



Safely Observing the Sun for Yourself

Compiled by Deborah Scherrer

Never look directly at the Sun with your eyes or through a telescope or in any other way, unless you have the proper filters – you could permanently damage your eyes!

Note: This document is designed to be used by adults. Children observing the Sun should always be supervised.

Techniques Described:

- Observing Eclipses
- Using Eclipse Glasses
- Projecting the Sun by Pinhole Camera, Binoculars, Small Telescopes, or Sun Funnels
- Using a Sunspotter Telescope
- Solar Filters on Nighttime Telescopes
- H-alpha Solar Telescope
- NASA's Solar Dynamics Observatory
- Observing and Sketching Sunspots
- Observing Transits
- What Color is the Sun?
- Where does the Sun rise and set?

Great American Eclipses

The most glorious way to observe the Sun is to personally experience a total solar eclipse. On 21 August 2017, millions of people across the United States enjoyed nature's most grandiose show – a total eclipse of the Sun. When is the next great solar eclipse? Don't miss it!

<https://www.greatamericaneclipse.com/future>

Look for the next solar and lunar eclipses:

<https://www.timeanddate.com/eclipse/list.html>



Eclipse Glasses – for anytime!

For very little money you can purchase a pair of paper eclipse glasses. They are great for both total and partial eclipses, and they work anywhere, anytime you can see the Sun! Available on the web.



Projecting the Sun by Pinhole Camera

You can easily, cheaply, and safely observe the Sun by projecting it through a tiny hole onto a white sheet of paper. This simple device is called a "pinhole camera". You'll need:

- 2 sheets of stiff white paper
- A pin
- A sunny day
- Perhaps a friend to help

With the pin, punch a hole in the center of one of your pieces of paper. Go outside, hold the paper up and aim the hole at the Sun. **(Don't look at the Sun either through the hole or in any other way!)** Now, find the image of the Sun that comes through the hole. Move your other piece of paper back and forth until the image looks best. What you are seeing is not just a dot of light coming through the hole, but an actual image of the Sun!



Experiment by making your holes larger or smaller. What happens to the image? What do you think would happen if you punched a thousand holes in your paper, and you put little lenses in front of each hole to refract (e.g. bend) the solar images to all fall on top of each other? What do you think you'd see? In fact, optical telescopes can be thought of as a collection of millions of "pinhole" images all focused together onto one place!

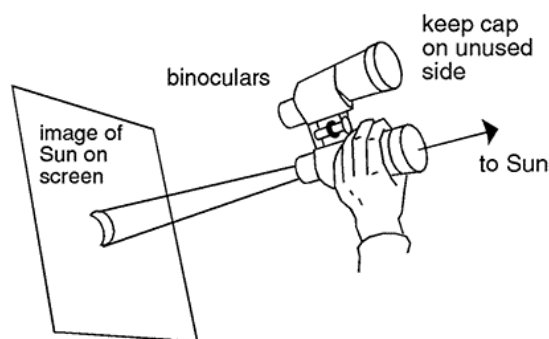
If you want, you can make your pinhole camera fancier by adding devices to hold up your piece of paper, or a screen to project your Sun image onto, or you can even adapt your pinhole camera into a "real" camera by adding film. Google "pinhole camera" for lots of ideas!

Projecting the Sun by Binoculars or a Small Telescopes

You can project an image of the Sun using a pair of binoculars or small telescope:

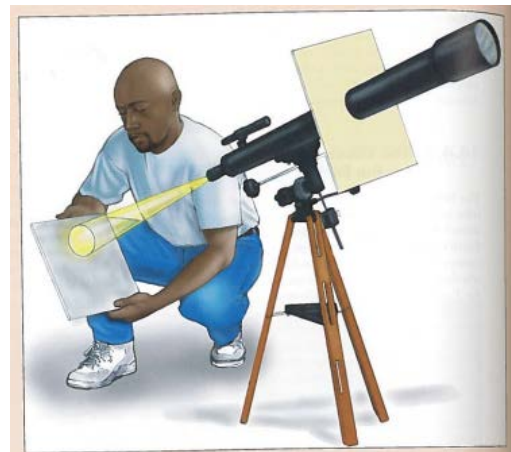
<https://skyandtelescope.org/astronomy-news/how-to-look-at-the-sun/>

You can project an image onto a piece of paper by covering one side of a pair of binoculars, then aiming the other side at the Sun. Move the paper back and forth to find the best focus. **NEVER LOOK AT THE SUN THROUGH THE BINOCULARS!**

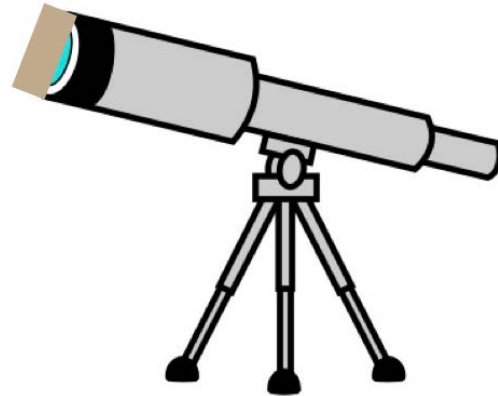


If you attempt to use a telescope, **take note: when projecting a solar image you can easily burn out the optics in your telescope** if you are not careful. A solar image will be very hot -- the spot is about 180 times hotter than unfocused sunlight. This could damage your primary mirror/lens and/or your eyepiece!

- It is often best to cover part of the aperture (opening or light-collecting region) with cardboard. See illustration below.
- If the hot spot drifts off to the side of the telescope tube while you are not keeping it pointed correctly, it can burn or ignite the inside of the telescope tube.
- If an eyepiece is being used to project the image to a screen or paper, note that the eyepiece must be moved out from the normal focus position **BEFORE** pointing at the Sun. When the eyepiece is all the way in it may well be that the hot image will actually be at the eyepiece and it could crack the lenses. So move it out an inch or more first. And, obviously, keep everybody from actually looking into the eyepiece.



We often cover most of the telescope aperture with cardboard to reduce the lit area of the mirror. Cutting it to 30% or 40% will leave a bright enough projected image. But be very careful – with some telescopes one could light the mask on fire by not paying attention! Obviously, if you ever smell smoke, stop what you are doing!



Projecting the Sun by Sun Funnel

There is an easy-to-make cone device you can attach to a telescope so that multiple people can easily view your projection. Really awesome, and your friends will love it! *Instructions at: <https://eclipse2017.nasa.gov/make-sun-funnel>*



Observing an eclipse with a Sun funnel

Using a little Sunspotter Telescope

This is a safe and inexpensive solar telescope of your own! The Sunspotter is an innovative, wooden, easy-to-use telescope that uses a system of mirrors and a powerful 62mm lens to project a brilliant 3" solar image onto a white viewing screen. If there are sunspots, they are generally easily seen. Especially good for kids and school groups, since they can set it up by themselves. Cost is usually \$400-\$500. Available on the web.



Filter Your Own Night Sky Telescope

If you or a friend have a night-sky telescope, you can often adapt it for solar viewing by using a solar filter. Baader filters are best, but others are available as well. For help in choosing a solar filter:

<http://oneminuteastronomer.com/999/choose-solar-filter/>



Your Own H-alpha Telescope

There's a particular color of red (called H-alpha, coming from hydrogen atoms) that is good for viewing the Sun's chromosphere, the part of the Sun directly above the surface, and that shows the best solar activity. You can purchase a Coronado PST (Personal Solar Telescope) to observe in H-alpha! These show prominences (solar eruptions), filaments (dark, magnetically-induced lines), sunspots, plages (white areas around sunspots). They run about \$550-\$600, available on the web. Plus you'll need to add a tripod.

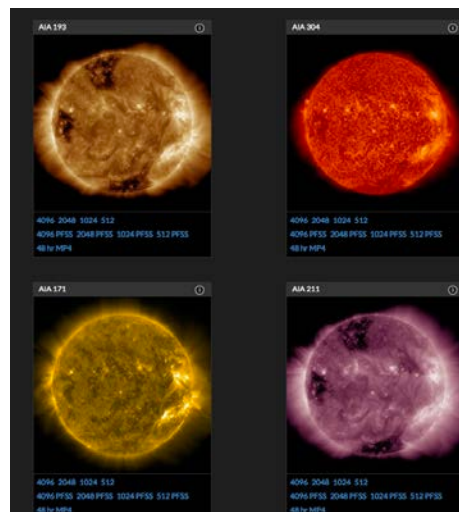


View the Sun Through NASA's Solar Dynamics Observatory spacecraft

If you can't afford your own NASA space telescope, you can at least view the glorious imagery that NASA's Solar Dynamics Observatory (SDO) produces:

<http://sdo.gsfc.nasa.gov/data/>

There is even a special tool that allows you to access this imagery and generate your own videos. It's called JHelioviewer: <http://www.jhelioviewer.org/>



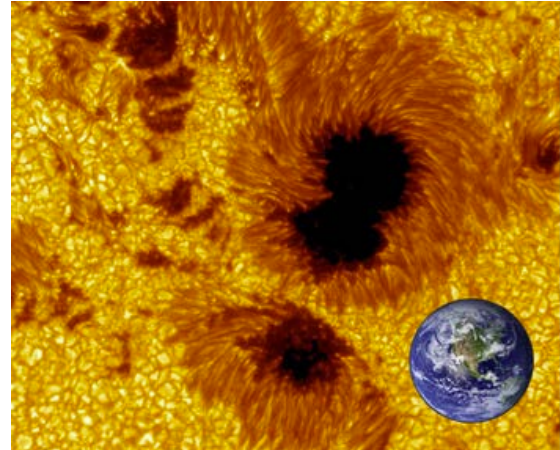
*SDO solar images
(artificially colored)*

If you would REALLY like to get into JHelioviewer, or you end up having to teach a community college course in astronomy, you can learn how to use this tool for yourself or for student laboratories at: <http://solar-center.stanford.edu/activities/SDO>

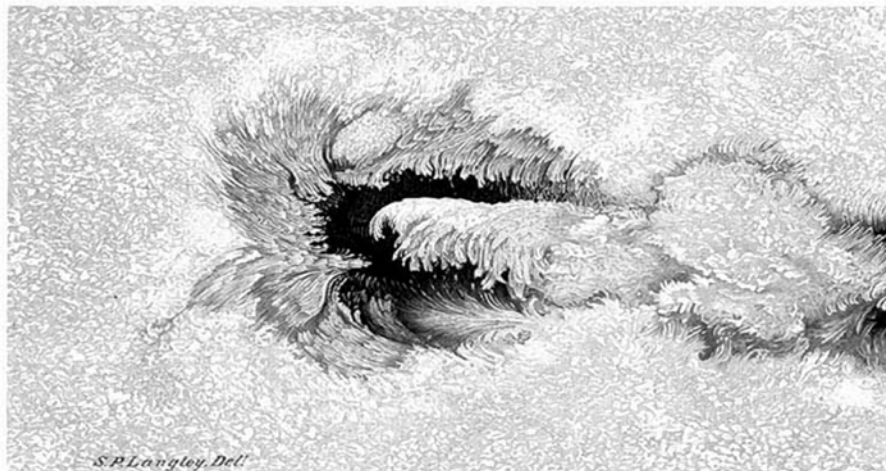
Observing and Sketching Sunspots

Sunspots are giant magnetic storms on the Sun. They appear dark because they are cooler than the solar surface. But they are still very hot! For more information on sunspots, see

<http://solar-center.stanford.edu/about/sunspots.html>



Before the advent of exotic cameras and other technological wonders, astronomers had to rely on drawings or sketches to document the sunspots they had seen. Humans have been sketching sunspots for hundreds of years, see <http://obs.astro.ucla.edu/resource.html>



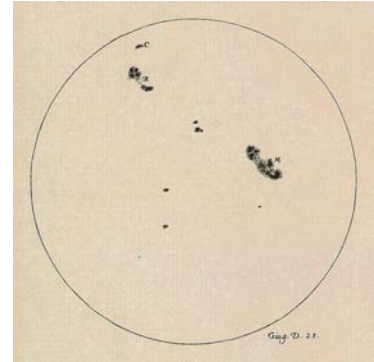
S. P. Langley sunspot sketch (mid 1800s)

Sunspot observations were first recorded in China during the Shang Dynasty (~1700 BC to ~1027 BC). In the I Ching (an ancient Chinese divination text and the oldest of the Chinese classics, c. 800 BC), a very early observation of sunspots was recorded as "three suddenly bursting fires eating a chunk of the sun" -- the first instance in *recorded* history of someone observing sunspots. However, large sunspots are occasionally visible with the naked eye, so it is very likely humans have been observing sunspots for thousands of years.

An English monk named John of Worcester made the first drawing of sunspots in December 1128. Later, around 1611, Galileo's drawings touched off a huge controversy about whether the blotches were on the Sun or small planets orbiting it. Historic drawings are still very important. And even today, drawings are still most accurate at recording exactly what the eye sees, unaltered by the processing of fancy electronics. One of Galileo's Sunspot Drawings (on the right)

To see more of Galileo's sunspot drawings, go to http://galileo.rice.edu/sci/observations/sunspot_drawings.html

To learn more about Galileo and his solar observations, see Take the Galileo Challenge: <http://solar-center.stanford.edu/gal-challenge/gal-challenge.html>



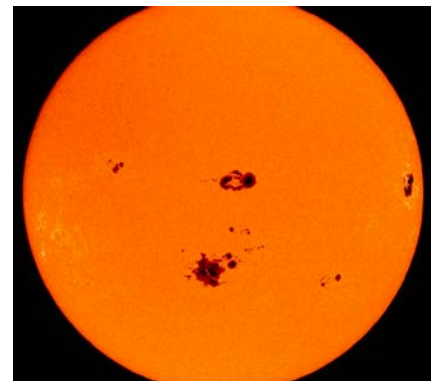
Do your own sunspot drawings

You can make your own sunspot drawings by observing sunspots using any of the above techniques. Then you can compare your sketches to those at Mt. Wilson (in Pasadena, California), an observatory that has been collecting sunspot drawings since 1917. This tradition still continues. Daily Sunspot Drawings at Mt. Wilson: http://obs.astro.ucla.edu/150_draw.html

Counting Sunspots

In 1843 an amateur German astronomer named Samuel Schwabe discovered the rise and fall of yearly sunspot counts. We now call this the sunspot cycle, which lasts roughly 11 years. There are periods of many sunspots, followed by periods of few sunspots. Then the cycle continues. Daily counts have been done since 1849, and still continue. You can do your own, although counting sunspots is not as straightforward as it sounds. You have to figure out how many spots there are, as well as how many groups. And it's hard to determine what qualifies as a sunspot group! How to follow this procedure and count your sunspots is explained at:

<http://solar-center.stanford.edu/activities/Sunspots>



Viewing Transits

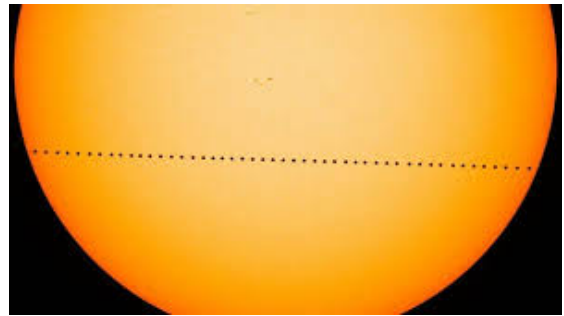
A transit is somewhat like an eclipse, only there is a large disparity between the sizes of the objects. Occasionally the planets Mercury and Venus line up with our view of the Sun and appear to transit across its disc. (Thought for the day: why can't you see other planets transit the Sun?) Mercury transited the Sun on 9 May 2016 and 11 November 2019. You can view transits with any of the techniques above.



SDO time-lapse view of Mercury transit

For viewing the next Mercury transits, see <http://eclipse.gsfc.nasa.gov/transit/catalog/MercuryCatalog.html>

The image to the right shows Venus transiting the Sun in June of 2012. The next occurrence will be in December 2117. Encourage your grandchildren to witness it!



In this image from SDO, the Sun is artificially colored yellow and the small dots showing Venus were taken in time-lapsed photography.

What Color is the Sun?

As you observe the Sun through any of these techniques, what color did you find it? The Sun is actually white. Many images from solar telescopes artificially color the Sun to make details more prominent (i.e. it's hard to see details when a white Sun is placed on a white background). This is a similar problem to using crayons to color the Sun on white paper. Hence many young artists choose yellow, orange, or red for the Sun. If you view the Sun at sunrise or sunset, or through eclipse glasses or filtered telescopes, the Sun may appear non-white.

To explore the various colors of the Sun, and find ways to determine what they are, see <http://solar-center.stanford.edu/activities/SunColor/>



Where Does the Sun Rise and Set?

Most people know that the Sun “rises in the east” and “sets in the west”. However, this is only partially true. In fact, it is only true at two times during the year – the equinoxes. During the other times of the year, the sunrise and sunset positions make a track from north to south, and back again.



A model showing the tracks of the Sun in the sky at the summer solstice, equinoxes, and winter solstice. These tracks change at different latitudes.

If you would like to better understand how this works, see <http://solar-center.stanford.edu/AO/sunrise.html>