Astronomy

Abell 1758
Galaxy Cluster
~3.2 billion ly

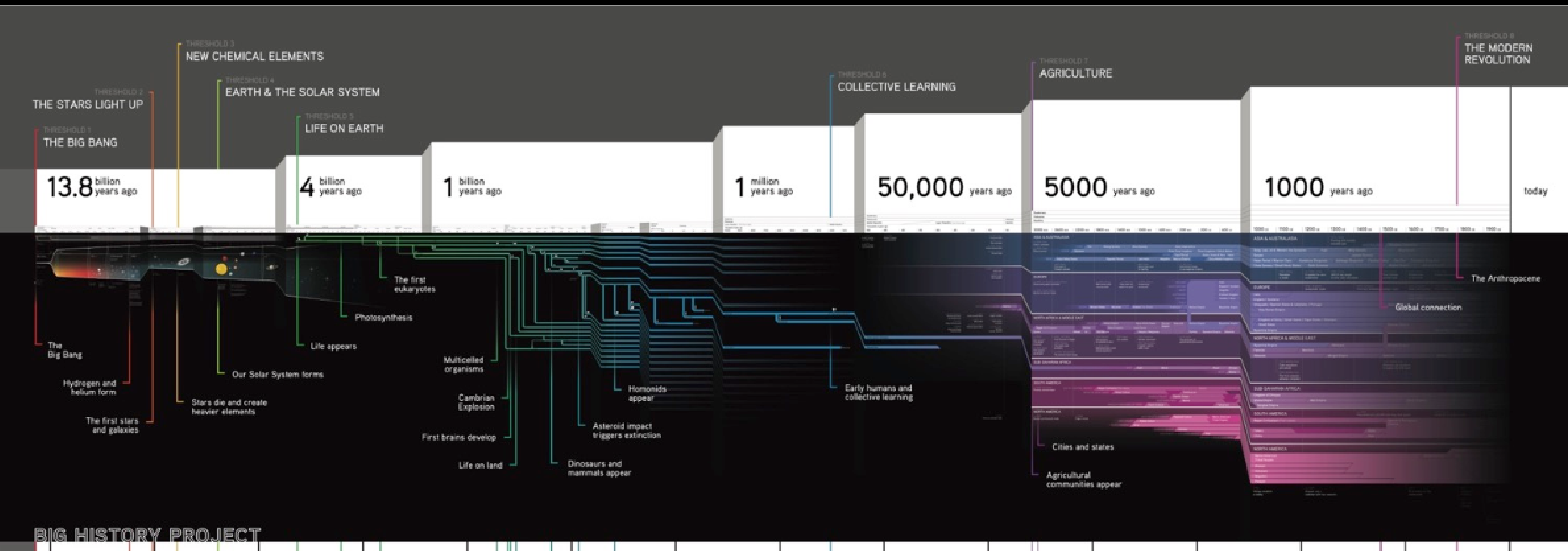
From http://chandra.harvard.edu

A Presentation for Arrow Head District Merit Badge Day

Mitzi Adams, Dr. Dennis Gallagher, Dr. Michael Zanetti
NASA/MSFC

March 9, 2019

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.

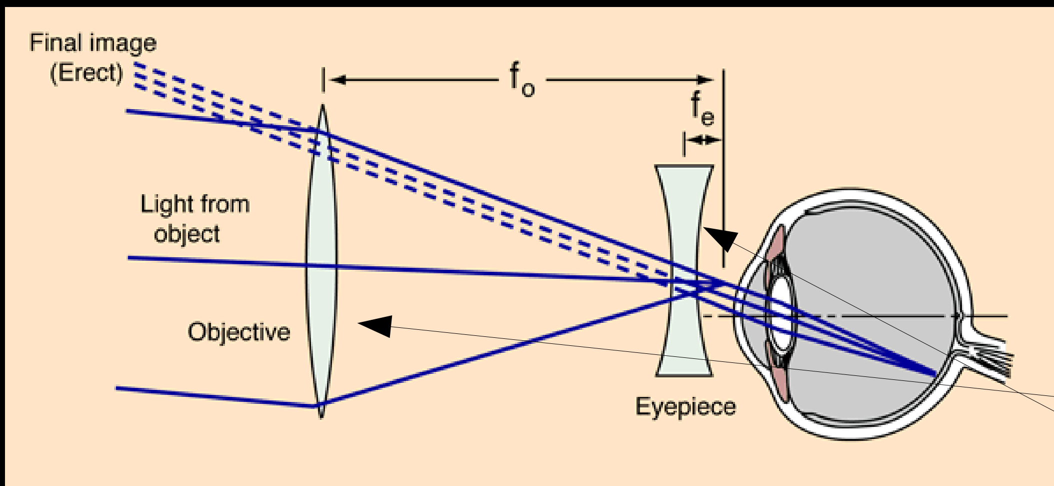
Count to one million -- 11.6 days

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

Count to 13.8 billion --> 439 years

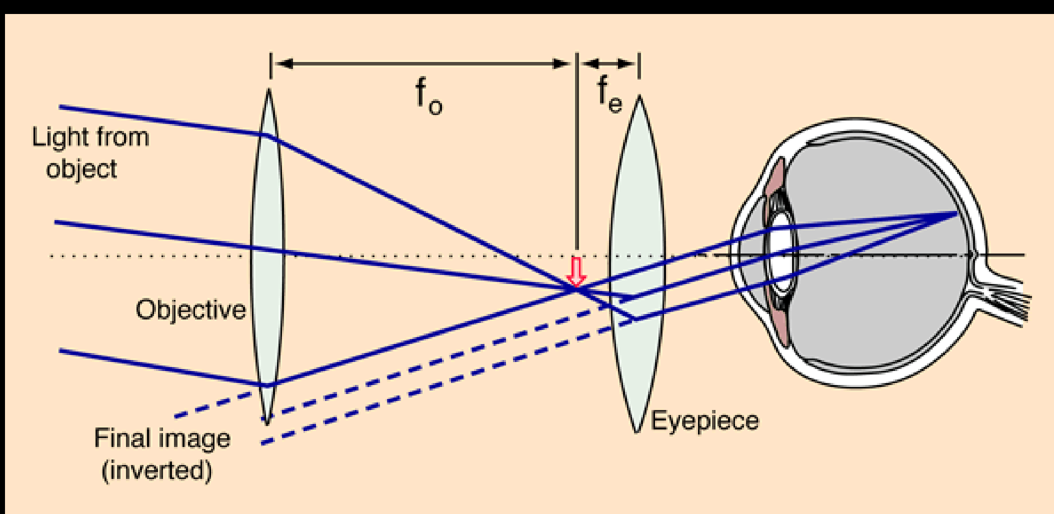
Optical Telescopes

Refractor
First Used by Galileo to do Astronomy



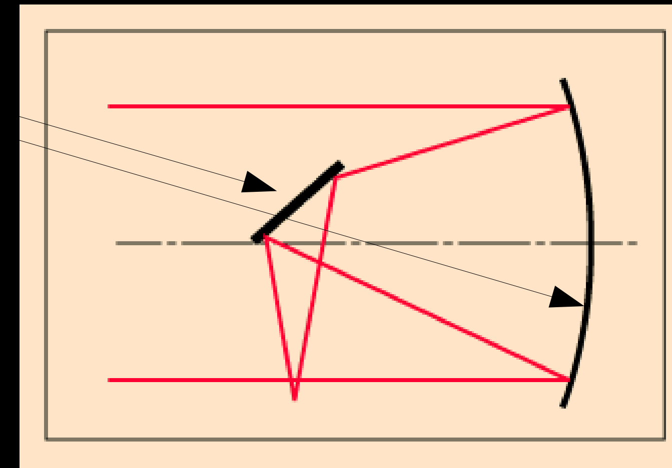
Lenses

Astronomical

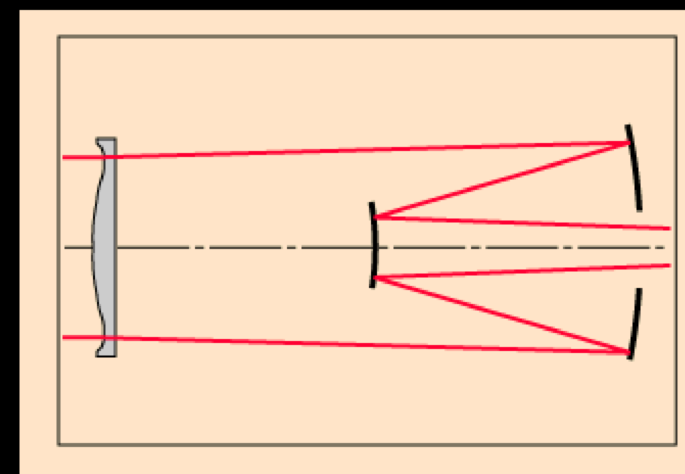


Reflector
Newtonian

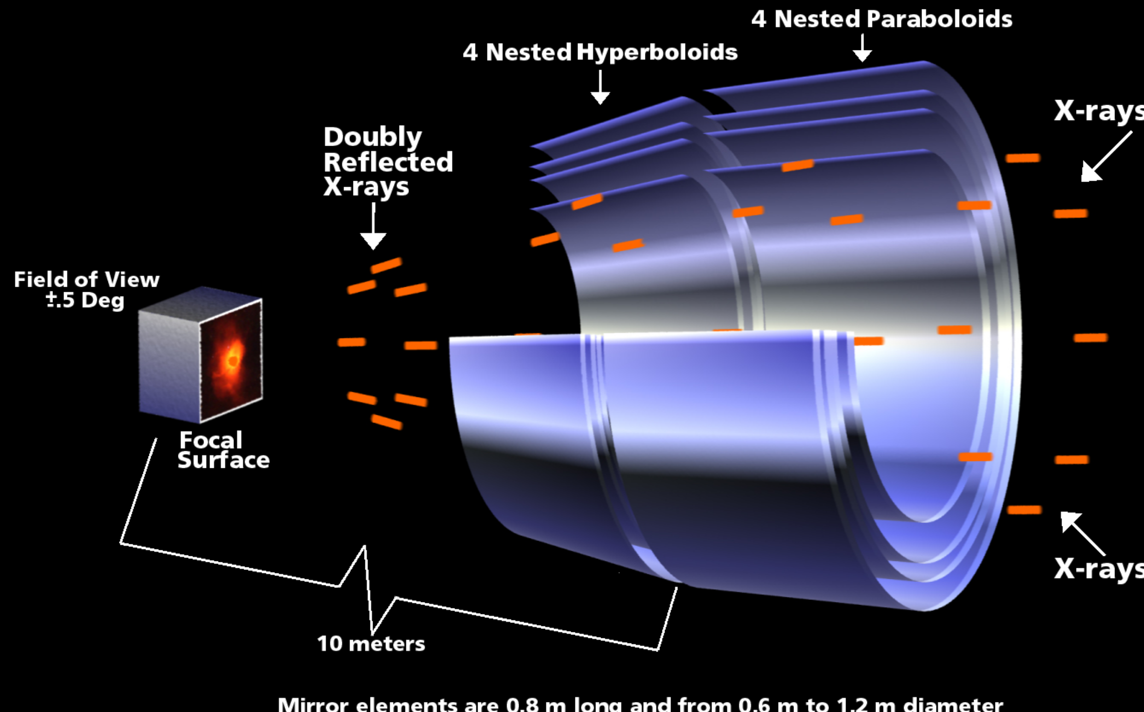
Mirrors



Schmidt-Cassegrain

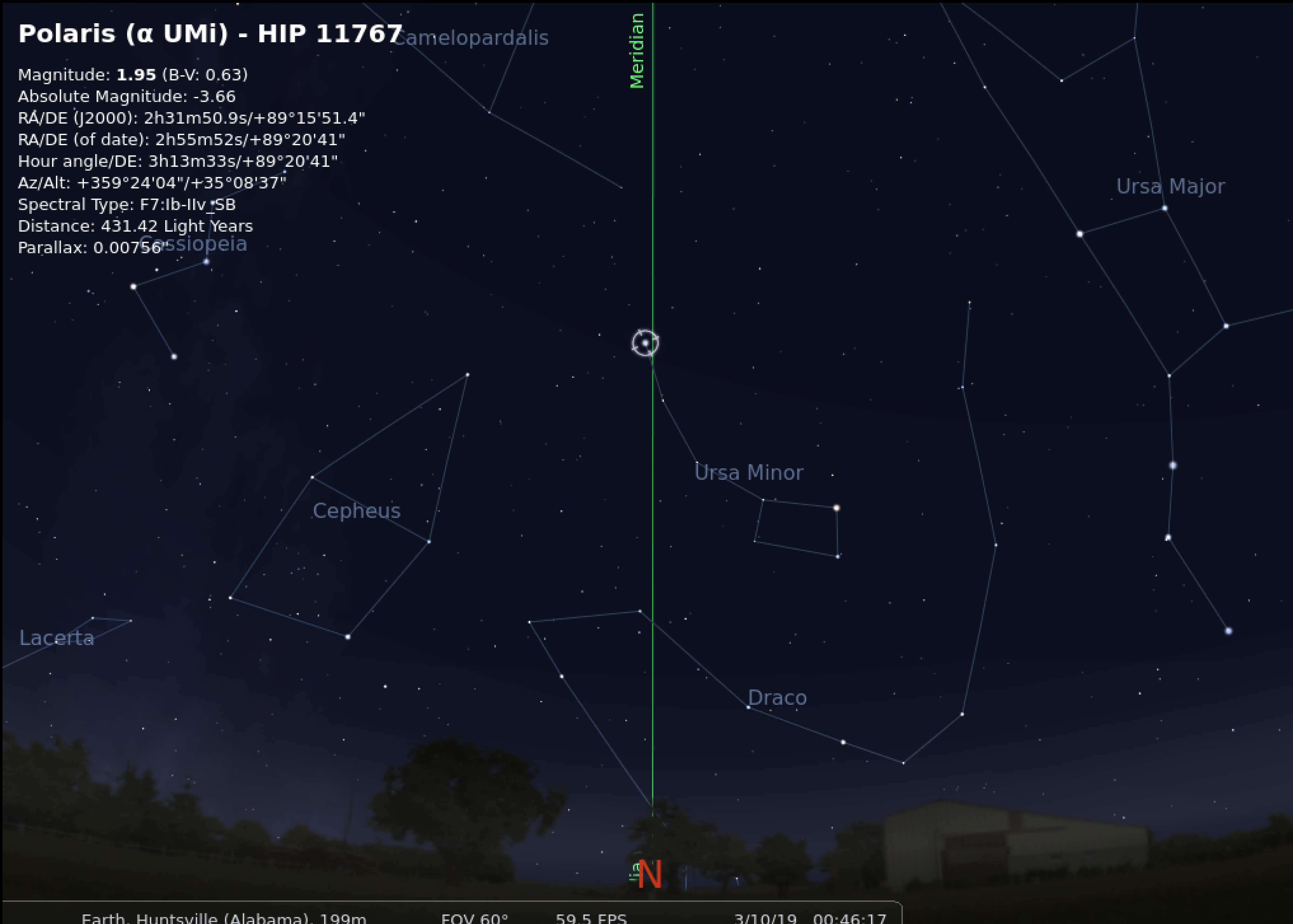


Chandra X-ray Optics

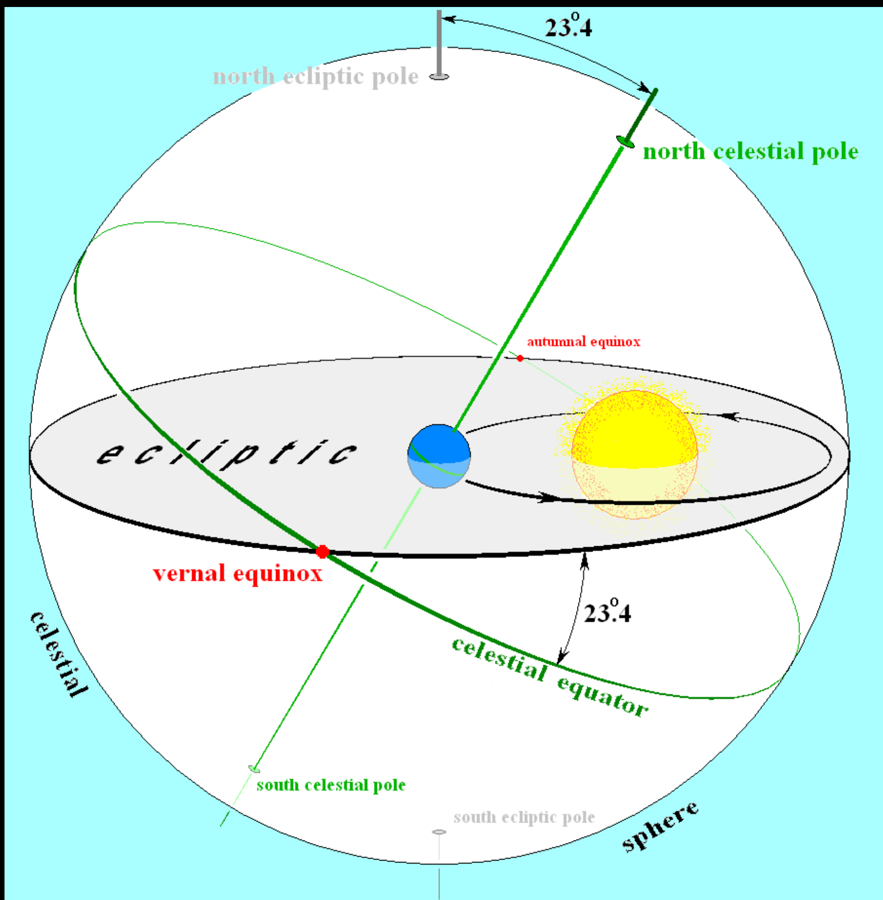


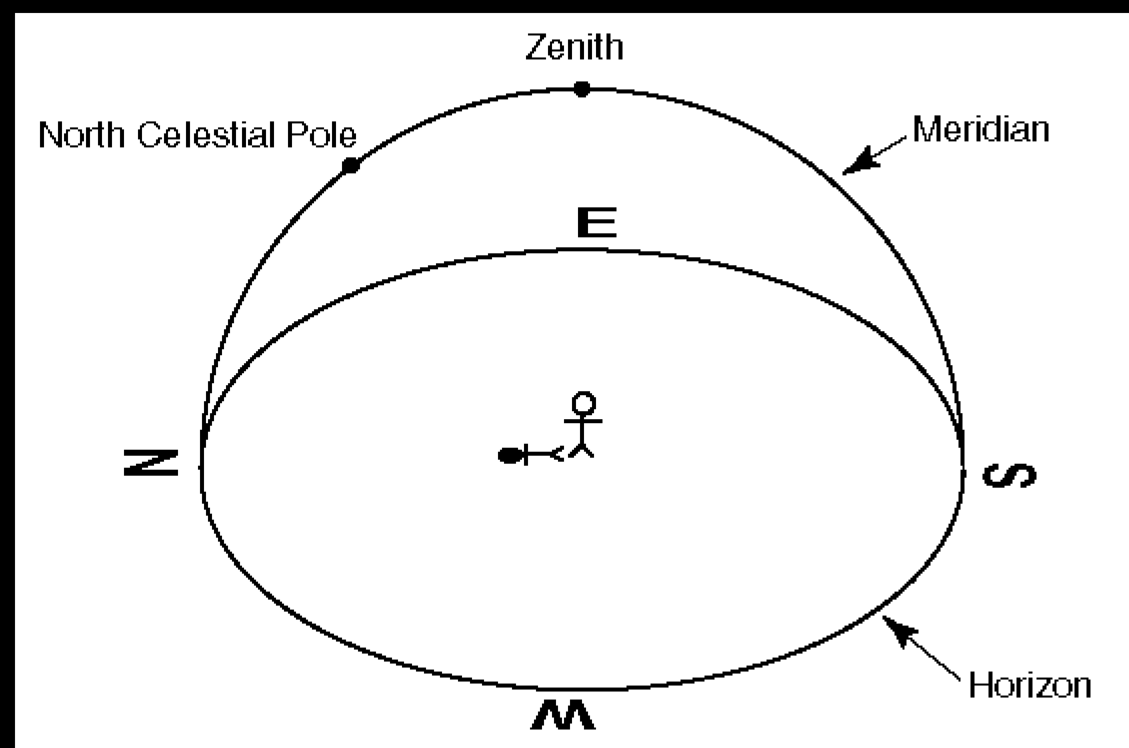
The alignment of the mirrors from one end of the mirror assembly to the other (2.7 meters or 9 feet) is accurate to 1.3 micrometers (50 millionths of an inch) or about one fiftieth the width of a human hair!

Constellations and Bright Stars


Polaris (α UMi) - HIP 11767
Magnitude: 1.95 (B-V: 0.63)
Absolute Magnitude: -3.66
RA/DE (J2000): 2h31m50.9s/+89°15'51.4"
RA/DE (of date): 2h55m52s/+89°20'41"
Hour angle/DE: 3h13m33s/+89°20'41"
Az/Alt: +359°24'04"/+35°08'37"
Spectral Type: F7:Ib-IIv_SB
Distance: 431.42 Light Years
Parallax: 0.00756"
Camelopardalis
Meridian
Cassiopeia
Ursa Major
Ursa Minor
Cepheus
Lacerta
Draco
N
Earth, Huntsville (Alabama), 199m
FOV 60°
59.5 FPS
3/10/19 00:46:17

Ecliptic, Equator, and Meridian

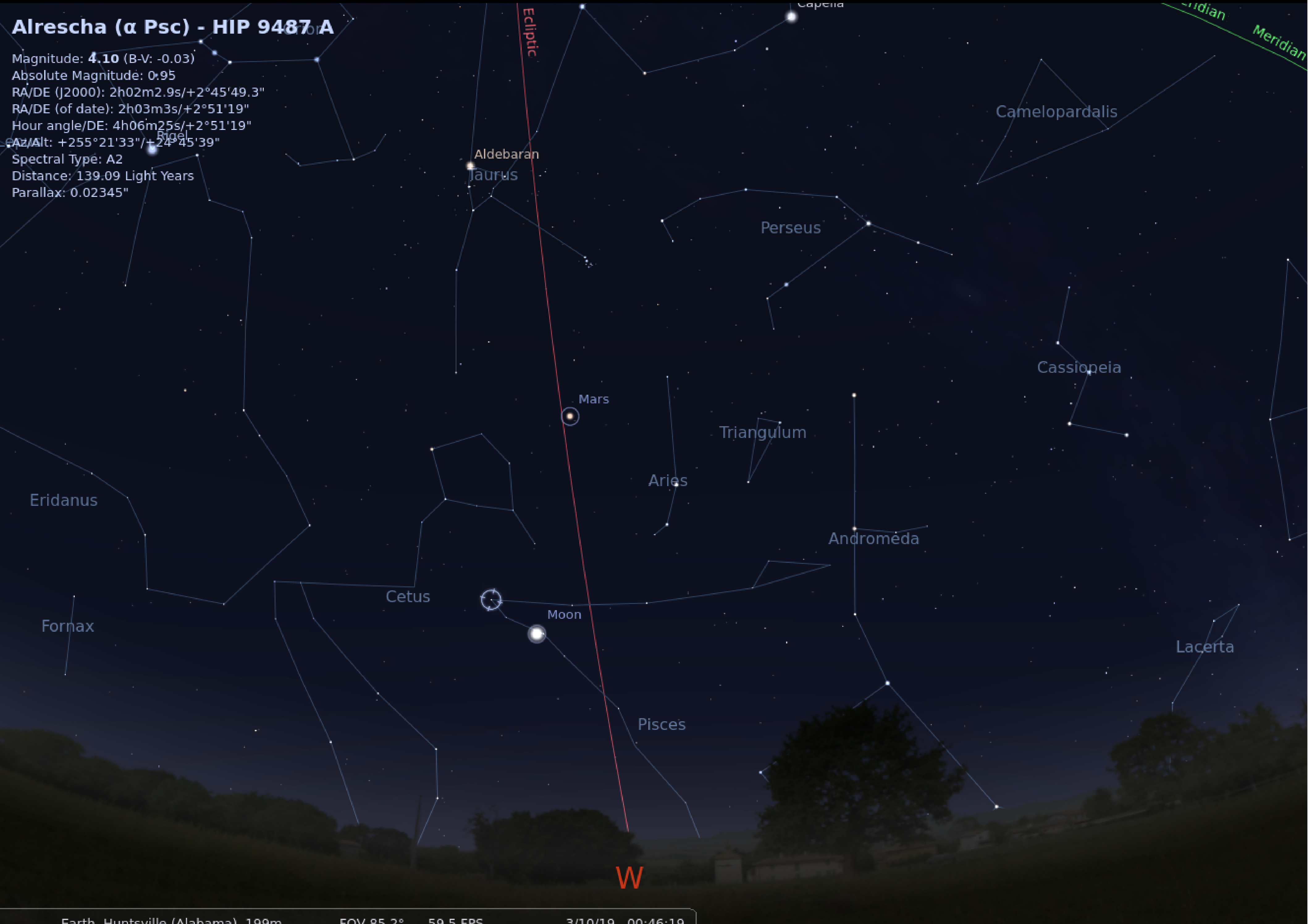




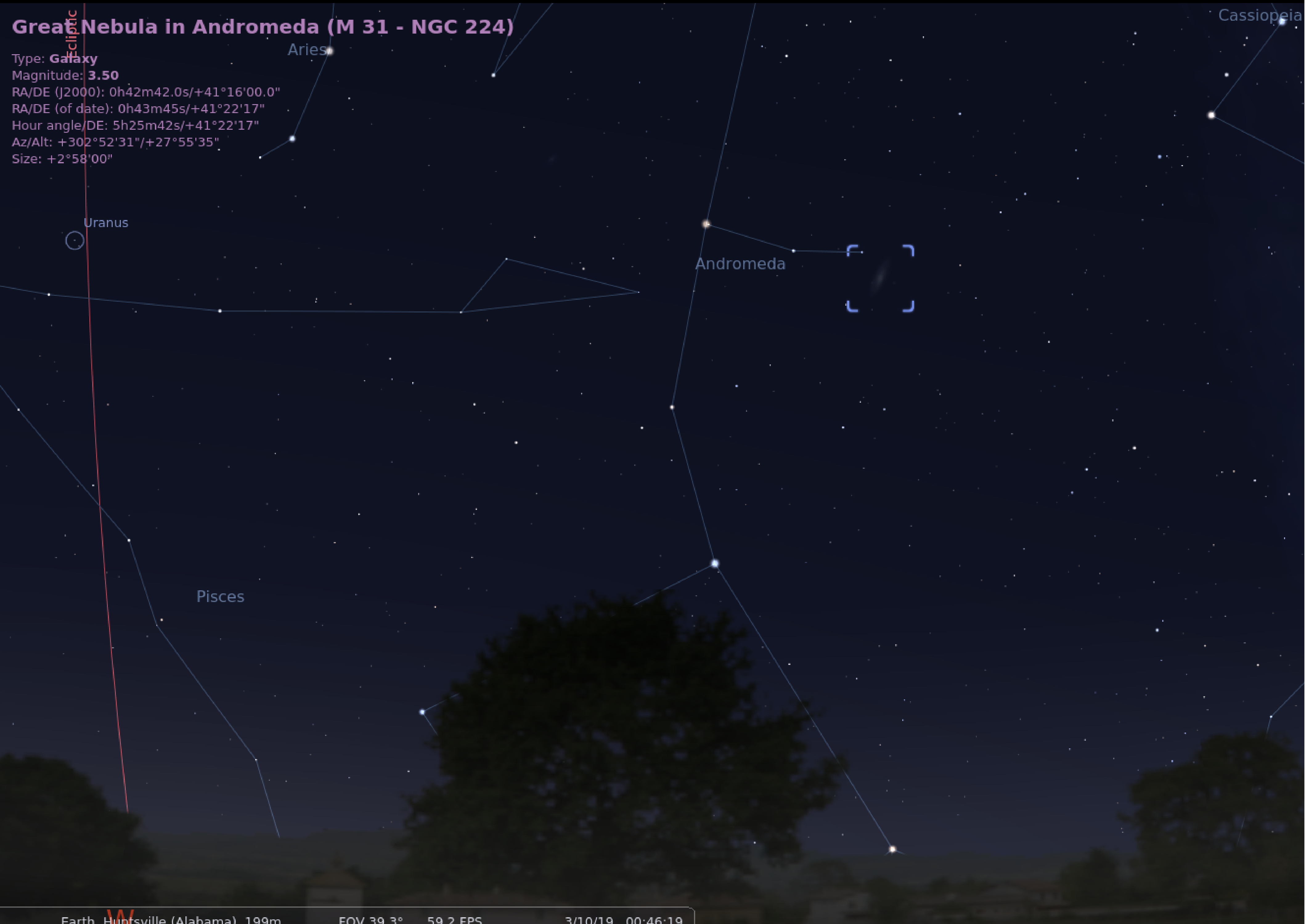

Regulus (α Leo) - HIP 49669
Magnitude: 1.35 (B-V: -0.09)
Absolute Magnitude: -0.53
RA/DE (J2000): 10h08m22.1s/+11°58'02.9"
RA/DE (of date): 10h09m24s/+11°52'23"
Hour angle/DE: 20h00m4s/+11°52'23"
Az/Alt: +97°22'14"/+31°18'10"
Spectral Type: B7V
Distance: 77.49 Light Years
Parallax: 0.04209"
Gemini
Ecliptic
Monoceros
Canis Minor
Procyon
Lynx
Cancer
Ursa Major
Leo Minor
Leo
Hydra
Sextans
Canes Venatici
Coma Berenices
Antlia
Pyxis
Earth, Huntsville (Alabama), 199m
FOV 85.2°
59.3 FPS
3/10/19 00:46:19

Alnitak (ζ Ori) - HIP 26727 A
Magnitude: 1.85 (B-V: -0.09)
Absolute Magnitude: -5.15
RA/DE (J2000): 5h40m45.5s/-1°56'33.2"
RA/DE (of date): 5h41m44s/-1°56'02"
Hour angle/DE: 0h27m43s/-1°56'02"
Az/Alt: +191°30'08"/+52°47'01"
Spectral Type: O9.5Ib_SB
Distance: 817.43 Light Years
Parallax: 0.00399"
Gemini
Meridian
Cancer
Taurus
Aldebaran
Mars
Ecliptic
Betelgeuse
Orion
Canis Minor
Procyon
Monoceros
Rigel
Hydra
Sirius
Lepus
Canis Major
Eridanus
Columba
Pyxis
Puppis
Fornax
Caelum
Antlia
Canopus
S
Earth, Huntsville (Alabama), 199m
FOV 85.2°
59.7 FPS
3/10/19 00:46:19


Capella (α Aur) - HIP 24608
Magnitude: 0.05 (B-V: 0.79)
Absolute Magnitude: -0.51
RA/DE (J2000): 5h16m41.6s/+45°59'48.0"
RA/DE (of date): 5h18m7s/+46°00'59"
Hour angle/DE: 0h37m41s/+46°00'59"
Az/Alt: +330°33'13"/+76°37'42"
Spectral Type: M1:_comp
Distance: 42.20 Light Years
Parallax: 0.07729"
Meridian
Camelopardalis
Andromeda
Leo Minor
Lynx
Perseus
Triangulum
Capella
Auriga
Aries
Cancer
Gemini
Mars
Taurus
Aldebaran
Canis Minor
Procyon
Betelgeuse
Orion
Monoceros
Meridian
Rigel
Earth, Huntsville (Alabama), 199m
FOV 85.2°
59.6 FPS
3/10/19 00:32:42

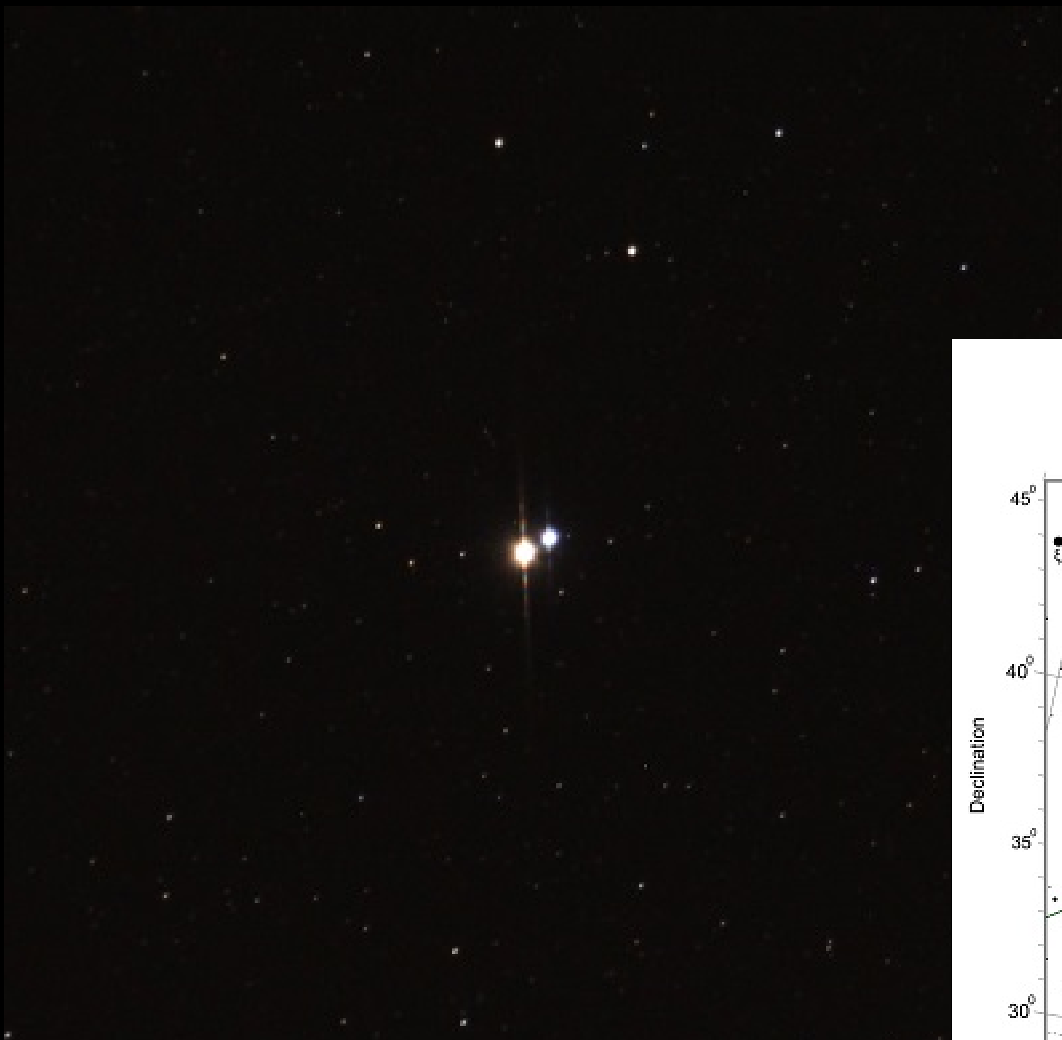


Alrescha (α Psc) - HIP 9487 A
Magnitude: 4.10 (B-V: -0.03)
Absolute Magnitude: 0.95
RA/DE (J2000): 2h02m2.9s/+2°45'49.3"
RA/DE (of date): 2h03m3s/+2°51'19"
Hour angle/DE: 4h06m25s/+2°51'19"
Az/Alt: +255°21'33"/+24°45'39"
Spectral Type: A2
Distance: 139.09 Light Years
Parallax: 0.02345"
Ecliptic
Meridian
Camelopardalis
Aldebaran
Taurus
Perseus
Cassiopeia
Mars
Triangulum
Aries
Eridanus
Andromeda
Cetus
Moon
Fornax
Lacerta
Pisces
W
Earth, Huntsville (Alabama), 199m
FOV 85.2°
59.5 FPS
3/10/19
00:46:19

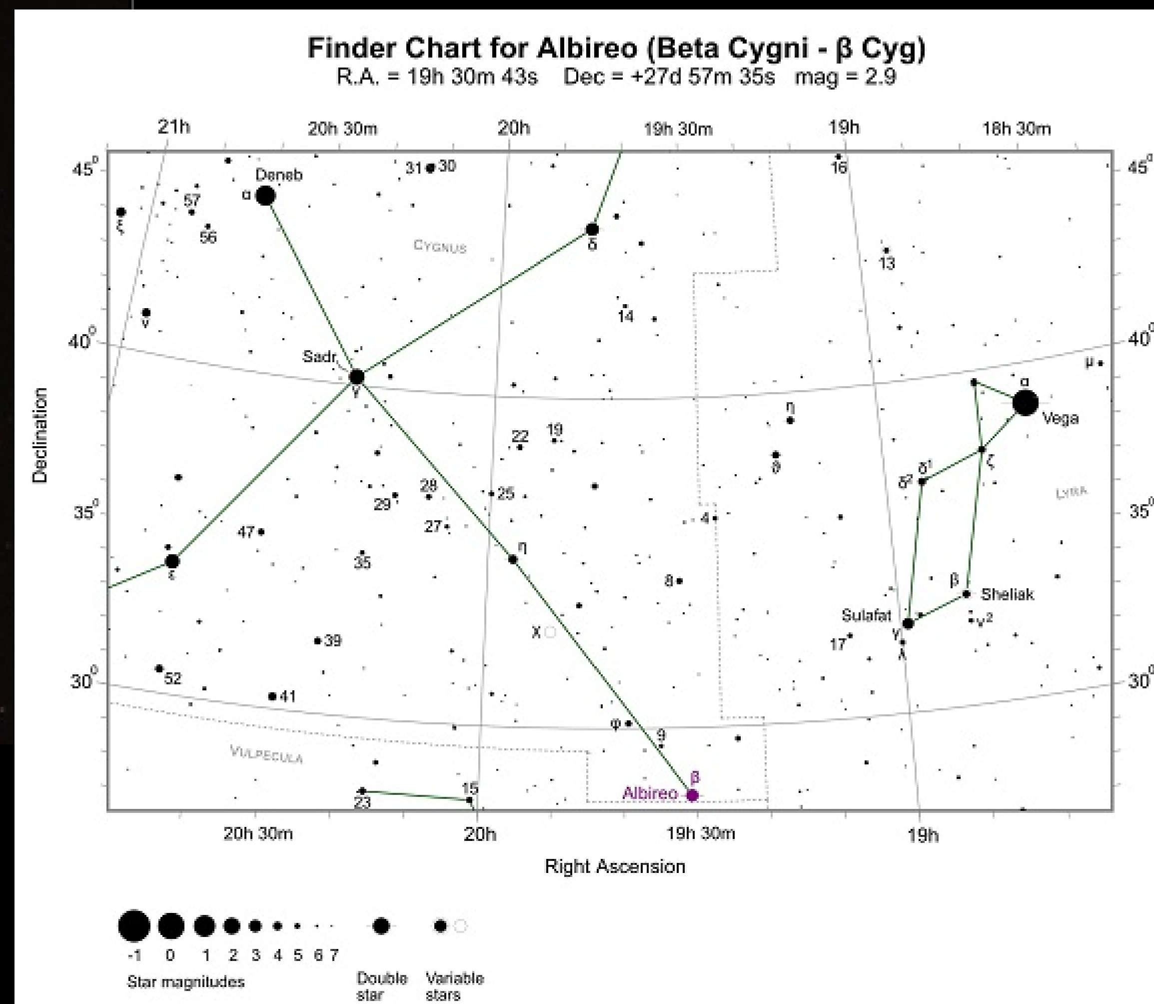


Great Nebula in Andromeda (M 31 - NGC 224)
Type: Galaxy
Magnitude: 3.50
RA/DE (J2000): 0h42m42.0s/+41°16'00.0"
RA/DE (of date): 0h43m45s/+41°22'17"
Hour angle/DE: 5h25m42s/+41°22'17"
Az/Alt: +302°52'31"/+27°55'35"
Size: +2°58'00"
Ecliptic
Aries
Cassiopeia
Uranus
Andromeda
Pisces
W
Earth, Huntsville (Alabama), 199m
FOV 39.3°
59.2 FPS
3/10/19 00:46:19

A Beautiful Binary Star System
Albireo

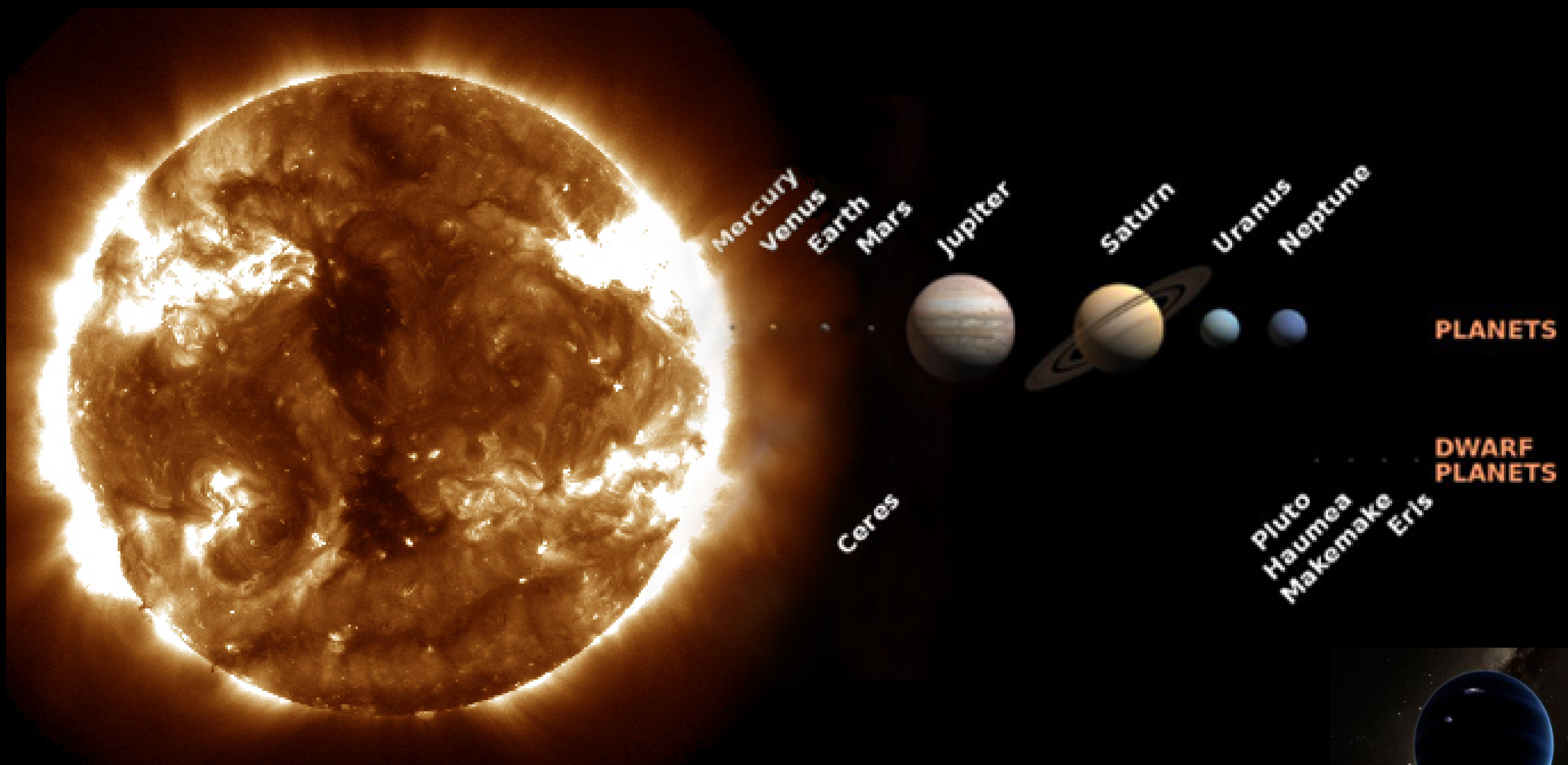


430 ly away
Look for Cygnus in summer



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

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

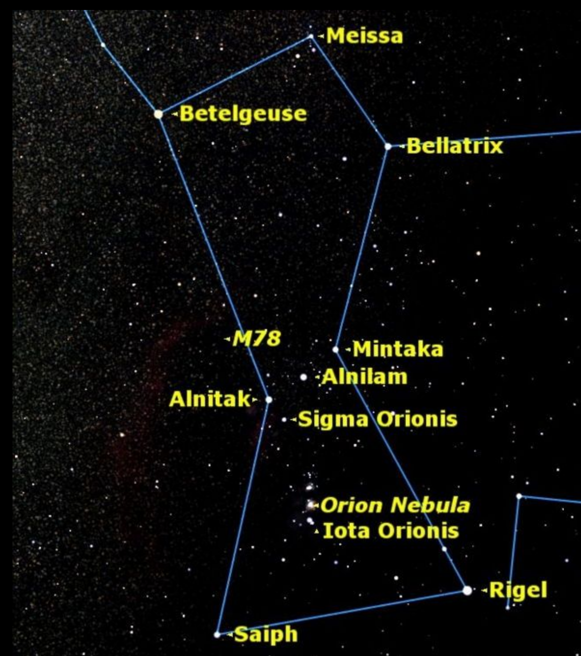


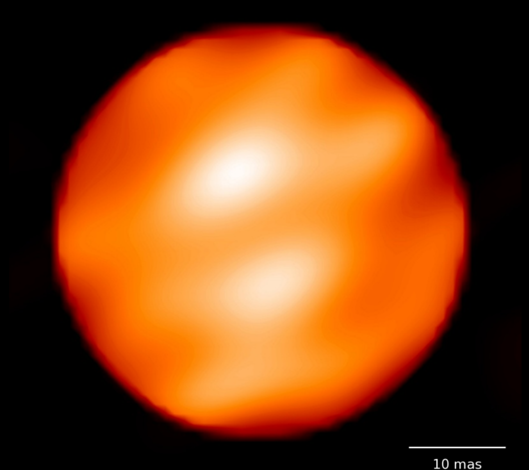
Planet Nine?

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.





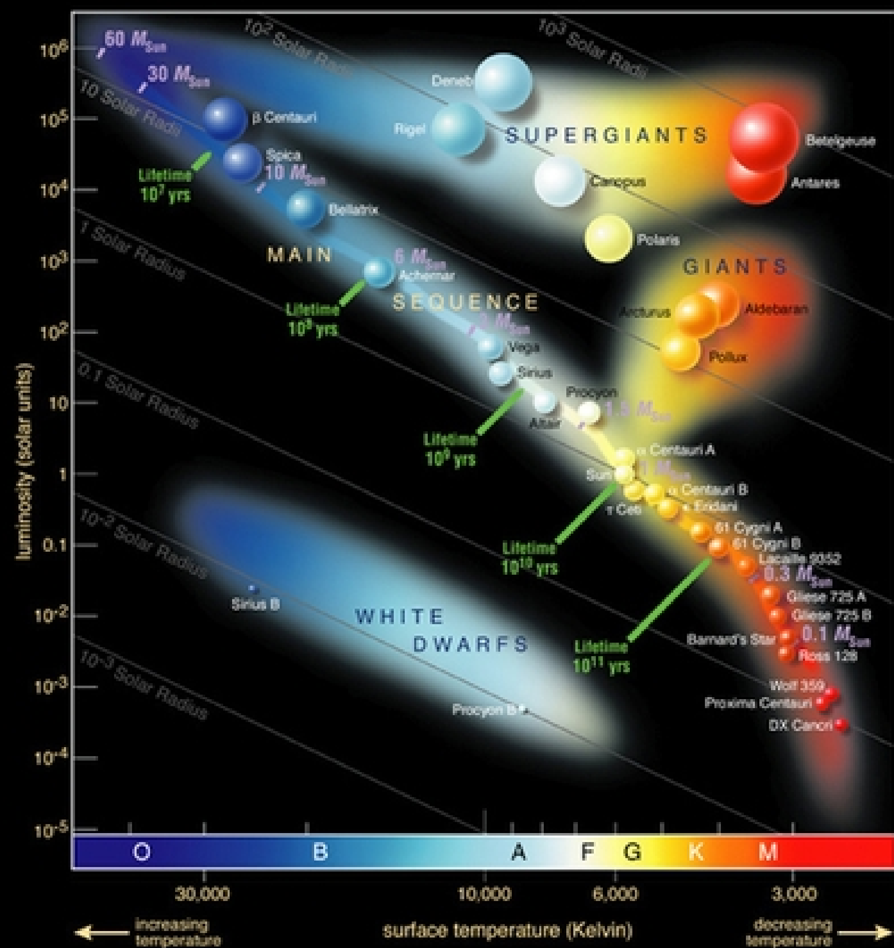
Betelgeuse: A red giant star, about 600 ly away, 3500 K, 1,180 $R_{\odot}$, 7.7 $M_{\odot}$.

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

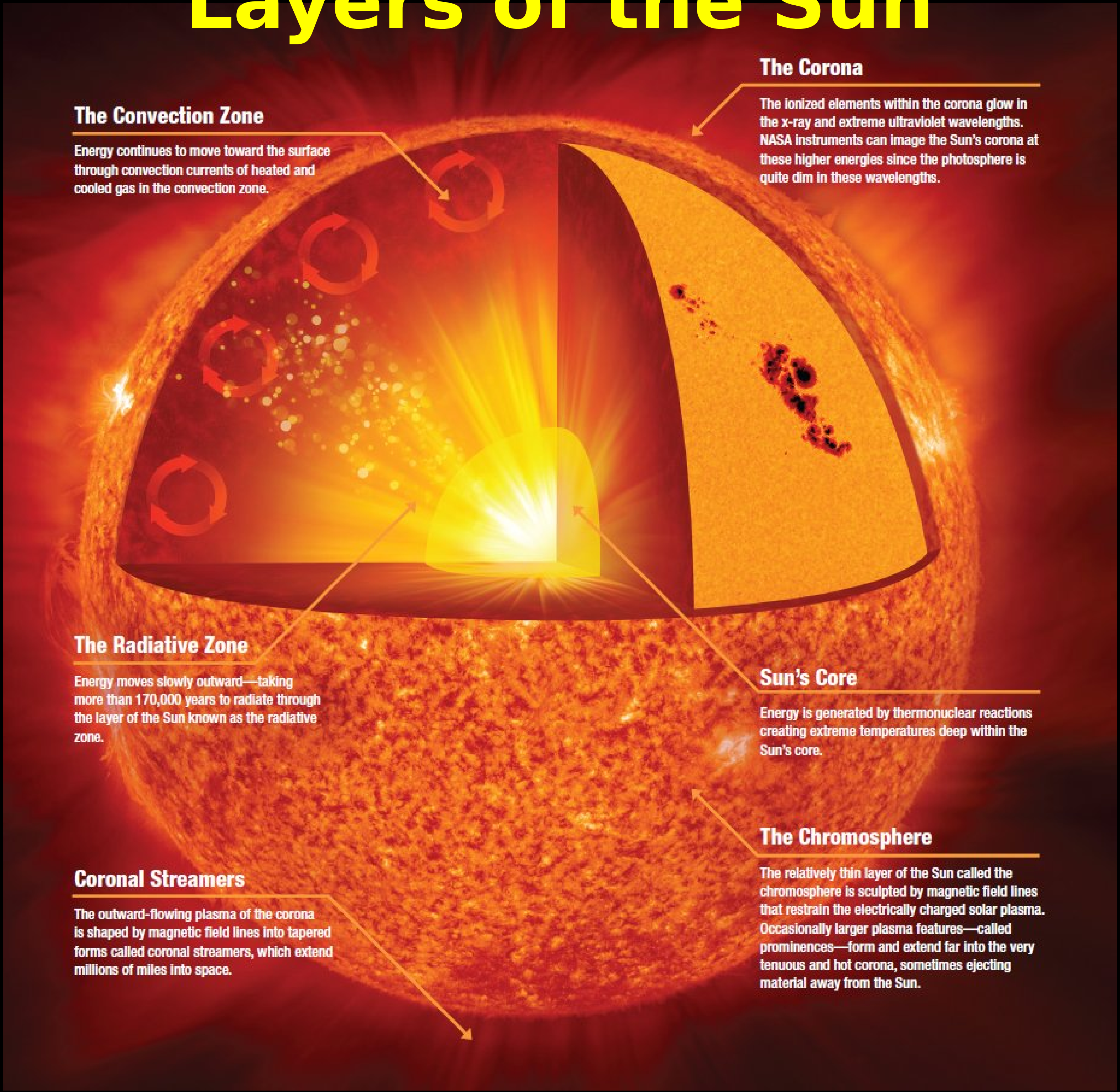


Cooler

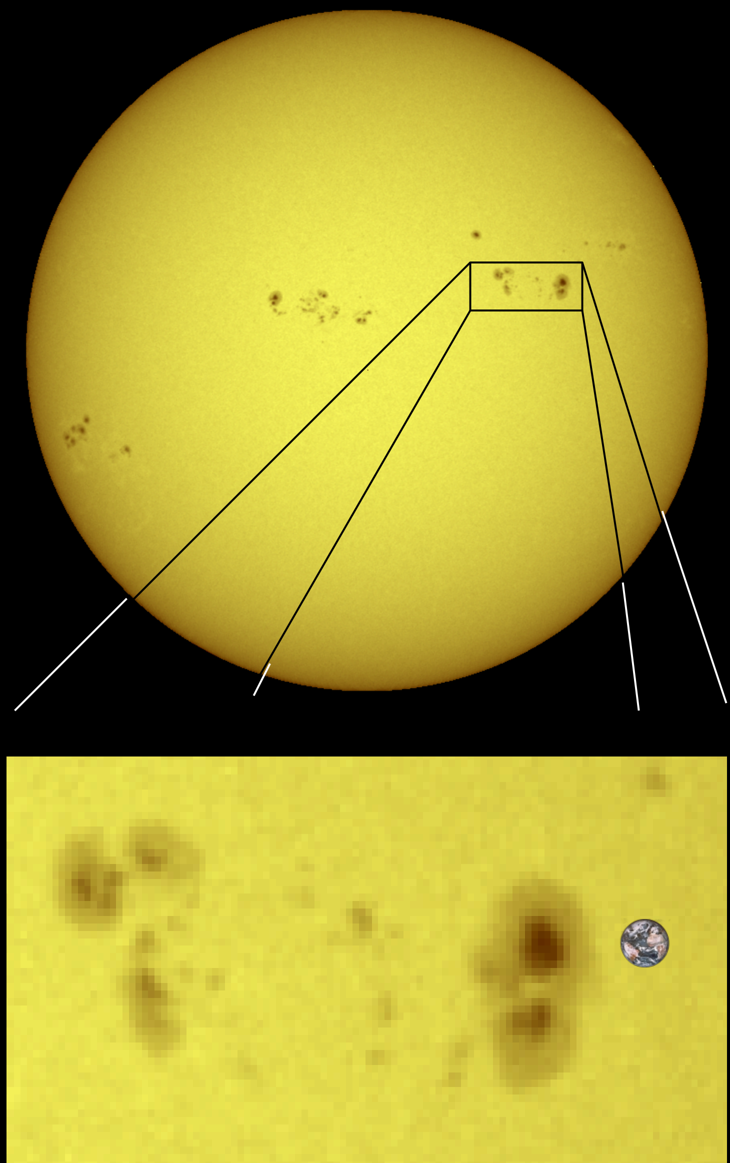
OBAFGKM

Overseas Broadcast A Flash, Godzilla Kills Mothra

Layers of the Sun



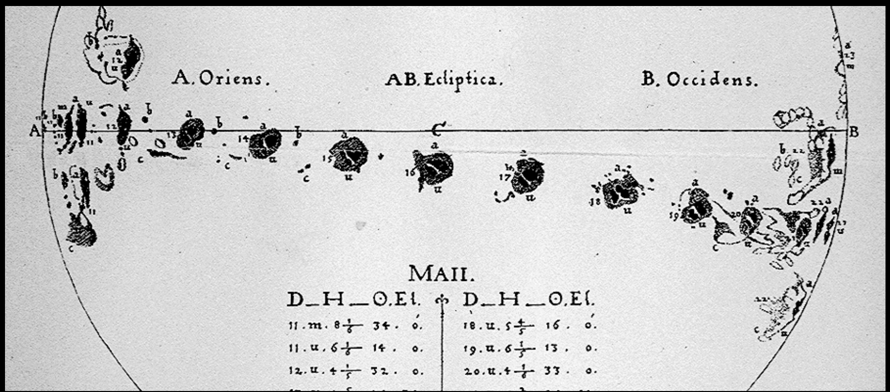
Sunspots



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).

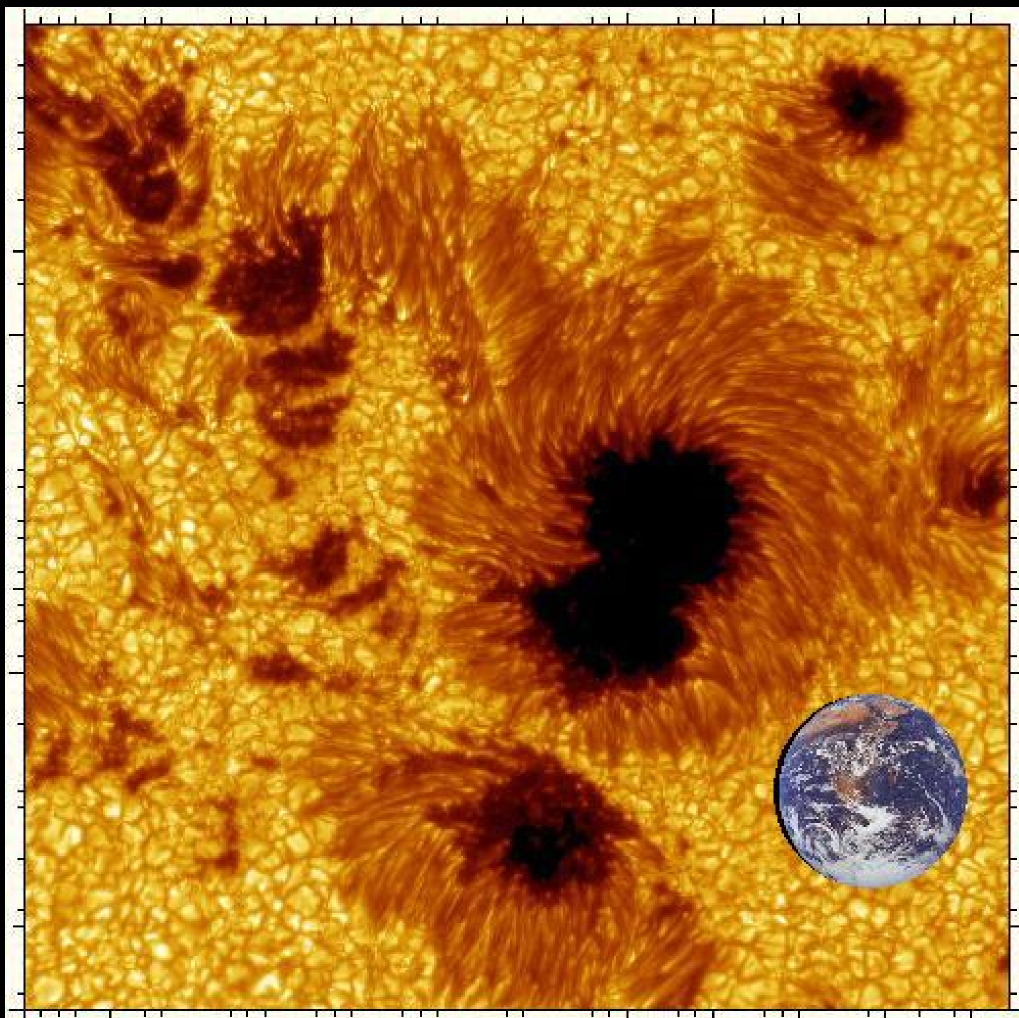
Sunspots usually appear in groups that form over hours or days and last for days or weeks.

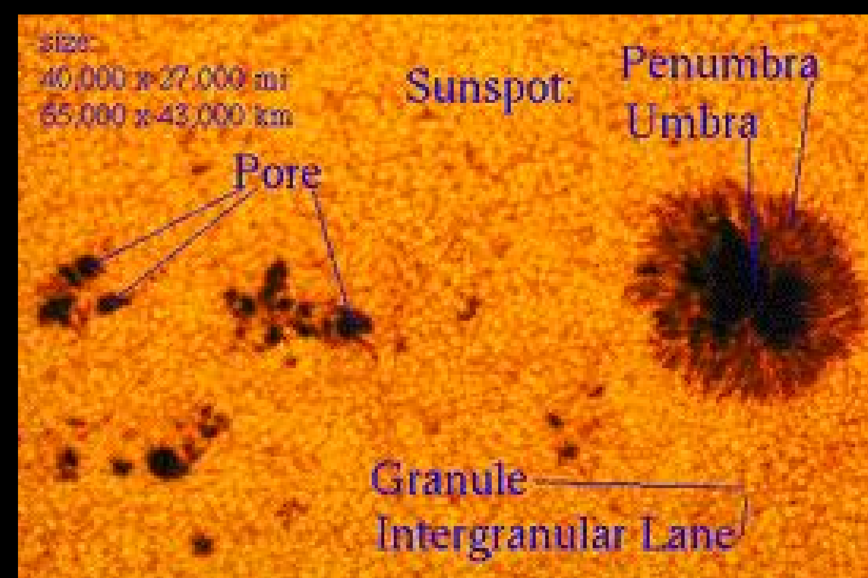
The earliest sunspot observations (c. 1609) indicated that the Sun rotates once in about 27 days.

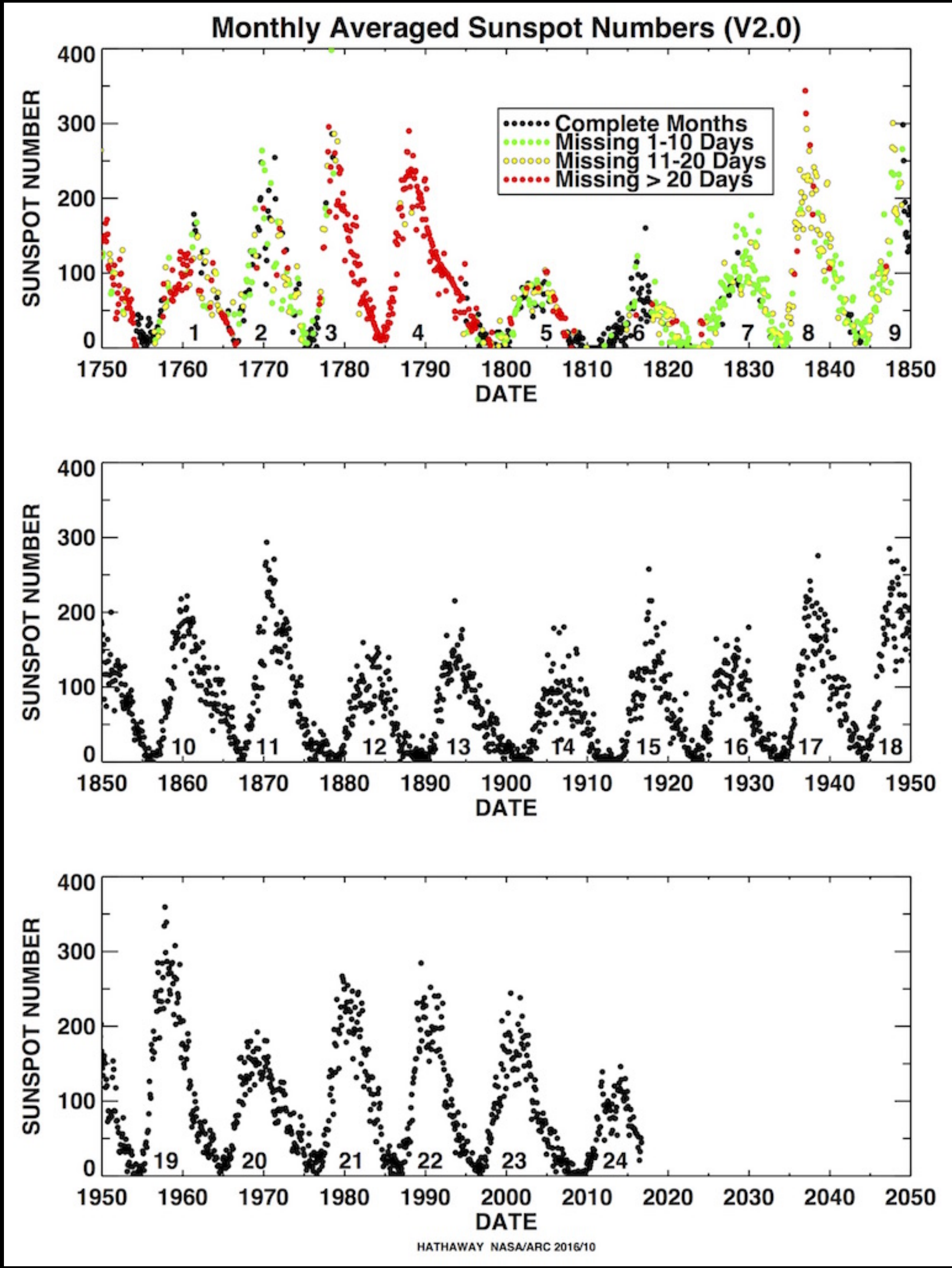


Sunspots

Examples







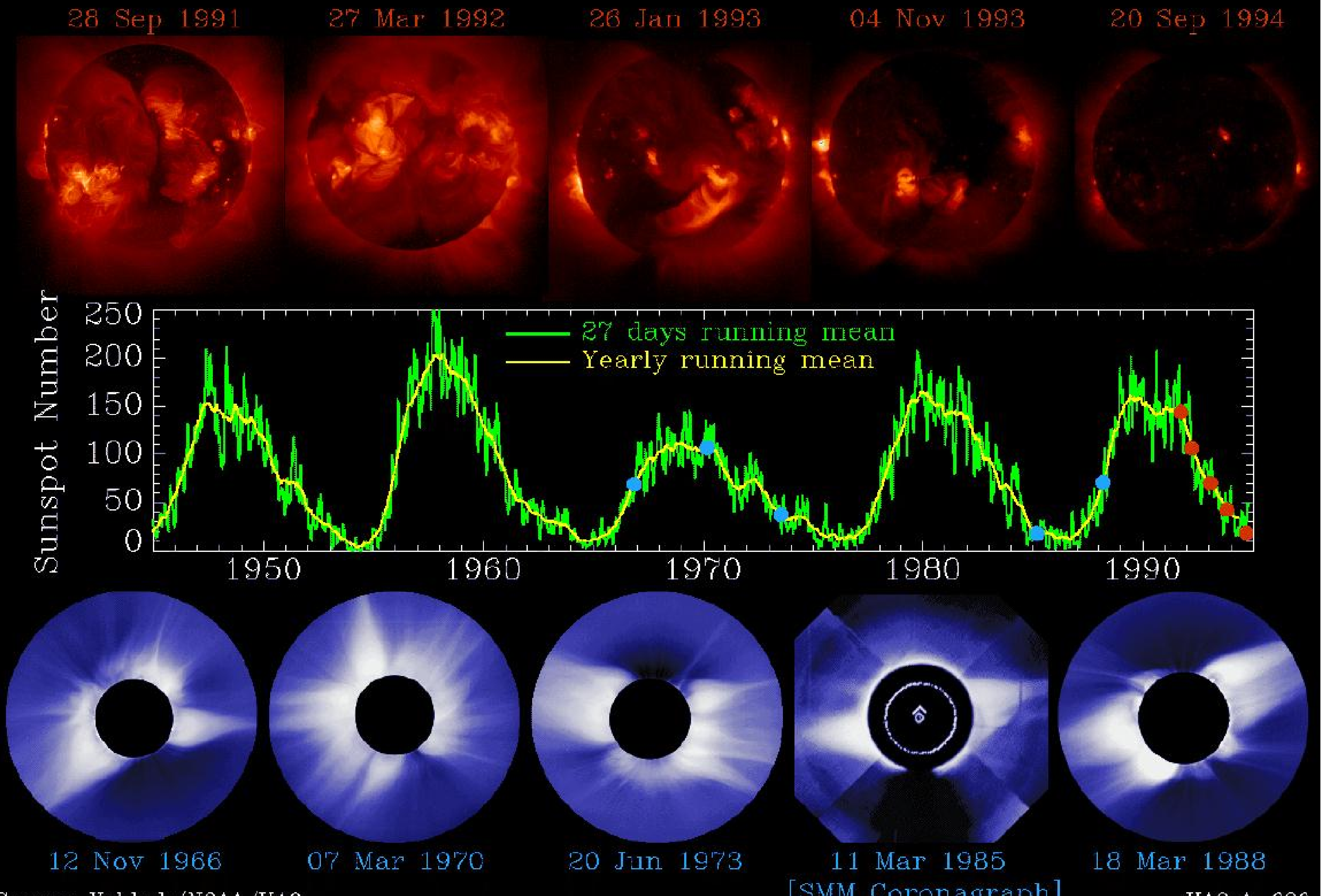
23 Full Cycles

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

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

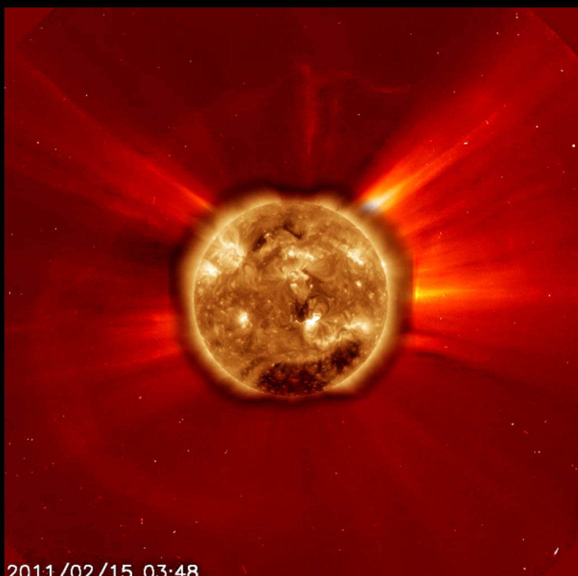
The average maximum number is about 100, but ranges from 50 to 200.

The Corona and the Solar Cycle

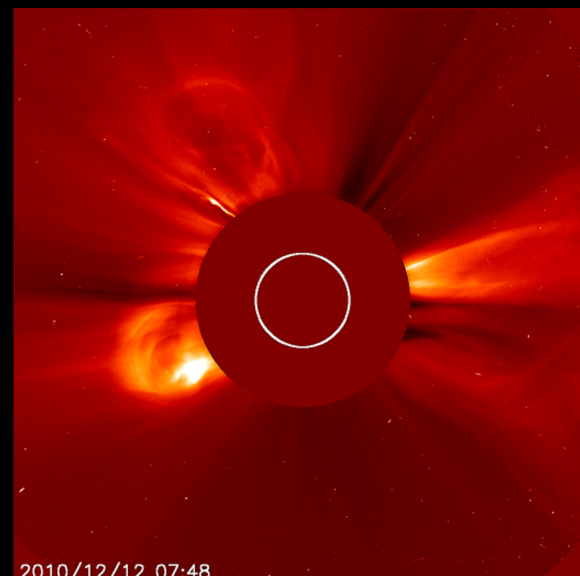


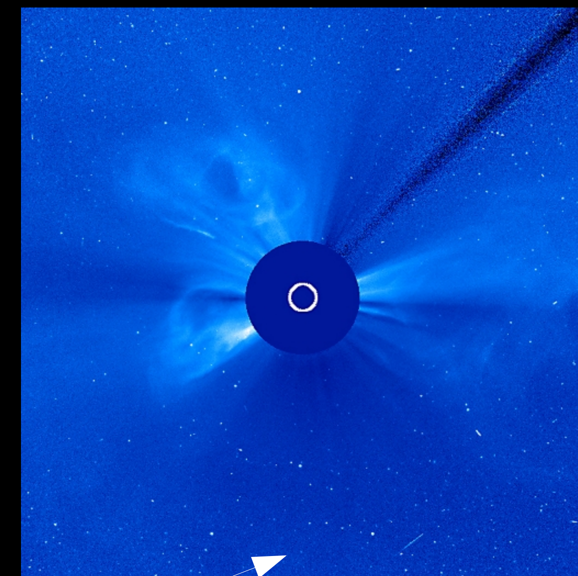
Solar Eruptions

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.

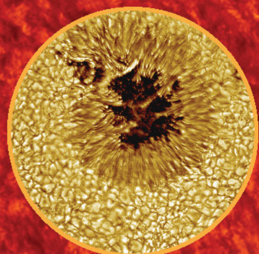
Animations!
c2_halloween_2003.mpg, c3_halloween_2003.mpg, X2_C2_combo_best.mpg

Space Weather

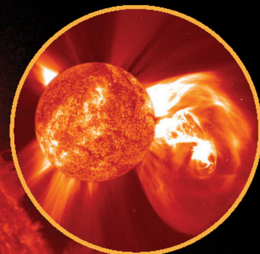
Space weather refers to the variable conditions on the Sun and in the space environment that can influence the performance and reliability of space-based and ground-based technological systems, as well as endanger life or health. Just like weather on Earth, space weather has its seasons, with solar activity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



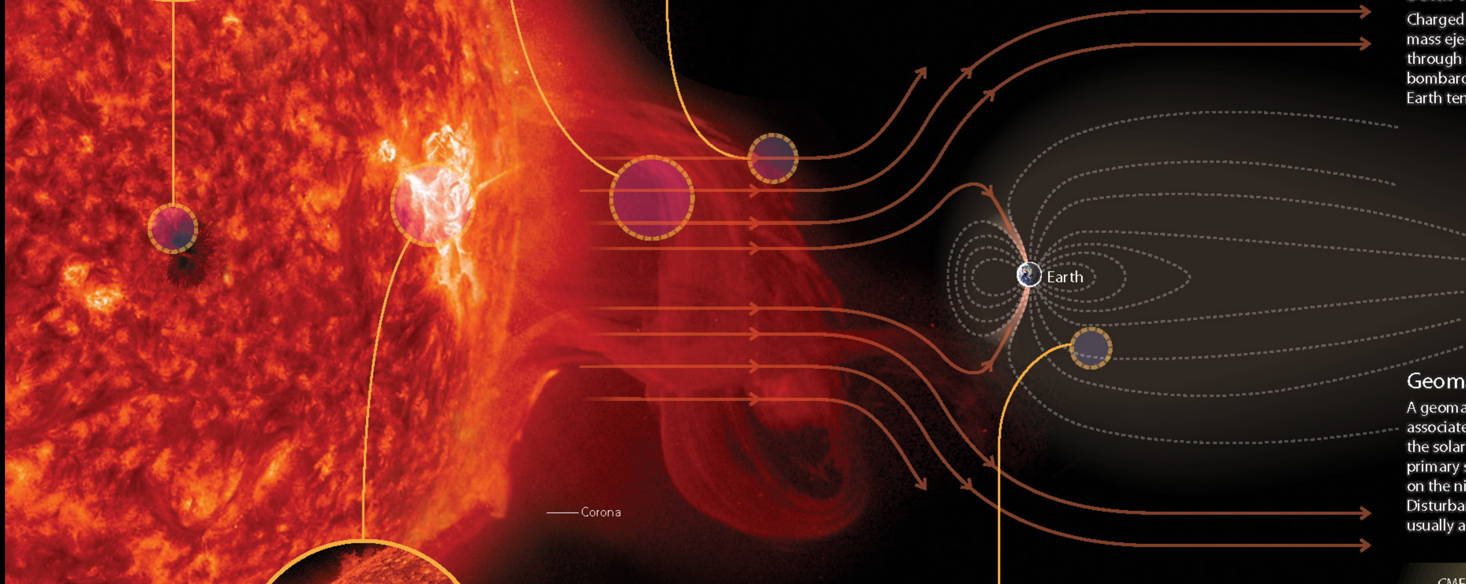
Coronal Mass Ejections (CMEs)



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!

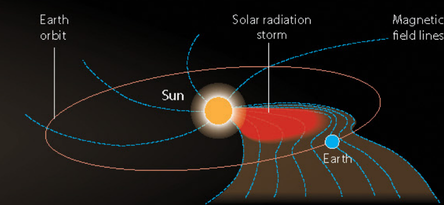


Sun's Magnetic Field

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.

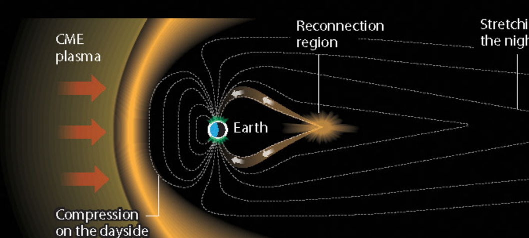
Solar Radiation Storms

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.

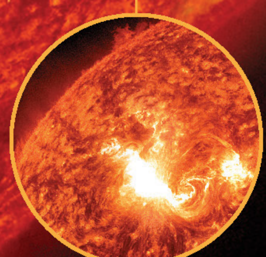


Geomagnetic Storms

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 atmosphere) 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.

NOAA Space Weather Prediction Center – www.spaceweather.gov

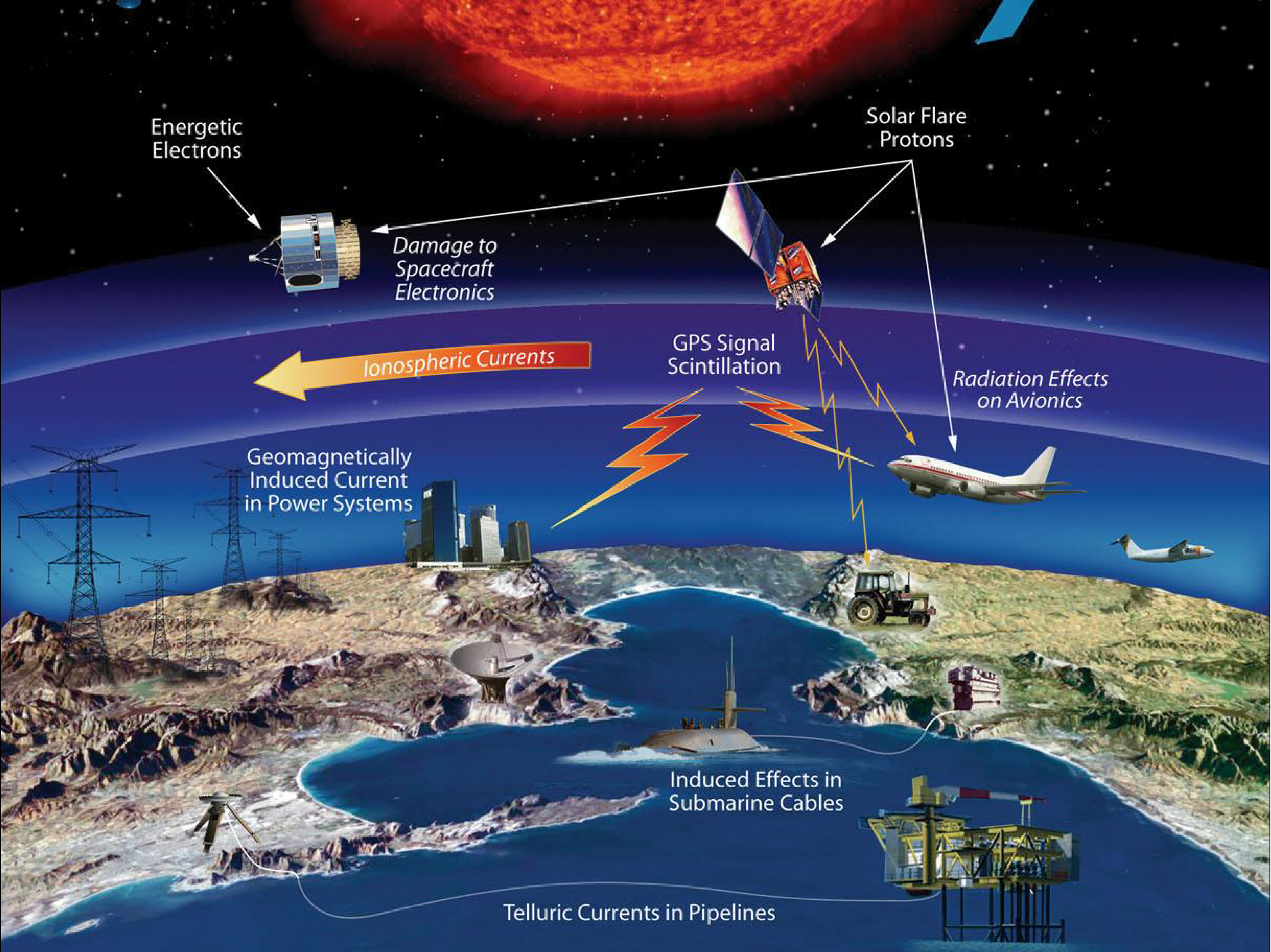
Source images: NASA, NOAA.

Aurorae

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

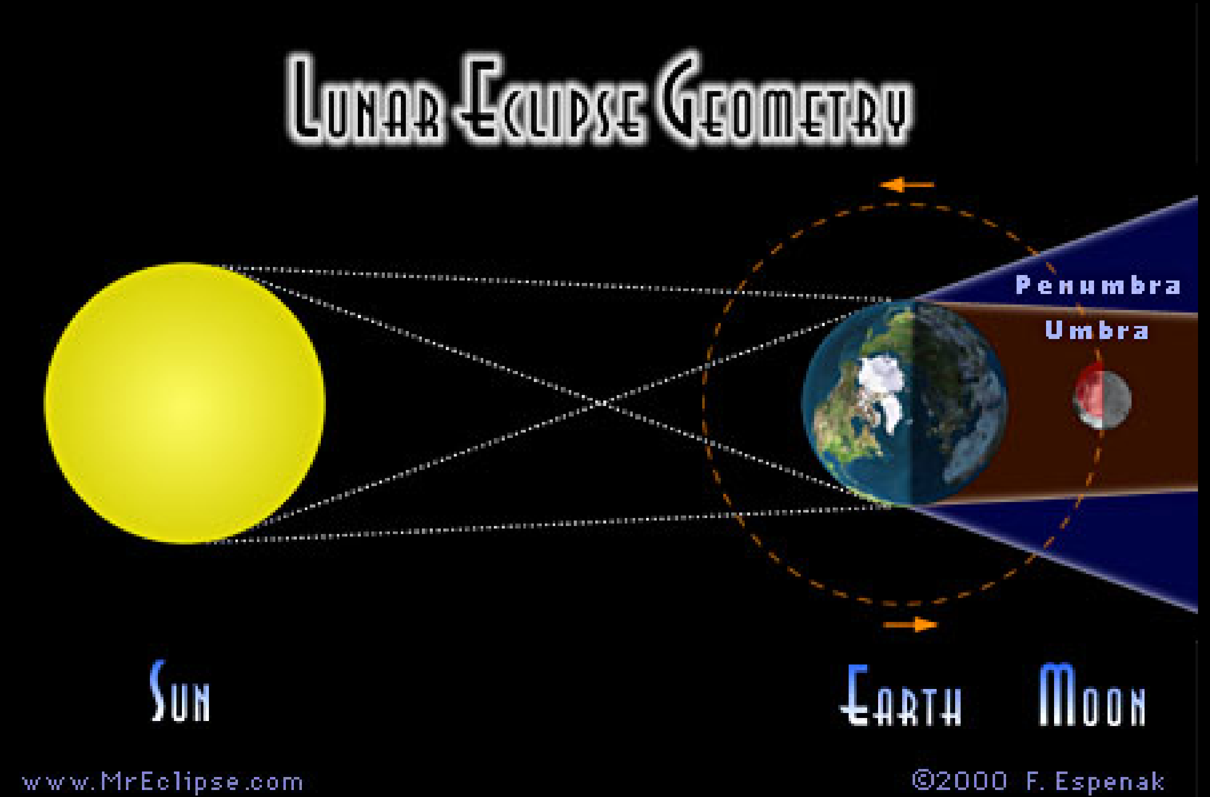
Plasma from the magnetosphere precipitates into the upper atmosphere.

Reds are from oxygen
Greens are from lower in atmosphere.


Energetic Electrons
Solar Flare Protons
Damage to Spacecraft Electronics
GPS Signal Scintillation
Ionospheric Currents
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.

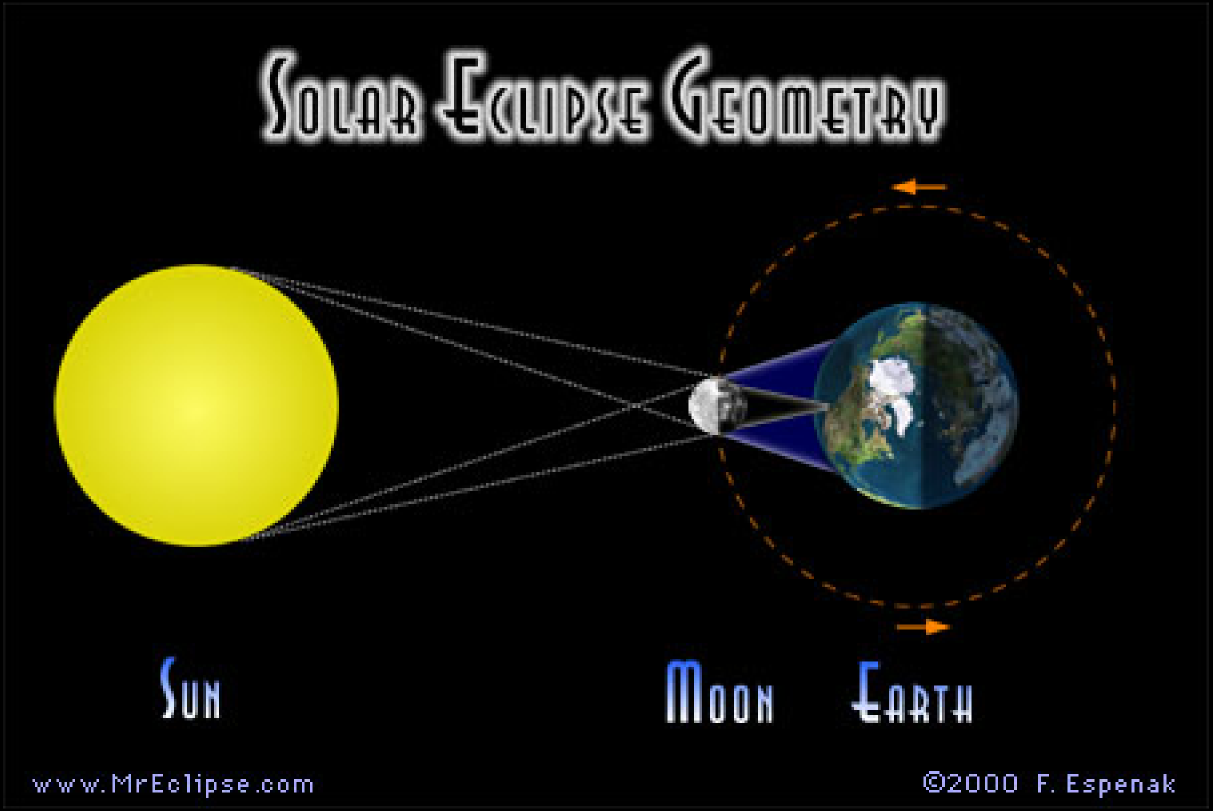


Images Used With Permission

Phases of the Moon

Image Credit: NASA/Bill Dunford

Solar Eclipses



Images Used With Permission

What You Can See

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

The Corona and Prominences

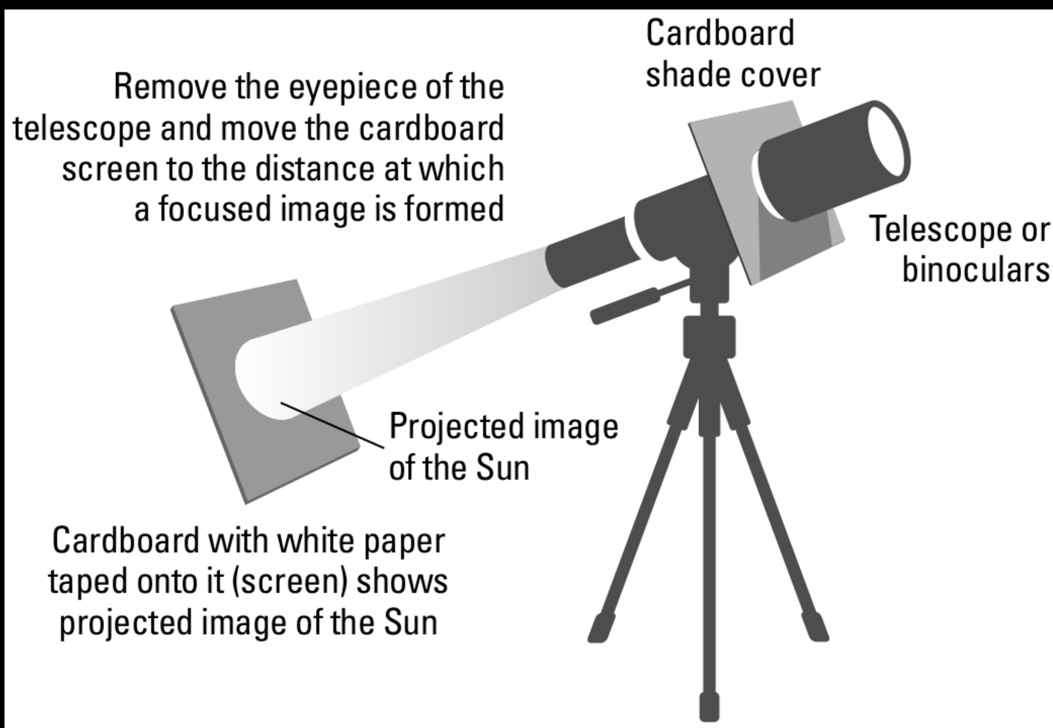
Rob Lucas, with Jay Pasachoff's 2013 Eclipse Expedition

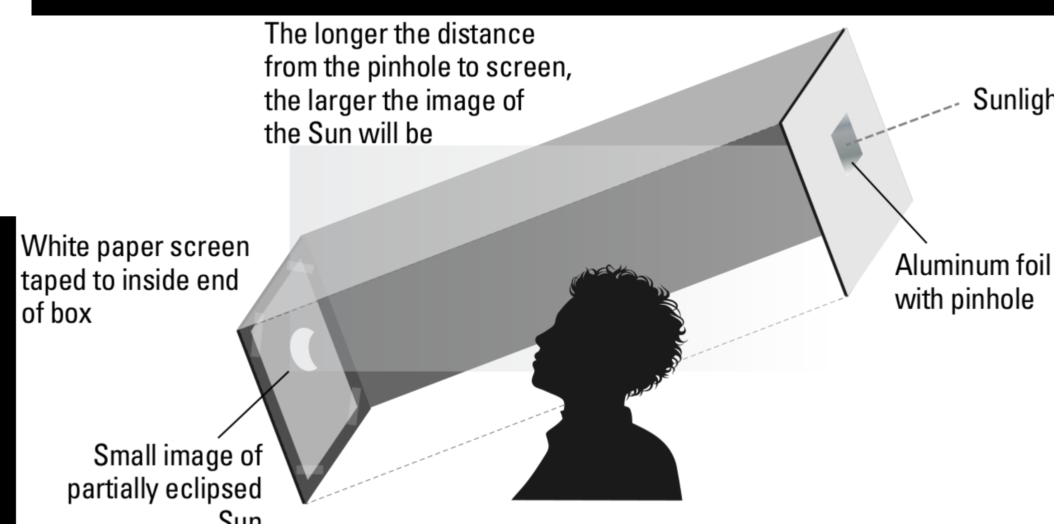
How to Safely Observe An Eclipse

No Special Rules for Lunar Eclipses

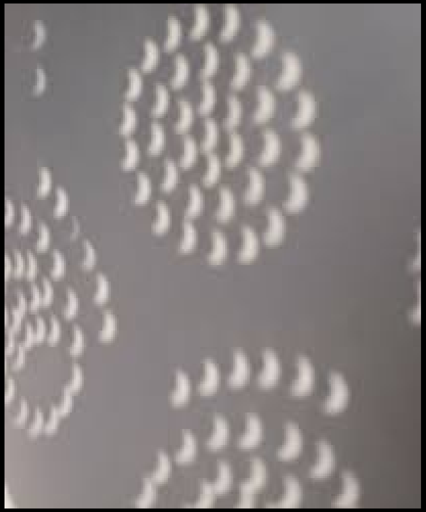
For Solar Eclipses:

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

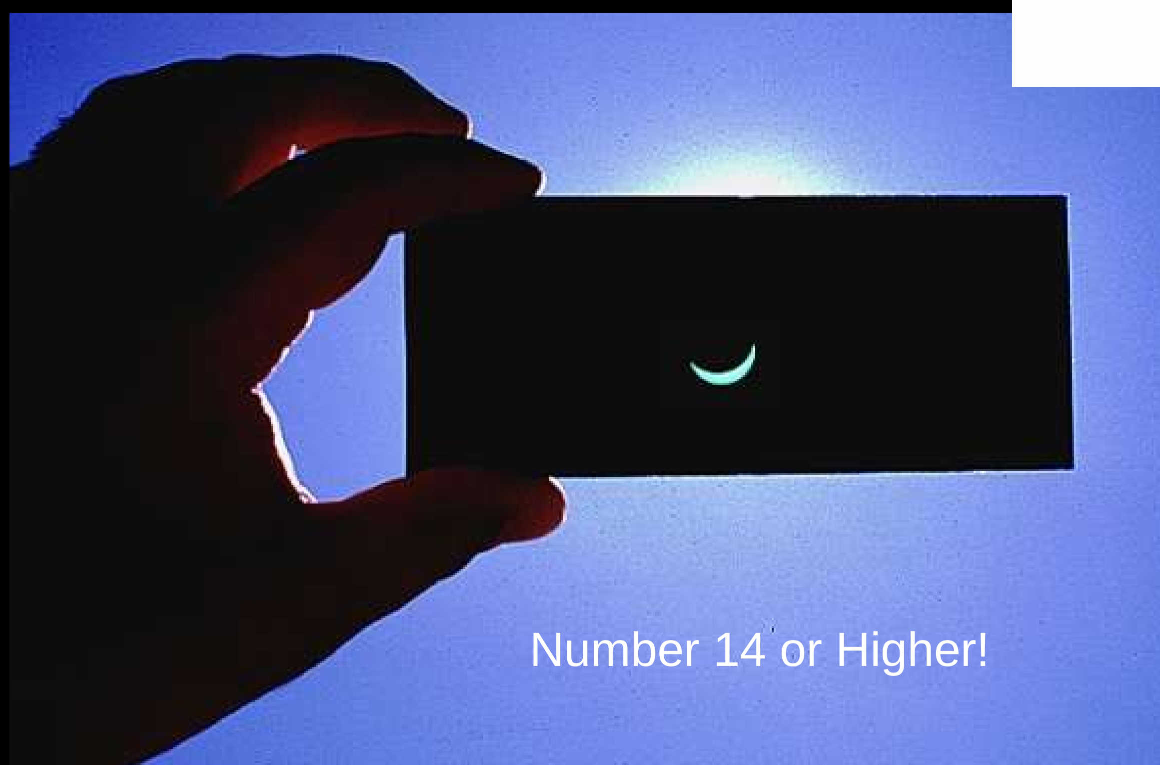




Use a Kitchen Colander For Partial Phases



Eclipse Glasses
and Welder's Glass



Von Braun Astronomical Society
in Monte Sano State Park
Observatories and Planetarium

Planetarium Program each Saturday night at 7:30 p.m.
Telescope Observing after, weather permitting