**How to View the August 21, 2017 Solar Eclipse Safely**

An eclipse is a rare and striking phenomenon you won't want to miss, but you must carefully follow safety procedures. Don't let the requisite warnings scare you away from witnessing this singular spectacle! You can experience the eclipse safely, but it is vital that you protect your eyes at all times with the proper solar filters. No matter what recommended technique you use, do not stare continuously at the sun. Take breaks and give your eyes a rest! Do not use sunglasses: they don't offer your eyes sufficient protection.

**Viewing with Protection** -- Experts suggests that one widely available filter for safe solar viewing is number 14 welder's glass. It is imperative that the welding hood houses a #14 or darker filter. Do not view through any welding glass if you do not know or cannot discern its shade number. Be advised that arc welders typically use glass with a shade much less than the necessary #14. A welding glass that permits you to see the landscape is not safe. Inexpensive eclipse glasses have special safety filters that appear similar to sunglasses, but these do permit safe viewing.

**Telescopes with Solar Filters** – Eclipses are best viewed directly when magnified, which means a telescope with a solar filter or solar telescopes. These will give you a magnified view that will clearly show the progress of an eclipse. Never look through a telescope without a solar filter on the large end of the scope. And never use small solar filters that attach to the eyepiece (as found in some older, cheaper telescopes.)

**Pinhole projectors** – Pinhole projectors and other projection techniques are a safe, indirect viewing technique for observing an image of the sun. These provide a popular way for viewing solar eclipses.

**Related projection methods** – One viewing technique is to project an image of the Sun onto a white surface with a projecting telescope. This is explained further here:

**Activity: Observing the Sun — Safely**

by John R. Percy, University of Toronto



[Editor's note: Since other stars are so far away, much of the progress we are making in understanding stars in general comes from studying our own "hometown" star, the Sun. Although most of us associate the study of astronomy with the night, in this month's activity our newsletter's newest contributing editor shows that the Sun can lend itself to useful daytime astronomy activities. (Dr. Percy is professor of astronomy at the University of Toronto in Canada and one of the world's leaders in the field of astronomy education.)]

We must begin with an important warning: Never look directly at the Sun, especially when using binoculars or a telescope. Direct sunlight can cause permanent eye damage in seconds, without the victim being aware of it until it is too late.

For safe direct viewing of the Sun, #14 welder's glass can be used, or a proprietary material known as Solar Skreen (Roger W. Tuthill, Inc., 11 Tanglewood Lane, Mountainside, NJ 07092). Although some telescopes are equipped with Sun filters, many of these are not reliable, and should not be used unless you are absolutely sure of what you are doing. The only reliable filters are some (but not all) which fit over the front of the telescope, and reflect away most of the light.

The best way to view the Sun with binoculars or a telescope is by projection — looking at an image of the Sun rather than at the Sun itself. Instructions for doing this are given below.

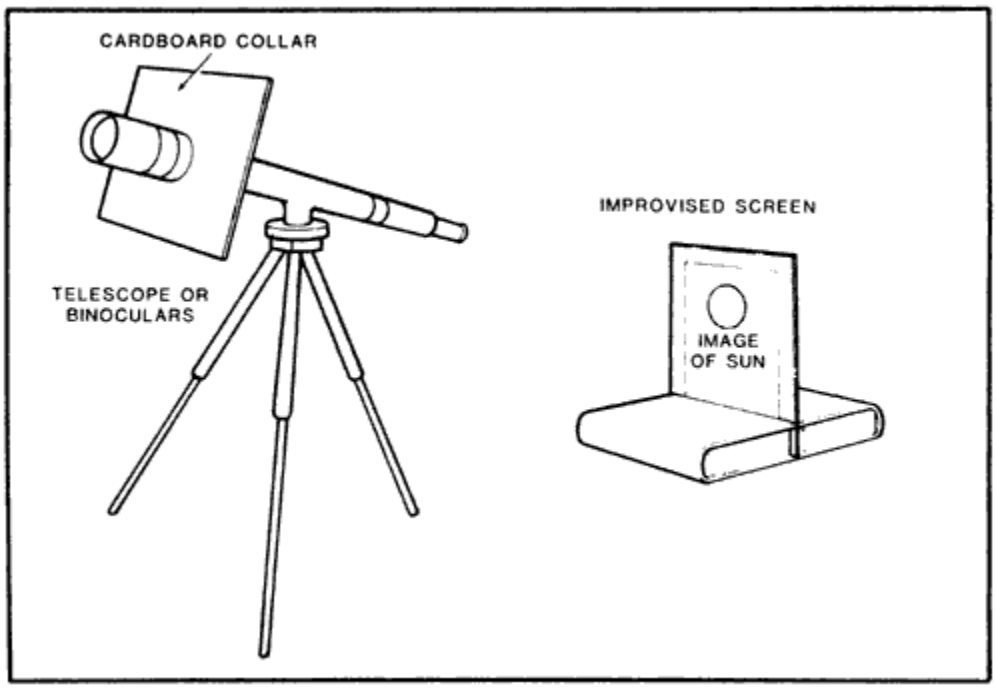
We should note that some school officials feel that all viewing of the Sun should be forbidden. Even though there are safe ways to view the Sun, there is always a chance that some student will not take the necessary precautions, or will disobey instructions, and an accident will occur. The projection methods described below are quite safe, however — and the number of astronomy-related school accidents is far less than the number encountered in other science subjects!

**Viewing the Sun by Projection**

This method is relatively safe and, with it, many people can view the Sun at once. You will need a pair of binoculars or a small telescope, a piece of plain cardboard about 30 centimeters square for the "collar,'' and a second piece of white cardboard (or paper) at least 10 centimeters square for the screen. If you use a telescope, you should mount it on a tripod. If you use binoculars, you can hold them in your hand, but it is much more convenient (and you will have a steadier image) if you improvise some sort of stand or tripod to hold them.

This demonstration can be done at any time of the day when it is clear and when your class has access to direct sunlight.

Note: Do not use binoculars whose front lenses are 50 millimeters across or wider. (Binoculars usually are described by a pair of numbers separated by an 'x', such as "7 x 3'' or "7 x 50''; the number to the right of the 'x' is the diameter of the front lenses in millimeters.) Big lenses gather a lot of light, and the heat generated by direct sunlight in side large binoculars can damage their complex optics.




**Method**

1. Make a cardboard collar to fit around the front end of the binocular or telescope, as shown in the figure. This shades the area where the image will be from sunlight. And (in the case of binoculars) will cover the lens which you are not using.

2. Focus the binocular or telescope on infinity by looking at a distant object (not the Sun!) in the normal way. (If you are using a telescope. use a low-magnification eyepiece.)

3. Point the binoculars or telescope at the Sun (do not look through the instrument to do this!), as shown in the figure, and adjust the direction of pointing until the image of the Sun appears on the screen. (This may take a minute or two. One useful trick is to watch the shadow of the binoculars or telescope tube: if pointed directly toward the Sun, then the sides of the tube will cast no shadows, and the instrument's shadow will be as small as it can be.)

4. Move the screen toward or away from the eyepiece until the image of the Sun fits neatly in the middle. And adjust its tilt until the Sun's image is circular.

5. Jiggle the binoculars or telescope very slightly. Any specks on the image of the Sun which do not jiggle along with the image when you do this are specks in the binoculars or telescope (or smudges on the screen), and not spots on the Sun itself.

**Observations**

When you and your students examine an image of the Sun, you will notice the following properties:

1. The image is brighter in the middle of the disc than at the edges. This effect is called limb-darkening. It occurs because, when we look at the middle of the Sun's disc, we are looking straight down into the

hotter part of the Sun. At the edges of the disc, we look more obliquely, and see only the cooler, less bright gases, higher in the Sun's atmosphere.

2. The image moves slowly across the screen. This is due to the east-to-west motion of the Sun in the sky, caused by the rotation of the Earth. The direction of motion of the image therefore tells you which direction on the screen (and on the Sun's image) is west.

3. There may be small darks spots on the image. These are called sunspots and are regions in the outer layers of the Sun which are cooler and therefore not as bright as their surroundings. In sunspots, the Sun's magnetic field is exceptionally strong, and astronomers suspect that this is connected to their being darker than the material around them. Sunspots, when examined closely with a telescope, are seen to be very complex. They can form within a few days, and may endure and evolve for weeks or months.

**An Alternate Way to Project An Image of the Sun**

This method produces an image which is a bit fuzzy, but good enough to show large sunspots, and it is particularly suitable for observing a partial eclipse of the Sun. It is very safe, and can be used to show an image of the Sun to an entire class. You will need a small pocket mirror or hand mirror. A piece of plain cardboard to fit over the mirror (or some tape to cover it), and a piece of white cardboard or paper to use as a screen.

**Method**

1. Cut the plain cardboard or paper so it fits over the mirror.

2. Cut or punch a very small hole, about 5 millimeters in size. in the middle of the plain cardboard. You could also use tape to cover all but a small portion of the surface of the mirror.

3. Put the mirror on a window sill in the sunlight such that it catches the rays from the Sun. Turn the room lights off and draw the window blinds so that as little as possible of the room other than the mirror is in sunlight.

4. Reflect the sunlight onto a wall of the darkened room.

5.Put the white cardboard or paper on the wall at this point, so you can use it as a screen to display the image of the Sun.

**Observations**

1. You will notice that the image of the Sun is round (unless an eclipse is in progress), even if the hole which you cut or punched in the plain cardboard or paper was square!

2. You can also demonstrate that the size of the image of the Sun is proportional to the distance of the screen from the mirror. The larger the distance. The larger (and fainter) the image. In a more advanced class, you might want to develop an explanation for these two observations.

If you do not have a classroom in which there is a sunlit window, you can do the activity outdoors. Find a place where you can catch the sunlight with your mirror, and can reflect it onto a shaded wall. (Better still, reflect it into a darkened classroom.) Again, you can use a sheet of white paper or cardboard as a

screen. It takes a few minutes to discover the best arrangement for the mirror and the screen, but once you have done so, it is easy to set up the demonstration again on any following day.

The Exploratorium demonstrates how to view a planet in transit or an eclipse safely by projecting the image with binoculars: http://www.exploratorium.edu/transit/how.html. There are commercially available projection telescopes as well.

# Eye Safety During a Total Solar Eclipse

A boy wearing protective viewing glasses watches a partial solar eclipse from Arlington, Virginia, in 2014.
Credits: NASA/Bill Ingalls

It is never safe to look directly at the sun's rays – even if the sun is partly obscured. When watching a partial eclipse you must wear eclipse glasses at all times if you want to face the sun, or use an alternate indirect method. This also applies during a total eclipse up until the time when the sun is completely and totally blocked.

During the short time when the moon completely obscures the sun – known as the period of totality – it is safe to look directly at the star, but it's crucial that you know when to take off and put back on your glasses.

First and foremost: Check for local information on timing of when the total eclipse will begin and end. NASA's page of eclipse times is a good place to start.

Second: The sun also provides important clues for when totality is about to start and end.

---

1) As the moon moves in front of the sun, there comes a time when several bright points of light shine around the moon's edges. Known as Baily's Beads, these are light rays from the sun streaming through the valleys along the moon's horizon.

Credits: © 2005 Miloslav Druckmüller (used with permission)

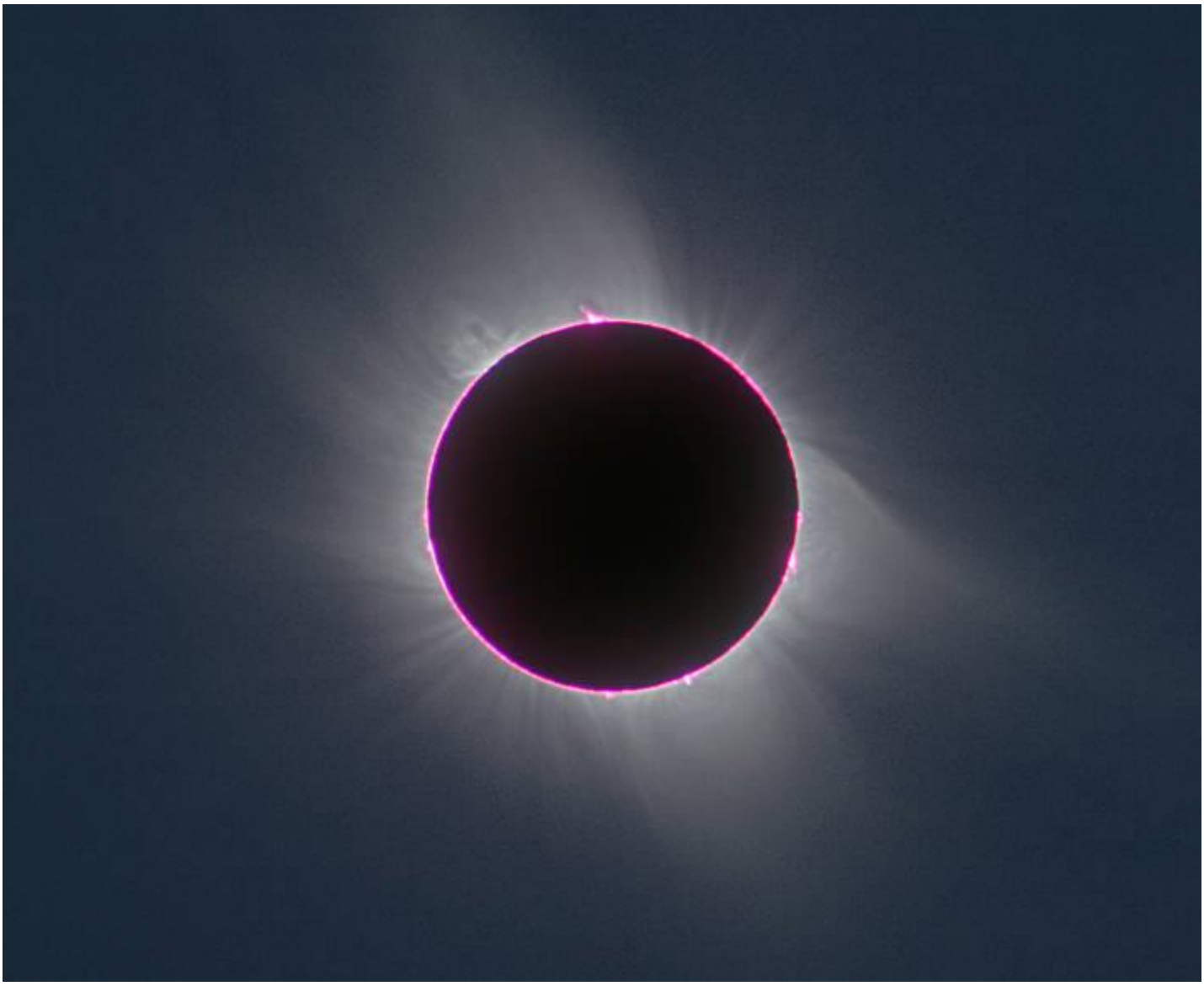
---

2) As the moon continues to move, the extent of these beads diminish, until there is only one – a bright spot that, in combination with the atmosphere of the sun still visible around the moon looks like a giant diamond ring. It is still not safe to look at the sun at this point! Only when that bright spot completely disappears can you safely look at the sun.

Credits: © 2005 Miloslav Druckmüller (used with permission)

---

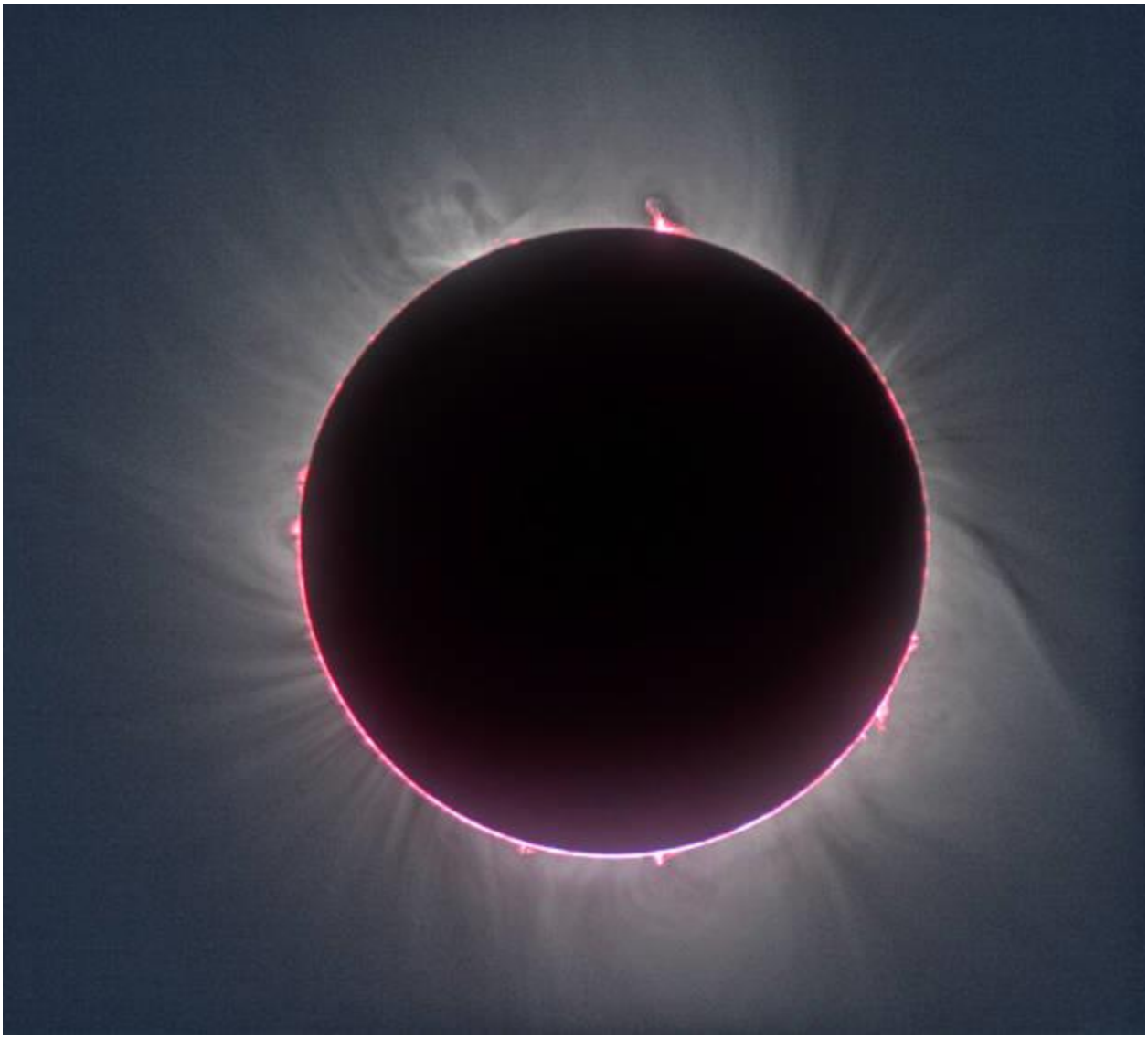
3) Once the bright "diamond" disappears and there is no longer any direct sunlight coming toward you, you may look at the total eclipse safely. But you must still be vigilant to make sure you protect your eyes again before the end of totality. The entire total eclipse may take only a minute or two in some locations.



Credits: © 2005 Miloslav Druckmüller (used with permission)

---

4) As the moon continues to move across the face of the sun, a crescent will begin to grow larger on the opposite side 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.



Credits: © 2005 Miloslav Druckmüller (used with permission)

---

5) Once your eyes are protected again, you may continue to watch the final stages of the eclipse as the end process mirrors the beginning: You will once again see a diamond ring and then the Baily's Beads, before the entire sun is once again visible.

Credits: © 2005 Miloslav Druckmüller (used with permission)