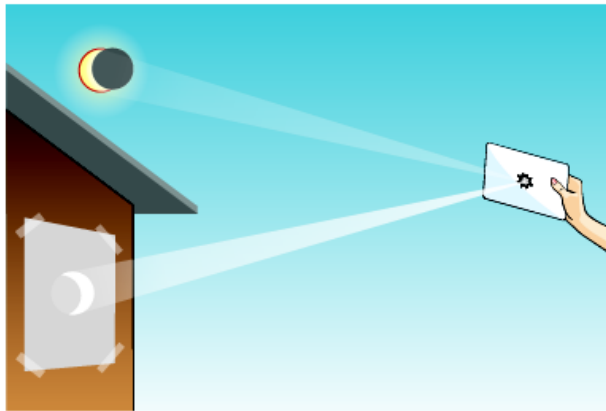
<http://mail.colonial.net/~hhalter/index.html>

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.

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Safely Observing the Sun

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

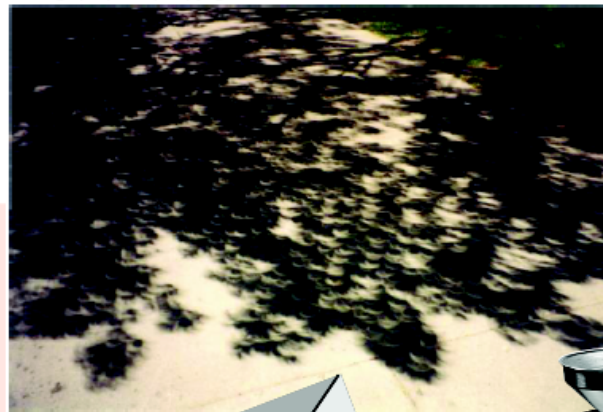


Mirror in an Envelope

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.

Photograph (below) Copyright © Elisa J. Israel



Strange Shadows!

Sunlight through trees produces projected crescents during partial phases.

Go Stick Your Head in a Box

You can make this simple "eclipse telescope" 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

White paper screen taped to inside end of box

Small image of partially eclipsed Sun

Aluminum foil with pinhole

Sunlight



Sun Funnel

Make this device for your telescope with simple instructions at: www.astrocity.org/toy/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



All images used with permission.

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>

The Great American Eclipse
August 21, 2017

VBAS
Von Braun
Astronomical
Society

Eclipse Science

Proposed Activities for Total Solar Eclipse 2017
Involving Advanced Space Academy Kids
Select Local (Huntsville, AL) High School Students
Austin Peay State University Students
University of Alabama in Huntsville Students

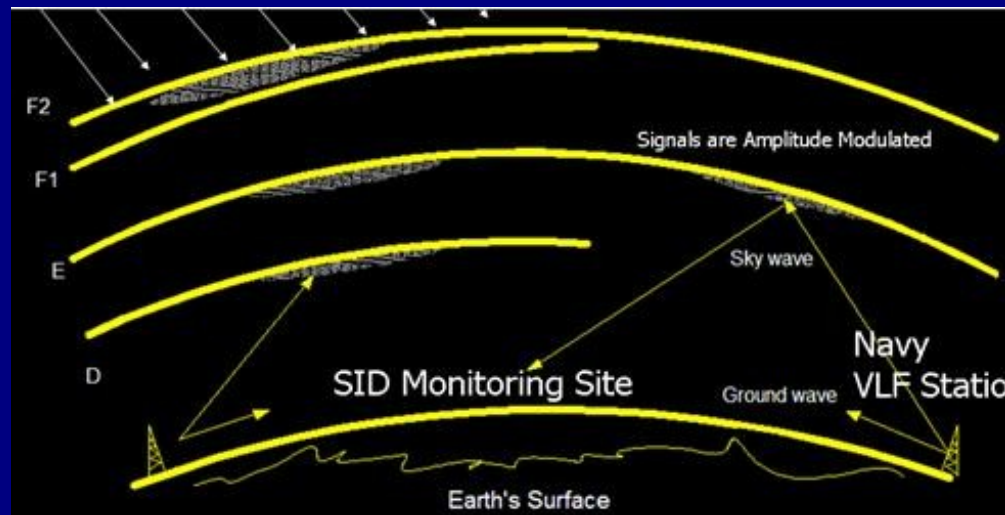
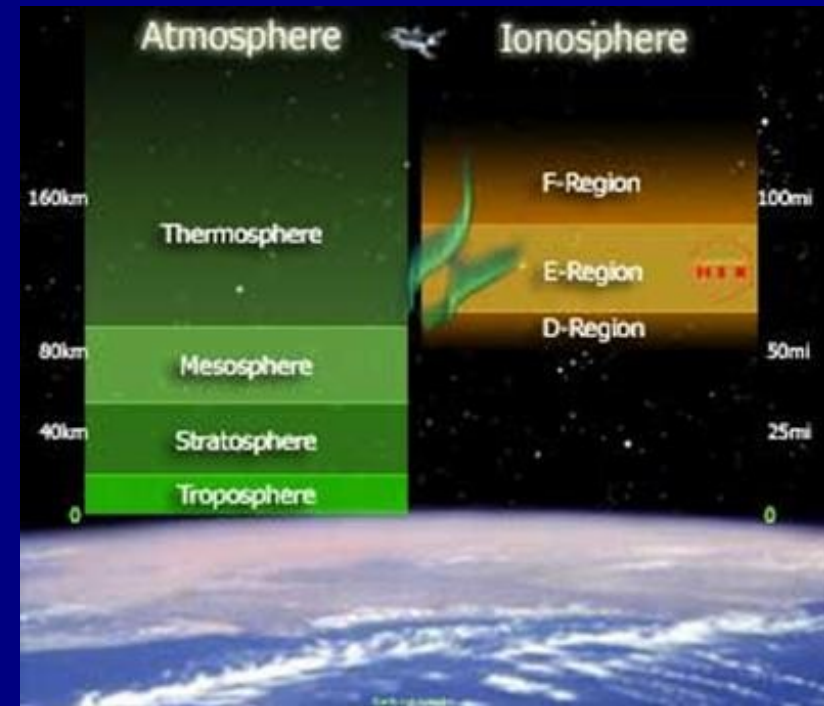
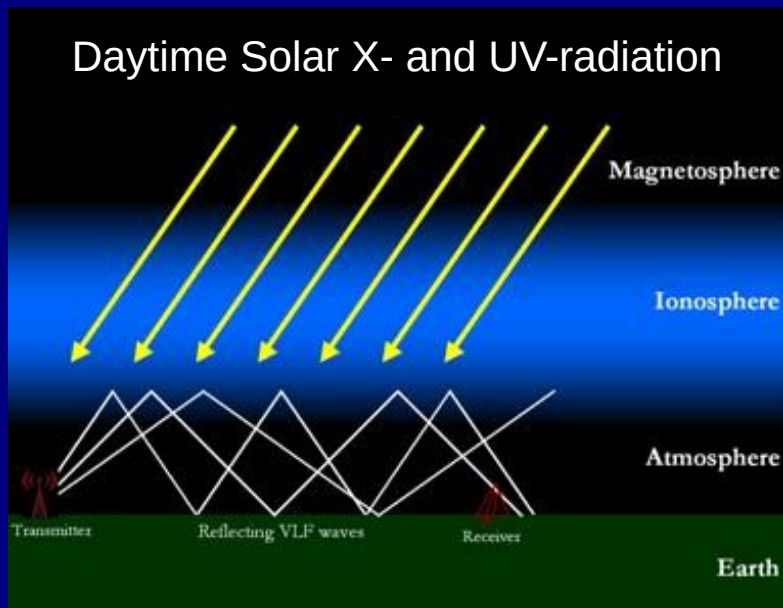
1. RadioJove/INSPIRE/Reverse Beacon
2. Balloon Experiments -- meteorological and other
3. Weather Observations
4. Animal/Plant Observations
5. Solar Corona/Chromosphere Observations

Austin Peay State University Clarksville, Tennessee

- 45 minutes from downtown Nashville
- Bachelor and Master degree programs
- Departments include Agriculture, Health Sciences, Biology, Geosciences, and Physics and Astronomy

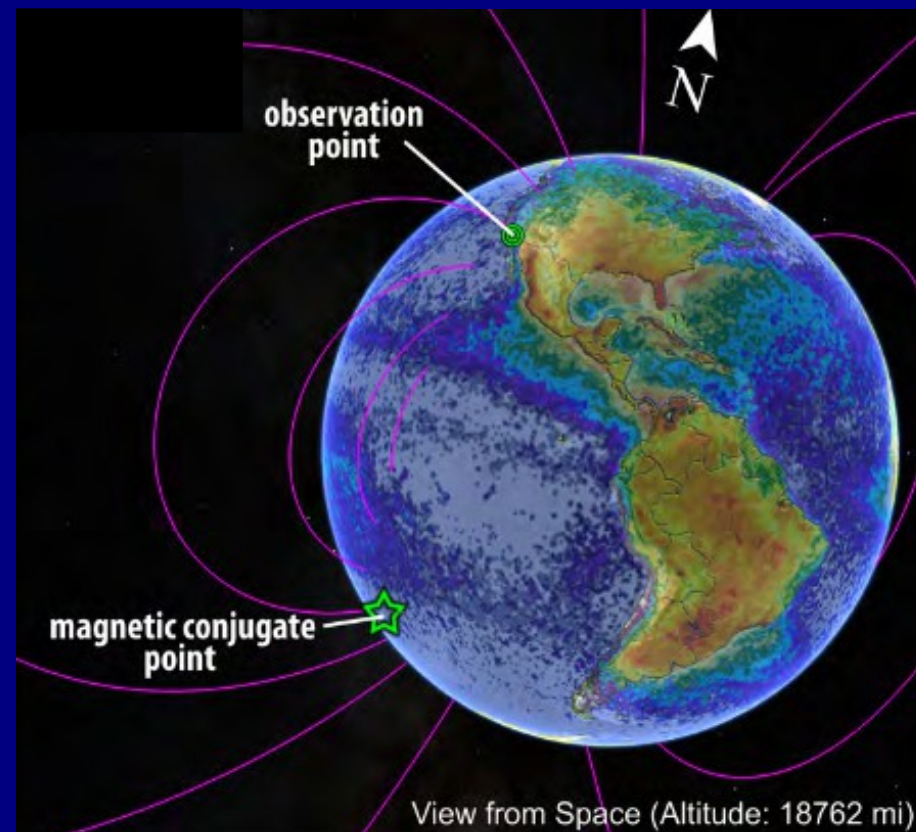


Ionospheric Changes



At night (on right), ions recombine, ionosphere has only F and E layers, transmitted radio signals travel higher before bouncing, so can be received at larger distances.

The INSPIRE Project provides creative hands-on opportunities for students of all ages to observe Very Low Frequency waves (i.e. lightning and other atmospheric sounds) by using the INSPIRE VLF-3 Natural Radio Sound Receiver.



WAV File!

Weather Observations

The Mobile Integrated Profiling System (MIPS)

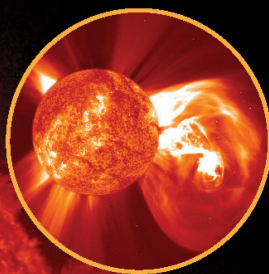
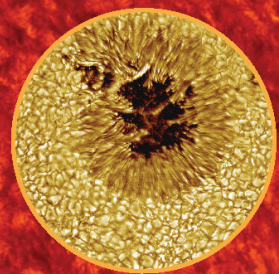


Sounding Equipment



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

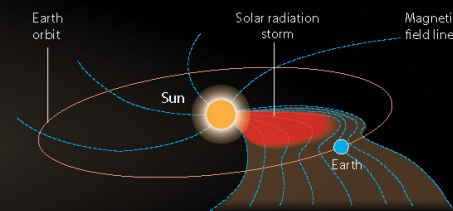
The solar wind is a constant outflow of electrons and protons from the Sun, always present and buffeting Earth's magnetic field. The background solar wind flows at approximately one million miles per hour!

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.

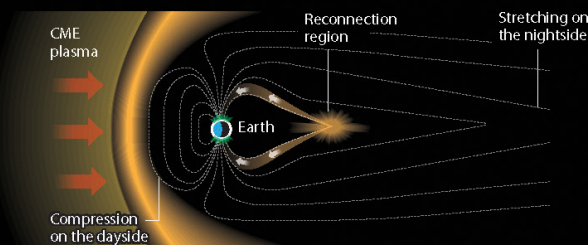


Geomagnetic Storms

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 atmosphere) are usually associated with geomagnetic storms.

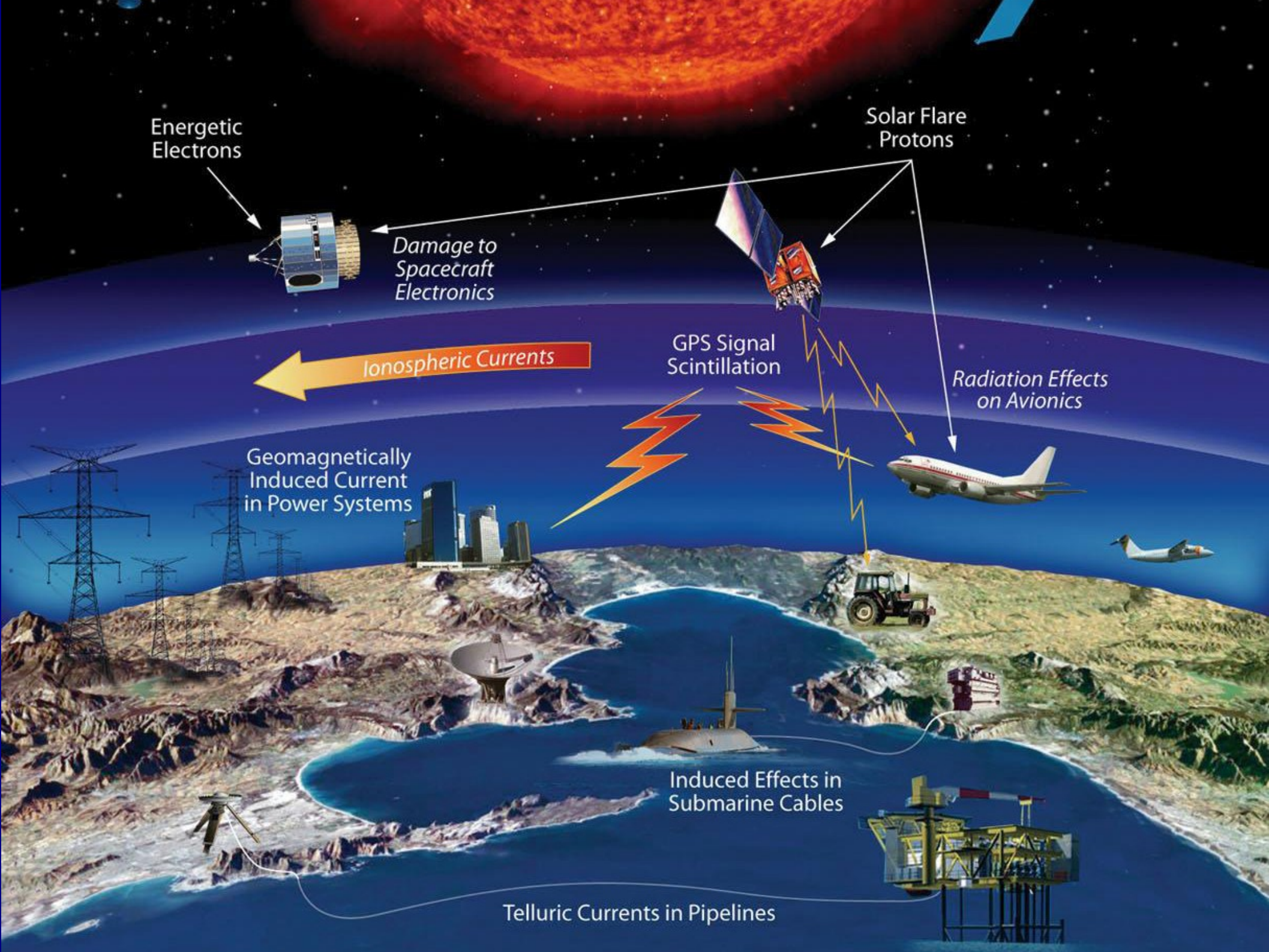
Earth's Magnetic Field

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.



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.



Energetic
Electrons

Solar Flare
Protons

Damage to
Spacecraft
Electronics

Ionospheric Currents

GPS Signal
Scintillation

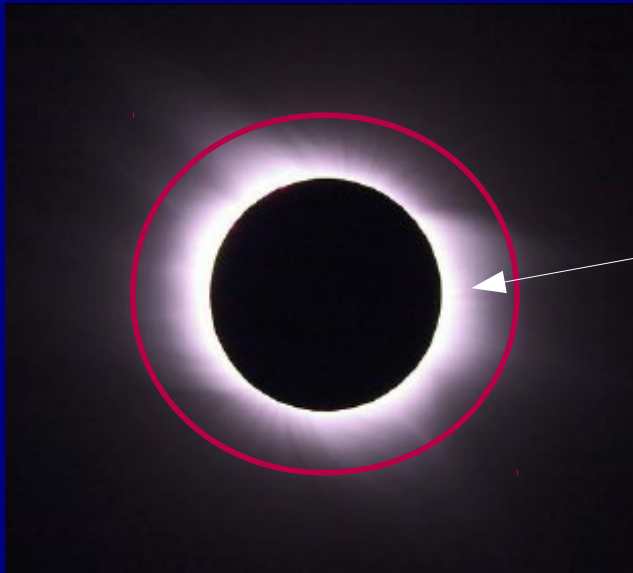
Radiation Effects
on Avionics

Geomagnetically
Induced Current
in Power Systems

Induced Effects in
Submarine Cables

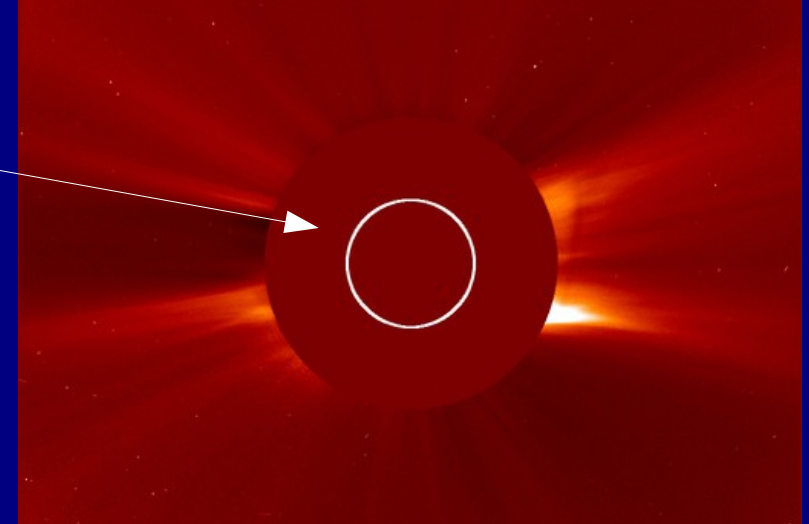
Telluric Currents in Pipelines

Coronal/Chromospheric Observations

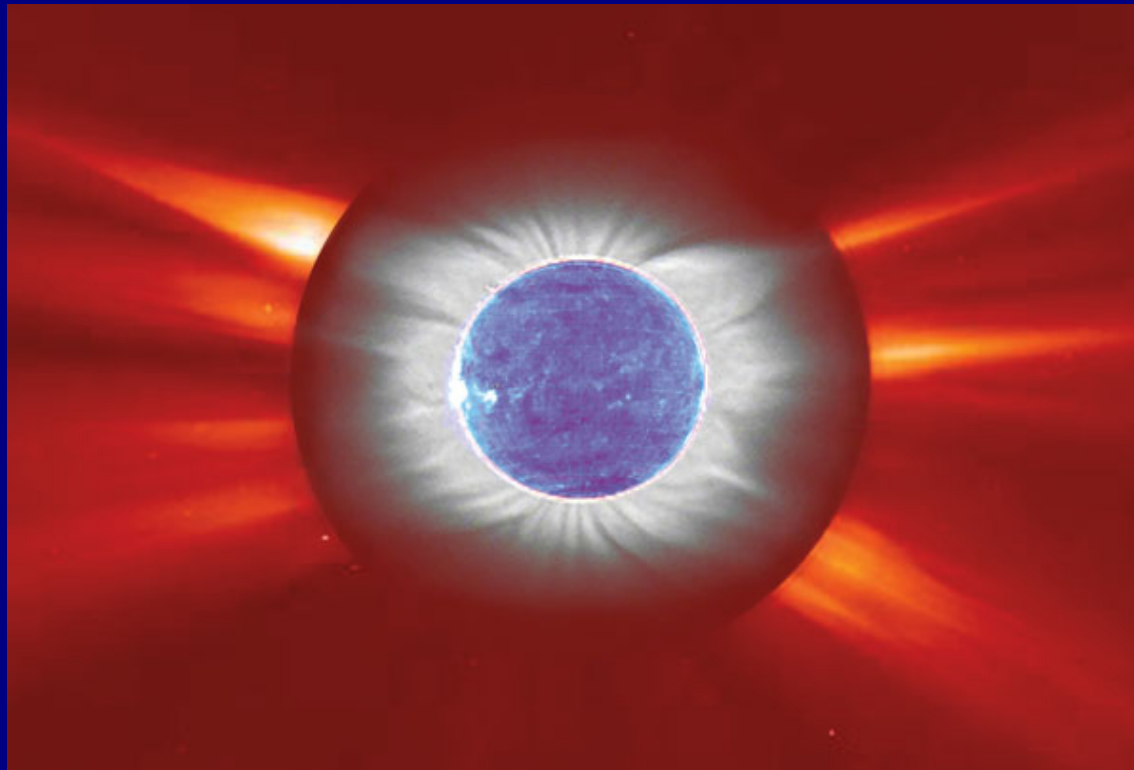


Inner Corona

SOLar and Heliospheric Observatory (SOHO) Coronagraph



Ground-based observatories see up to about 1.3 times the radius of the Sun.



Space-based telescopes see from about 2.2. to 30 times the solar radius.

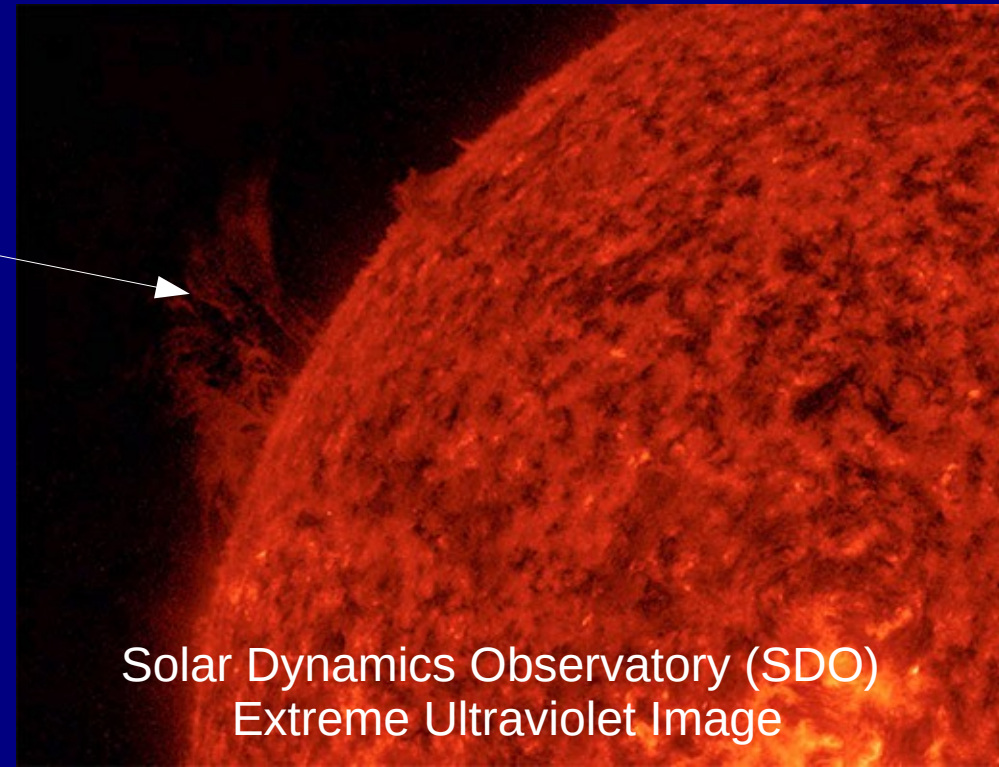
March 2006

Standardized Eclipse Observations

Citizen Continental-America Telescopic Eclipse Experiment (CATE):
<https://sites.google.com/site/citizencateexperiment/home/>



Prominences



Solar Dynamics Observatory (SDO)
Extreme Ultraviolet Image