Prepare for Totality

Get Ready for the August 21 Total Solar Eclipse
Got your EclipSmart Solar Shades, Solar Glasses, or solar optical products yet? Don’t wait ‘til the last minute to obtain these crucial pieces of solar viewing equipment. If you’re planning to record images or video of the eclipse, you’ll want to be sure you have the right Solar Safe protection – like the EclipSmart Photo Filter - for your camera and smart phone.

The experience of a solar eclipse can be overwhelming. Determining what you want to do in advance and “going through the motions” beforehand will help prevent something important from being forgotten. Remember, with solar eclipses, there are no “do-overs.”
1. CAN'T WATCH IT IN PERSON? Watch it live via the Lowell Observatory's feed.

2. GO FOR A RUN. Sign up and complete the Virtual Running Club's Total Solar Eclipse 5K/10K and you could win a Celestron telescope.

3. KEEP HYDRATED and wear plenty of sunblock. Even during the partial phases of the eclipse, the Sun's rays can still burn your skin.

4. BE MOBILE. Weather can change quickly, so be prepared to move to clear skies if necessary.

5. DON'T FIXATE ON THE SKY. Air temperature changes as the eclipse progresses, animals can behave curiously; take notice.

6. WATCH THE SHADOWS. Crescent Sun shadows can appear as sunlight filters through tree leaves; moving shadow bands may be visible on flat pale surfaces just before and after totality.

7. SEE THE ENTIRE ECLIPSE. Watch the Moon transit the Sun.

8. DURING TOTALITY, look towards the horizon and witness a 360° sunrise/sunset.

9. ENJOY the sheer beauty of the eclipse, so you can create your own memorable experience. Read about Celestron's Kevin Kawai's, search of The Elusive Ring of Fire.

10. PAUSE FOR A MOMENT to think of what ancient people must have thought during an eclipse when the Sun disappeared from the sky.

celestron.com/eclipsewatch2017
What’s happening in space and on Earth.

by Michael E. Bakich; illustrations by Roen Kelly

ON August 21, the dark inner part of the Moon’s shadow will sweep across the United States, creating a total solar eclipse for regions in 14 states. But, you may ask, the Sun is so much larger than the Moon, so how does this work? While our daytime star has a diameter about 400 times larger than that of the Moon, it also lies roughly 400 times farther away. This means both disks appear to be the same size, so at certain times from certain locations, the Moon can completely cover the Sun.

Be sure to protect your eyes during the partial phases. The simplest way is to buy a pair of solar viewing glasses. Wear them even when 99 percent of the Sun is covered because the remaining part is still intense enough to cause retinal burns. But remember: During the 2 minutes and 40 seconds of totality, remove any solar filters, or you’ll miss the most spectacular part of the eclipse.

Types of eclipses

The three main types of solar eclipses are total, where the Moon completely covers the Sun’s surface; annular, during which the Moon lies too far from Earth (or Earth too far from the Sun) for it to cover the Sun completely; and partial, where the lineup isn’t exact and only the Moon’s outer shadow touches our planet.

Top: Some central eclipses are total and others annular because the Moon’s distance from Earth changes. Bottom: An eclipse doesn’t happen every New Moon because our satellite’s orbit tilts more than 5° from the plane of our orbit.
**Two types of shadows**

If the Sun were a point source, like one of the nighttime stars, the Moon would cast only one kind of shadow. Instead, the Sun stretches 0.5° across, so even during total solar eclipses, some of its light passes either above or below the Moon, creating a less-dense shadow called the penumbra. Only where the Moon blocks all the light from the Sun — in its dark inner shadow called the umbra — can people on Earth see a total solar eclipse. Anywhere in the penumbra, the eclipse will be partial, but the percentage of the Sun covered will increase as you get near the umbra. Unfortunately, the umbra is small, no more than a hundred miles in diameter. On the other hand, the penumbra measures more than 4,000 miles across.

---

**Left:** From now until the end of 2037, 12 total solar eclipses will occur. This map shows the paths of totality in orange and each eclipse’s center line in black. **Below:** This sequence shows an entire total eclipse in 11 images. The center shows totality, while the two diamond rings flank it.

Michael E. Bakich is a senior editor of *Astronomy* who will be hosting the world’s largest eclipse event August 21 at Rosecrans Memorial Airport in St. Joseph, Missouri.
Observe from the center line

An extra minute of totality is worth almost anything you have to do to get it.

In all likelihood, the most important thing you’ll read or hear about the August 21, 2017, eclipse is that you must get to the path of totality. It’s true. As I like to say in my talks, the difference between viewing a partial eclipse and experiencing a total one is the difference between almost dying and dying — there’s no comparison.

Once you’ve decided to adopt this sage advice, consider going one step further: Try your best to position yourself on the eclipse’s center line. Any detailed map that shows the path of the 2017 total solar eclipse will have three curved lines on it. The two outer ones show the northern and southern limits of totality. Within their borders is where the Moon’s umbra — its dark inner shadow — falls on Earth. And just like your art teacher told you in third grade: Stay inside the lines.

But it’s the line midway between those two extremes that’s most important. Astronomers call this the center line for obvious reasons. It’s along this path that the central part of the Moon’s shadow falls, and that’s where you should try to be on eclipse day.

Rehearse for eclipse day

Here’s how to do an actual run-through months before August 21, 2017.

As you read this, America’s eclipse is a year away. But people are beginning to get nervous already. They ask questions, start making plans. The “hands-on” folks desire a bit more, however. They want to get out under the daytime sky and check out the circumstances themselves. If you’re one of them, I have good news: There’s a way to conduct an accurate rehearsal for the eclipse.

First, some background. Earth’s axis tilts 23.5° to the pole of its orbit around the Sun. This orientation explains why we have seasons. When the northern tip of our planet’s axis points toward the Sun, it’s the Northern Hemisphere’s summer. When the southern tip points sunward, the Northern Hemisphere experiences winter. Spring and autumn lie midway between these extremes. All seasons reverse in the Southern Hemisphere.

Because of the tilt, the Sun’s maximum altitude at any location changes by 47° in the six-month span from June to December or December to June. On the June solstice (the Northern Hemisphere’s first day of summer), the Sun stands as high in the sky at midday as it gets all year. Conversely, on the December
Imagine for a moment an image of the Moon with two lines drawn through it — one passes through the Moon's center, and the other is parallel to it but only half as long. We know the shadow cast by our satellite has the same shape as the Moon itself, so you'll enjoy a longer duration of totality if the shadow traces the longer line through your location than you will if it traces the shorter one. So, if the duration of totality on the center line you imagined is, say, two minutes, you might experience only one minute of totality along the other line.

If you take this example to the extreme, you could select a position on Earth that lies along the northern or southern limit of the path of totality. The duration of totality along the path’s edges would be the briefest moment, much less than a second. And, in fact, some intrepid observers will position themselves at the umbra shadow’s limit to record irregularities along the Moon’s limb (its visible edge). These observations are possible because only a tiny percentage of the Sun’s disk shines through lunar valleys or between mountains. It’s important work, but it’s a job for scientists. You, as a first-time eclipse viewer, want to maximize your time under the umbra.

So, get to the center line!

Michael E. Bakich is a senior editor of Astronomy who will be conducting a huge free public eclipse watch at Rosecrans Memorial Airport in St. Joseph, Missouri, on August 21, 2017.
ARE YOU PREPARED?
FOR THE AUGUST 21ST 2017 SOLAR ECLIPSE

Check out the videos below for helpful tips on how to safely view and photograph this incredible event.

WATCH VIDEO

WATCH VIDEO

WATCH VIDEO

WATCH VIDEO

Get ready to comfortably view the eclipse and everyday sunspot activity in detail!

GET PREPARED
MAGNIFY YOUR SOLAR OBSERVING EXPERIENCE
WITH SAFE AND DURABLE GEAR

ECLIPSMART solar binoculars and solar scope feature Solar Safe filter technology built directly into the glass. Our Solar Safe products provides the ultimate protection from harmful solar radiation, including both IR and UV light, and filters out 99.999% of intense visible light. Owning a good pair of solar optics is a must for anyone who is fascinated by viewing our planet’s nearest neighboring star, and future solar astronomy events.

VIEW THE SUN AT DIFFERENT MAGNIFICATIONS!

*Image provided for scale only

10x25 & 10x42 SOLAR BINOCULARS
- 10x magnification brings the Sun up close to observe excellent detail, including sunspots
- Weather resistant, rubber armored aluminum body

SOLAR TRAVEL SCOPE 50
- Includes a unique solar finderscope which allows locating the Sun in the center of the eyepiece without directly looking at the Sun
- Includes backpack which holds and protects solar scope and tripod, with additional room for extra accessories

celestron.com/EclipSmart
View the Sun safely

Billions of people have experienced solar eclipses safely. Here’s how.

Observing the Sun can be dangerous. Solar radiation that reaches Earth’s surface ranges from ultraviolet to radio waves, but only visible and near-infrared light concern us. If too much of this radiation reaches our light-sensitive retinas, “eclipse blindness” or retinal burns may occur.

Intense visible light damages rod and cone cells. The light triggers chemical reactions within the cells that damage their ability to respond to visual stimuli and, in extreme cases, can destroy them. Blindness — either temporary or permanent — results. When someone looks at the Sun without proper eye protection, a thermal injury also might happen. The high level of visible and near-infrared radiation heats the exposed tissue and literally cooks it. Man, that sounds nasty! This thermal injury destroys rods and cones, creating a blind spot. And what’s worse is that retinal injuries occur without your knowing it — the retina has no pain receptors, and the bad effects don’t appear immediately. The only time you can view the Sun safely with the naked eye is during totality. Even during the late partial phases, when the Moon covers 99 percent of the Sun’s visible surface, the slim solar crescent still packs enough of a punch to burn the retina. To avoid permanent eye damage, use the right observing methods.

The safest and least expensive technique is projection. Use a pinhole or a small opening to form an image of the Sun on

Decipher the eclipse pattern

Skywatchers have been accurately predicting eclipses for centuries. How do they do it?

You don’t have to be an astronomer to know how eclipses happen: the Sun, the Moon, and Earth line up precisely. But you do have to know how these objects move to understand the pattern eclipses go through — one called the “saros.” This is the time period after which nearly identical eclipses repeat.

The saros equals 6,585.3211 days. That’s how long it takes for four periods related to the Moon to once again coincide. The first is the sidereal period — our satellite’s orbital period with respect to the stars, 27.32166 days.

The second is the synodic period, 29.53059 days, the time it takes the Moon to go from any phase to the next occurrence of the same phase. Because we’re talking about solar eclipses, we can simplify this to the time between successive New Moons — the phase at which such eclipses occur.

We don’t experience a solar eclipse at every New Moon, however, because our satellite’s orbit tilts with respect to Earth’s orbit around the Sun. The Moon’s orbit intersects Earth’s twice each lunar month at points called nodes. That’s the origin of our third period. A draconitic period is the time it takes the Moon to go from one node back to the same node, 27.21222 days.

Two successive eclipses in a saros have essentially the same duration because the Earth–Moon distance is nearly the same for each. If you guessed that this is because of the fourth period, you’re catching on! The anomalistic period equals 27.55455 days. This is the time between two successive lunar perigees — our satellite’s closest approach to Earth.

On average, the Moon travels approximately 13° relative to the background stars each day. This rapid motion allows it to complete one circuit (a sidereal period) every 27.32166 days.

The Moon’s orbit around Earth intersects the apparent path of the Sun (which coincides with our planet’s orbital plane) in two spots called “nodes.” Our satellite returns to the same node (a draconitic period) every 27.21222 days.
a white card lined up with the Sun and the opening. Multiple openings in a hat or even between crossed fingers will cast a pattern of eclipsed Suns on a screen. This effect happens more naturally beneath trees within the eclipse path. The many “pin-holes” formed by overlapping leaves create hundreds of solar images.

Another projection technique uses binoculars or a small telescope mounted on a tripod to project a magnified image of the Sun onto a white card. This method is great for showing to a group of observers, but make sure no one looks through the device.

To view the Sun directly, you need an approved solar filter. The ones that look like mirrors have atoms of aluminum deposited on plastic. Others (that look dark) use a thin piece of polycarbonate. Each drastically cuts both visible and near-infrared radiation to a safe level.

One filter many amateur astronomers have used for solar viewing is a #12 or #14 welder’s glass, which produces a light-green image. But #14 is a dense filter, and welders seldom use it. So, although they aren’t expensive, you may still have to special-order one of these.

Now let’s see how these periods relate. One saros — the next time all four of these lunar months align — equals 241 sidereal periods, which also equals 223 synodic periods, 242 draconitic periods, and 239 anomalistic periods. After one saros, therefore, the positions of the Sun, the Moon, and Earth will be nearly identical. It will be New Moon, our satellite will lie at the same node, and its distance to Earth will be the same.

And consider this: A saros is some 11 days longer than 18 years. In 11 days, Earth travels only 3 percent of its orbit, so its position with respect to the stars will be nearly the same, too. The second eclipse, however, will occur at a much different place on Earth.

Here’s why. The saros is not an integer. The extra 0.3211 day equals 7 hours 42 minutes and 23 seconds. So each successive eclipse in a saros happens this much later in the day, which means the region of visibility on Earth shifts 115.6° to the west.

Now it gets interesting. After three saros intervals — 54 years and 33 days — the region of visibility shifts $3 \times 115.6° = 346.8°$ — just 13.2° less than a full circle. Thus, the eclipse won’t have only the same characteristics as one that occurred 54 years before, it will occur at roughly the same time of day and within an hour of the same time of day.

A saros series begins with partial eclipses visible at high latitudes in either the Northern or Southern Hemisphere. Next, a group of annular and then total eclipses appears over Earth’s middle and equatorial latitudes. The series ends with more partial eclipses near the opposite pole from where the saros started.

About 238 solar eclipses occur each century. So, roughly 42 eclipses occur during a saros period of 18 years and thus, at any time, approximately 42 different saros series must be active.

The August 21, 2017, total eclipse belongs to saros 145. It’s the 22nd eclipse in the series, which contains a total of 77. The first one was a partial eclipse January 4, 1639. The most recent one, a total eclipse, occurred across Europe and Asia on August 11, 1999. After 2017, the next one will happen September 2, 2035. And the last eclipse of saros 145 (a partial) will occur April 17, 3009.