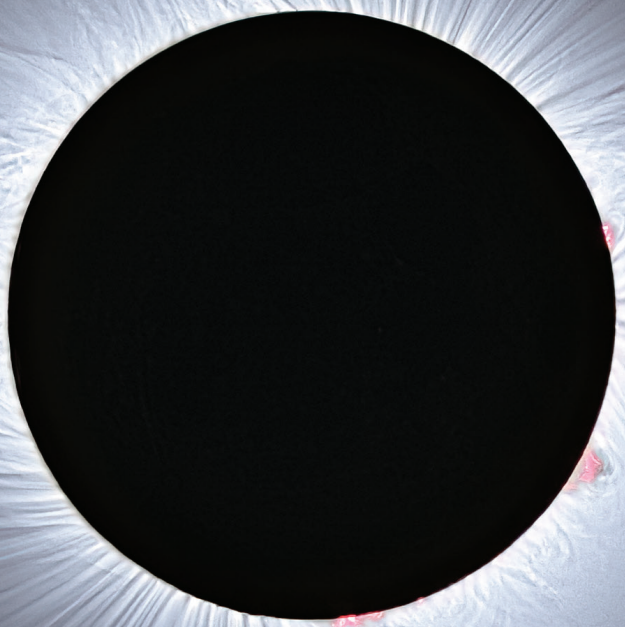
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IN THE SHADOW:
Why Solar Eclipses Happen

TOTALITY:
Out-of-this-World Beauty

The Great 2026 ECLIPSE

YOUR COMPLETE GUIDE TO AUGUST'S SOLAR ECLIPSE

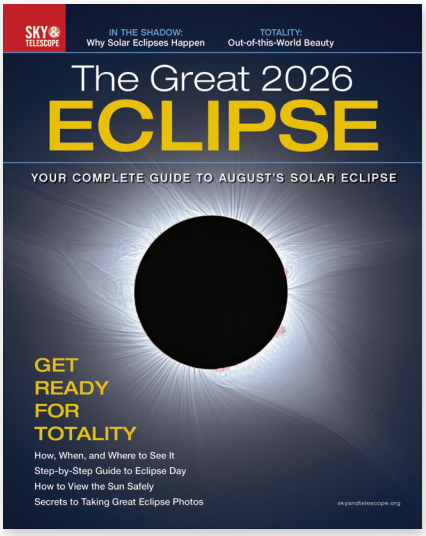


GET READY FOR TOTALITY

- How, When, and Where to See It
- Step-by-Step Guide to Eclipse Day
- How to View the Sun Safely
- Secrets to Taking Great Eclipse Photos

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The Great 2026 Eclipse



The Sun's corona stands out strikingly in this composite photo on August 21, 2017.

SEAN WALKER / *S&T*

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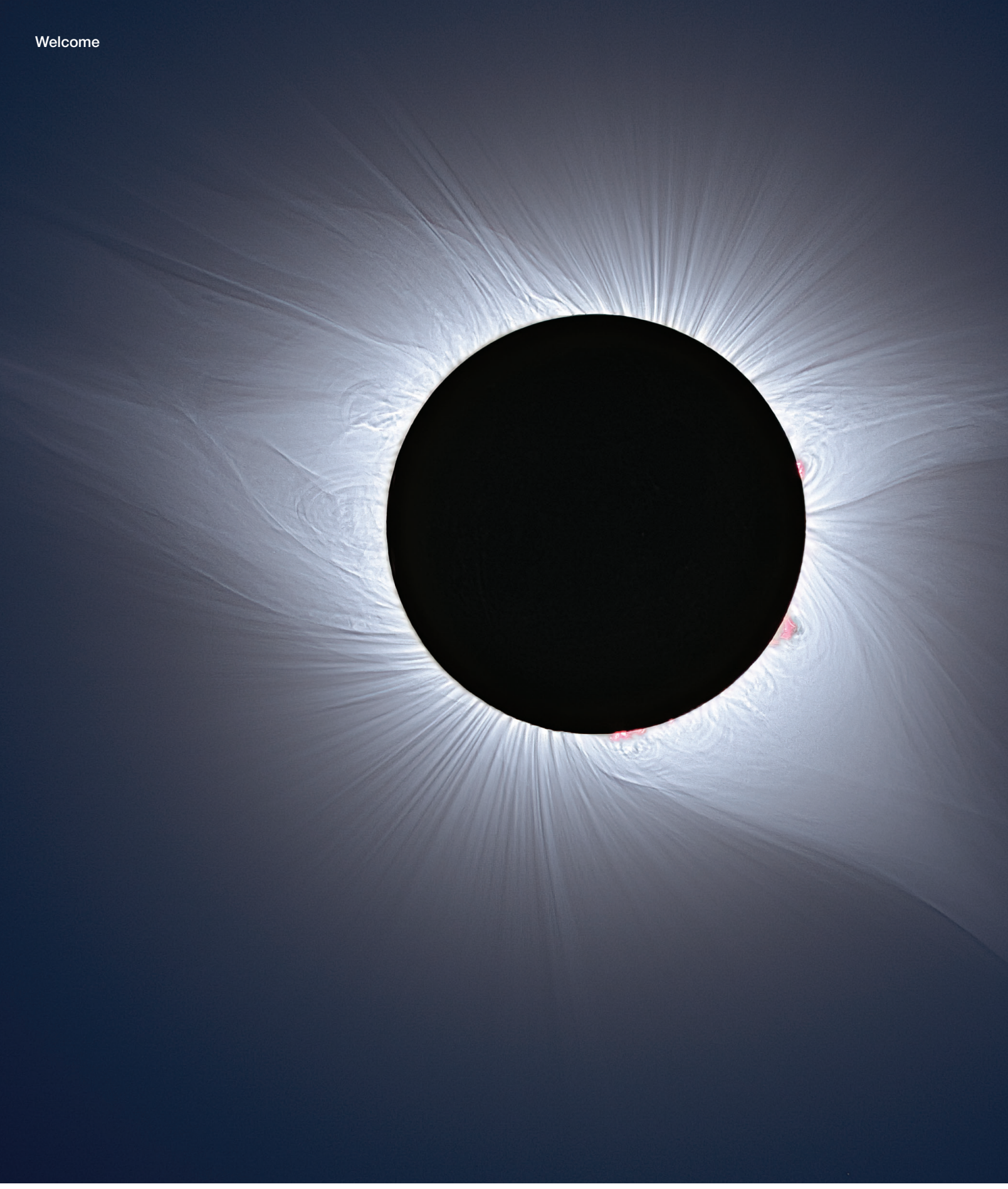
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Totally Unforgettable!

Since you're reading this special issue, you're probably anticipating the August 12, 2026, total solar eclipse. Whether you'll be on a cruise in the Mediterranean, perched atop a cliff on the island of Mallorca, or wandering the battlements of a medieval castle in Aragon, you'll be in for the experience of a lifetime.

Totality — the fleeting moments when the Moon completely covers the Sun during a total solar eclipse — is by far the most breathtaking and unforgettable celestial event you can witness from Earth's surface. Those who have been lucky enough to spend a few minutes in the Moon's shadow know that the emotions the experience elicits are powerful. People have tears streaming down their faces, some sob, some laugh, children shriek gleefully — not one person isn't moved by the event. Even nature reacts — diurnal birds stop singing, and nocturnal insects start chirping.

It's not uncommon for first-time totality *experiencers* to become lifelong eclipse *chasers*. It's that "unforgettable" bit in the title of this welcome note — once you've seen one, you simply cannot forget it and you'll yearn for more. You'll want to find ways to get back into the path of totality. And this is why we at *Sky & Telescope* not only work diligently at tailoring the best eclipse experience for you through our tours, but we've also prepared this handy guidebook with everything you need to prepare for the event.

So whether this be your first total solar eclipse or one of many, please dip into these pages. Turn to page 14 for a detailed preview of the eclipse you're about to witness. You'll find articles on the mechanics of eclipses (page 10), how to view the eclipse safely (page 22), and how to photograph the phenomenon (page 26). An eclipse-day infographic will help you prepare step-by-step for the big moment (page 20).

Do avail yourselves of the resources that the team at *Sky & Telescope* has collected for you on page 38. While anticipating your adventure, you can drool over the photos taken by talented astrophotographers during past eclipses and read a moving, personal account (page 4). And finally, we wouldn't be at all surprised if this experience will entice you back into the path of totality for the next solar eclipse — the article starting on page 36 will tell you all about how to get there.

We hope this issue will inspire you as you get ready to embark on your big adventure. And, more importantly, that you fully revel in the experience itself. Here's to clear skies!



EDITOR IN CHIEF
Sky & Telescope

SEAN WALKER / S&T

The Eclipse Experience

What's it like to be in the path of totality during those awe-inspiring moments of darkness?

By Kate Russo

Talk to people who've witnessed a total solar eclipse, and you'll notice their eyes light up. They become increasingly animated and overuse words like "awesome" and "life-changing." The intensity of their passion is evident — yet surely it can't be that exciting, can it?

Before my first total solar eclipse in 1999, I'd never met anyone who had seen "totality." From what I'd read, it was certainly going to be special and interesting. But I had no inkling that it would be such an overwhelming, emotional rollercoaster.

I have now witnessed 13 total solar eclipses from six continents. I continue to research the eclipse experience, helping to communicate the intensity and emotional complexity of this spine-tingling experience. I also guide communities within the path of totality in their preparations with my evidence-based White Papers and resources and am actively involved with national eclipse-planning endeavors. When I wrote this, I sensed the growing anticipation for the annular solar eclipse in October 2023, which was merely a warm-up for what was to come — the Great American Eclipse of 2024.

What to Expect: Above, Around, Within

On August 12, 2026, parts of North America, Europe, and Africa will see the Moon partly (not fully) cover the Sun, an event called a partial solar eclipse. Seeing the Moon's silhouette marching across our star (with safe filters, of course) is a wonderful demonstration of fortuitous celestial alignments.

But for the full experience, you must be within the narrow path of totality. As the eclipse progresses and more of the Sun is covered, the environment changes. You notice the dimming and special quality of the light around you, the fading colors, and the drop in temperature. Nature quiets, and you too become hushed as the Moon's shadow sweeps eerily toward you.

The ominous darkening in the sky can be seen and felt. Many have an intense physical reaction at this moment. The hair on the back of your neck rises, and goosebumps cover your arms. Excitement fills you, tinged with mild terror, as the world rapidly becomes engulfed in an unknown darkness.

Those final, quick moments before totality are incredibly powerful. The brilliant "diamond ring" — a last gleam of sunlight seen against the lunar silhouette — heralds the start of totality. This sight is so otherworldly that you think it's a special effect from some science-fiction movie. You find yourself screaming excitedly, not knowing what you're saying. The remaining arc of light reduces until there are only tiny beads of it shining through the valleys of the Moon — creating an effect called "Baily's Beads."

And then you are plunged into darkness. You are standing in the shadow of the Moon. Totality.

A black hole appears in the sky where the Sun should be, like a celestial eye gazing back at you. The world around you is now in deep twilight — dark enough to show planets and the brightest stars, with glorious sunset colors all around the horizon. As your eyes adapt to this surreal darkness, the Sun's outer atmosphere becomes visible. Silvery, wispy, and ethereal, it seductively surrounds the eclipsed Sun. Crimson-hued prominences sometimes also leap from the edge.

The world suspends in time, as you are lost in your own little rapture. You feel an immediate connection to our primitive ancestors, who would have been terrified by all this, possibly believing the end of the world was imminent. A little part of you also wonders if the Sun will ever return. You recognize that we humans are but a small part of the vastness of our universe. It's a strangely comforting and empowering insight, like you've finally figured out what life is all about.

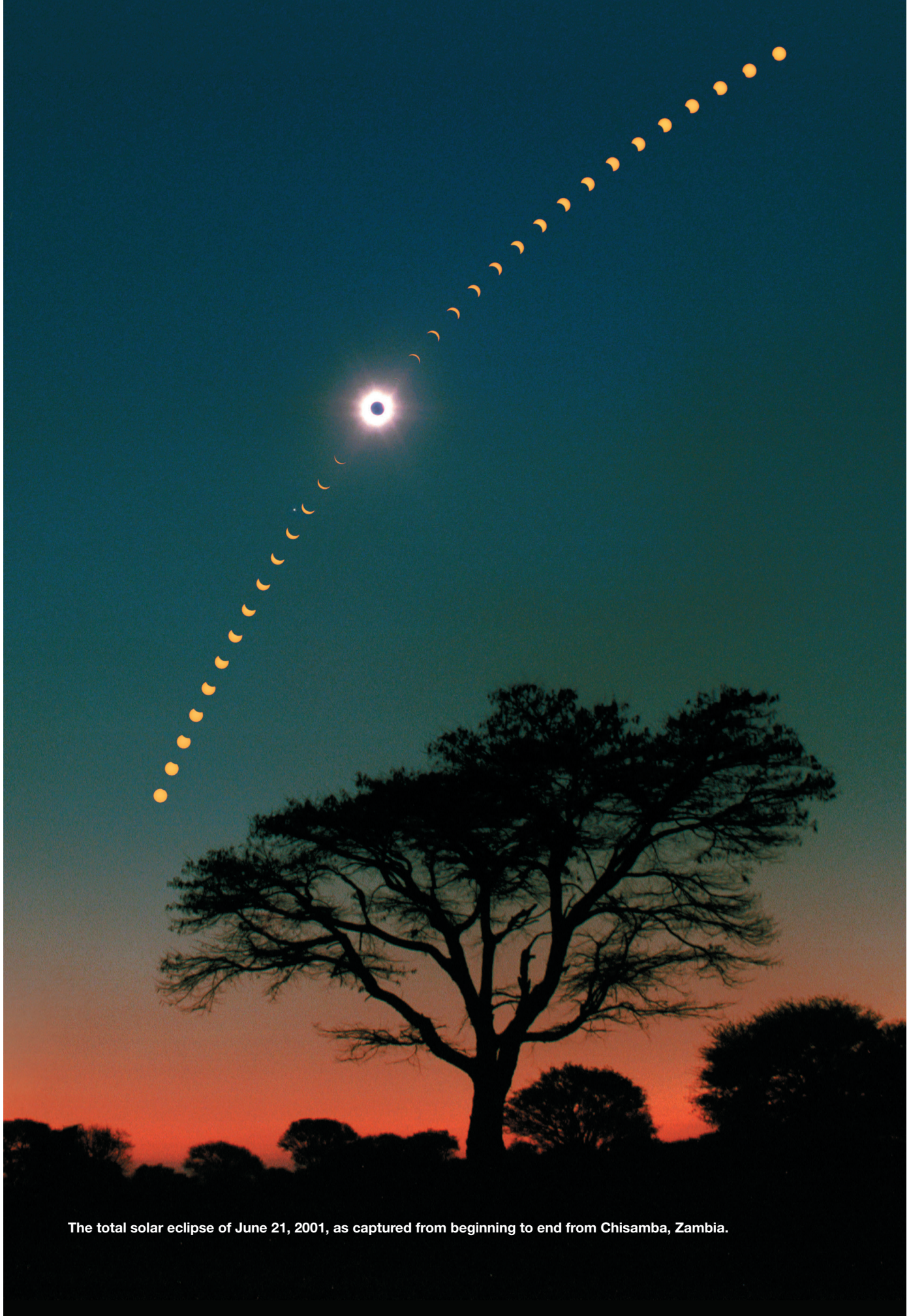
More brilliant beads of light mark the beginning of the end. The diamond ring again dazzles before daylight's full brightness returns. Totality might be over, but the experience has been seared into your brain, heart, and soul — a new, vivid memory that you'll hold dear forever.

Not Just "Once in a Lifetime"

Those who witness a total eclipse are connected in a way no words can express — nor are they needed. No other event in my life has had such a positive and powerful impact, igniting a passion that will burn forever. Every total solar eclipse is unique and special, like a new chapter in my life, and I will continue to chase and support planning efforts for the rest of my days.

A total solar eclipse is so much more than you can ever imagine and is worthy of the hype. Totality is the dramatic moments of awe, beauty, and wonder we experience within the Moon's shadow. Totality happens above you, around you, and within you. Join us eclipse-chasers in the path of totality on August 12, 2026, and share this life-changing experience — by being in the shadow.

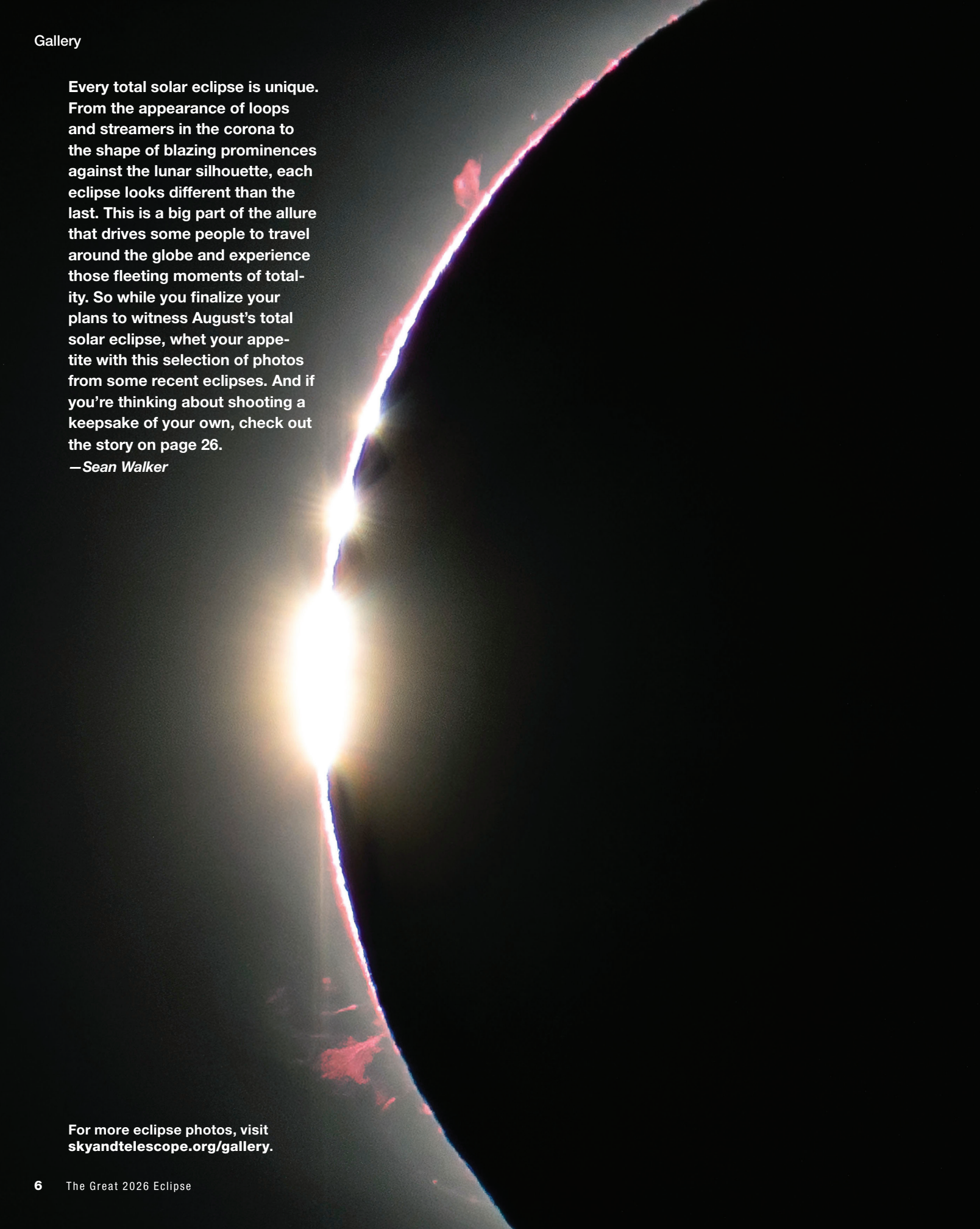
***Dr. Kate Russo**, founder of* Being in the Shadow, *is an eclipse consultant and keynote speaker now based in Australia, where she is excitedly leading the way for that country's "eclipse quintet."*



FRED ESPENAK

The total solar eclipse of June 21, 2001, as captured from beginning to end from Chisamba, Zambia.

Every total solar eclipse is unique. From the appearance of loops and streamers in the corona to the shape of blazing prominences against the lunar silhouette, each eclipse looks different than the last. This is a big part of the allure that drives some people to travel around the globe and experience those fleeting moments of totality. So while you finalize your plans to witness August's total solar eclipse, whet your appetite with this selection of photos from some recent eclipses. And if you're thinking about shooting a keepsake of your own, check out the story on page 26.
—Sean Walker

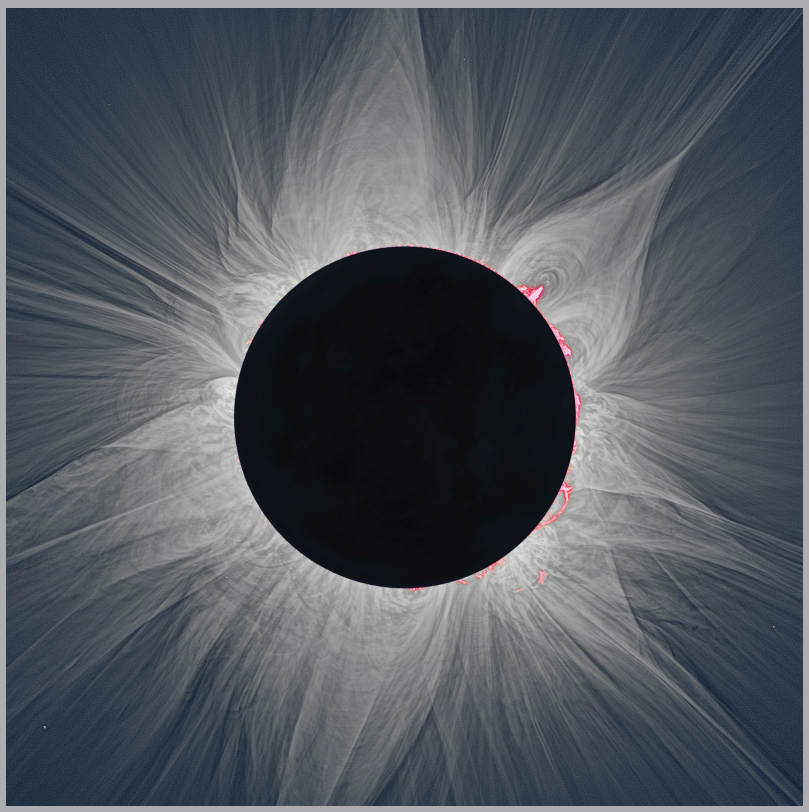


For more eclipse photos, visit skyandtelescope.org/gallery.

◁ SOLAR BLING

Fred Espenak

Several pinkish prominences appear to dance along the lunar limb as the first rays of the Sun emerge like glittering diamonds at third contact during the July 2, 2019, total eclipse seen from Vicuña, Chile.



▷ LOOPS AND STREAMERS

Pavel Štarha, Shadia Habbal, Miloslav Druckmüller

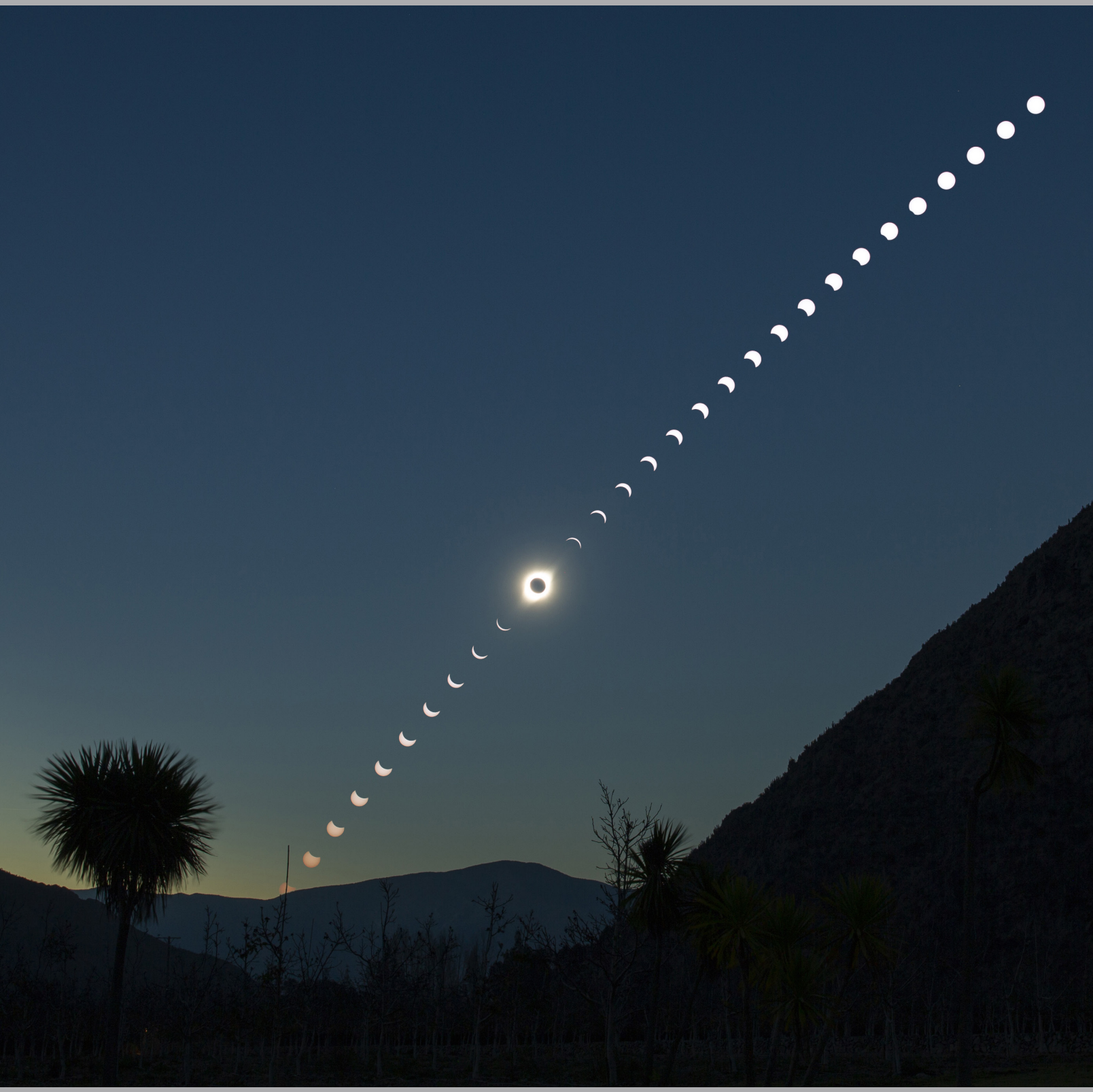
The corona and chromosphere were both bustling with activity during the April 20, 2023, "hybrid" (a combined total-annular) eclipse.

▽ FROM START TO FINISH

Tunç Tezel

This composite image captures every step of the April 20, 2023, hybrid solar eclipse as seen from a beach in Exmouth, Australia. Tezel used a 10-mm fisheye lens and Canon EOS 5D DSLR camera equipped with a solar filter to snap an exposure every 5 minutes, being sure to remove the filter during the middle of totality.





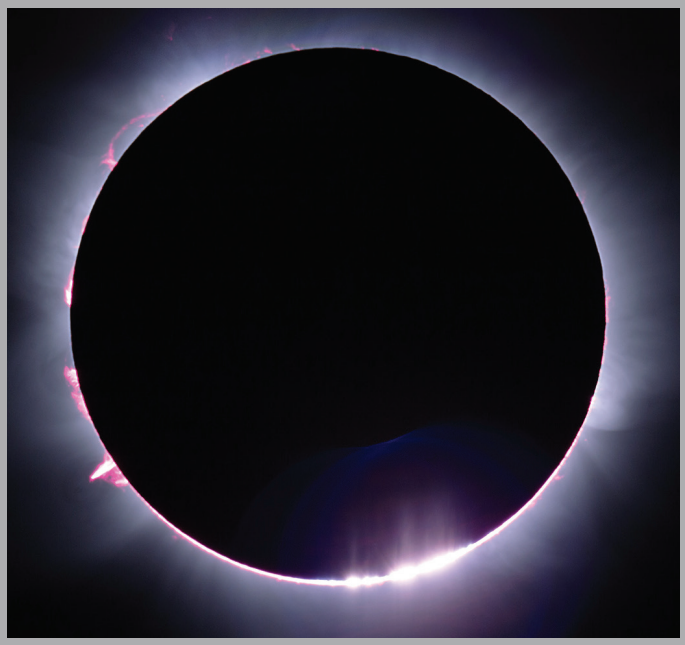
△DRAMATIC CHILEAN BACKDROP FOR ECLIPSE SEQUENCE
First-time eclipse-chaser Callan Carpenter created this impressive sequence, with images taken every 5 minutes, during the total solar eclipse on July 2, 2019. He and other *Sky & Telescope* participants witnessed the dramatic event from a site in central Chile next to rugged foothills of the Andes.



△A CUP OF TOTALITY

Dan Hurley

Umbraphile Dan Hurley captured this unique photo of totality reflected in his coffee with his iPhone during the hybrid solar eclipse over Exmouth, Australia, on April 20, 2023.



△BAILY'S BEADS

Tunç Tezel

The final jewel-like glimpses of the photosphere blaze along the lower half of the lunar disk just before second contact during the April 20, 2023, hybrid solar eclipse.



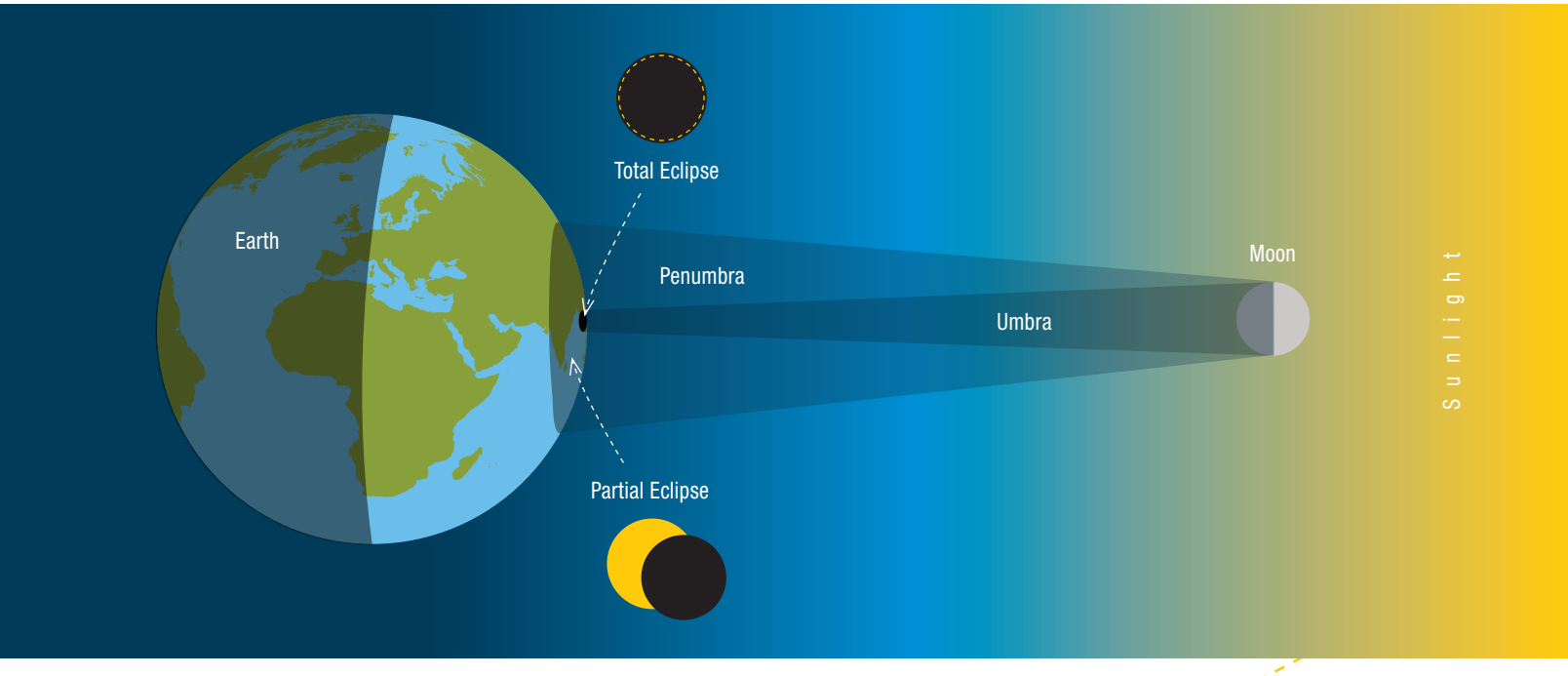
△SHADOW AT THE BOTTOM OF THE WORLD

Andreas Möller

Witnessing a total solar eclipse can be addictive, with some eclipse-chasers travelling to the most remote locations on Earth in order to briefly stand in the shadow of the Moon. This group traveled to Antarctica to catch totality on December 4, 2021.

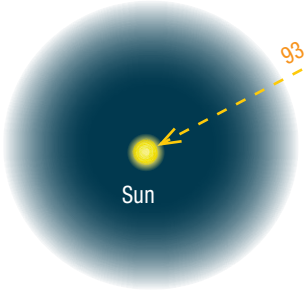
Hows & Whys of Eclipses

TAKE 10 MINUTES HERE & BE AN ECLIPSE EXPERT FOR FAMILY AND FRIENDS.



When the Moon casts its shadow onto Earth, people on the ground see the Moon eclipsing the Sun. The shadow's umbra is the dark central part where the eclipse is total. In the penumbra the Moon covers only some of the Sun, for a partial eclipse. (Not to scale!)

By Alan MacRobert • Sure, you know the basic idea: A solar eclipse happens when the Moon passes between you and the Sun, hiding part or all of the Sun from view. It's weird, it's unearthly, and it scared the bejeezus out of our ancestors who didn't know what was going on. The stories they made up to explain eclipses were hair-raising. The drive to actually *understand* eclipses — well enough to predict them! — was one of the drivers of ancient astronomy, and thus one of the drivers for the whole idea of science itself.



One breakthrough was grasping the scene from another viewpoint: The Moon is a sunlit ball and casts a shadow, and we see an eclipse of the Sun when the Moon's shadow sweeps over us, like in the diagram above.

But there's more to it than that — and if you want a fuller picture of what's going to occur on August 26th, read on.

Celestial Geometry

First off: The Moon orbits around Earth about once a month. This repeating journey brings the Moon close to our line of sight to the Sun at the time of "new Moon." At that time the sunlit side of the Moon faces directly away from us; the Moon shows us only its darkened nightside. And we can't *see* even that — because when the Moon is near our line of sight to the Sun, it's hidden in the Sun's dazzling glare in the bright blue daytime sky.

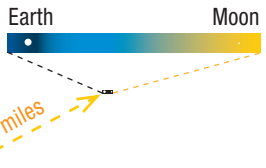
Usually the Moon misses the Sun in these monthly near-lineups (for reasons I'll get to later). But about every six months on average, at least part of the new Moon crosses at least part of the Sun's face as seen from somewhere on Earth. Hence a solar eclipse.

If the Moon crosses the Sun off-center

EARTH: SHUTTERSTOCK / FLUIDWORKSHOP. S&T ILLUSTRATION: PATRICIA GILLIS-COPPOLA



The Earth, Moon, and Sun are much farther apart in empty space than most illustrations suggest. Shown above is the Earth–Moon system correctly to scale. The Moon, a quarter of Earth's diameter, is 30 Earth diameters away from us. But that's puny compared to the pair's distance from the Sun! The Sun is 109 times larger than Earth — so in the smallest inset at right, Earth and especially the Moon would be pinpricks invisibly small. Their separation there is correctly scaled to the distance of the Sun at the bottom of the facing page.



as seen from your location, you get only a *partial* solar eclipse, with the Moon's silhouette making what looks like a dent in the Sun's brilliant face. A deep partial eclipse, where the dent is big, turns the Sun into a dazzling crescent.

But the really good stuff happens if the Moon crosses the Sun nearly dead center as seen from your location. Then you may get a *total* solar eclipse, blacking out the Sun completely for anything from a few seconds up to 7½ minutes.

A total eclipse also has partial-eclipse phases before and afterward. The partial phases take their time; the whole event usually runs about 3 hours from beginning to end.

What to Expect

A total eclipse is much more spectacular than a partial — not only because the sky and land get much darker, but especially because during totality we get a rare look at the Sun's intricate, feathery *corona*: its outermost atmosphere, made mostly of free electrons and protons that are trapped in the Sun's loopy, streaky magnetic field.

The partial phase of a solar eclipse can be seen from a large swath of the world. On Ausut 12th that will include much of North America, western Europe, western Africa, and even a bit of Siberia.

But totality is reserved for a much smaller area. The dark center of the Moon's shadow, the part where the Sun is completely blocked (the shadow's *umbra*) is never more than about 160 miles wide by the time it reaches Earth, usually less. On Augusst 12th, the narrow shadow-patch of totality will just miss the North Pole before sweeping over Greenland, Iceland, and Spain, as shown starting on page 14. That's the part for which so many people are preparing to travel.

Your Eyes Are Worth Keeping

As you've probably heard many times, staring at the Sun's blazing surface, even when only part of it is in view, can damage your eyes and leave a permanent blind spot in your vision. Never stare at the bright Sun, whether a partial eclipse is in progress or not.

Instead, during the partial phases you need to look through a safe solar filter. One example is the kind that's made to go over the front of a telescope. For viewing just by eye, all of the inexpensive little "eclipse glasses" that we have tested do just fine.

Or you can watch an image of the Sun as projected onto a piece of paper — using either a pinhole, which gives a very small, dim, crude image, or a pair of binoculars or a telescope, which project a much bigger, brighter, and sharper image onto paper. See page 22.

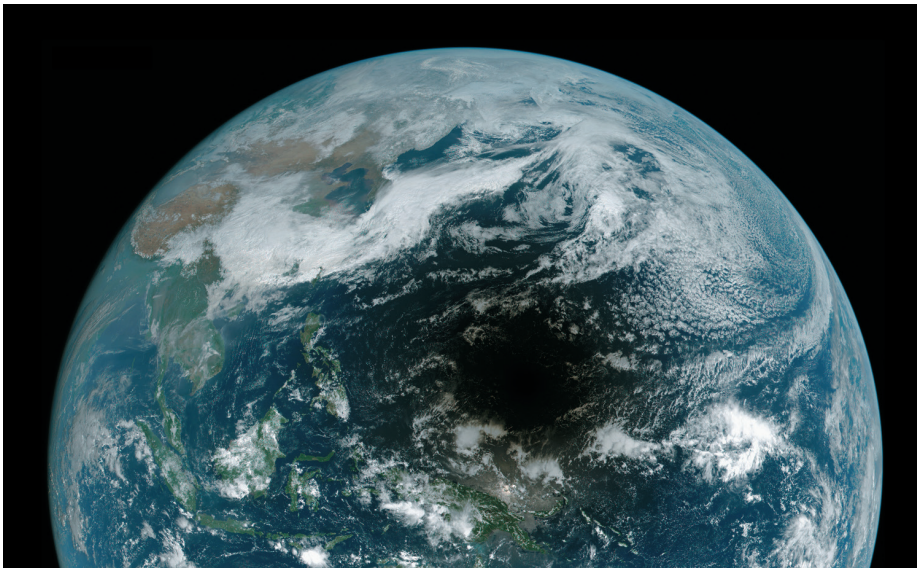
While the Sun is hidden during totality, no filter is needed!

The Workings in 3D

So why don't we get a solar eclipse at *every* new Moon, you might ask? How does the Moon usually sneak by unseen?

The answer is that the solar system is not perfectly flat. In particular, the orbits of the Moon and Earth do not lie in quite the same plane. If you drew Earth's orbit around the Sun on a flat sheet of paper, the Moon's orbit around Earth would be tilted 5° out of the paper, floating a little above and below it except where the planes intersect. Eclipses happen only when both the Sun and Moon are close to this intersection, along what's called the *line of nodes*.

A 5° tilt might not seem like much. But it's 10 times the ½° width of the Sun as we see it in the sky. So, when new Moon happens somewhere other than at the line of nodes, the Moon has plenty of room to pass north or south of the Sun without crossing it. That's why solar eclipses are uncommon.



Here's how the Moon's shadow looked as it crossed Earth during the total solar eclipse on March 9, 2016. The islands of Indonesia are at lower left.

S&T ILLUSTRATION: PATRICIA GILLIS-COPPOLA.
PHOTO: JMA / SSEC / UNIV. OF WISCONSIN AT MADISON

Sun & Moon Dance Steps



First Contact
The eclipse show starts when the Moon's leading edge first begins to creep onto the Sun's face, about an hour before totality. The Moon goes right to left.

(Partial Phase)
As more and more of the Moon blocks the Sun, the landscape around you begins to dim: very slowly for a long while, then faster.

Second Contact
Total eclipse begins! The last bit of the Sun fades away at the point of second contact, causing a brief "diamond ring" effect.

Third Contact
During totality, bright stars, planets, and the solar corona appear in the dark blue sky. Then a second "diamond ring" starts the Sun's return.

(Partial Phase)
As the Moon slowly slides off the Sun's face, the land and sky rebrighten, stars and planets fade in the brightening blue, and the Sun again feels warm.

Fourth Contact
The last edge of the Moon slides off. The Moon then stays out of sight for a day or two, until its thin crescent returns low in the western evening twilight.

The stages of a solar eclipse, from partial to total to partial, begin and end when the edges of the Moon and Sun make contact with each other. This happens four times from start to finish, as labeled above.

Eclipses of the Moon

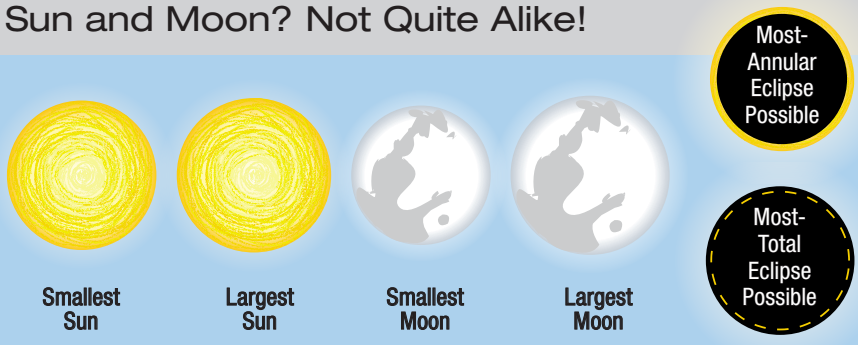
What about *lunar* eclipses? I haven't mentioned them yet. These happen whenever the Earth–Moon geometry is reversed: when the *Moon* passes through *Earth's* shadow. This is such a different kind of event that solar and lunar eclipses hardly both deserve to have the same name "eclipse"!

Why not? With a lunar eclipse, instead of something hiding something else as seen by you, you're just seeing the Moon get shaded. And, the Moon never goes completely dark. Think of covering the Sun in the sky with your hand, versus looking at your hand's shadow on the ground. Two different things.

During a lunar eclipse, people on the entire side of the world facing the Moon all see the same thing happening to the Moon at once, just like friends around you can all see the shadow of your hand on the ground. But when you cover the Sun with your hand, the Sun disappears only for you, not for the people off to the side. That's part of what makes a total solar eclipse rare and special.

Alan MacRobert *is a senior contributing editor of* Sky & Telescope *magazine. His first solar eclipse was a deep partial, seen in 1963 from summer camp in Vermont. He's witnessed totality thrice: from Mexico in 1991, Aruba in 1998, and Wyoming in 2017.*

Sun and Moon? Not Quite Alike!



By an amazing coincidence, the Sun and Moon both appear about the same size as viewed from Earth. That's because the Sun, which is really about 400 times bigger than the Moon, also happens to be about 400 times farther away. So they both *appear* about the same size in the sky (½° wide, about the size of your little fingernail held at arm's length).

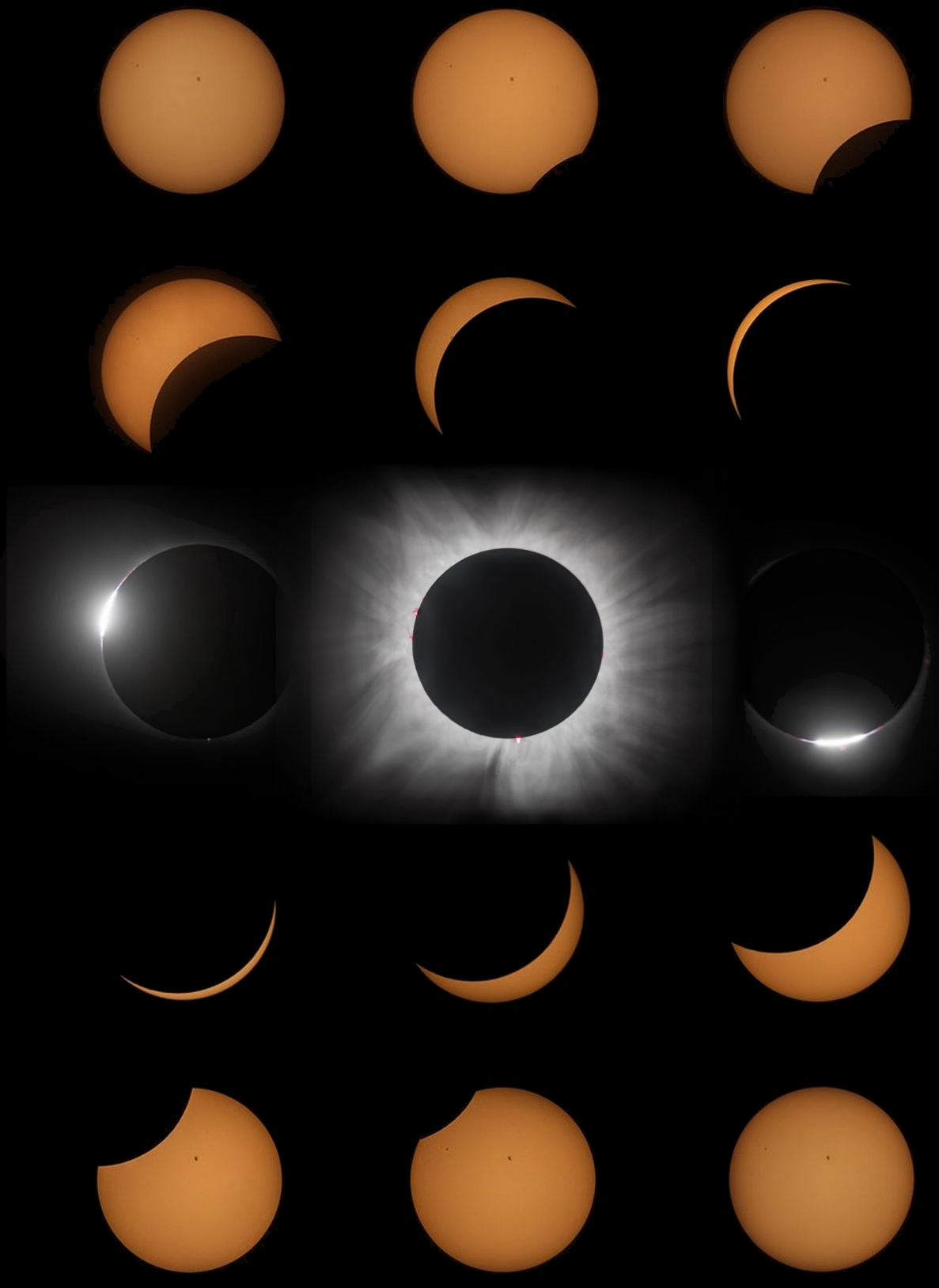
However, their apparent sizes do vary a bit. The Sun appears smallest in early July every year, when Earth is farthest away from the Sun in our orbit (at what's called *aphelion*). The Sun appears largest in early January when we're closest to it (at *perihelion*). But the difference is only 3.3%, 1 part in 30.

The Moon varies by a greater amount. It looks smallest when it's at the *apogee* of its orbit around Earth, and it looks largest at *perigee*. This difference can sometimes amount to as much as 14%. These size variations in the Sun and Moon are shown at their true scale in the row above.

As a result, we can get two types of "central eclipses" of the Sun. If the Moon appears a little bigger than the Sun, the Sun gets completely covered and the eclipse is total. If the Sun appears a bit bigger than the Moon, its brilliant edge shows all around the Moon's rim and the eclipse is *annular,* meaning ring-like. The two views on the right show the most annular and most total solar eclipses that are possible.

The total eclipse on August 12th won't be total by very much; the Moon will appear just 4% wider than the Sun.

S&T ILLUSTRATION: LEAH TISCIONE & GREGG DINDERMAN (2)



RODNEY POMMIER

A GREAT AMERICAN ECLIPSE This montage of images shows the total solar eclipse of April 8, 2024, from start to finish, as witnessed from Hot Springs, Arkansas. It captures key partial phases, both "diamond ring" effects, both sets of Baily's beads, and totality with the middle-level corona.

The Where and When of August's Eclipse

This year's total solar eclipse will be a geometric challenge that offers the chance to see rare, dramatic phenomena during totality.

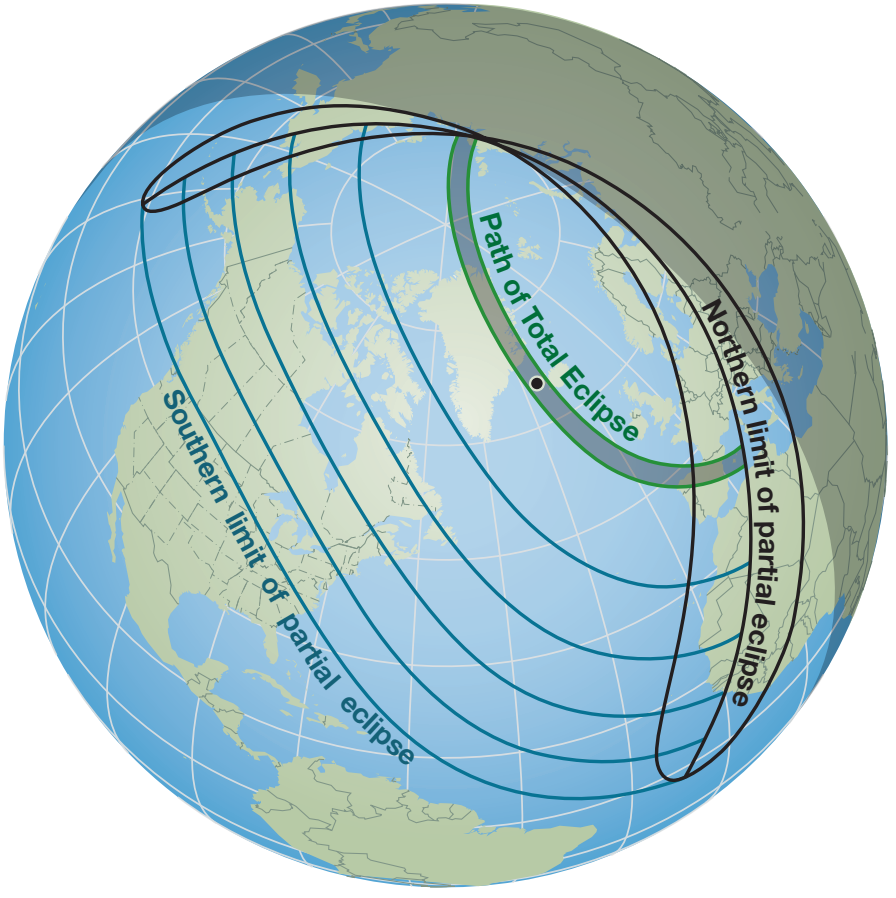
By J. Kelly Beatty • There was no total solar eclipse in 2025, so eclipse junkies have had to wait nearly 2½ years since April 2024's event across North America for their next chance to stand in the Moon's shadow. Although the global map at lower right suggests that there will be few places to witness this one, a closer look shows that the path of totality crosses Greenland, Iceland, and Spain.

Some eclipse-chasers might be tempted to venture close to the center of the path off Iceland's western coast, where totality will last its longest — a relatively brief $2^m\ 18^s$ (58 seconds in downtown Reykjavík).

But heading to this amazing island nation is *not* a good choice. As detailed later, statistically, the chances of cloudy skies over and near Iceland on eclipse day range from 70% to nearly 100%. (Actually, the weather prospects are much better in the parts of Greenland in the eclipse path.) Instead, most eclipse-chasers are taking advantage of the swath of totality that crosses northern and southeastern Spain, where the weather prospects are *much* better.

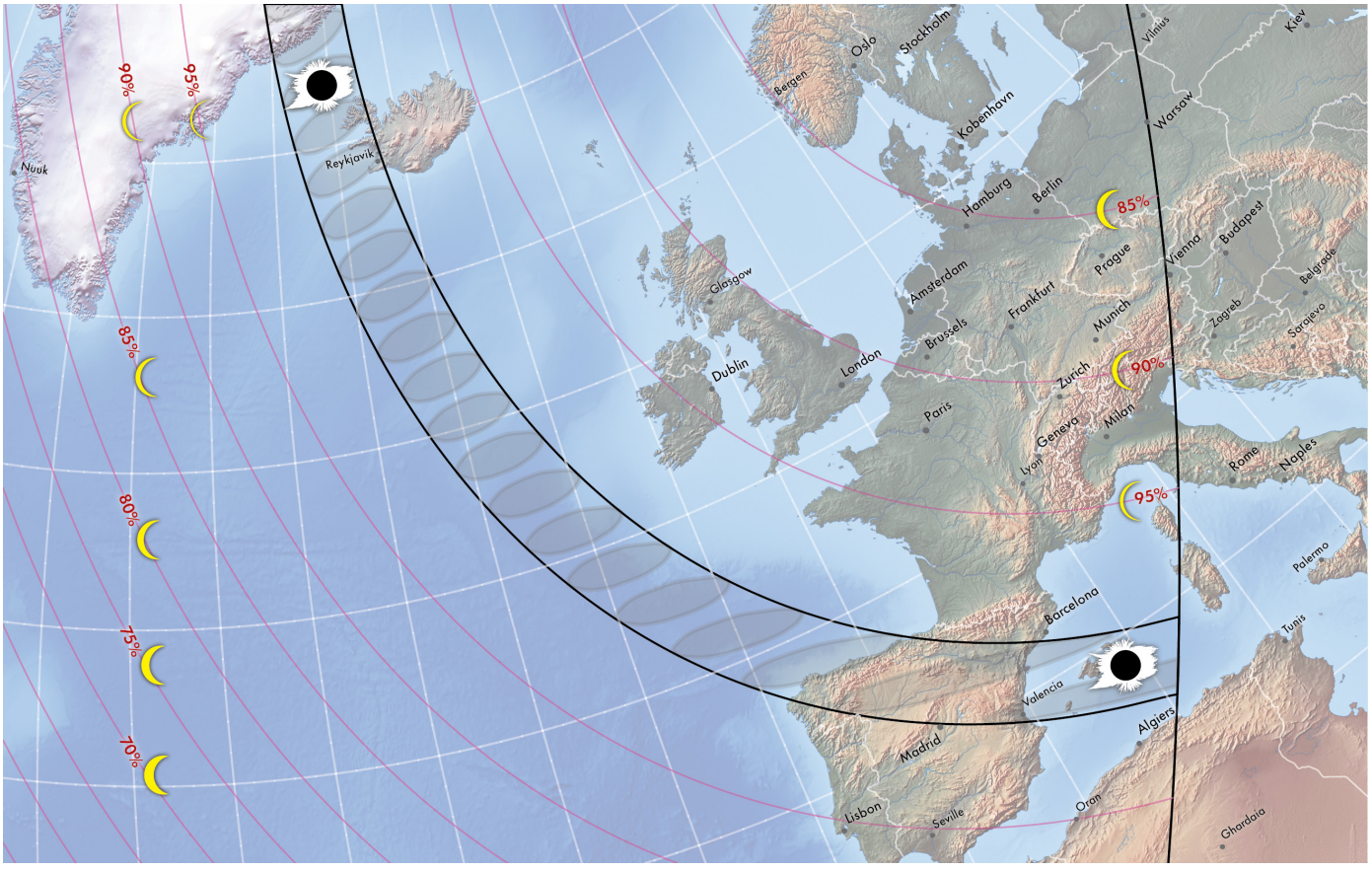
The Moon's umbral shadow makes landfall on the northern coast of Spain in Basque country. By that point, the duration of totality will have dropped to $1^m\ 50^s$ even along the path's centerline. And the day will be nearly over, with the totally eclipsed Sun only 11° above the western horizon. In fact, from many locations farther along the track in southeastern Spain, sunset occurs before the partial phases of the eclipse are over. The duration of totality drops to no more than $1^m\ 39^s$ by the time the path hits the Mediterranean coast.

Because this eclipse takes place late in the day and at relatively high latitudes, far from the equator, the Moon's umbra will have a very elongated shape, which creates an unusually broad path of totality — roughly 200 miles wide. Yet, as luck would have it, Spain's two most prominent cities barely miss out on the Big Show. Madrid will see a *very* deep partial eclipse with 99.99% of the Sun's disk covered. Anyone living there would need to travel only a short distance to the northeast to see totality (albeit briefly). Meanwhile, Barcelona will get a 99.82% partial eclipse. Check out the timetables



LEAH TISCIONE / *SKY & TELESCOPE*; SOURCE: FRED ESPENAK

NORTHERN ROUTE August's total solar eclipse, which begins in the Arctic and is seen near sunset from Spain, provides a partial event for much of North America, western Europe, and westernmost Africa. Blue curves show the maximum fraction of the Sun's diameter covered by the lunar disk, and red lines show the Universal Time at mid-eclipse along the path.



SOUTHERN SWEEP Although totality will last longest at a point just off the west coast of Iceland, most eclipse-chasers are flocking to Spain and the western Mediterranean Sea to view August's event.

on page 19 for the eclipse circumstances throughout Spain and from major cities elsewhere.

This eclipse will be remembered for how close it occurs to the horizon for observers in Spain and the Mediterranean, not long before sunset, and so you'll have your best-ever opportunity to take selfies with the corona in view behind you. Also, you can expect to see rare, dramatically different phenomena around the time of mid-eclipse. For example, the Moon's silhouetted disk should appear slightly flattened, due to the pronounced *differential atmospheric refraction* near the horizon, and the corona might well have a reddish tinge.

Also, because the cone of the Moon's shadow will be almost parallel to Earth's surface, you'll be able to watch the zone of umbra-darkened atmosphere approach the Sun from right to left along the horizon. During totality, watch for a distinct darkening of the sky on either side of the magnificent corona (see the image on page 30), followed by a rapid leftward shift as totality ends.

As seen from Mallorca, the eclipsed Sun's altitude will be *just five solar diameters* above the horizon. Fortunately, the viewing from Port de Sóller on the island's northwest coast will be unobstructed. By the time the umbral shadow lifts off the Mediterranean Sea and returns to space, it will have traversed a track 5,200 miles (8,300 km) long — and yet having covered just 0.47% of Earth's surface area.

Every solar eclipse belongs to a long sequence of sequential, geometrically linked events known as a *saros cycle*. The late Fred Espenak, the acknowledged dean of eclipse-chasers worldwide, noted that August's event is the 48th of the 72 eclipses belonging to saros 126, which began in the year 1179 and will continue through 2459. Notably, of these 72, only 10 were total, and only one more will occur (in 2044) after the this one.

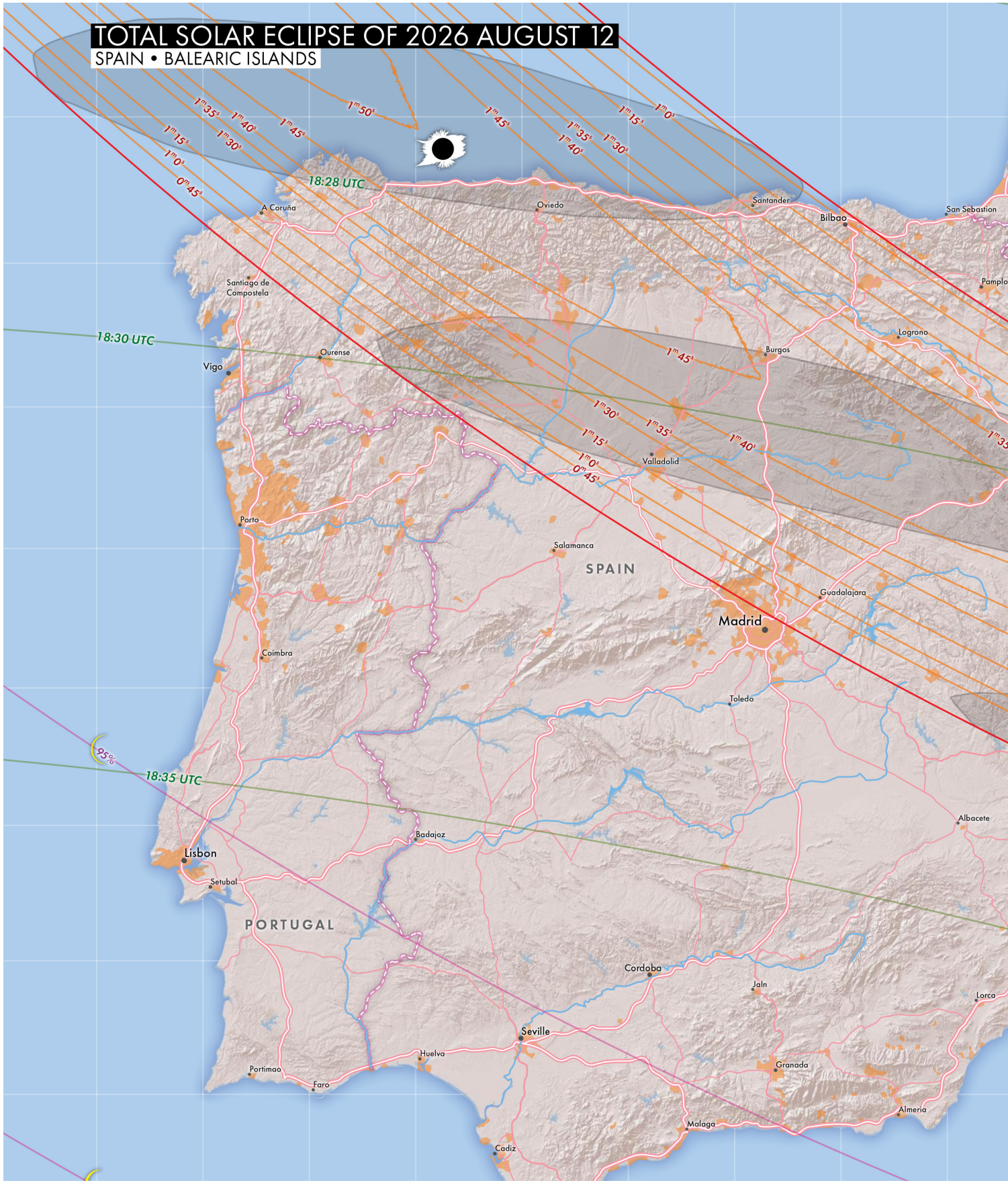
So this August's event is special in many ways. But, of course, it will be far more special if you can actually see it firsthand — and fortunately the weather prospects across Spain are very favorable.

Eclipse-Day Weather

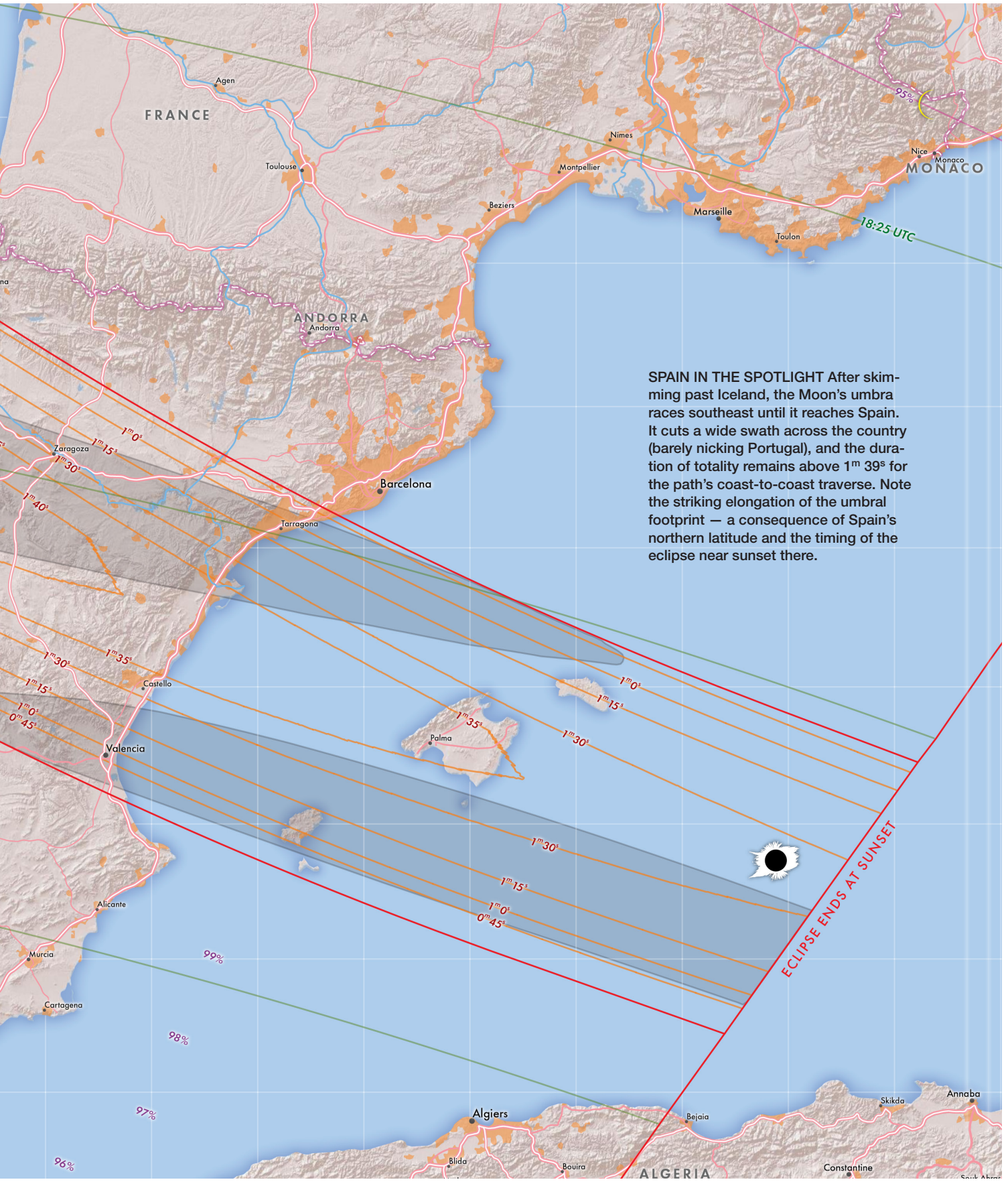
According to Jay Anderson, a Canadian meteorologist who specializes in predicting the weather you'll most likely encounter during any given solar eclipse, the path of the Moon's shadow in August crosses a swatch of Earth's surface with very different weather prospects, statistically speaking.

After its initial touchdown, the track crosses the Arctic Ocean on its way to Greenland, passing only 60 miles south of the North Pole. The whole of this route is plagued by heavy cloudiness. In fact, the climatology in summer is characterized by extensive, persistent cloudiness that nears its peak in August.

MICHAEL ZEILER / ECLIPSE-MAPS.COM



MICHAEL ZEILER



SPAIN IN THE SPOTLIGHT After skimming past Iceland, the Moon's umbra races southeast until it reaches Spain. It cuts a wide swath across the country (barely nicking Portugal), and the duration of totality remains above 1^{m} 39^{s} for the path's coast-to-coast traverse. Note the striking elongation of the umbral footprint — a consequence of Spain's northern latitude and the timing of the eclipse near sunset there.

Iceland is a destination of striking beauty — an island of volcanoes, glaciers, and aurorae. But it's also a land of plentiful cloud and frequent precipitation, due to its location astride the North Atlantic's main storm track. Reykjavík might lie in the path of totality, but its residents have only about a 30% chance of cloud-free skies on eclipse day.

So that leaves Spain. Anderson notes that the Iberian Peninsula is a topographically rugged and complicated place, defined along the eclipse path by three mountain ranges, two elevated central plateaus, a river valley, and two coastal plains. In the north, the Cordillera Cantabrica blocks moisture from the Bay of Biscay, preventing its intrusion past the coastal lowlands and into the central part of the peninsula.

A haphazard collection of mountain ranges and peak, collectively called the Sistema Iberico, begins southeast of Burgos and arcs southward — at first on the north side of the central line, but then spreading across almost all of the south side of the track as it approaches the Mediterranean coast. All of this up-and-down topography has an impact on the region's cloud climatology. Broadly speaking, higher elevations tend to be cloudier during August and lower ones somewhat sunnier.

Anderson estimates that the *Sky & Telescope* site in Alcañiz offers a 77% chance of clear skies on eclipse day. But that optimism has to be tempered with concern about strong southerly winds that carry Saharan dust onto the Iberian peninsula, affecting southern regions most dramatically, and by the haze created by forest fires, which have become more common in recent years. And of course the eclipsed Sun will be very low in the late-afternoon sky.

Finallly, Anderson notes, cloud cover on Mallorca is least on the coasts, particularly on the west side, facing the setting Sun. For such a low view toward the sun, the skies must be very clear, a condition that is not particularly reliable. Of course, the reward is a spectacular eclipse, just off the horizon, featuring a slightly flattened solar orb and a red-tinted corona. If everything works out, you will go home with views and pictures of an eclipse-chasing lifetime.

Partial-Eclipse Opportunities

Although the path of totality is never very wide, a much broader portion of Earth's globe will experience a partial solar eclipse on August 12th. In particular, anyone located in a generous swath of North America — much of the Northeast U.S., along with all of Alaska and Canada — will get to see the Moon take a bite out of the Sun. And the inhabitants of western Europe will get especially deep partial eclipses in late afternoon. From western Ireland, 95% of the Sun's disk will be covered; residents there should notice a slight dimming of daylight at maximum.

Of course, nothing compares with seeing *all* of the Sun covered — that's why "getting to totality" is always worth it.

J. Kelly Beatty, a senior contributing editor at Sky & Telescope, *has been waiting his whole eclipse-chasing life to witness totality so close to the horizon.*



NO RAIN IN SPAIN? A statistical analysis of average cloud cover over Spain, derived from images taken by from polar-orbiting satellites between 2002 and 2020, suggests that clear skies are likely to prevail on eclipse day.

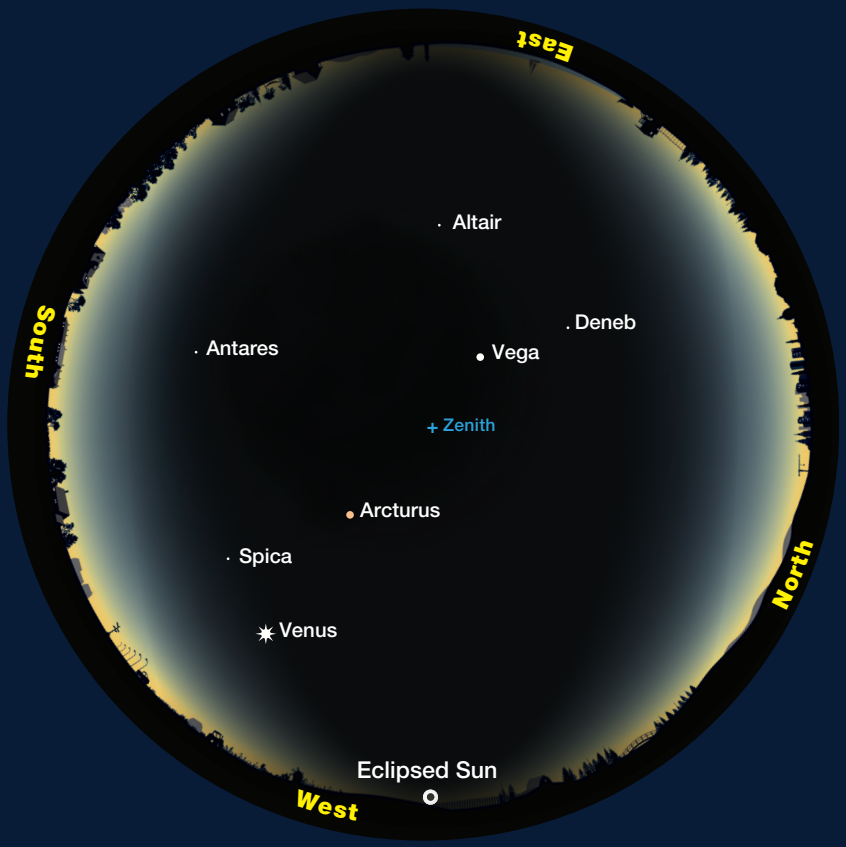
JAY ANDERSON / ECLIPSOPHILE.COM

When Day Briefly Becomes Night

To use this all-sky map, hold it so that the yellow label for the direction you're facing is at the bottom. As seen from Spain, the eclipsed Sun will be no more than several degrees above the western horizon. And, with the duration of totality fairly short, you can expect the sky to remain fairly bright.

So even through a few bright stars are marked in this all-sky plot, you may be hard-pressed to notice anything besides Venus and perhaps Arcturus to the upper left of the eclipsed Sun during totality.

But more remarkable might be the appearance of the sky itself. With the eclipsed Sun so close to the horizon, you can expect to see the Moon's dark umbra sweep from right to left before, during, and after totality, dramatically framing the corona at mideclipse. And if you can, tear your eyes away for a moment and turn around, facing the direction opposite where totality is happening, you should also be able to see the dark umbral stain extending toward the eastern horizon.



LEAH TISCIONE / S&T

Times and Circumstances for August 12th's Total Solar Eclipse

Location	Partial Begins	Totality Begins	Totality Ends	Partial Ends	Totality Duration	Sun's Altitude
Vandreblok, Greenland	3:35	4:36	4:37	5:35	1m 15s	24°
Reykjavík, Iceland	4:47	5:48	5:49	6:48	0m 58s	24°
Alcañiz, Spain	7:36	8:30	8:31	9:04*	1m 33s	5°
Bilbao, Spain	7:32	8:27	8:28	9:20*	0m 29s	8°
Burgos, Spain	7:33	8:28	8:30	9:21*	1m 44s	8°
Oviedo, Spain	7:31	8:27	8:29	9:21	1m 48s	10°
València, Spain	7:38	8:33	8:34	9:02*	1m 1s	4°
Zaragoza, Spain	7:35	8:29	8:30	9:08*	1m 22s	6°
Port de Sóller, Mallorca, Spain	7:38	8:31	8:32	8:50*	1m 34s	2½°

Location	Partial Begins	Maximum	Partial Ends	Obscuration	Sun's Altitude
Boston, Massachusetts	1:02	1:55	2:46	16%	59°
Lisbon, Portugal	6:39	7:36	8:29	94%	10°
London, England	6:17	7:13	8:06	91%	10°
Madrid, Spain	7:37	8:32	9:17*	99.97%	7°
Oslo, Norway	7:03	7:57	8:49	83%	8°
Paris, France	7:22	8:17	9:09	92%	8°
St. John's, Newfoundland	2:29	3:35	4:37	53%	45°

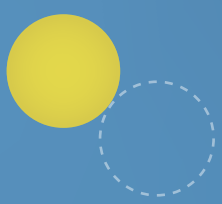
Source: Xavier Jubier. All times are p.m. in local daylight/summer time. * Time of sunset, which occurs before partial eclipse ends.

The Eclipse Experience

Here's your guide to the phenomena that occur before, during, and after a total solar eclipse. Glasses icons (👓) indicate when you must only look at the Sun through safe filters.

By Camille M. Carlisle, Terri Dubé & Beatriz Inglessis

FIRST CONTACT
The Moon's edge touches the right edge of the Sun's disk. *(The farther northeast you are, the more toward lower-right first contact appears.)*



Look for a slight dent in the Sun's edge. It might take a few minutes to be visible.

T-15 minutes
The sky and landscape darken. Temperatures cool.



Look to the northwest: Can you see the lunar shadow approaching?

T-10 minutes
The crescent Sun narrows to a sliver. Shadows become sharp. Daylight is dim and silvery.



Look for Venus and Jupiter. Venus will be lower right of the Sun, Jupiter upper left. (See page 32.)

T-30 seconds
Twilight. Darkness sweeps toward you from the northwestern horizon.



SECOND CONTACT

OK TO REMOVE GLASSES

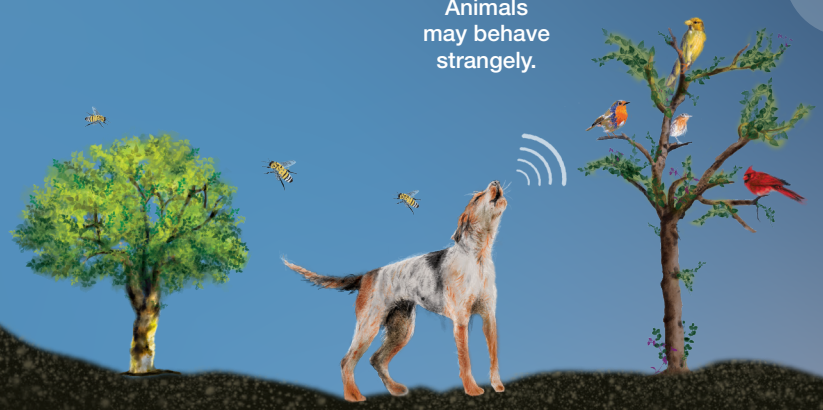
Baily's Beads and diamond ring



The razor-thin solar crescent breaks up into arcs and beads, as the last bits of sunlight shine through valleys along the Moon's advancing edge. Best seen through safely filtered binoculars or a telescope.

When there's only one bead left, gleaming like a diamond, remove your eclipse glasses.

Animals may behave strangely.



Birds are roosting. Flowers may close.

Try It:

With a safely filtered telescope or pair of binoculars, look for:

- lunar hills and valleys along the Moon's silhouetted edge
- sunspots on the Sun

Use a colander, a tree's foliage, or your splayed hands stacked on top of each other to project tiny crescent Suns onto a piece of white paper.

One minute before totality, look for wavy "shadow bands" on uniform surfaces, like a sheet or the side of a vehicle. These happen when heat waves in Earth's atmosphere refract the thin slit of sunlight. (This refraction is also why stars twinkle.)

TOTALITY

The solar corona appears as a glorious white halo surrounding the eclipsed Sun. The Moon's silhouette looks like a hole in the sky.



As totality begins, quickly look for a red layer along the Moon's advancing left edge. This is the Sun's chromosphere. It will soon disappear behind the Moon.

A few seconds before totality's end, an arc of chromosphere will re-emerge along the Moon's receding edge at right/bottom right.

A sunset blush spans the entire horizon.

WITH UNSHIELDED BINOCULARS OR A TELESCOPE:

Explore the corona's intricate filaments, shaped by the Sun's magnetic field.

Check along the Moon's receding edge for solar prominences — tiny red spots, loops, or arcs sticking out from the Sun.

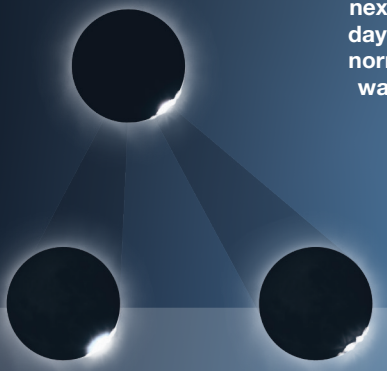
THIRD CONTACT

PUT GLASSES BACK ON

Observing through binoculars or a telescope? Put the solar filters back on now!

Looking with your eyes alone? Have your eclipse glasses handy: You'll need them in a few seconds.

Diamond ring and Baily's Beads



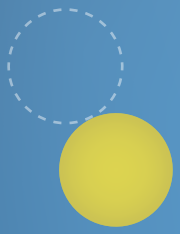
As the deepest valley on the Moon's receding edge uncovers the first bead of sunlight, the no-longer-totally-eclipsed Sun once again resembles a diamond ring. Marvel at its beauty for only a moment, then put your solar viewers back on.

The Sun peeks through additional valleys along the Moon's bottom-right edge. Within seconds, the beads and arcs merge into a crescent.

Watch the crescent Sun grow over the next hour or so as daylight returns to normal and the air warms up again.

FOURTH CONTACT

The Moon moves off the Sun's bright face.



Animals, plants, and insects respond as if dawn has come.



Look for shadow bands on the ground or on a nearby wall.

Can you see the Moon's shadow racing off to the northeast, with the landscape brightening as it goes?

The eclipse is over. It's time to celebrate!

View the Solar Eclipse Safely



You'll enjoy the eclipse a lot more knowing that your eyes and equipment are protected from harm.

By Richard Tresch Fienberg

I can still hear my mother's voice from when I was a child: "Never look at the Sun! You'll go blind!" Telescope manufacturers' mothers must have said that too, because nearly every instrument sold today has a sticker on the tube with a similar warning: "Never point this telescope at the Sun. Severe eye injury will result."



Above: August 12, 2026, brings the opportunity to see a deep solar eclipse — and maybe even totality — to millions of skywatchers. But before glancing toward the Sun, make sure you're viewing it safely. Top: In preparation for April's eclipse, manufacturers have been working overtime to print millions of solar viewers. You can purchase them inexpensively — in bundles they can cost less than 50 cents each.

Yet throughout these pages, experts are urging you not to miss the solar eclipse on August 12, 2026, and, if possible, to get into the path of totality so you can see the glorious solar corona. Were our mothers wrong? Not exactly.

The problem is the word "never." There is actually one time when it's perfectly safe to look directly at the Sun — with your unaided eyes, with binoculars, and even with a telescope. That time is when the Moon completely covers the Sun's bright face — during the brief total phase of a total solar eclipse. This complete coverup permits the Sun's diaphanous, ethereally beautiful outer atmosphere, the *corona,* to become visible, and it too is safe to view directly.

At all other times follow Mom's advice — unless you have a safe solar filter and know how to use it. Here I'll describe the different types of filters available, explain what makes them safe (or not), and tell you how to use them. I'll also share some ideas on how you can observe the Sun safely even if you don't have a solar filter.

Sunlight and the Eye

Our daytime star poses no more of a threat during a solar eclipse than at any other time — it shines the same before, during, and after an eclipse. It won't emit light or other kinds of radiation on August 12th that it isn't emitting right now. The corona is there all the time, too, shining with the eerie fluorescent light of million-degree gas. We just can't see it because it's only as bright as the full Moon, and so the dazzling brilliance of the Sun's surface ordinarily overwhelms it.

So where's the danger? The Sun emits energy across the electromagnetic spectrum, most of it in the form of visible light. It puts out lesser amounts of ultraviolet (UV) and infrared (IR) radiation, too. Many people think these invisible rays are the main dangers, but that's not true.

The real issue is that the Sun is insanely bright, even when all but a tiny sliver of it is covered by the Moon, and the danger it poses to the retinas in your eyes is ever present. "Exposure of

RICHARD BOUHET / AFP / GETTY IMAGES; GLASSES: *SKY & TELESCOPE*

the retina to intense visible light causes damage to its light-sensitive rod and cone cells," explains Dr. Ralph Chou, professor emeritus of optometry and vision science at the University of Waterloo in Canada. "The light triggers chemical reactions within the cells that damage them and, in extreme cases, can destroy them."

A single fraction-of-a-second glance sunward with your unaided eyes won't hurt you, but if you look longer, or repeatedly — and *especially* if you look through unfiltered binoculars or a telescope — you're in deep trouble. Then, says Dr. Chou, "the photochemical damage may be accompanied by a thermal injury, in which sunlight absorbed by the retina is transformed into heat that literally cooks the exposed tissue." And you won't realize it's happening, because retinas don't have pain receptors.

Solar Viewers: The Good, the Bad, and the Ugly

So what's the solution? For direct viewing, it's to look at the Sun only through a special-purpose solar filter designed expressly for looking at the Sun's bright face. Such filters reduce sunlight to safe levels across the spectrum.

Just because some material blocks most of the Sun's visible light doesn't mean it's safe. Unless it also blocks other parts of the spectrum, while you're enjoying a "comfortable" view of the "dim" Sun, infrared radiation could be frying your retinas. Ultraviolet light is less of an issue, because it doesn't get past our eyes' lenses; we wear UV-blocking sunglasses on bright days to protect against the development of cataracts, not because of any threat to our retinas.

Safe solar filters come in two main types: "eclipse glasses" or other handheld viewers that go between the Sun and your eyes (or eyeglasses, if you wear them); and filters that cover the front opening of a camera lens, telescope, or binoculars.

In 2015 the International Organization for Standardization (ISO) took the guesswork out of knowing whether filters for direct solar viewing are safe. Any filter that meets the new ISO 12312-2 transmittance standard reduces visible sunlight to a safe, comfortable level and simultaneously blocks solar UV and IR radiation.

Most safe solar viewers are made with black polymer (a specially tinted resin), silver-black polymer (the same resin plus a layer of aluminized polyester), or layers of metal-coated polyester film. You'll find "ISO 12312-2" or "ISO 12312-2:2015" printed on all of these filters. You can buy them directly and inexpensively from their manufacturers or from authorized resellers.

Unfortunately, some vendors sell counterfeit solar viewers bearing the ISO logo and backed by fake documents claiming they comply with ISO 12312-2. The American Astronomical Society maintains a list of manufacturers and resellers whose solar filters have been confirmed to be safe by a properly accredited testing laboratory. Make sure you get your eclipse glasses or handheld viewers from a source listed there (**eclipse.aas.org/resources/solar-filters**).

But do you really need to be so careful? Yes! Lots of everyday materials might *seem* to dim the Sun enough but are not



Smoked glass, CDs, DVDs, and Mylar food wrapping — along with everyday sunglasses, no matter how dark — are not safe for solar viewing.





If you view the partially eclipsed Sun with binoculars, you must cover the front lenses with ISO-certified solar filters (as in the upper image). It's extremely dangerous to put on solar viewers meant only for your eyes and then look through unfiltered binoculars or a telescope (lower image).

SKY & TELESCOPE (3)

safe. These include dark sunglasses, neutral density or polarizing filters, smoked glass, unexposed or exposed film, "space blankets," snack bags, CDs, and DVDs. Anything you might have heard about for solar viewing that lacks the ISO certification is *not safe*.

In addition to using a filter that meets the ISO 12312-2 safety standard, make sure it's in good condition. If the filter is torn, scratched, punctured, or coming loose from its cardboard or plastic frame, discard it. Read and follow any instructions printed on or packaged with the filter, and always supervise children using solar filters.

If you're within the path of totality, you can safely remove your solar filter *only* when the Moon completely covers the Sun's bright face and you're plunged into darkness. Experience the magnificence of totality — and then, as soon as the bright Sun begins to reappear, put your solar viewer back on to glance at the remaining partial phases.

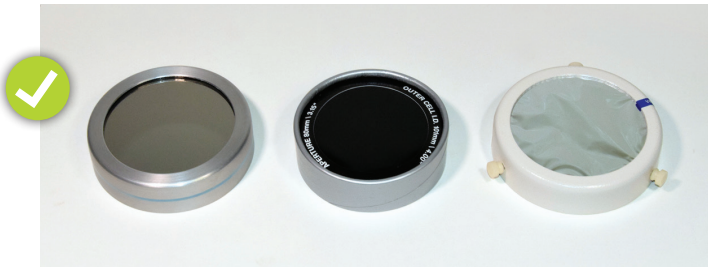
Solar Filters for Your Gear

Never look at the uneclipsed or partially eclipsed Sun through a camera, telescope, binoculars, or other optics while using eclipse glasses or a handheld solar viewer — the concentrated solar rays will instantly burn through the filter and injure your eye(s).

Instead, solar filters designed for use with cameras, telescopes, and binoculars must be attached to their *front*. You'll encounter three types: metal on glass (usually the most durable and expensive), aluminized polyester film (frequently but incorrectly called aluminized Mylar), and black or black-silver polymer. They're typically mounted in aluminum rings sized to fit snugly over the front of your optics. (When ordering these, you'll need to measure your optical tube's outer diameter.)

The ISO 12312-2 standard doesn't apply to filters for optics, so you should buy from a reputable manufacturer or dealer whose products have been independently tested and found to be safe. Again, you'll find a list of suppliers on this webpage: **eclipse.aas.org/resources/solar-filters**.

There was a time when telescopes routinely came with a "Sun" filter designed to thread into an eyepiece. Untold thousands of these still exist alongside scopes stashed in closets and attics, but they are *not* safe. Sunlight concentrated by the telescope's main lens or mirror can crack the dark glass, with disastrous results. Also, if your telescope has a small finderscope or other optical aiming device, make sure it is capped, removed, or safely filtered just like the main telescope whenever you're pointing at the Sun.



Solar-safe filters utilize three types of materials: metal-coated glass (left), black polymer (middle), and metal-coated polyester (right). These are available in various sizes made to fit snugly on the front of your binoculars or telescope.



When using a telescope to observe the Sun at any time other than during the total phase of the eclipse, you must put a safe solar filter over the aperture (front) of the telescope, as shown here. Note that the small finderscope has been capped; this prevents concentrated sunlight from melting the crosshairs in its eyepiece.

Pinhole & Optical Projection

There's another safe way to observe the Sun: indirectly, by projecting an image onto a card, wall, or other surface. And it comes with a bonus: Multiple people can view the projected image simultaneously.

The simplest approach is *pinhole projection*. If you have leafy trees at your observing site, look at the dappled sunlight on the ground during the partial eclipse. You'll see a bunch of crescent Suns projected by the tiny spaces between the leaves, each of which acts as a pinhole camera.

No trees? No problem! A "handy" way to achieve the same effect (pictured on the facing page) is to cross the outstretched, slightly open fingers of one hand over the outstretched, slightly open fingers of the other, creating a waffle pattern. With your back to the Sun, look at your hands' shadow on the ground. The little spaces between your fingers will project a grid of small crescent Suns that everyone around you can admire. Straw hats, kitchen colanders, and other household items with lots of small holes in them will also work.

You can also use a telescope or binoculars to project images of the partially eclipsed Sun onto a flat, white surface (such as a sheet of cardboard). This *optical projection* generally provides bigger, brighter, sharper images than pinhole projection does. But because bright sunlight passing through binoculars or a telescope can damage the device, and because of the danger that someone might accidentally look into the bright beam of concentrated sunlight emerging from the eyepiece, you shouldn't try optical projection unless you're an experienced astronomical observer, you're using your own

SKY & TELESCOPE (2)

equipment, and you can remain with your setup at all times.

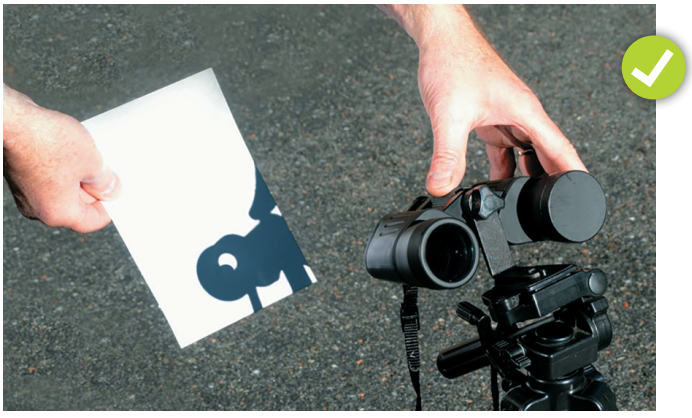
The Sun Funnel is probably the safest tool for solar projection with a telescope, because no bright sunlight comes out of the optics. Instead, the eyepiece is secured in the neck of a funnel and casts the Sun's image onto a rear-projection screen stretched over the funnel's mouth. This DIY device can be assembled inexpensively from readily available materials; instructions are online at **https://is.gd/buildasunfunnel**. Even if you don't plan to build a Sun Funnel, you might download the tutorial anyway for its helpful tips on how to aim a telescope at the Sun without looking through it.

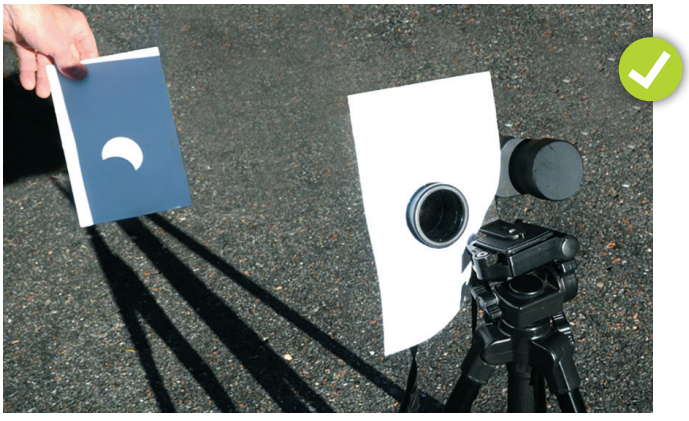
As when using aperture solar filters, be sure to cap or remove any finderscope or other auxiliary optics when doing solar projection. You might also find it helpful to add a cardboard or foam-board shade collar around the front end of your telescope or binoculars to cast a shadow around the projected image, making it easier to see in bright daylight.

Ready & Waiting

You are now immunized against "alternative facts" and "fake news" that might direct you to stay indoors and draw the shades during the upcoming eclipse. My own mother, who told me never to look at the Sun, has seen two total solar eclipses. And although she didn't travel to the path of totality for April 2024's eclipse, she, my dad, and other residents and staff of their retirement home were outside watching the partial eclipse through their ISO-compliant eclipse glasses!

Rick Fienberg *is project manager of the American Astronomical Society's Solar Eclipse Task Force, a senior contributing editor of* Sky & Telescope *magazine, and a veteran of 14 solar-eclipse expeditions around the world.*





Put your binoculars on a short tripod, uncover one side, and point them toward the Sun. Then put a white card near the eyepiece to see a projected image of the Sun (you'll need to focus for a sharp image). By moving the card farther away, the Sun's image gets bigger but somewhat dimmer. Add a shield around the binocular's main lens to create a larger dark projection area on the card.





During the eclipse, cross two hands so your fingers make a waffle pattern. The tiny holes between them will act like pinhole projectors to create a pattern of tiny crescent Sun images in the shadow below.

USEFUL LINKS

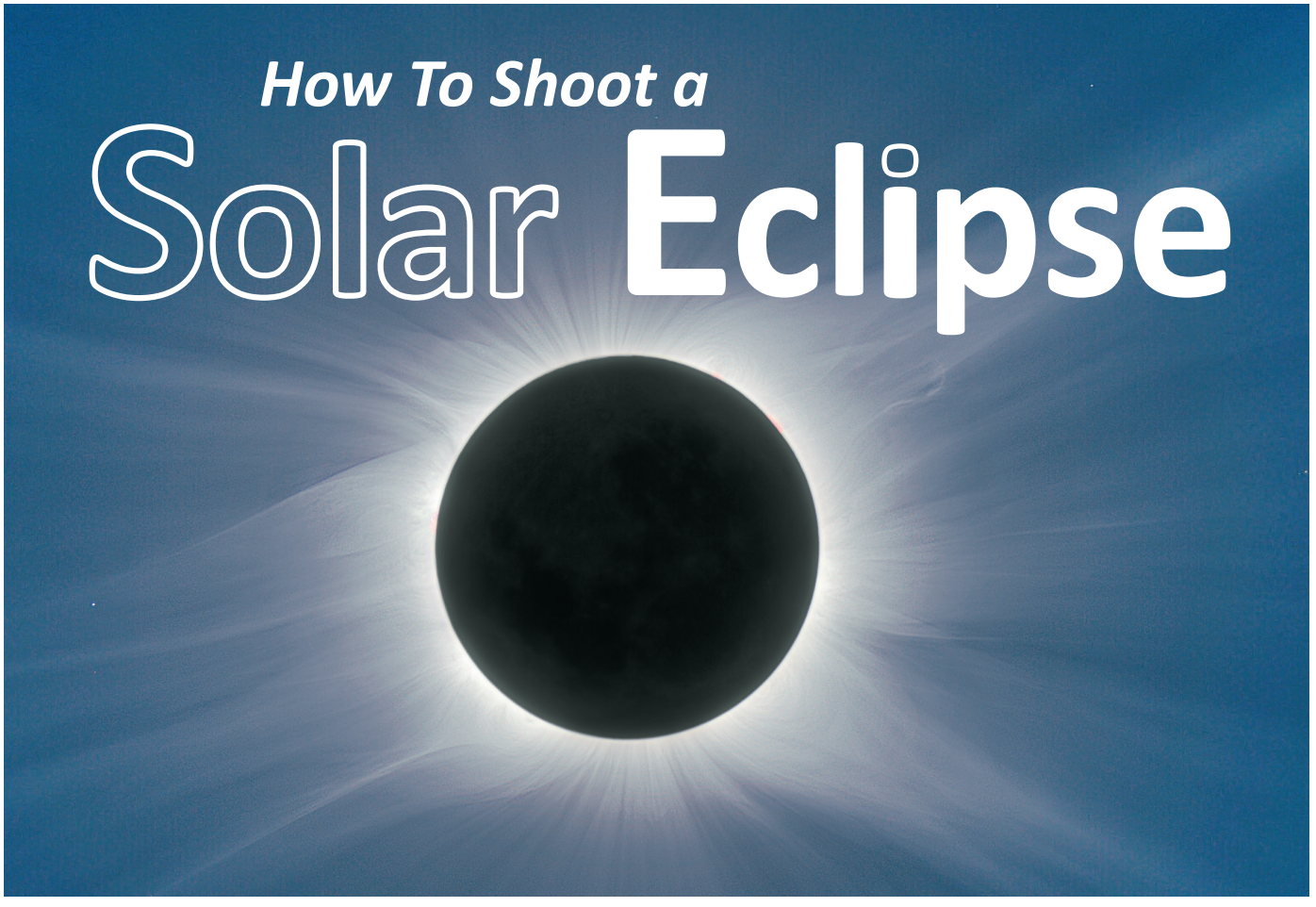
American Astronomical Society
eclipse.aas.org/safety

NASA
solarsystem.nasa.gov/eclipses/safety

Manufacturers
eclipse.aas.org/resources/solar-filters

BINOS: *SKY & TELESCOPE* (2); FINGER-SPREADING: J. KELLY BEATTY (2)

How To Shoot a Solar Eclipse



A LITTLE ADVANCE PLANNING CAN HELP MAKE YOUR PICTURES OF THIS RARE EVENT MEMORABLE.

By Dennis di Cicco • Avid eclipse chasers have called total solar eclipses nature's most spectacular *predictable* photo ops. And the one occurring in April will likely be among the most-photographed in history.

Having photographed 20 solar eclipses during the past half century, I have witnessed a huge transformation in the techniques used to record these remarkable events. Digital photography, in particular, has made capturing them much easier than in the past. Consider, for example, the above photo taken from Easter Island in 2010. It's perhaps my finest picture of totality to date, yet I took it with the simplest camera setup I've ever used for close-up eclipse photos.

That's the good news. The bad news is that today's digital cameras offer such a varied spectrum of features, it's impossible for an article like this to give specific instructions for using all of them. In fact, some of the most useful features that many digital cameras offer for eclipse photography are ones *not* used for daily shooting. You might need to check your camera's manual to find out if you even have them. Thus, general suggestions and pitfalls to avoid are the order of the day.

This view of the 2010 eclipse seen from Easter Island was captured with a Nikon D700 (full-frame) DSLR camera and a Tele Vue TV-85 refractor, which is effectively a 595-mm f/7 telephoto lens. Nine bracketed exposures ranging from 1/500 to ½ second at ISO 200 were combined to create an image showing detail across a wider range of the corona's brightness than would show in any single exposure.

First, a Warning

If this is your first time seeing a total solar eclipse, think twice before committing to photographing it. You're going to be in for a shock at how quickly 1+ minute of totality will pass. In 1980, astronomy popularizer Norm Sperling wrote that no matter how long totality lasts, it always seems like only 8 seconds. That concept resonates so well with veteran eclipse chasers that it's become known as "Sperling's 8-second Law."

There's a lot to experience in the moments surrounding totality, and time spent fiddling with cameras is precious time that won't be available to absorb other things going on. Besides, in the days (even hours) after the eclipse, the internet will be awash with images of

UNLESS OTHERWISE NOTED, ALL PHOTOS BY DENNIS DI CICCO; ECLIPSE IMAGES PROCESSED BY SEAN WALKER

the event. You'll have no problem obtaining a keepsake photo of the eclipse.

But it's also true that there's nothing like having your own photographs. I like my pictures of the Eiffel Tower more than those on postcards. So if you do have your heart set on shooting your own pictures of the eclipse, let's consider some details.

A Few Ground Rules

• Except during totality and a few seconds before and after, you must always use a *safe solar filter* (see page 22) when looking at the Sun with your unaided eye or through any optical device, including cameras. This includes times when the Moon partly covers the Sun, no matter how much or little. Doing so can perminantly damage your eyes and your camera's sensor.

For the best results your filter should be securely mounted so that it can't be dislodged by an accidental bump or a gust of wind — but can still be quickly removed and replaced. Don't treat this issue lightly. The safe, fast, and easy removal and replacement of a filter can make all the difference when it comes to successfully capturing Baily's Beads, the diamond ring, and the Sun's electric-pink chromosphere in the fleeting seconds at the beginning and end of totality.

• The most useful feature for eclipse photography, one often found in today's digital cameras, is called *exposure bracketing*. It lets you shoot a sequence of images that automatically vary the exposure by preset amounts without you having to fiddle with settings on the camera other than initially enabling the bracketing function. Not all cameras offer automatic bracketing, but I've met a lot of eclipse chasers who were surprised to learn that it is indeed a feature of their cameras. Check your manual!



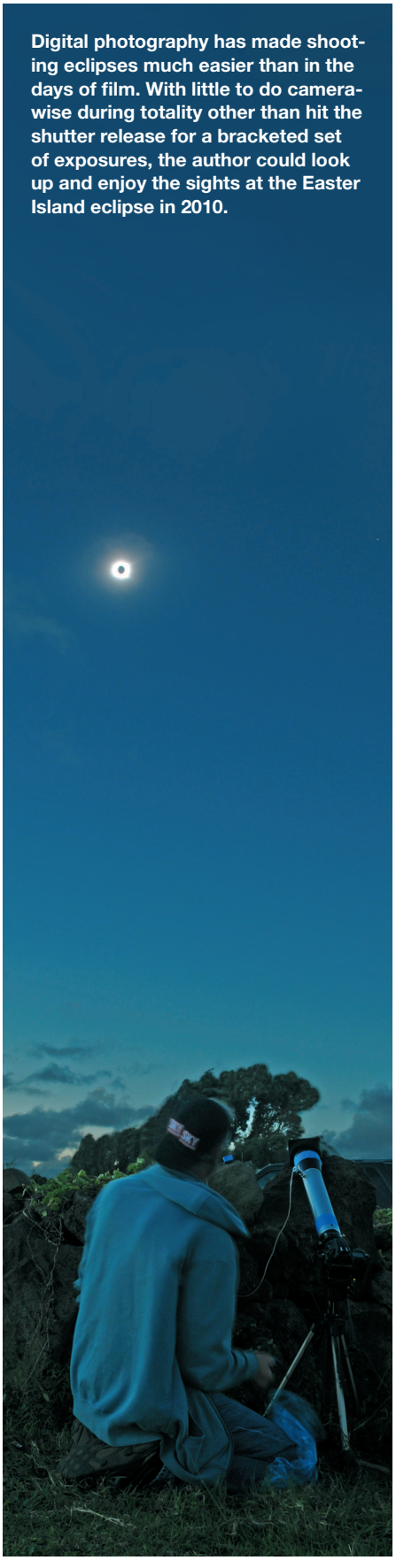
One key to successfully capturing rapid-fire events at the beginning and end of totality is the ability to quickly and easily remove and replace a solar filter without disturbing the aim of your photo setup. Cardboard, masking tape, a little hot-melt glue, and black spray paint were all the author needed to make this simple slide-out holder for his Baader AstroSolar filter material.

Bracketing is useful because there's no single, perfect exposure for capturing everything visible during totality. Short exposures record detail in the brightest portion of the corona near the Sun's limb (which is roughly the same as the full Moon). But this same coronal detail is blown out in the longer exposures needed to capture wisps of the faint outer corona. Even bright features like Baily's Beads and the diamond ring, which record well with a relatively predictable short exposure (see the table on page 30), will benefit from bracketing — especially if there is haze, smoke, or thin clouds in front of the Sun.

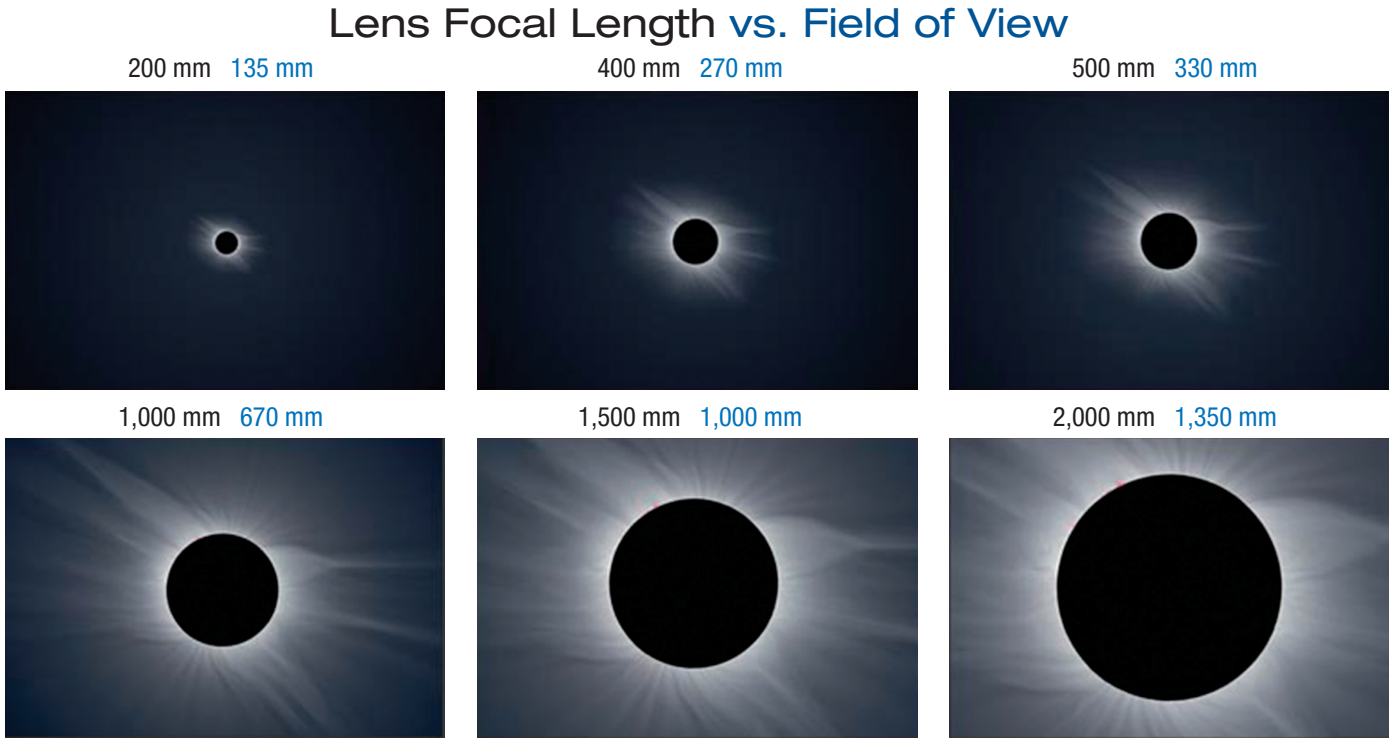
• In addition to capturing different aspects of totality with bracketed exposures, you can also use special image-processing techniques to combine the different exposures and create one image showing detail over a wider range of brightness than is possible with a single exposure. This technique, called *high-dynamic range* (HDR) imaging, is becoming increasingly popular among everyday photographers, and it's how my Easter Island image was processed.

• If your camera has a flash, *turn it off*. A flash offers no advantage for eclipse photography and will almost certainly annoy others around you.

• You should also disable any auto-ISO setting your camera may have. Auto ISO is designed to boost a camera's sensitivity in low-light situations — but at the expense of increasing the digital noise in images. While an eclipse scene might be dark overall, thus tricking your camera to use a high ISO setting, the detail you're generally trying to capture, including the corona, is bright enough to record well with a lower (and thus low-noise) ISO setting. For most cameras



Digital photography has made shooting eclipses much easier than in the days of film. With little to do camera-wise during totality other than hit the shutter release for a bracketed set of exposures, the author could look up and enjoy the sights at the Easter Island eclipse in 2010.



To capture coronal detail, you'll need a telephoto lens with a focal length of at least 300 to 400 mm. This comparison shows what some typical lenses will show during totality. Note: The blue values are for cameras equipped with APS (cropped-frame) sensors.

this falls between an ISO of 50 to 400.

• If your camera can save images in RAW format, use it. Capturing images is only half the story when it comes to creating an eclipse masterpiece. The other half is image processing, and the best results always come from processing RAW-format images.

• My final generality involves the focal length of lenses. In this article, as well as in other material you might encounter, most lenses are stated has having an *equivalent* focal length, and this might create some confusion.



Capturing the partially eclipsed Sun is relatively easy to do with a short exposure. But you'll need a protective filter, typically with an optical density (OD) of 5, to protect your camera's sensor.

The issue is that many cameras use an APS sensor or similar that's smaller than a standard 35-mm frame, essentially cropping and enlarging the view by 1.5×. This is known as the *crop factor.* If your camera has an APS-format sensor, you need to do the math to determine the real focal length of the lens you want to use to achieve a given field of view. For example, a 200-mm lens on an APS-equipped camera has a field of view equivalent to that of a 300-mm lens on a full-frame 35-mm camera (200 × 1.5 = 300).

Close-Up Photos

Photographs of the partial eclipse, Baily's Beads, the diamond ring, and the chromosphere do not need to cover a field of view much larger than the apparent ½° diameter of the Sun's disk. As such, focal lengths up to 2,000 mm are reasonable. On the other hand, anything shorter than about 400 mm will sacrifice detail, showing a rather small image of the Sun with a few stars.

Much of the same advice that applies to any extreme-telephoto photography also applies to this type of eclipse shooting. You'll need a very solid camera support and some form of external shutter release so you don't have to touch the camera itself to snap pictures. While it's a physical inconvenience to keep tripod legs their shortest when you're trying to aim a camera high in the sky, the increased stability is worth the discomfort. Consider hanging weight like a bag of sand from the tripod head to further increase its stability.

Critical focus is important at these long focal lengths, and you can't count on a camera's auto-focus to work for eclipses. Fortunately, most all digital cameras these days have a "live-view" feature that produces a real-time, zoomable image on the camera's viewing screen, which assists with critical focusing. But, here, too, eclipses present problems — especially in the final moments before totality when you're trying to make last-second focus tweaks using the shrinking crescent Sun visible through your solar filter. This scene, all black except for the thin sliver of Sun, might

TOP: FRED ESPENAK (6)

cause a camera's live-view electronics to blow out the image on the monitor, making it all but impossible to focus.

Your best bet is to actually shoot a picture and check the resulting image at high magnification on the camera's monitor. Do this when there's still about 5 minutes to go before the start of totality, since it could take a few attempts at adjusting the focus before you get everything perfect.

Medium-field Photos

Exposures made with effective focal lengths of 400 to 800 mm are ideal for capturing the full extent of the Sun's corona. Many photographers consider these the classic images of totality.

The key to success here is to bracket your exposures. With ISO settings of 50 to 400 and lenses with f/ratios between f/5.6 and f/11, essentially any exposure from $^1/_{1,000}$ second to 2 seconds will record an interesting aspect of the totally eclipsed Sun. Given the variables of sky conditions and the Sun's corona, it's difficult to say which of these exposure times will produce a single "best overall" shot during totality, but my experience shows that the sweet spot is between $^1/_8$ and $^1/_{60}$ second at ISO 200 with an f/8 lens. As mentioned earlier, you can later combine bracketed exposures to create an HDR image showing an extended range of coronal brightnesses.

For shooting the partially eclipsed Sun through an OD5 solar filter at ISO 100, use an exposure of $^1/_{2,000}$ second with the lens set at f/4, $^1/_{1,000}$ at f/5.6, and $^1/_{500}$ at f/8. Again, bracket your exposures.

In the days of film, carefully tracking the Sun's motion across the sky was essential for exposures long enough to record the Sun's faint, outer corona. This was especially true when photographing with focal lengths of 500 mm or more, which magnify the Sun's diurnal motion. But the sensitivity of digital cameras makes such long exposures a thing of the past. My 2-second digital exposures now routinely record more outer corona than I captured with 16-second exposures on film. With exposures this brief, you can get away with not tracking the Sun even when working with focal lengths of up to 600 or even 800 mm. Part of the reason is that detail in the outer corona is relatively diffuse and thus not blurred by the Sun's apparent motion during a 2-second exposure.



This composite view of the 2008 eclipse seen from China was assembled from a series of exposures made at 5-minute intervals with a Nikon D200 camera and 24-mm lens. The partial-eclipse images were shot through a solar filter, which was removed for a bracketed set of exposures made during totality, recording the foreground, eclipsed Sun, and the planets Mercury (close to the Sun's upper left) and Venus (farther out at upper left).

Wide-field Photos

Despite having an image of the eclipsed Sun too small to show much detail, wide-angle views during totality can be exceptionally dramatic. In addition to including foreground, these images often capture stunning sky coloration along with the brighter stars and planets visible during totality. And some can even show the Moon's approaching or receding shadow. I've had very good success shooting these scenes with lenses ranging from fisheyes that take in the full 180° of heaven's vault up to conventional wide-angle lenses of 24- to 35-mm focal length. I've also had very good success shooting these photos using my camera's auto-exposure setting, but bracketing is still a good idea.

The composite picture on the previous page, made during the 2008 eclipse in China, is one of my personal favorites. It was taken with a camera and equivalent 36-mm lens on a small tripod about 8 meters (25 feet) behind me. The camera's internal intervalometer snapped a bracketed set of exposures every 5 minutes for the multi-hour duration of the eclipse. Unlike the days of film when multiple exposures were recorded on a single frame of film and you had to carefully plan shooting intervals beforehand, with digital images you can shoot on short intervals and select frames to composite later. It takes approximately 2 minutes for the Sun to move its own diameter across the sky, so images spaced at 5- or 10-minute intervals should work well for compositing.



STRIKING LUNAR SHADOW The shadow of the Moon sweeping over Patagonia in southern Argentina plunged the western horizon into darkness just before sunset on July 11, 2010. The sharp delineation of the Moon's umbra in the sky stunned everyone, including lucky photographer Daniel Fischer.

If you try to take a photo like this, keep in mind that you'll want to include a picture made during the middle of totality at your location, so you'll need to calculate the start time of your sequence by stepping backward from this time in increments of your exposure intervals. The only other thing I had to do for my photo was remember to remove the solar filter for the bracketed burst made during totality, and replace the filter quickly afterward.

Use a Smartphone? Yes, But . . .

Experienced eclipse photographers might sneer at the thought of shooting the eclipse with a smartphone's camera. But the quality of these cameras has become quite good, so there will probably be more pictures of the upcoming eclipse taken with phones than with any other type of camera. And I wouldn't be surprised if some, especially ones in the wide-field category mentioned above, turn out quite well. That said, location and luck, more than photographic skills, will likely be the determining factors.

There are two large hurdles to overcome when trying to shoot close-up eclipse pictures with a smartphone: focus and exposure.

Notice that I didn't mention magnification. That's because you'll find a

Best Exposures for Recording the Total Eclipse

f/ratio for ISO 100:	f/2.8	f/4	f/5.6	f/8	f/11	f/16
Baily's Beads*	—	—	1/2,000	1/1,000	1/500	1/250
Diamond ring**	1/1,000	1/500	1/250	1/125	1/60	1/30
Prominences	1/1,000	1/500	1/250	1/125	1/60	1/30
Chromosphere	1/2,000	1/1,000	1/500	1/250	1/125	1/60
Inner corona	1/250	1/125	1/60	1/30	1/15	1/8
Outer corona	1/8	1/4	1/2	1	2	4
Wide-field view***	1/4	1/2	1	2	4	8

* These exposures assume the camera's solar filter has been removed. ** Use longer exposures to capture more corona around the "ring." *** For especially dark horizons, use longer exposures.

DANIEL FISCHER

seemingly endless variety of gizmos made to attach cell phones to telescopes and binoculars, not to mention a growing assortment of so-called zoom lenses that clip over your phone's built-in lens. I've tried a handful of them with varying degrees of success, but the best focused and exposed results have always been with terrestrial pictures (think birds on a feeder). These scenes have lighting that's easy for the camera's auto-exposure algorithms to interpret, and they are also filled with detail for the auto-focus to latch on to.

Neither of these exists with close-up views of an eclipse. There are apps, however, that let you control the smartphone's auto focus and exposure. I've used them to photograph the Moon in twilight conditions that will likely mimic the sky during totality at the coming eclipse. They do work, but they remind me of the days of film when I spent far too long fumbling with camera settings rather than looking up and enjoying the spectacle around me during totality. If you are set on trying to shoot close-ups of the eclipse with a smartphone, get the necessary accessories and camera-control apps well before the event and learn to use them by shooting the Moon or Sun (with an appropriate solar filter) ahead of time.

Moving Pictures

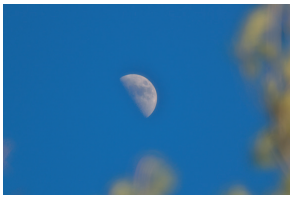
Video brings the added dimensions of motion and sound to eclipse photography, and both can be extraordinarily dramatic. Even years later, playing back an eclipse video and hearing the rising excitement of people around you as you see the shrinking crescent give way to the corona can bring back memories of an eclipse unlike any that a still photograph ever will. But you'll also be paying a price for the advantages that video brings. Views of the corona captured with consumer-grade video cameras or smartphones will lack the dynamic range and overall detail recorded with even relatively simple still photography.

If you do shoot video, most of the same rules mentioned above for still photography will also apply. You'll need a stable tripod or other support, especially if you use a camera that can zoom in for close-ups. Additionally, a fluid head for your tripod is also necessary to smoothly pan around a surrounding crowd of observers.

And you should heed my earlier advice about having a safe solar filter mounted in a way that can be quickly and easily removed and replaced. The most dramatic moments to be captured on video are the fleeting seconds at the beginning and end of totality as the Sun's shrinking crescent gives way to Baily's Beads and the diamond ring. You don't want to lose them fumbling with the filter.

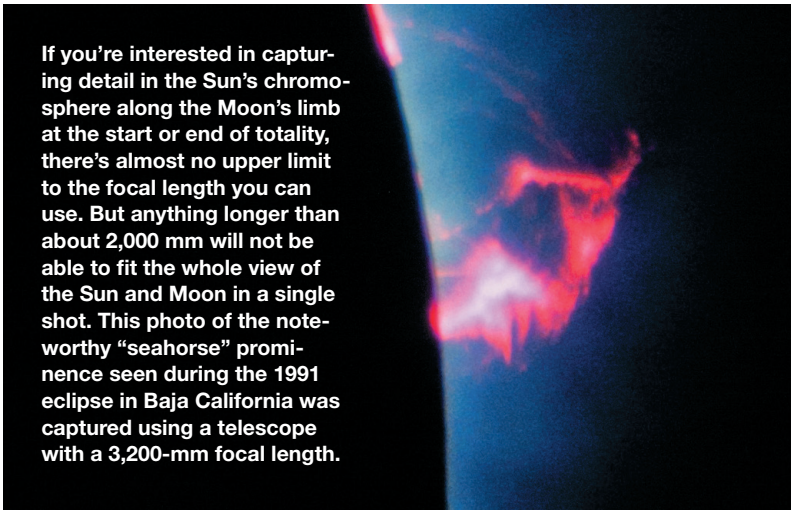
Regardless of how you record the eclipse, the best advice is always to become familiar and comfortable with your equipment, practice using it, and create a solid plan well beforehand. That way you'll be able to enjoy the event for years to come with treasured memories *and* good photographs.





Regardless of the camera body it's attached to, the 420-mm lens used for these shots produces an image of the Moon the same size on the camera's sensor (3.8 mm in this case). But the small sensor on the camera with a 1.5× crop factor (above) captures a smaller field of view than the full-frame camera (top), making it seem like it's a more powerful telephoto — which it really isn't.

Veteran eclipse chaser ***Dennis di Cicco*** *still claims that someday there will be a total solar eclipse that he simply watches and doesn't photograph.*

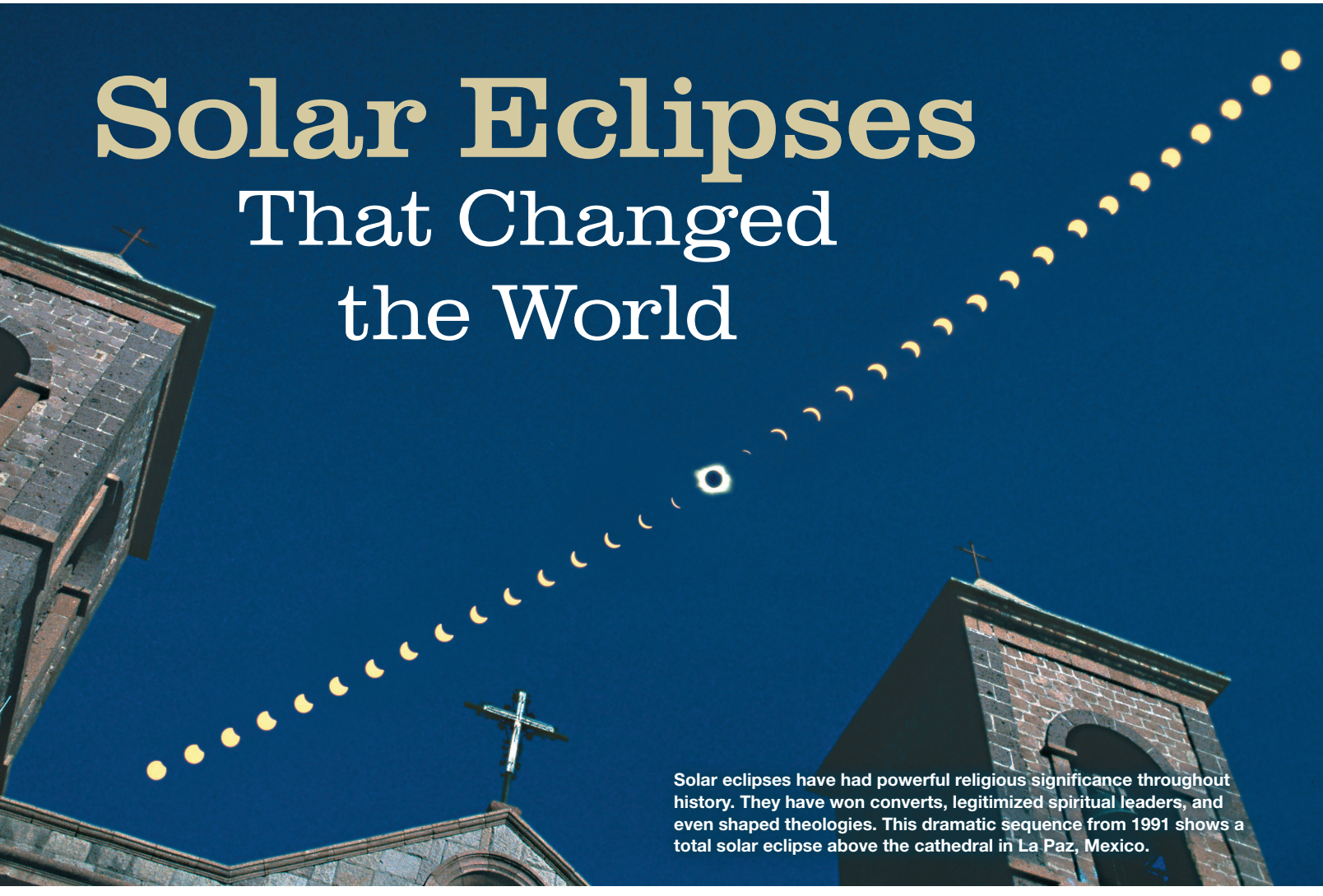


If you're interested in capturing detail in the Sun's chromosphere along the Moon's limb at the start or end of totality, there's almost no upper limit to the focal length you can use. But anything longer than about 2,000 mm will not be able to fit the whole view of the Sun and Moon in a single shot. This photo of the noteworthy "seahorse" prominence seen during the 1991 eclipse in Baja California was captured using a telescope with a 3,200-mm focal length.



Lasting only seconds at the beginning and end of totality, the diamond ring is always a challenging event for eclipse photographers. This one was captured with a 1/125-second exposure at ISO 200 with the TV-85 f/7 refractor shown on page 29.

Solar Eclipses That Changed the World



Solar eclipses have had powerful religious significance throughout history. They have won converts, legitimized spiritual leaders, and even shaped theologies. This dramatic sequence from 1991 shows a total solar eclipse above the cathedral in La Paz, Mexico.

AKIRA FUJII, HIROYUKI TOMIOKA & YONEMATSU SHIONO

Almost anything can happen — and has — when the ultimate source of Earth's light and life disappears from the sky.

By Bradley E. Schaefer

A TOTAL SOLAR ECLIPSE IS one of the most beautiful spectacles the sky has to offer. But many cultures viewed these dramatic celestial events as ominous portents. In fact, because of their rarity from any given location, solar eclipses occasionally have had enough impact to change the course of history — often centered on little-known stories involving famous people. Here are some of the most interesting examples.

Muhammad

The prophet Muhammad, the founder of Islam, was born in Mecca in the Year of the Elephant, AD 569–70. His birth year got its picturesque name due to an invasion by the Abyssinians, who used elephants in the assault. The invading army was miraculously driven off when a flock of birds dropped stones on the troops, causing an epidemic similar to smallpox.

The Year of the Elephant was also memorable (and datable) because of its solar eclipse. In ancient times, the births and deaths of great leaders were frequently associated with celestial omens, and Muhammad's beginning was no exception. However, Islamic theology does not accept that God produced the eclipse as an omen of the prophet's birth, a doctrine that is based on another solar eclipse closely tied to Muhammad.

The prophet's infant son, Ibrahim, died tragically on January 22, 632. An annular eclipse occurred that day, and some Meccans claimed it was a sign from God. Muhammad quickly corrected them, declaring, "The Sun and Moon are signs of God and do not eclipse for the death or birth of any man." Islamic legal scholars have since used this statement to reject astrology.

A third solar eclipse associated with Muhammad occurred 39 years after his death. In 661 Mu'awiyah became leader of the empire after a revolt against Ali (the prophet's first

cousin, second convert, and son-in-law). The son of Muhammad's chief Meccan enemy, Mu'awiyah decided to transfer the prophet's pulpit in 671 from Medina to his capital and power base in Damascus, Syria. But as his men were removing it, the sky darkened such that stars could be seen. They took this as a sign of divine displeasure, and the relic remained in Medina as a symbol of Mu'awiyah's failure.

Tecumseh

At the start of the 19th century, Americans were vigorously expanding into areas west of the Appalachian Mountains. Unfortunately, the many diverse Native American tribes who occupied this land did not have the population base or technological skills to hold back the advancing settlers. Another handicap was that the tribes seldom acted in concert or with long-term goals. But this wasn't always true.

Tecumseh, a warrior of the Shawnee tribe in the Ohio River valley, had the necessary vision. He realized that all tribes in the area would be killed or pushed out unless they formed a united front and protected each other. To this end he worked tirelessly to create a tribal confederation. He was aided by the logic of his arguments, his great diplomatic powers, and his brother, Tenskwatawa.

The Prophet, as Tenskwatawa was called, preached religious revival with a strong rejection of all white customs, particularly the drinking of alcohol. He attracted many followers because tribal society was collapsing, and his call for a return to traditional practices promised to stem the tide of change. Thus both brothers tried to preserve Native American lands and culture.

Any leader of a religion that supports the existence of miracles is always in a precarious position should he or she be challenged to perform one. William Henry Harrison, governor of the Indiana Territory, demanded that Tenskwatawa provide "some proofs at least of his being the messenger of the Deity." Tecumseh learned of an upcoming solar eclipse from members of an expedition to the area who were preparing for the event. He induced his brother to announce that on the morning of June 16, 1806, the Great Spirit would take the Sun in hand and hide it from the world. On the appointed morning, a large gathering in Greenville, Ohio, saw the prophet's promise come true. Then he saved the world from perpetual night by ordering the Great Spirit to release the Sun.

Backed by such dramatic evidence, Tenskwatawa became a powerful leader in the territory. The two brothers traveled from tribe to tribe, winning converts and organizing the confederation. For a time the allied tribes successfully held back the onslaught of white settlers, and they built a capital, called Prophetstown, near the Tippecanoe River in northern Indiana.

The confederation later collapsed, however, when Governor Harrison led a strong army against the town, and in a rash night assault Tenskwatawa made his warriors an ill-conceived promise of immunity from death. Their loss at Tippecanoe on November 7, 1811, was decisive, and the Prophet's followers turned on him. Tecumseh died in 1813, during a large battle in what is now southwestern Ontario, and the defeated tribes were soon transported across the Mississippi River. The confederation forged by two brothers of vision and a solar eclipse could not survive failed prophecies and the loss of its leaders.

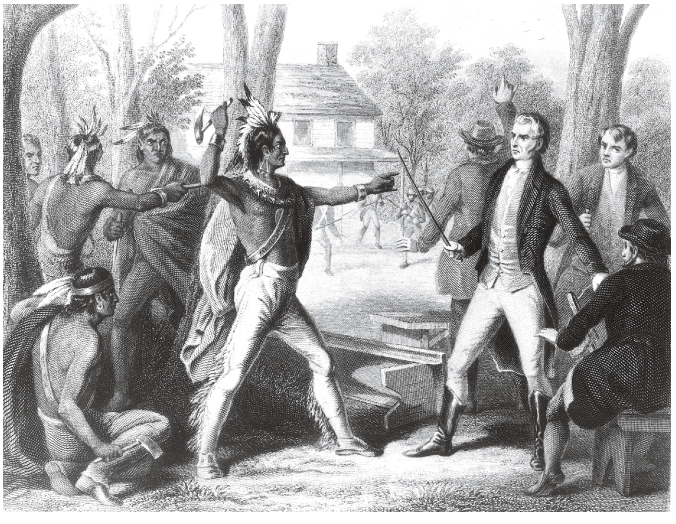
Nat Turner

The treatment of Native Americans and black slaves reflects the most despicable episodes in U.S. history. Kidnapped Africans were transported to the New World and forced to work long hours under squalid conditions for no reward. Any such situation is inherently unstable, so the slave masters lived in deep fear of an uprising by their chattel.

The best-known slave rebellion in America centered on the charismatic figure of Nat Turner. Born in 1800 in Southampton County, Virginia, he learned to read from his master's son. His literacy was unusual because slave owners knew that education could lead to revolt. Turner channeled his energy into religious devotion and became a preacher for his fellow blacks, who came to call him the Prophet. In 1828 Turner had a vision that he would lead his people to freedom. He slowly gathered his forces by recruiting an inner circle of roughly 20 trusted friends.

But first Turner had to await a sign from God. He interpreted a solar eclipse on February 12, 1831, as a black angel occulting a white one. This omen symbolized blacks overcoming their white owners, so the time for revolt had come.

The slaves planned to murder local farmers, seize their weapons, gather recruits from nearby farms, march on the armory in Jerusalem, Virginia, and then turn east to the Great Dismal Swamp, where capture would be difficult. Turner timed the revolt for the Fourth of July, both as a symbol of freedom and because the slaves were allowed greater movement on that holiday. However, the uprising was delayed when Turner became ill, forcing the group to await another sign. It arrived on August 13th, when the Sun appeared dim, with green



In the early 1800s Shawnee leader Tecumseh assembled a confederation of tribes to fight white settlers after his brother, Tenskwatawa, correctly "prophesied" that the Great Spirit would hide the Sun during an eclipse in 1806. Here Tecumseh is shown confronting William Henry Harrison, then governor of the Indiana Territory.

CINCINNATI HISTORICAL SOCIETY



Nat Turner led a slave uprising after interpreting a solar eclipse in 1831 as a black angel overcoming a white angel — signaling to him that the time for rebellion had come.

and blue coloring. Then he saw what was likely a naked-eye sunspot group (1831 was the year just after a maximum of the sunspot cycle).

The revolt started on the night of August 21st with the murder of Turner's owners. However, the next morning a small band of militia stopped the march on Jerusalem, and the revolt soon degenerated into a rout with the capture and execution of the slaves. A total of 60 whites and perhaps 200 slaves (many innocent of rebellion) died in the uprising. Turner remained in hiding for 70 days until he too was caught and hanged.

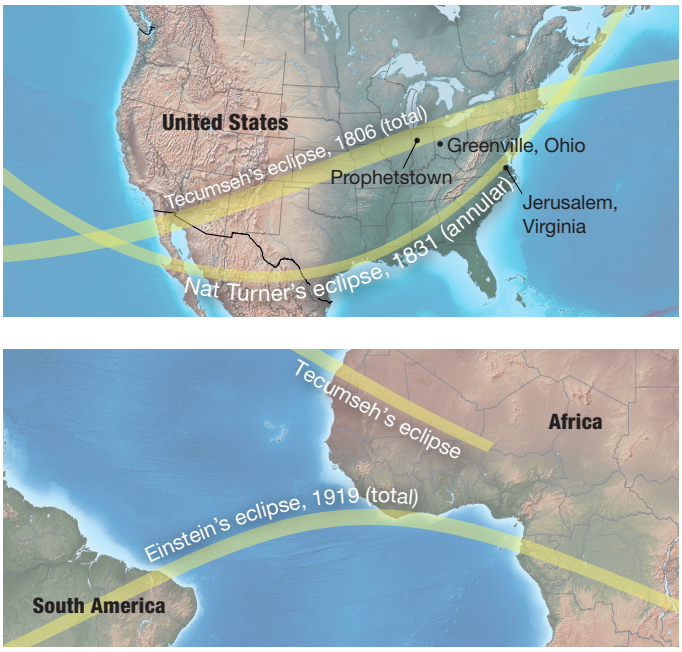
Albert Einstein

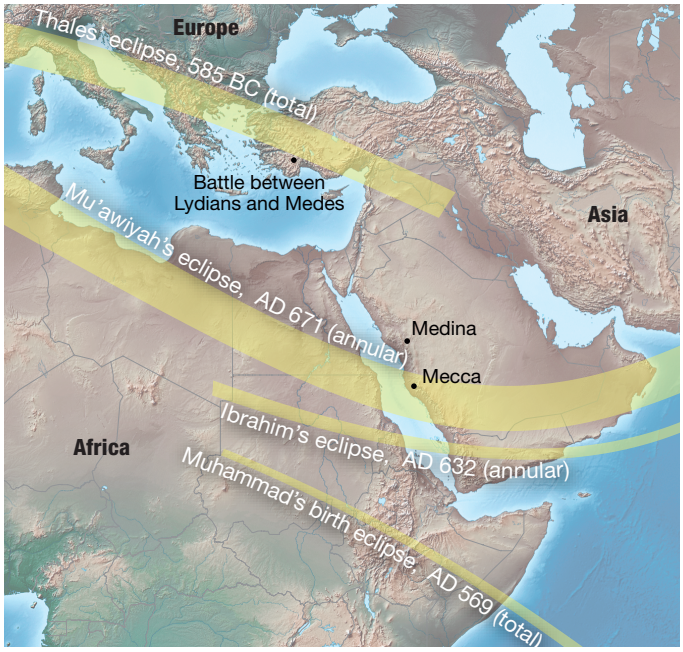
In 1905 Albert Einstein wrote three papers, each worthy of a Nobel Prize, that explained Brownian motion, the photoelectric effect, and special relativity. The success of these papers transformed him from an obscure Swiss patent clerk to one of the top scientists in the tiny field of physics. He followed this phenomenal start with many significant advances in the field, including the discoveries of Bose-Einstein statistics, the cosmological constant, and the Einstein-Rosen-Podolsky paradox.

Einstein's most famous and influential work after 1905, by far, was his theory of general relativity, which describes the distortion of spacetime in a strong gravitational field. He completed his formulation of the theory between 1913 and 1916 while working in Berlin, and during this time he predicted a previously unknown phenomenon that, if observed, would validate his work. He believed that the curvature of space near a massive object like the Sun would bend light that passed close by. Specifically, a star seen near the edge of the Sun during a total solar eclipse would appear to have shifted by 1.75 arcseconds (0.0005°) from its usual place.

To test Einstein's prediction, some German astronomers mounted an expedition to the Crimea for a total solar eclipse on August 21, 1914. But that wasn't a good time to be a German national in Russian territory — ultimately, the team's members took no photographs because they were interned for a month until an exchange could be arranged.

During World War I scientific ideas moved precariously between Germany and the Allies. When English astronomer Arthur Eddington received Einstein's 1916 paper on general





Upper left: Tecumseh and Nat Turner used solar eclipses in the United States to rally forces against their oppressors. Lower left: Astronomers led by Arthur Eddington used the total solar eclipse in 1919 to confirm a key aspect of Albert Einstein's theory of general relativity. Right: Three solar eclipses associated with the Islamic prophet Muhammad occurred in the year of his birth; on the day his son died; and when one of his successors tried to remove the prophet's pulpit from Medina. The Thales eclipse in 585 BC ended a war between two Middle Eastern kingdoms (see the box on the facing page).

PHOTO: TWENTIETH CENTURY FOX FILM CORP.; MAPS: MICHAEL ZEILER / GREATAMERICANECLIPSE.COM

relativity, he immediately realized its importance. He mounted an eclipse expedition of his own for the May 29, 1919, event. The planning started at the height of the war, when prospects were darkest for the Allies. This British test of a German's theory provided a great display of internationalism in science and served to repudiate attempts to boycott German scientists after the war.

To guard against clouds, Eddington planned to have two observing sites: one on Príncipe Island off the west coast of Africa and one in Sobral, Brazil. On Príncipe, eclipse day began with heavy rain that stopped by noon, allowing the observing team to glimpse the Sun after the lunar silhouette's first contact. In a routine familiar to many modern amateurs, Eddington took 16 photographs through scattered clouds yet glanced up only twice.

The effort's results, announced on November 6, 1919, at a meeting of the Royal Astronomical Society, confirmed Einstein's theory exactly. The packed audience immediately sensed the shifting of humankind's worldview. The international press trumpeted the discovery and lionized Einstein as the epitome of genius. It's doubtful he would have progressed from renowned physicist to scientific legend without the dramatic fanfare that followed the eclipse.

Eclipses and Religion

In the first examples detailed here, three figures — each known as "the Prophet" — used eclipse phenomena, deliberately or otherwise, for religious purposes. Others have done the same. St. Patrick purportedly used a "great darkness" to convert Irish pagans in the 5th century, and in 1884 the Mahdi used a solar eclipse to demoralize the defenders of Khartoum.

Eclipses have also been connected with the deaths of religious figures, including those of St. Olaf at the battle of Stiklestad in 1030 and of Jesus Christ, whose crucifixion coincided with three hours of darkness. Both Christians and Muslims have prophecies of eclipses associated with Judgment Day in their holy scripture.

Eclipses have probably been associated so closely with religion because they occur in the heavens — the abode of the gods where mortals cannot intervene. What better place to look for divine signs? Fear of eclipses perhaps developed because Sun worship is such a strong part of humankind's past. Our distant ancestors often viewed a total solar eclipse as a terrifying symbol of the death of a god.

In modern society the association between eclipses and religion is largely gone. Now that we know what causes them and can predict precisely when they'll occur, the "fear factor" is gone. Any modern-day preacher trying to capitalize on a solar eclipse would be laughed at.

In the last century eclipses have changed from signs of God to the tools of science. Professional astronomers still use total solar eclipses to study the Sun's corona (and they are still learning from such observations). Historical researchers have even used Ibrahim's eclipse in 632 to quantify the acceleration of Earth's rotation.



An engraving by French artist Georges Rochegrosse depicts how a total solar eclipse caused great alarm among the Medes and Lydians during their battle on May 28, 585 BC.

Totality Stops a War

The best-known example of a solar eclipse affecting a historical event occurred during a war between the Lydians and the Medes in 585 BC. Darkness fell in the middle of a pitched battle, and both sides became eager to make peace. The Greek historian Herodotus wrote that the year of the eclipse had been predicted by Thales of Miletus. But the contribution of Thales is under a modern cloud because of the vagueness of the claim and the lack of a calendrical framework for his predictions.

This shift in attitude is symptomatic of a change in our worldview. No longer is religion the only model for all thought. Indeed, science has become a guiding paradigm for art, philosophy, and even commerce — primarily because it delivers miracles and its prophecies come true. In a sense, science has become a new religion, with solar eclipses providing one of its most captivating rituals.

Bradley E. Schaefer *is an astronomy professor at Louisiana State University. During the August 2017 total solar eclipse he repeated the observations that Eddington used in 1919 to verify the curvature of spacetime by gravity.*

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When's the Next One?

Don't be surprised if seeing the totally eclipsed Sun becomes habit-forming.

By J. Kelly Beatty

Like snowflakes, every total solar eclipse is different. Some are frustratingly short, others luxuriously long. The Sun's ethereal corona can vary from nearly formless to astoundingly structured. And the Moon's umbral shadow, which points our way about every 18 months on average, can drape itself across any part of Earth's surface.

Take, for example, the total solar eclipse seen coast to coast across the contiguous United States in August 2017. "Epic" doesn't begin to describe the attention lavished upon that first-time-ever event for millions of people. And yet the very next opportunity to witness totality, on July 2, 2019, crossed very little land — modestly populated parts of Chile and Argentina — and thus relatively few saw it.

Regardless of the specifics, however, these celestial spectacles are *always* amazing. In fact, a common refrain after someone's first full immersion in totality is, "When's the next one?!" And so, should you likewise be looking ahead, past August 12, 2026, here's a glance at three upcoming total solar eclipses.

AUGUST 2, 2027: NORTHERN AFRICA

Most "umbraphiles" have had this event circled on their calendars for many years. Why? Because it's literally going to be the event of a lifetime — this eclipse offers the longest duration of totality (6^m 23^s) for the next 87 years. (It will *not* be the longest total solar eclipse in the 21st century, however; the one on July 22, 2009, was 16 seconds longer.)

The path of totality in 2027 makes an appealing sweep across the northern coast of Africa, straddling the Strait of Gibraltar before moving eastward across northern Algeria, central Tunisia, and eastern Libya. Tripoli is just at the southern limit of totality, but the city of Benghazi lies on the centerline.

Yet the path's trek across Egypt is what's drawing the most attention from diehard corona-lovers. If you can handle the heat — it'll be August in Egypt, after all — consider heading to Luxor, which sits very near the centerline and offers a near-maximum 6^m 21^s of totality. Thousands of eclipse-chasers have already locked up reservations in this ancient city, which straddles the mighty Nile and serves as portal to some of the country's most amazing archaeological treasures. Meanwhile, those likely to wilt in the midday Sun are looking into cooler coastal sites farther west, such as Tangier, Morocco, or a cruise ship bobbing in the Mediterranean.

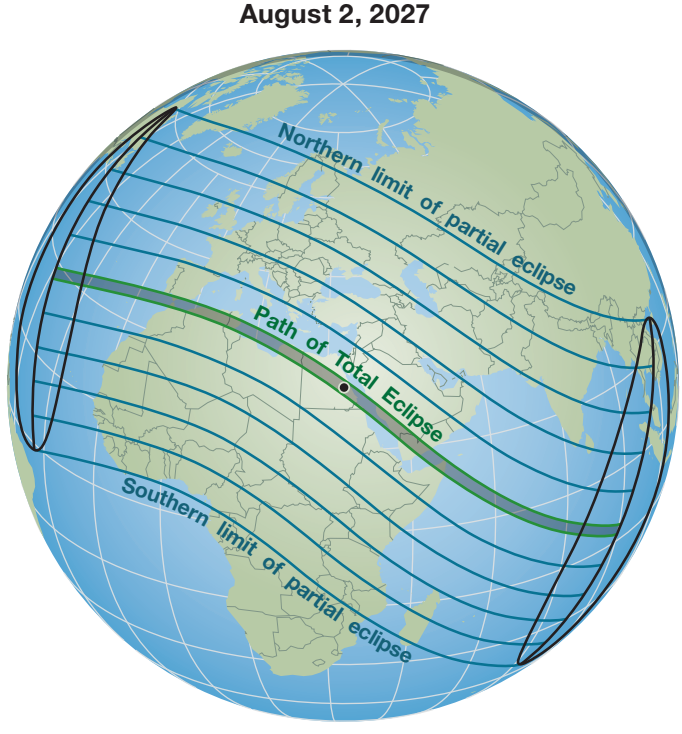
After crossing the Red Sea, the path of totality slides along the western coast of Saudi Arabia (Jeddah gets a generous 6^m 0^s of totality) and Yemen (which, like Libya, is not recommended) before heading into the Indian Ocean.

Weather-wise, the odds of clear skies are as good as they get: Statistically, you've got about a 90% chance of cloud-free skies all along this event's very broad central path. I imagine that many will spend the modest fee for a Gibraltar Nature Reserve pass then hike to the top of this world-famous rock to witness the eclipse. Sure, totality there will drop to 4^m 27^s, but being able to watch the Moon's umbral shadow race over you at 2,800 miles per hour from that unique vantage will likely be unforgettable.

JULY 22, 2028: AUSTRALIA, NEW ZEALAND

When it comes to total solar eclipses, Australia is getting more than its fair

DESIRABLE DESTINATIONS
The green-edged bands mark the paths of totality for each of the three total solar eclipses that follow 2026's. For each event, a black dot marks where the duration will be longest, and sets of blue lines show the extent of partial-eclipse visibility (in 20% increments).



SKY & TELESCOPE / SOURCE: FRED ESPENAK (3)

share recently. The path that barely clipped its westernmost spit of land in April 2023 was the first of five total solar eclipses visible from Down Under over a span of just 16 years.

The best of these, offering up to 5^m 10^s of totality — sixth longest in the 21st century — will slash across the continent for 2,100 miles from its north-central to southeastern coasts. The Moon's shadow makes landfall in the Kimberley region, an area of breathtakingly rugged ranges and dramatic gorges. Then it moves across the sparsely populated Outback, passing well north of Alice Springs and Uluru (Ayer's Rock) before moving into New South Wales. The view could be great from Siding Spring Observatory (where totality will last 1^m 50^s), and the vibrant city of Sydney lies right on the centerline (3^m 48^s from its iconic Opera House).

Even though July is midwinter in Australia, the weather prospects for this eclipse are generally excellent, especially in the country's north and middle. Sydney tends to have many cloudy winter days, the locals tell me, and the chance of *not* seeing the corona rises to 60% once the path reaches New Zealand's South Island, where totality lasts up to 2^m 57^s.

NOVEMBER 25, 2030: SOUTHERN AFRICA AND AUSTRALIA

Diehard umbraphiles will have to wait more than two years after 2028's total solar eclipse across the Australian Outback to witness the next one. Remarkably it *also* crosses Australia — but not until very near its end.

For this event, the Moon's shadow first touches Earth in the South Atlantic Ocean, but it quickly races eastward across the southern tip of Africa. Parts of Namibia, Botswana, Lesotho, and South Africa will witness up to 2½ minutes of totality in the hours after dawn. Then the dark umbral oval races past Durban and out across the Indian Ocean at nearly 3,000 miles per hour (1.3 km/s). The eclipse hits its maximum duration — 3¾ minutes of totality — in a remote stretch of southern ocean.

But then the umbral oval pivots northward, making landfall again as it crosses into South Australia at about 7 p.m. local time. By then the duration of totality drops to just 2 minutes. (Sadly, Adelaide lies about 120 miles outside the path and will have to settle for a 91% partial eclipse.) Then shadow sweeps east-northeastward, with 90 seconds of breathtaking totality at sunset from locations about 100 miles northwest of Brisbane.

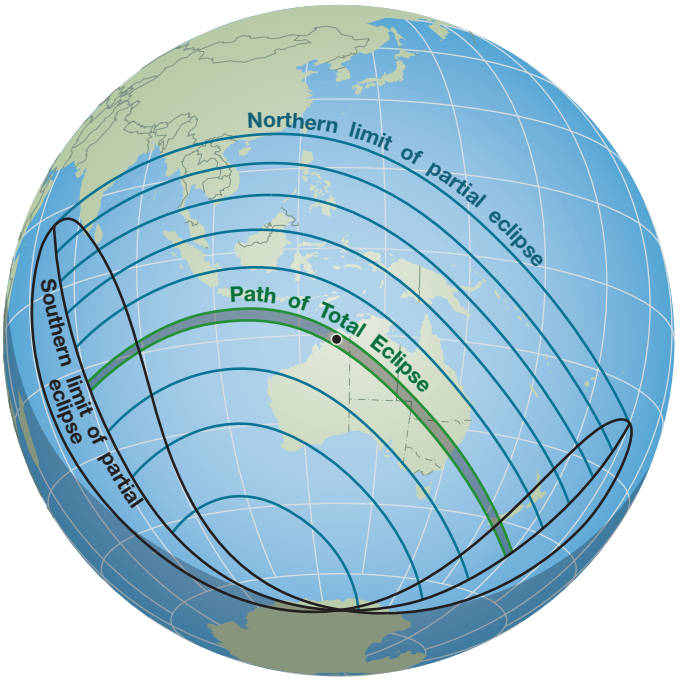
Will totality on August 12, 2026, become the first entry in your personal "life list" of treasured moments in the Moon's shadow?

Late November is nearly mid-summer Down Under, and eclipse-weather specialist Jay Anderson foresees decent chances for clear skies in both Australia and the western two-thirds of the track across Africa. That will surely be reason enough to lure dedicated eclipse-chasers to those locations.

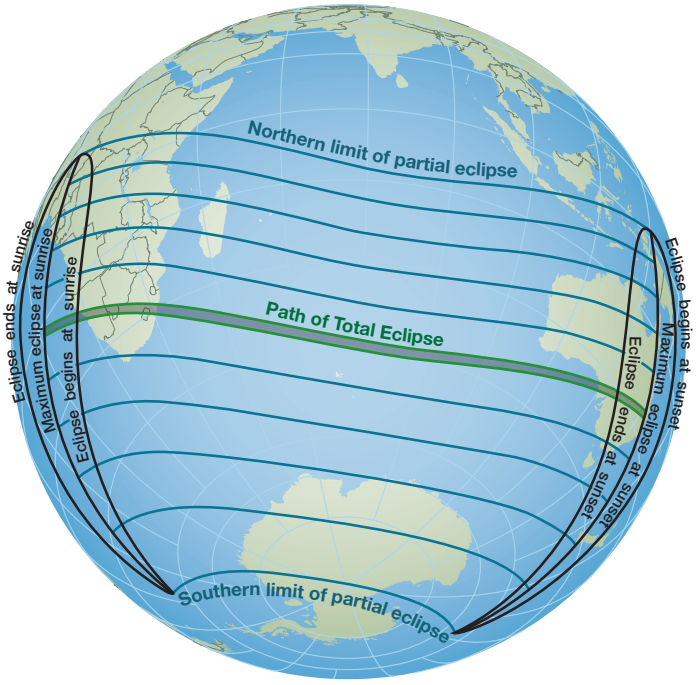
So that's the lineup for the next few years. Many dedicated umbraphiles have traveled to every corner of the world to witness dozens of eclipses over their lifetimes. Will you do likewise? Will totality on August 12th become the first entry in your personal "life list" of treasured moments in the Moon's shadow?

J. Kelly Beatty, a senior contributing editor at Sky & Telescope, has traveled to 24 total and annular eclipses. He planned Sky & Telescope*'s two eclipse expeditions to Spain this year, along with five more tours to see total and annular eclipses in 2027 and 2028. For details about these and other astro-themed adventures, go to* ***skyandtelescope.org/tours****.*

July 22, 2028



November 25, 2030



Eclipse Resources

With all the interest in April's sky spectacular, it's no surprise that you can find lots of great information about solar eclipses. Here are some favorite resources chosen by the editors of Sky & Telescope *magazine. Note: Some website links are case-sensitive.*

Books About Eclipses

American Eclipse: A Nation's Epic Race to Catch the Shadow of the Moon and Win the Glory of the World by David Baron (W. W. Norton, 2017, 352 pages)

Atlas of Solar Eclipses: 2020 to 2045 by Michael Zeiler and Michael Bakich (Great American Eclipse, 2020, 256 pages)

Being in the Shadow: Stories of the First-Time Eclipse Experience by Kate Russo (Being in the Shadow, 2017, 144 pages)

Eclipse and Revelation: Total Solar Eclipses in Science, History, Literature, and the Arts Edited by Henrike Lange and Tom McLeish (Oxford University Press, Feb. 2024, 384 pages)

In the Shadow of the Moon: The Science, Magic, and Mystery of Solar Eclipses by Anthony Aveni (Yale Univ. Press, 2017, 328 pages)

Mask of the Sun: The Science, History, and Forgotten Lore of Eclipses by John Dvorak (Pegasus Books, 2017, 272 pages)

Sun Moon Earth: The History of Solar Eclipses from Omens of Doom to Einstein and Exoplanets by Tyler Nordgren (Basic Books, 2016, 264 pages)

Guides to the 2026 Eclipse

Guide for the Total Solar Eclipse of 2026 by Fred Espenak (Astropixels Publishing, 2024, 40 pages)

Complete Guide to the Total Solar Eclipse 2026: Greenland, Iceland and Spain by Jamie Carter and Gill Carter (WhenIsTheNextEclipse.com, 2025, 85 pages)

Solar Eclipses 2024–2027: Where and When to Experience Totality by Sheridan Williams (Bradt Travel Guides, 2023, 80 pages)

Spain Solar Eclipse Guide 2026: Chase Totality Across Spain by Jane Doe (2026, 93 pages)

Solar Eclipse Guide Spain 2026 by Jan Hattenbach and Daniela Pujado Lizama (Oculum-Verlag, 2025, 54 pages)

2026 Total Solar Eclipse Travel Guide by San Franklin (2026, 146 pages)

Solar Eclipse 2026: The Complete Kids' Guide to Spain & Iceland Solar Eclipse Viewing by Kathleen J. Honda (2025, 40 pages)

Websites

aa.usno.navy.mil/data/UpcomingEclipses
U.S. Naval Observatory website generates custom eclipse predictions for your location

eclipse.aas.org
Comprehensive resource for all aspects of the August 2026 eclipse

eclipses.info
Website of the International Astronomical Union's Working Group on Solar Eclipses

eclipsewise.com
Vast listings of tabulations and maps for solar (and lunar) eclipses from 1900 to 2100

eclipseatlas.com/2026-august-12
Extensive collection of detailed maps for 2026 eclipse, along with historical eclipse records

xjubier.free.fr/en/site_pages/solar_eclipses.html
Interactive maps of past and future solar eclipses that provide specifics for any location

nso.edu/for-public/eclipse-map-2026/
Website of the National Solar Observatory with resources for amateur astronomers and educators

skyandtelescope.org/astronomy-news/plan-now-for-the-2026-total-solar-eclipse-in-europe *Overview of the eclipse circumstances and weather prospects for the August 2026 total solar eclipse*

exploratorium.edu/eclipse/2026-total-solar-eclipse-guide *General overview of the eclipse circumstances and a link to a livestream broadcast on eclipse day*

timeanddate.com/eclipse/solar/2026-august-12 *Well-illustrated overview of the eclipse circumstances and a link to a livestream broadcast on eclipse day*

Weather Forecasts

astrospheric.com
Astronomy-focused weather predictions include extended cloud-cover forecasts; also available as a free smartphone app

eclipsophile.com/2026tse
Canadian meteorologist Jay Anderson's comprehensive analysis of eclipse-day weather prospects and other logistics

goes.noaa.gov
Real-time satellite imagery from NOAA satellites show infrared, visible, and water-vapor views

wunderground.com
Forecasts, plus satellite imagery and radar available for specific locations

Smartphone Apps (for Apple & Android)

Great American Eclipse
(Free, Michael Zeiler, GreatAmericanEclipse.com)

Solar Eclipse Timer
(Free with in-app purchases, Foxwood Astronomy)

Solar Snap (for use with Solar Snap filter)
(Free, Doug Duncan and American Paper Optics)

Totality by Big Kid Science
(Free, Jeffrey Bennett and the American Astronomical Society)

The Eclipse App (iOS/Android)
(Free, Stephen Watkins, Jesse Tomlinson, and The Planetary Society

Photography

How to Photograph the Solar Eclipses by Alan Dyer
(Amazing Sky Photography and Publishing, 2023, 350 pages, available from amazingsky.com/EclipseBook)

mreclipse.com/SEphoto/SEphoto.html
Time-tested advice and detailed tables for taking solar-eclipse photos

Solar Eclipses 2026: The Definitive Photography Guide Ultimate Guide for Solar Eclipse by Anthony Cladera (photopills.com/articles/solar-eclipse-photography-guide)

Safe-Viewing Guides

eclipse.aas.org/eye-safety *Information about using handheld viewers, projection techniques, and filters for optics*

eclipse.aas.org/resources/solar-filters
Reputable sources of solar filters for handheld use and for telescopes, binoculars, and cameras

Educator Resources

Eclipse Activities for Educators by Andrew Fraknoi
(2023, free PDF at https://is.gd/eclipseactivities)

Look UP, Below! An Educator's Guide to the April 8, 2024 Total Eclipse of the Sun by Deborah L. Skapik
(Friends' Central School, 2022, 58 pages, including 15 activity pages for various education levels)

Solar Science: Exploring Sunspots, Seasons, Eclipses, and More by Dennis Schatz & Andrew Fraknoi
(NSTA Press, 2016, 360 pages)

Total Solar Eclipse Education and Outreach Training
(NASA Heliophysics Education Activation Team, science.nasa.gov/learn/heat/resource/total-solar-eclipse-training/)

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