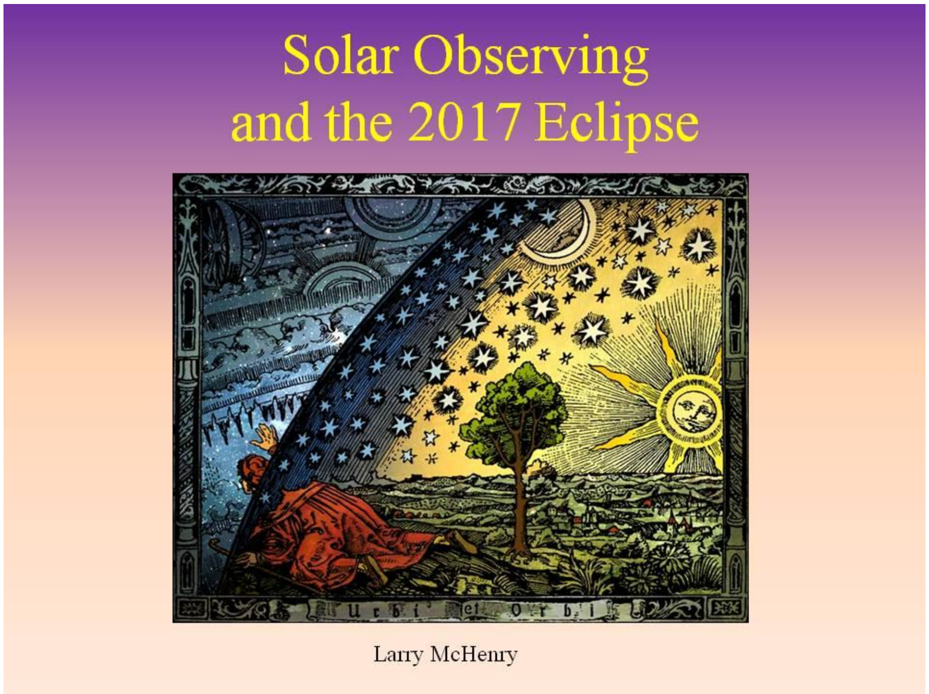
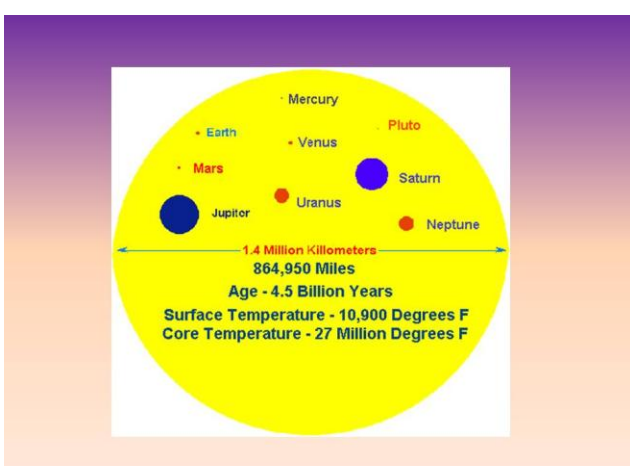
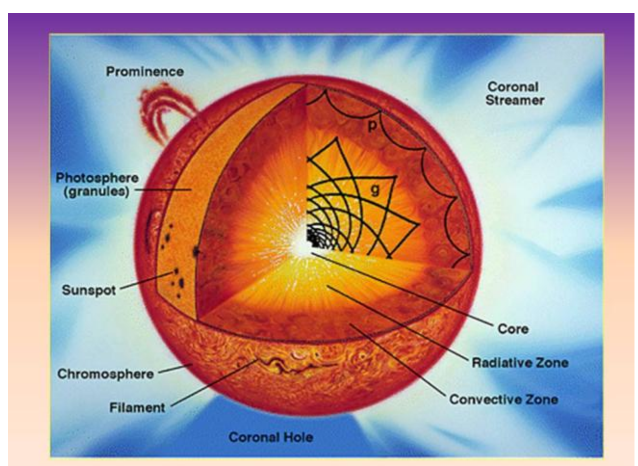


An Introduction to Solar Observing, and the Solar Eclipse of 2017:

Good Afternoon! Today I am going to introduce you to observing our nearest star, the Sun.
And we'll talk about the upcoming August 21st, 2017 Total Solar Eclipse.
For thousands of years, man has been interested in and inspired by the Sun. The Sun has held a special place in all of the early civilizations. There was the sun god "Re" of the ancient Egyptians. The rulers of the Aztecs considered themselves divine descendants of the sun. And the ancient Greeks who worshipped the Sun as 'Apollo', the Sun God. But as people became more knowledgeable of the sky, the Sun lost its religious importance. Modern Solar astronomy began in 1610 when Galileo used his telescope to observe the Sun and 'discovered' sunspots.

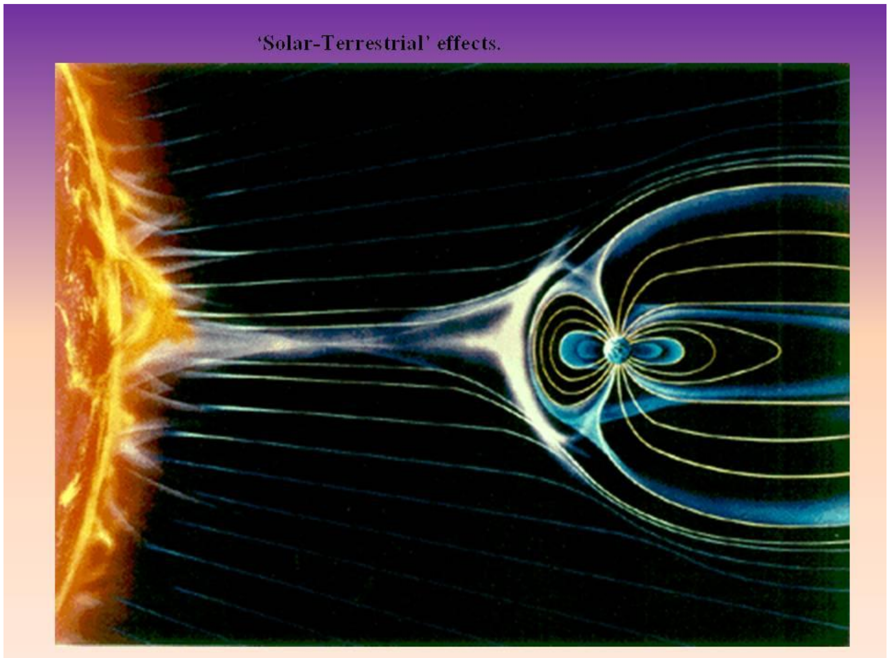
This is a good slide showing basic solar data and planetary size comparisons.
You can find information on the Sun in almost any basic astronomy book. It's about 864,000 miles in diameter, takes about 25 - 35 days to make one rotation, and the Sun is made up of mostly hydrogen and helium gas, with traces of other elements. Using telescopes, we can observe various features of the Sun's outer layers, what we would consider to be its atmosphere, (Chromosphere), and its surface (Photosphere). And using space based instruments, we've been able to deduce what is going on inside the Sun's interior zones.





One of the main reasons that I like to observe the Sun, is that it's one of the few astronomical objects that can have a real physical affect on us. Beyond the obvious, in which the Sun supplies us with heat, light, energy, & life, there are some lesser known but important affects caused by radiation from the Sun and solar flares hitting the Earth's atmosphere and magnetic field. These are called 'Solar-Terrestrial' effects, or 'Space Weather', and are caused by charged particles from the Sun striking the Earth's Magnetosphere and flowing around it.

The most common and beautiful effect is the Aurora or 'Northern Lights'. Aurora are shimmering, colorful curtains of light that sometimes glow in the night sky. It was only about a hundred years ago that scientists discovered that they were caused by interactions with the Sun. The solar wind carries charged particles from the Sun that excite gases in our upper atmosphere. These gases glow in different colors (like neon lights).



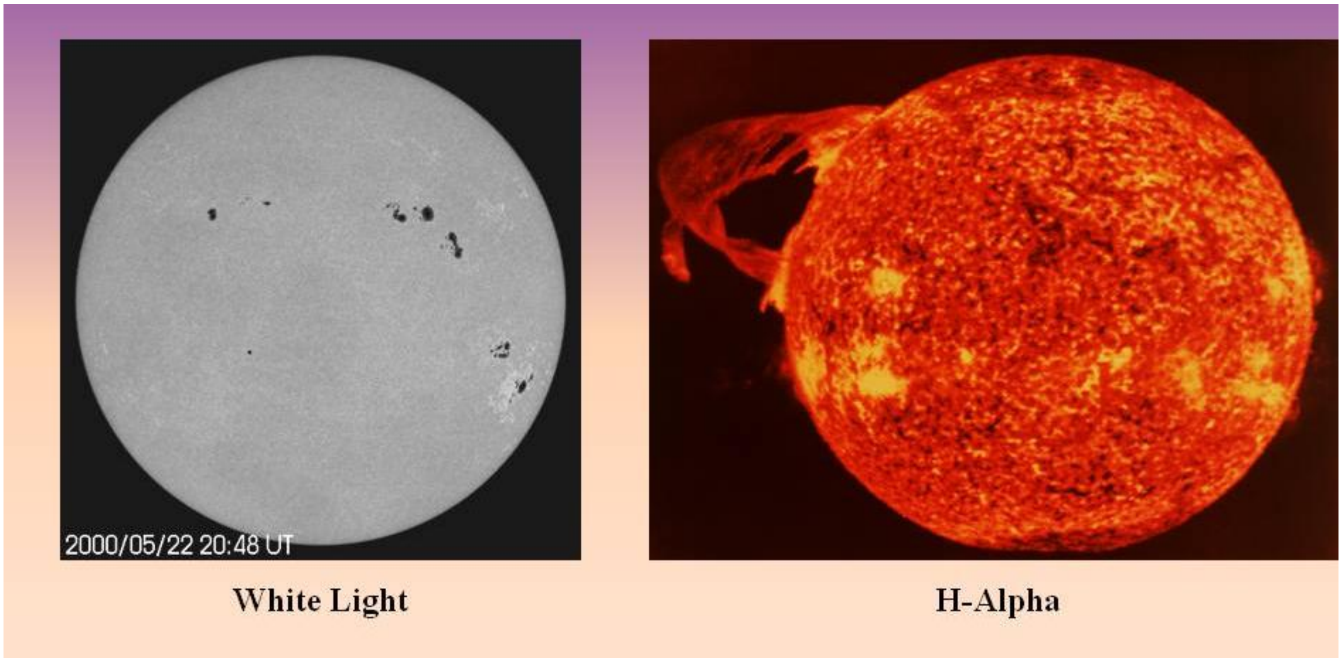
Other 'Solar-Terrestrial' effects include:

- Radio, TV, and cellular phone interference.
- Disruption of power systems (brownouts).
- Static electricity buildup on pipelines. (causes corrosion/leaks)
- Satellite and spacecraft electrical malfunctions.
- Radiation danger to astronauts.

Observing the Sun can be an interesting activity for amateur astronomers.
It is also one of the few areas where amateur's can still contribute scientific data to professional astronomers. (thru counting and tracking sunspots). Because of the Sun's brightness and size, even a small telescope will show plenty of detail. The solar features change from day to day, and it's exciting to observe the appearance of a giant sunspot group, or see a large loop prominence arching over the solar limb.

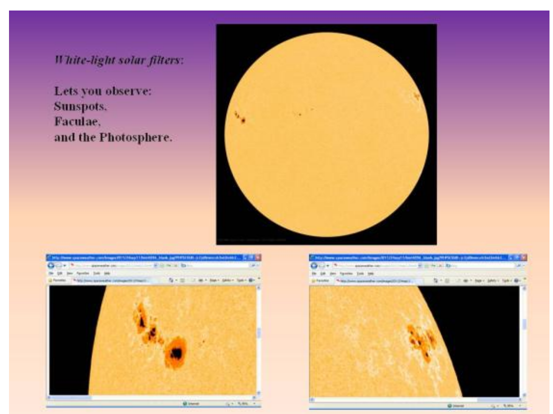
If you learn one thing today, that is: ***<u>Never</u>*** *look at the Sun* ***without*** *a solar filter!*
Your body will not be able to react quick enough to turn your head. In a split second, your retina will burn, and you will go blind in that eye. There's really only one safe to observe the Sun with your telescope, that is using a solar filter on the front end of the telescope that blocks the harmful UV and IR radiation. In addition, there's also dedicated solar telescopes that can only be used to observe the Sun.
Never use a "*eyepiece*" type solar filter. These will shatter from the heat.

The type of solar feature that you can observe depends on the type of solar filter:
White-Light or Hydrogen-Alpha filters.



Let's talk about White-light solar filters first.
You have many options today. The filters can be made of either glass, Mylar, or the Baader Solar Film. You can buy them premade or you can get a sheet of the filter material and make your own.
White-light solar filters: Lets you observe Sunspots, Faculae, and the Photosphere.


1000 Oaks Type II Glass, and Baader Solar Film



White-light solar filters:

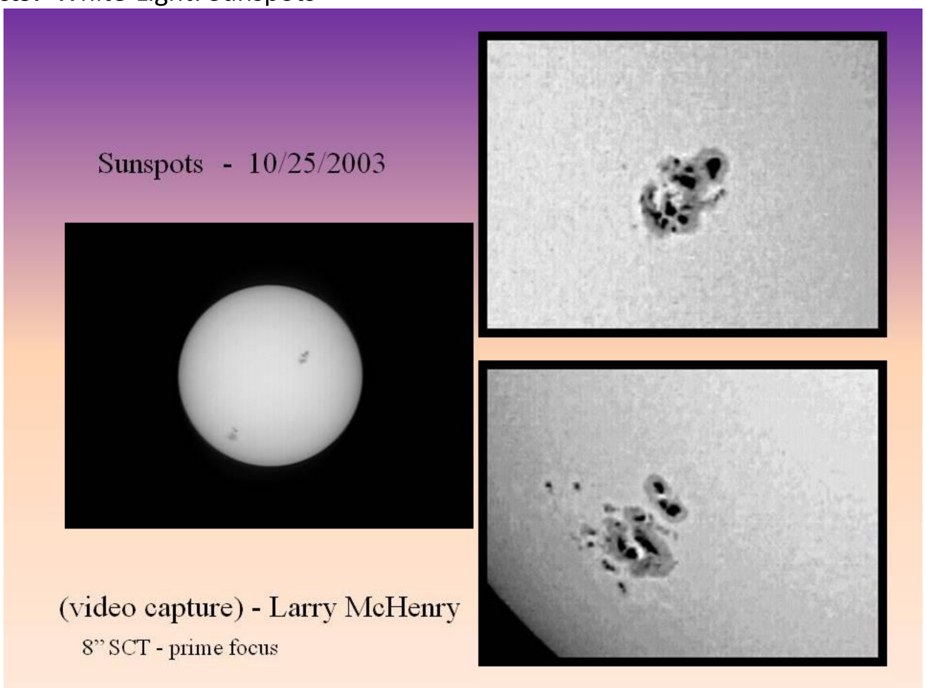
Sunspots:

Sunspots are Slightly cooler & darker areas on the Sun's surface, caused by intense magnetic fields that partly block the flow of energy. Last anywhere from a few days to over a month. Usually form as a single small spot, but can grow to form a groups larger than the Earth. The dark center is called the Umbra, lighter outer region is the Penumbra. One way to think of Sunspots is that they are like giant bar magnets, with one spot being the north and the other being the south pole of the magnet. The Sun goes thru a 11 year cycle of high & low magnetic activity.

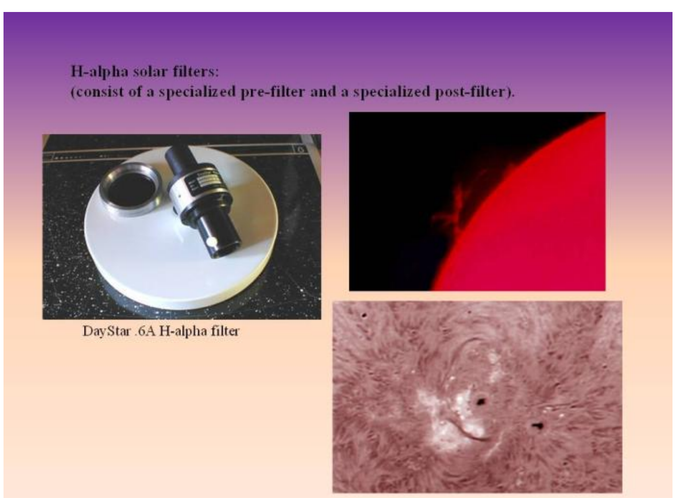
Another common feature visible in white-light are **Faculae**:
These are Bright clouds of hydrogen gas floating above the Sun's surface. They mark areas where sunspots may be forming, or where sunspots have decayed and disappeared. Faculae are best visible near the edge of the disk.

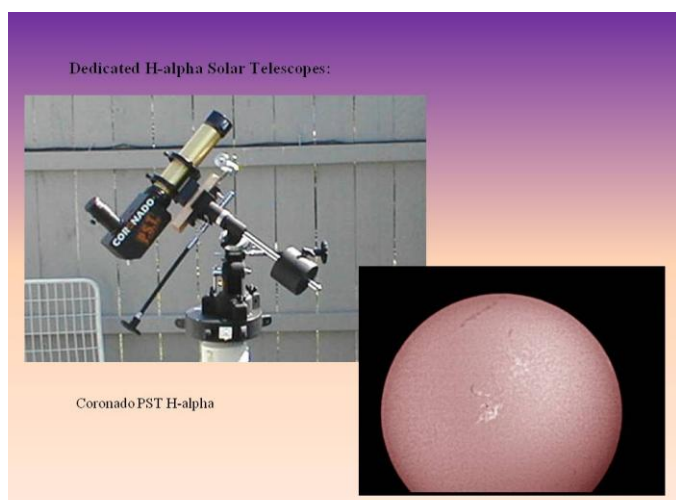
The last common feature visible in white-light is the **Photosphere**:
This is the Sun's visible surface. Has a grainy appearance in white-light, You can think of the Photosphere as giant convection gas bubbles, kind of like what you get when you boil water.

Observing Projects: White-Light: Sunspots



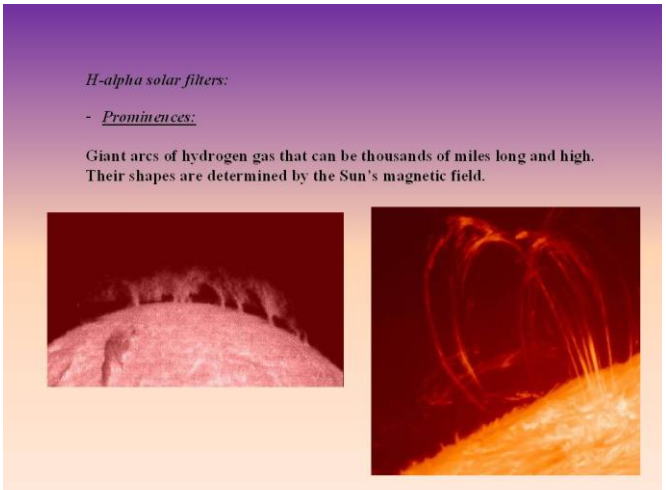
H-Alpha solar filters: Lets you observe Prominences, Flares, and the Chromosphere, or atmosphere of the Sun. **H-alpha** solar filters consist of a specialized pre-filter that fits on the front of the telescope, and a specialized post-filter that goes with the eyepiece. There's also dedicated solar telescopes sold by Coronado, Lunt, and others.

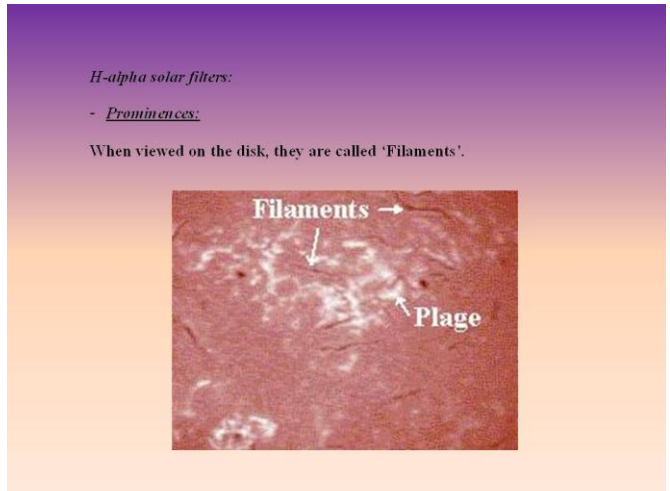




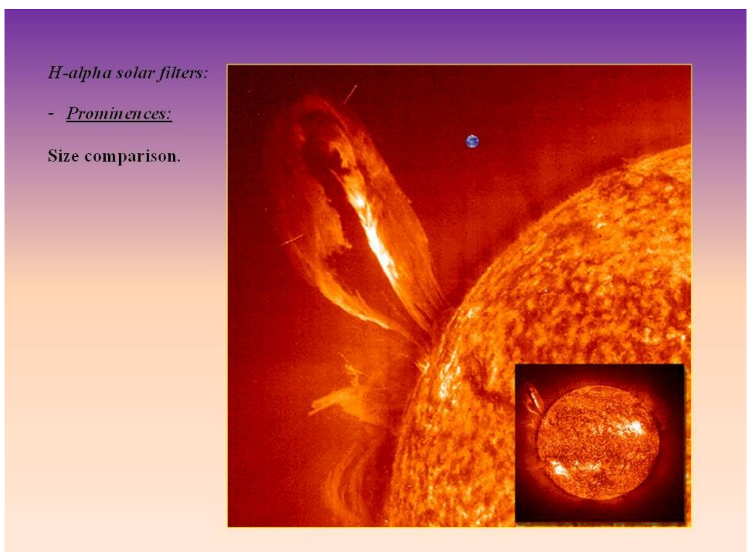
Prominences:

Are giant arcs of hydrogen gas thousands of miles long, whose shapes are determined by the Sun’s magnetic field in that area. When viewed on the face of the disk, are called **‘Filaments’**. *(look like squiggly lines)*
Back in the early days of solar astronomy, it was thought that Prominence and filaments were two different features. But, now we know that they are really the same feature, just viewed at a different angle.



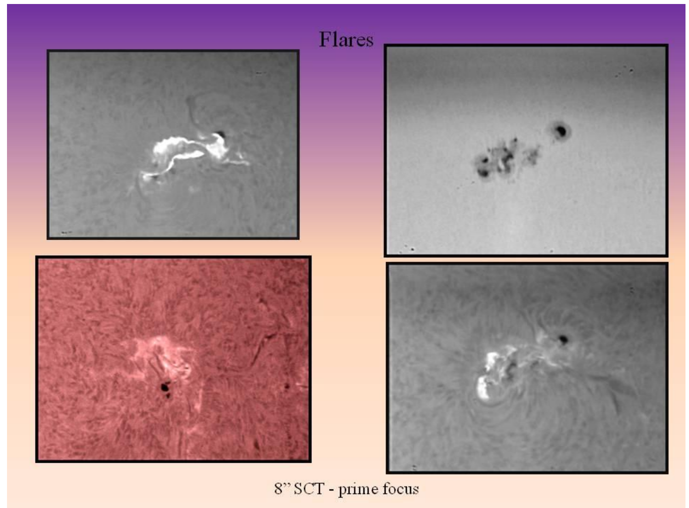


_It’s a good thing that the Earth is not really that close. We’d be a burned marshmallow!!!!



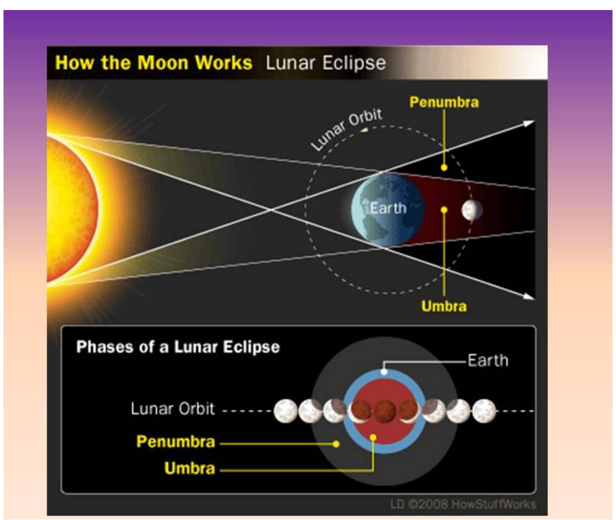
A less common feature that you might be lucky to see are ***Flares:***
Giant nuclear explosions of radiation, and energy caused by the magnetic field lines becoming twisted together and finally snapping, like giant rubber bands! Depending on the location of the flare on the solar disk and the geometry of the Earth’s orbit around the Sun, these can cause affects on the Earth.
Finally there is the **Chromosphere**.
This is the ‘atmosphere’ of the Sun when viewed in H-alpha. It has a mottled, freckly look.

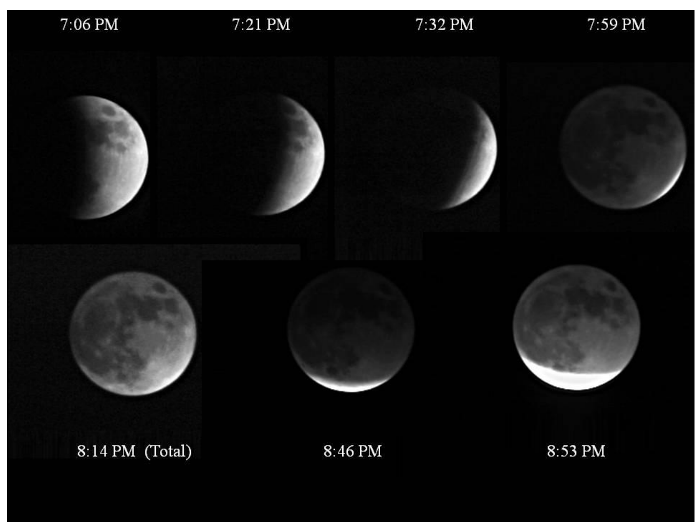
Observing Projects: H-Alpha: Prominences and Flares



Eclipses:
Lunar -

The first thing you notice when looking at the Moon is its phases.
The phases are caused by the way the Earth, Moon, and Sun line up, from new to first quarter, to full, to third quarter, and back to new.
It takes the Moon 29 days to revolve around the Earth. Occasionally, when the geometry is just right, the Sun, Earth, and Moon align so that the Earth's shadow falls on the Moon. This is what causes Lunar Eclipses.
Here's an example of a local Lunar Eclipse back in 2003.

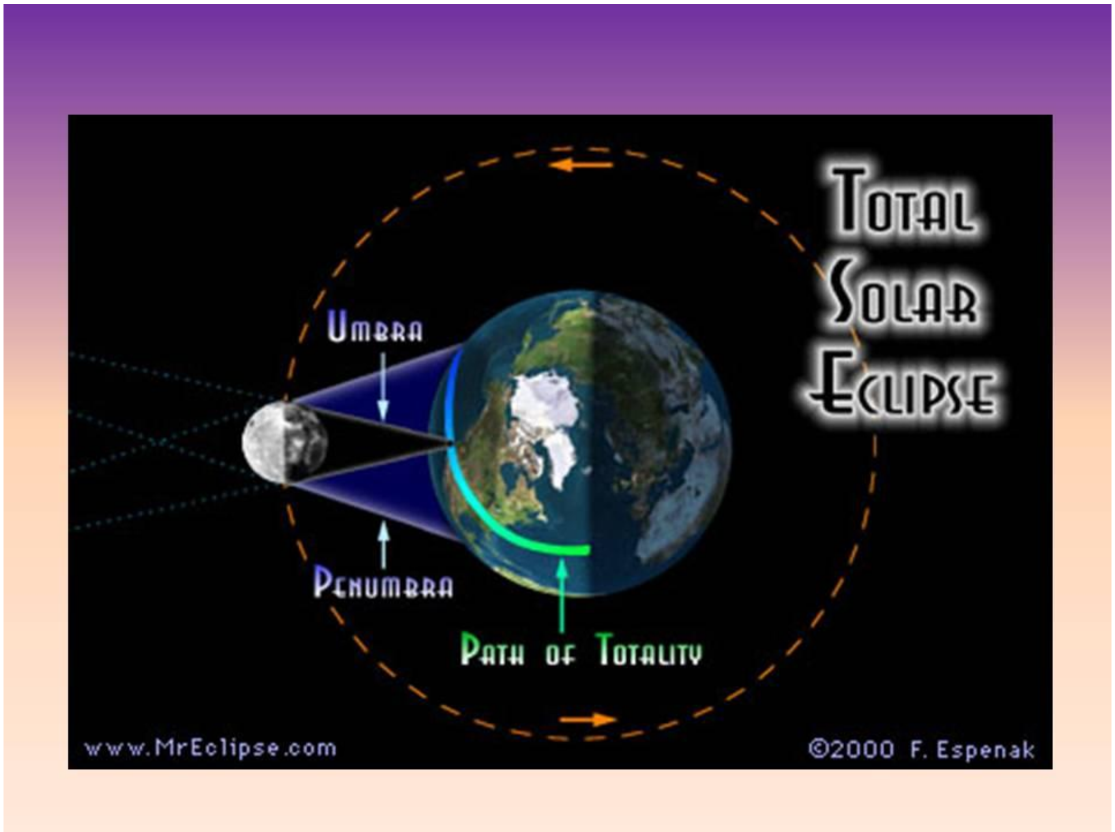




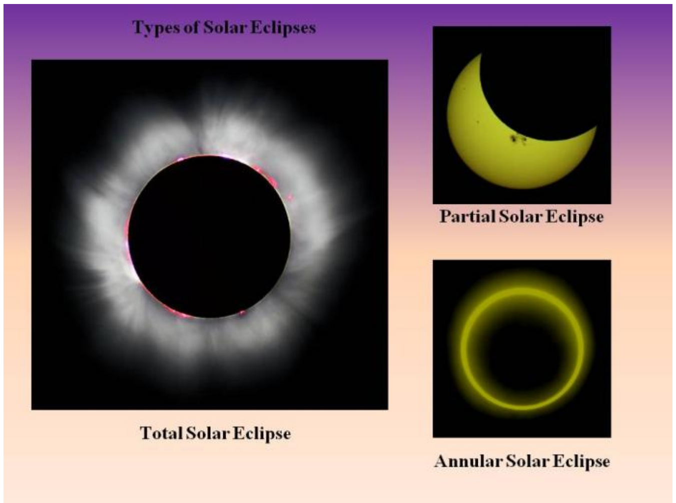
Eclipses:
Solar -

With Solar Eclipses, it's all about the geometry! Normally, during New Moon phase, the Moon passes either a little above or below the Sun. But occasionally, when the orbital geometry is just right, the Moon aligns between the Sun and Earth so that the Moon's shadow falls on the Earth. This is what causes Solar Eclipses.
The Moon is about 400 times smaller than the Sun. So how does such a small object block out the Sun?
Again, it's the geometry! The Moon is also about 400 times closer to the Earth than the Sun, making it almost a perfectly sized light-shield. There's generally between two to five solar eclipses a year, with at least one being total.

The dark Lunar umbra shadow that touches the Earth is only about 170 miles wide. To see a total eclipse, you must be under that. The Moon's lighter penumbra shadow is about 4000 miles wide, and anywhere under that will produce a partial eclipse. Total Solar Eclipses generally take several hours to run thru all stages, starting with a partial eclipse by the Moon slowly blocking the Sun's disk, that last about an hour before totality occurs. Totality can last from about 7 minutes or less, depending on where the Moon's shadow path falls on the Earth. For the 2017 Eclipse, totality will last for as long as about 2minutes and 40 seconds. Once those few short minutes of totality are over, the partial phases then proceeds for about another hour, with the Moon slowly moving away from the Sun's disk.

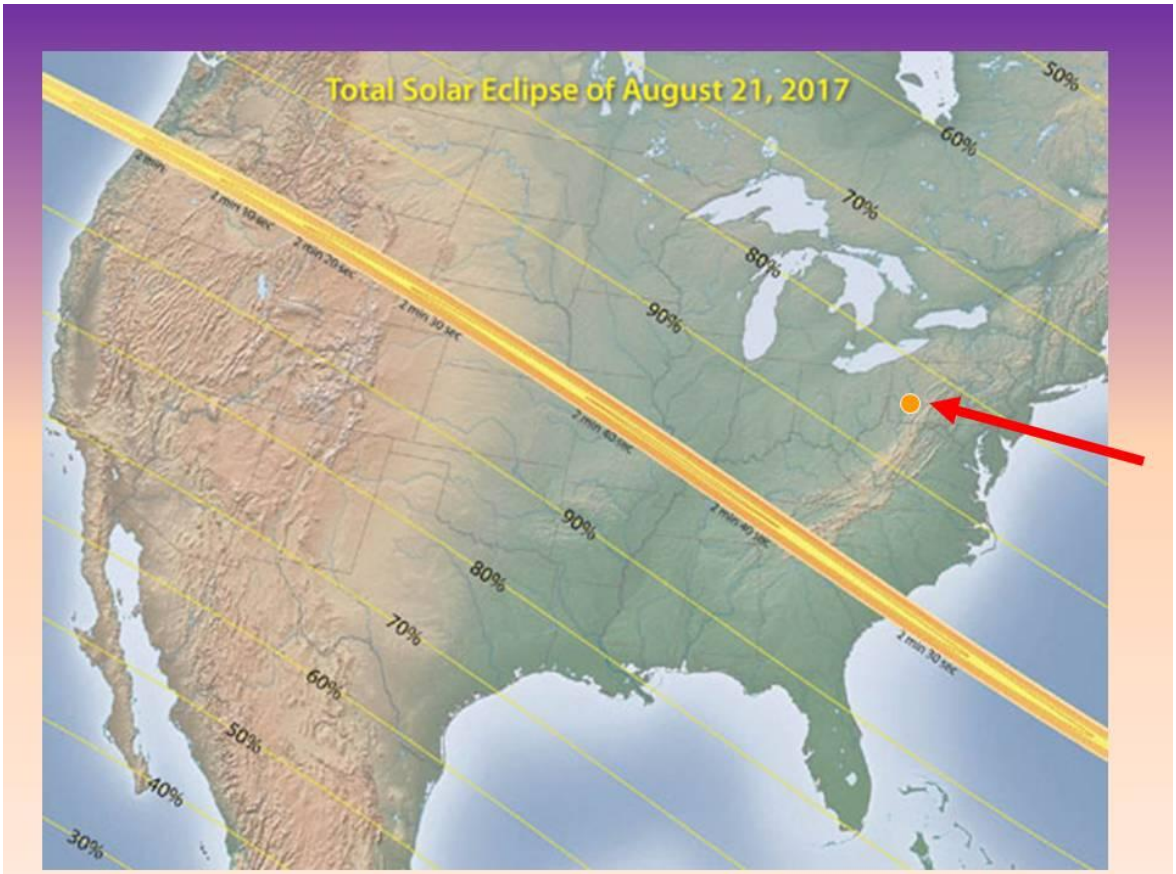


The Moon's orbit around the Earth is not a perfect circle, but is an ellipse. Due to this orbital variance, during some eclipses, the Moon doesn't always intersect the Sun directly, but is a little higher or lower. This causes a partial eclipse, where only a portion of the Sun is blocked. And, depending on the distance from the Earth to the Moon during the eclipse, the Moon may be just not be quite large enough to cover the entire solar disk. This causes what is called an annular eclipse. But, when the geometry is just right, we get a total eclipse that allows us to safely see the chromosphere, prominences, and the corona with the naked-eye.

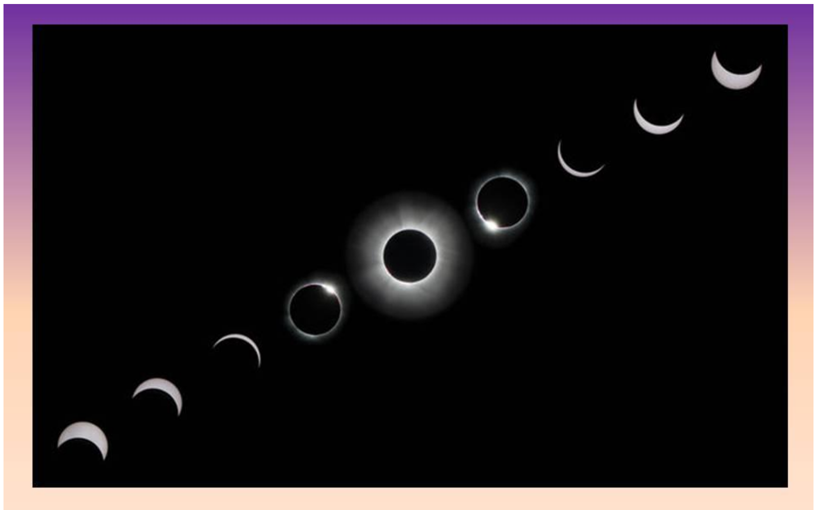


August 21st, 2017 slides:

What can you expect and where can you go see the Great American Eclipse of 2017 eclipse.
Here's a map of North America showing the path of the August 21st, 2017 eclipse.
(from the Great American Eclipse website: https://www.greatamericaneclipse.com/)
The eclipse shadow starts off in the state of Oregon, crossing over parts of Idaho, Wyoming, Nebraska, Kansas, Missouri, Illinois, Kentucky, Tennessee, North Carolina, Georgia, and exiting the continent off the cost of South Carolina.



From the Pittsburgh, PA region, we will see about an 85% partial eclipse, fairly deep and quite interesting with a properly solar filter shielded telescope. But if at all possible, don't settle for this!!!!
What you really want to see is the Diamond ring effect! You want to see Bailey's Beads flickering around the Moon! You want to see the pearly-white solar corona streaming away from the eclipsed disk of the Sun!!!
This is what you want to see!!!!!! You want Totality!!!! You want to stand under the shadow of the Moon!



So, what will it be like?

During the early stages of the eclipse, unless you are using a safe solar filter to observe the Sun, there will be no indication of what's going on, as the Sun stays bright. Once the partial phase gets well past 75%, then there will a noticeable drop in brightness, with the sky taking on the appearance of a late afternoon day.
In the last couple of minutes before totality, there is a noticeable darkening in the direction that the Moon's shadow is approaching your location from, appearing like a darkening storm front. The quality of the sunlight rapidly begins to weaken and everything around you appears washed-out and lacking color. Insects and birds become quiet, as if settling in for the evening. Even farm animals and pets have been reported to act strangely at this time.

Then, a few seconds before the Moon completely covers the Sun, what appears to be a dark mass rises over the western horizon rushing towards you. This is the Moon's umbra shadow approaching!!
The sight of this has been known to cause a deep sense of dread or fear in some people.

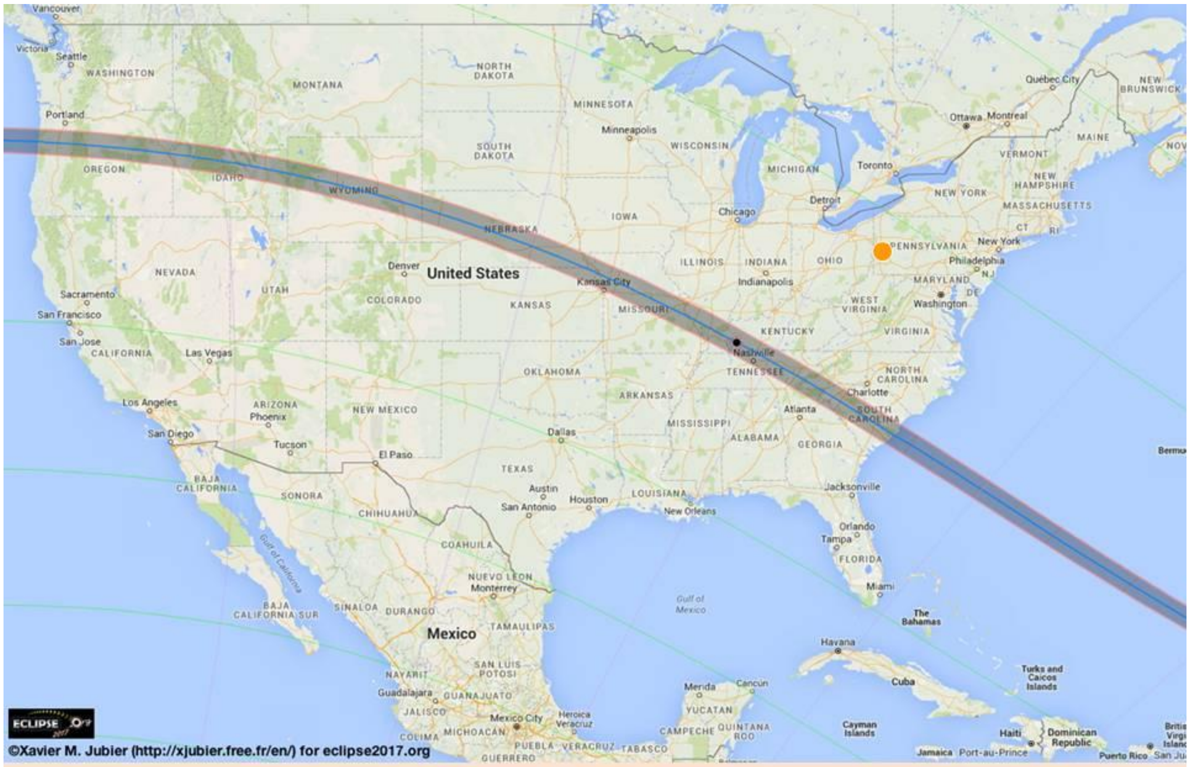
If you are standing near a light colored building or car, you might see flickering bands of shadow rapidly crossing over the structure. These are a light effect called shadow bands.

Then the thin crescent of remaining solar disk suddenly begins to break-up into brilliant blobs of sunlight which rapidly disappears. These are called Bailey's Beads after the 19th century astronomer who realized they were caused by sunlight shinning over the lunar mountain peaks and valleys.
Then the beads quickly vanish, leaving one last ray of visible sunlight, the Diamond Ring effect!

And then,,,,,,,, Totality!!!! You are standing under the shadow of the Moon!
It's now safe to take off your eclipse glasses or remove your telescope filters. In a matter of seconds, a thin red band of light appears around the blackened lunar disk, this is the Sun's chromosphere or inner atmosphere. You may also see small red flickering flames, these are large prominences on the Sun's limb, reaching high into the chromosphere past the occulting disk of the Moon. Finally, the ghostly glow of the Sun's outer atmosphere, the Solar Corona will extend for several diameters around the eclipsed Sun, looking like a large diffuse glowing ring of light, with possible streamers extending outwards.

The sky above you is a deep shade of twilight, with the brighter stars and planets visible overhead. The entire horizon around you will glow with the deep oranges and reds of sunset. It may grow dark enough that you will need a flashlight. The air temperature can drop 10 to 15 degrees and you may feel a slight chilly breeze.
Then, after about 2 and a half minutes of celestial glory, it will suddenly come to an end. The Corona will vanish as a reverse Diamond Ring and Bailey's Beads effects appear on the opposite side of the eclipsed solar disk as the Moon begins to slowly move away. At this point safe solar filters and glasses must be used to continue viewing.
The sky will rapidly brighten with daylight as the partial eclipse phase begins. In about an hour, the Moon will finally glide off of the Sun's disk. The Eclipse will be over, but not forgotten.

So, where to go? It all depends on how far you want to drive, and if you want to stay overnight.



Plan ahead and know the local Interstate Highway system and back roads.
Here’s the state of Tennessee for example. Do not attempt to drive the distance from Pittsburgh to the Eclipse centerline on the same day. You and millions of others will be attempting the same thing.
It’s been predicted by some that the East Coast will become one giant traffic jam,,,, "Car-mageddon"
You’ll end up stuck on a highway and miss the eclipse. The best advice is to leave one to two days in advance.
Either camp somewhere or find a hotel that’s not sold out within a very short drive of totality.

Naked-eye eclipse observing:
Throughout the partial phases of the eclipse, you **MUST** protect your eyes!
As long as even a slight sliver of the Sun's disk is visible, you must use a safe method of viewing the Sun.
There is still more than enough IR and UV radiation to cause eye damage if you stare at the Sun.
Either purchase ahead of time a pair of safe solar observing glasses, or use a pinhole projector to indirectly view the partial phases. You don’t need to actually use a telescope to enjoy the total eclipse, but if you do, you will need a safe solar filter that either goes on the front of the telescope, or use a dedicated solar telescope.

Imaging the Eclipse:

You can photograph a solar eclipse using any type of camera, as long as you are careful and take precautions. A solar filter must be used on the lens throughout the partial phases for photography. You can also use any lens, though the longer the focal length of the lens, the larger the images of the sun you’ll be able to capture. How large you want the sun to be in the frame will determine what focal length lens to use on your camera.

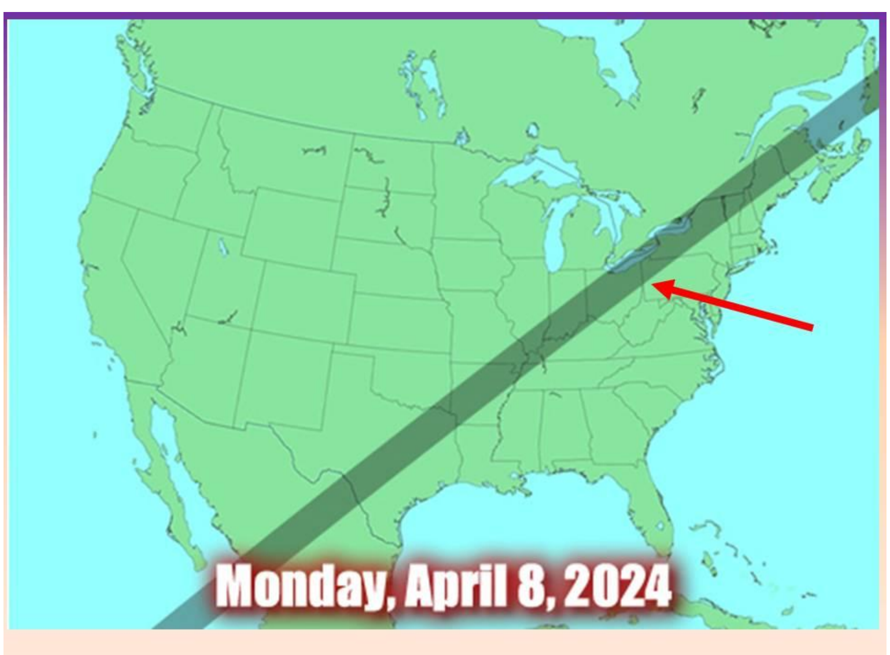
The easiest way to determine exposure is to run a calibration test on the un-eclipsed sun on a clear day prior to the eclipse. Choose the best shutter speed/aperture combination and use them to photograph the partial phases of the solar eclipse. Because the sun’s brightness stays the same throughout the partial phases, no exposure compensation will be needed. But, it never hurts to bracket your exposures, especially if the eclipse occurs on a hazy day.
If possible, you will want to turn off the camera's built-in flash. It won't help any, and will just be distracting to others.
You should attach your camera on a sturdy tripod, and manually focus the camera, setting it to infinity.
If you are using a telescope on an equatorial mount, either piggybacked, or at prime focus, make sure the telescope's drive is properly polar aligned and will track the sun keeping it centered in your camera throughout the eclipse.

During totality, all solar filters must be removed. It is completely safe to photograph and view the totally eclipsed sun directly. No filters are needed, and in fact, they would completely hide the view.
The average brightness of the solar corona varies as it extends away from the disk, so no single exposure can capture its full dynamic range. The best strategy is to bracket the exposures over a range of shutter speeds from 1/1000 second to 1 second. The Full Moon (or near Full) makes a good practice object as its brightness will generally match the brightness of the eclipsed Sun. You'll need to practice this several weeks before the eclipse date when the Moon is up with the correct phase.

Another great option is using a camcorder. Not only can you use it to zoom in when needed, but you can also record crowd noise and the reactions of your friends. Security cameras with auto shutter speeds and recording to a DVR can also be used. Doing video is how I plan on capturing the eclipse. I'll be using multiple vidcams, one with a fisheye lens for a wide-field, and another with a long focal length for close-ups. I'll make sure the cameras are running a few minutes prior to totality, and then I'll sit back in a chair to watch using eclipse glasses. Afterwards, I'll stop the video and later back home, I can extract individual frames for still photos.

Regardless of how you plan on imaging the eclipse, you should rehearse setting up the camera and adjusting exposures before the eclipse, as it's easy to get caught up in the overhead spectacle, so much so that you forget to take pictures. You should also automate as much as possible so that you don't end up tending the cameras and missing most of the eclipse. You might want to consider just snapping a few pictures of totality and your friends with your phone camera and later buying a few eclipse photos from the professionals.

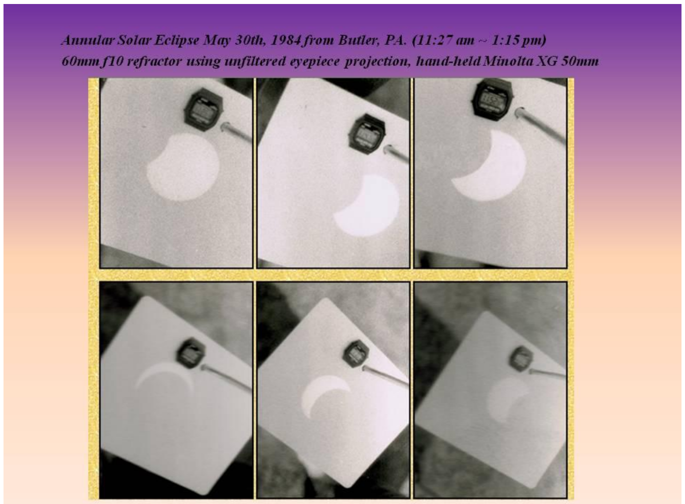
In case you miss the August Eclipse - a 'do-over' on April 8th, 2024!

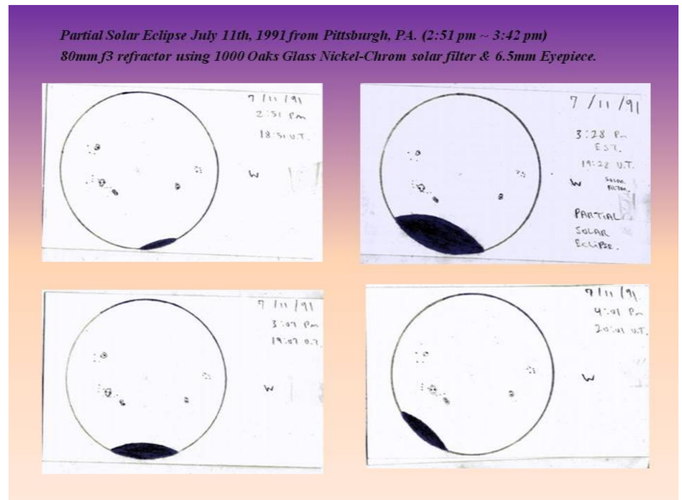


Observing Projects: Solar Eclipse examples:

Annular Solar Eclipse May 30th, 1984 from Butler, PA. (11:27 am ~ 1:15 pm)
60mm f10 refractor using unfiltered eyepiece projection, hand-held Minolta XG 50mm

Partial Solar Eclipse July 11th, 1991 from Pittsburgh, PA. (2:51 pm ~ 3:42 pm)
80mm f3 refractor using 1000 Oaks Glass Nickel-Chrom solar filter & 6.5mm Eyepiece.





Partial Solar Eclipse October 23rd, 2014 from Pittsburgh, PA. (~ 5:45 pm)
Coronado PST refractor & 24mm Eyepiece. Nikon Coolpix point-n-shoot camera

Recommended Readings:

"How to Observe the Sun"	Astronomical League
"Observing the Sun"	Peter Taylor
"Solar Astronomy Handbook"	Rainer Beck
"AstroPhysics of the Sun"	Harold Zirin

Favorite websites:

SOHO*:* *Solar and Heliospheric Observatory*
https://sohowww.nascom.nasa.gov/home.html

SDO*:* *Solar Dynamic Observatory*
https://sdo.gsfc.nasa.gov/

BBSO*:* *Big Bear Solar Observatory*
http://www.bbso.njit.edu/

Space Weather*:* Spaceweather.com
http://spaceweather.com/

Great American Eclipse*:*
https://www.greatamericaneclipse.com/

This concludes my introduction to Solar Observing and Eclipses.
Hopefully, you've learned a little about our closest star – the Sun! And the August 21st 2017 Total Solar Eclipse!

Thank You