A Total Solar Eclipse Feels Really Really Weird

Have you ever witnessed a total solar eclipse? Usually when I give a lecture, only a couple of people in an audience of several hundred people raise their hands when I ask that question. A few others respond tentatively, saying, “I think I saw one.” That’s like a woman saying, “I think I once gave birth.”

What these people are remembering is some long-ago partial solar eclipse. These are quite common. They occur every few years in various places across the globe. But believe me, if you’ve seen a total solar eclipse—when the moon passes directly between the sun and the earth—you’ll never forget it.

Part of what makes a total eclipse so breathtaking has to do with invisible light. During the “moment of totality”—the minutes when sun is completely blocked—observers experience the exquisitely odd and wondrous sensation of solar emissions, both visible and invisible, vanishing right in the middle of the day.

You have a chance to experience this firsthand. The United States has reached the end of the longest total-solar-eclipse drought in its history. A total solar eclipse—or totality—has not been observed from anywhere in the mainland United States since February 26, 1979. This bizarre thirty-eight-year hiatus ends on August 21, 2017, when a coast-to-coast totality sweeps across the continent, ramping up an eclipse fever that is already highly publicized.

For those who do not live in or travel to the narrow, ribbon- like path of totality—the area from which the sun will appear to be in total eclipse, which stretches from the Pacific Northwest to the Carolina coast but is about 70 miles wide2—a second totality will unfold on April 8, 2024. Two in a mere seven-year period.

Then, as if to compensate for the scarcity of these events (even the 1979 eclipse was a mostly cloudy, far-northern event only observable in a few places such as Helena, Montana), the middle and late parts of the twenty-first century will offer a second sudden flurry of them.

In any given place on earth, a totality appears just once every 375 years. If it’s cloudy, you have to wait another 375 years. So a totality is a very rare event for any location. But that interval of time is just the average. Here and there, a few places will enjoy two totalities in a single decade: Carbondale, Illinois1, for example, sits at the intersection of both eclipse tracks—2017’s and 2024’s. Yet residents of other cities, including Los Angeles, must cool their heels for more than a millennium.

In the United States, no major urban center has seen a total solar eclipse since the dual events of Southern California in 1923 and the now-famous New York City totality of 1924. Boston was scheduled for a sunrise totality in October of 1925, but it was cloudy.

Every eclipse path—a map of the places on earth from which the sun is completely blocked and where stars are seen during the day—is long and narrow. During that Roaring Twenties Big Apple eclipse, for example, the totality ran from central Canada southeast to Albany, in upstate New York, then down through the Bronx and Harlem, and ended unceremoniously at 86th Street in Manhattan, near an eatery that would someday be famous for hot dogs and papaya drinks. People south of the subway stop there stood in daylight: no stars out, no mind-numbing glimpse of the solar corona, no hot-pink flares shooting from the sun’s edge. Volunteers were dispatched to each street so scientists could later know the precise location of the edge of the moon’s shadow. The next day, a newspaper writer, watching the disappearing sun’s final dazzling pinpoint, described it as a diamond ring—a term that has since been fully incorporated into eclipse-speak.

You Will Literally Cry

The event has an indescribable effect on observers. While most experienced astronomers would concede that a total solar eclipse is the most powerful, gorgeous, and even life-altering of all celestial phenomena, they'd rate a vivid display of the northern lights as not too shabby, either. A big gap separates those two from the rest of what I call the top four natural spectacles, including a rare brilliant comet and a meteor storm, in which more than a dozen shooting stars flash across the sky each minute. Like the aurora borealis, a solar totality often invokes involuntary gasps and cries of wonder. You'll often hear that some kind of "feeling" accompanies the visual spectacle. Perhaps this has to do with the fact that both these events are indeed accompanied by large changes in the amount of incoming electromagnetic radiation. It should also be noted that lunar eclipses, even total ones, do not make this top-four list. Those fairly commonplace eclipses, which unfold every few years and are never limited to a narrow section of our planet but instead are visible to half the world, are certainly pretty and worth watching. But they are not life-altering.

> In just another few hundred million years, total solar eclipses will be over forever.

During a solar totality, animals usually fall silent. People howl and weep. Flames of nuclear fire visibly erupt like geysers from the sun's edge. Shimmering dark lines cover the ground. In both the 2017 and the 2024 events, the entirety of the United States and Canada will experience a partial eclipse, so that anyone using protective eyewear will be able to see it by standing outside or by looking out a window (provided that it's not cloudy, of course). In contrast, less than 1 percent of the continent will experience totality. To most people, it might seem that seeing a partial eclipse ought to be almost as good as seeing a total eclipse, and it's certainly a lot more convenient. Why travel? The sun being 99.9 percent eclipsed doesn't sound too different from its being 100 percent eclipsed, right?

Actually, seeing an almost total eclipse is no better than almost falling in love or almost visiting the Grand Canyon. Only full totality produces the astonishing and absolutely singular phenomenon that resembles nothing else in our lives, on our planet, or in the known universe.

No discussion of totality should omit the strange science lurking behind it. It starts with a bizarre coincidence: the moon is four hundred times smaller than the sun, but it also floats four hundred times nearer to us. This makes the two disks in our sky appear to be the same size. Now, if the moon appeared larger than the sun, it could still occasionally stand in front of it, but it would also blot out the dramatic prominences along the sun's edge, those geysers of pink nuclear flame. So for maximum amazingness, these bodies must have identical angular diameters—i.e., they must appear to be the same size. And they do.

The moon wasn't always where it is now, which makes the coincidence even more special. The moon has really just arrived at the "sweet spot." It's been departing from us ever since its creation four billion years ago, after we were whacked by a Mars-size body that sent white-hot debris arcing into the sky. Spiraling away at the rate of one and a half inches per year, the moon is only now at the correct distance from our planet to make total solar eclipses possible. In just another few hundred million years, total solar eclipses will be over forever.

For early cultures that regarded celestial phenomena as magical to begin with, eclipses occupied a spot entirely off the weirdness scale. Some, such as the Aztecs and the Babylonians, were obsessive enough to make astoundingly accurate observations that ultimately gave their priests the power to predict astronomical events.

The ancient Babylonians noticed that although some sort of eclipse happens every year, the exact same type of eclipse returns after precisely eighteen years and eleven and one-third days. The accuracy of this observation remains very impressive, especially because that one-third-of-a-day business means that the next eclipse can be best seen (or maybe only seen) in an entirely different region of the world. Babylonians called this eighteen-plus-year period a Saros. The ancient Greeks loved that word and concept so much that they embraced it without even translating the word into their own language.

The Saros's third-of-a-day feature means that the earth turns through 120 degrees of longitude before the next eclipse in that particular Saros takes place. Therefore, for an eclipse with specific properties (such as total versus partial, long versus short, and tropical versus arctic) to make a repeat appearance in any particular region, one has to wait while eclipses work their way around the world like a set of gears, which requires three Saroses—a length of time equal to fifty-four years and around one month, or, more precisely, thirty-three days. Because this surpasses human life expectancy in that era four thousand years ago, it's astonishing that the cycle was noticed at all. This three-Saros interval is called the exeligmos, which is Greek for "turning of the wheel." Using the exeligmos, we can calculate that there must have been a total solar eclipse in the United States fifty-four years and one month before the 2017 event and fifty-four years and one month before the 2024 event. Sure enough, a total eclipse in Maine unfolded in 1963, and another one amazed onlookers when it raced up the East Coast and covered Virginia Beach and Nantucket on March 7, 1970.

That three-and-a-half-minute March 1970 totality over Virginia Beach belongs to a series of Saroses given the number 139. This series consists of total (not partial) eclipses with paths that always move northeastward. In 1988, this Saros presented its next event a third of the world west of Virginia—a three-and- three-quarter-minute totality over Indonesia. Yet another Saros later, in March of 2006, the same northeastward totality swept from Libya to Turkey. Saros 139's next return, another third of the world west, will show residents of Cleveland, Rochester, Buffalo, and Burlington, Vermont, a totality in 2024.

So now our stage is set for the next eclipses over North America. After the two-and-a-half-minute coast-to-coast 2017 spectacle, the eclipse on April 8, 2024, will appear longest over central Mexico, at well over four minutes; then the moon's shadow will move northeastward like a tornado to the north-eastern United States.

After 2017, a solar totality will happen once, somewhere in the world, during most years. None will occur in 2018, but we'll get a sunset totality over central Chile and Argentina on July 2, 2019, then another in those same countries on December 14, 2020.

Ignoring a strictly Antarctic totality in 2021 and the eclipse-less year 2022 takes us to a marginal one-minute event in steamy equatorial Indonesia in 2023. But then things pick up, convenience-wise.

The 2024 US totality will be followed by the totality of the longest duration between 2017 and the end of the century—six and a half minutes—which will occur in Egypt and Gibraltar on August 2, 2027. That decade will be rounded out by a wonderful five-minute Australian totality on July 22, 2028.

If you want to limit your eclipse tourism to the United States, Canada, and Europe, note that the United States will see its longest-ever solar eclipse on August 12, 2045, a six-minute totality running from Northern California to Florida. Florida gets another eclipse just seven years later, on March 30, 2052. Then the United States will enjoy two within a twelve-month span, on May 11, 2078, and May 1, 2079, while France and Italy will experience their only totality of the century on September 3, 2081.

I have had the good fortune to see eight totalities; please allow me to share the experience. The fully eclipsed sun is always a breathtaking surprise.

Be Prepared (Except That's Impossible)

First off, no one is really prepared for a total eclipse. Pictures one may have seen don't do the event justice, because cameras never capture its true visual appearance. The reason has to do with the difference between human retinal sensitivity and the vagaries of a camera's exposure, whether using digital imaging or film. The inner corona is bright; the outer corona faint and delicate. The correct exposure for one part of the eclipsed sun either underexposes the other so that it's invisible or overexposes it so that it looks like a huge burned-out area ringed by wide white flares. So a real eclipse does not resemble the ones you see on nature documentaries or in magazines, even when the images are taken by professionals. To get an accurate image, you would have to Photoshop multiple images together.

The magic really starts around ten minutes before totality, when the sun is still partially blocked but almost gone. You need eye protection at this point; I prefer welding goggles fitted with shade 12 filters if the sun is low and shade 14 if the sun is high. These display a clearer, higher-quality image than cheap plastic eclipse glasses do. (Get the goggles from a welding supply store, which is absolutely never located in the mall but rather in the worst part of town, usually adjacent to a fenced-in yard protected by snarling dogs.)

> Solar ultra-violet energy drops to zero. So does infrared radiation, whose absence starts to be felt long before totality arrives.

At this stage the sun resembles a crescent moon, but the best thing to do is look at the surrounding countryside. Colors are saturated; shadows are stark; contrast is boosted; the shadows of trees and bushes contain innumerable strange crescent shapes. Ordinary objects such as trees and houses seem unfamiliar, as if illuminated by a star other than the sun. Everyday scenery has been transformed into something extraordinary.

Expectation fills the air. Then a minute or two before totality, shimmering dark lines suddenly wiggle over all white surfaces, such as sand or a sheet spread on the ground. These are called shadow bands, and they can't be photographed! If you try, your video or still images will show the white substance or object without any wavy bands at all. The rather anticlimactic reason for this is simply that shadow bands have extremely low contrast. Because they shimmer, the eye readily picks them out. But they lie below the contrast required to show up in a photographic image.

Then comes totality, which can last anywhere between one second and around seven minutes. Now you take off your welding goggles and look at the sun directly. The bright stars come out. The sun's corona leaps across the sky, much farther than you expected. Its delicate wispy structure, following the sun's normally invisible magnetic-field lines, depends on the part of the solar cycle you're in. At a glance you'll know if you're at sunspot minimum or maximum: during the latter period the corona is round and symmetrical, as if the sun's springs have been wound up tightly and all the power held in place is ready to pop. But a quiet sun, paradoxically, lets go with long, irregular coronal streamers. Whenever it's seen, the glow is obviously that of a light different from anything nature normally offers. There is a logical reason for this, too: the sun's corona is by far the hottest thing the human eye can observe. It's made of plasma—broken fragments of atoms—rather than the whole atoms that comprise the solar surface and everything else around us on earth.

It's an experience that does not seem of this life or this world. "The home of my soul" is how one eclipse watcher described it to me. But why? What has really happened? It's obviously not sim- ply a matter of the sun's visible light being blocked. Its invisible rays are extinguished, too. (As Victor Hess discovered during a 1912 near-total eclipse, when he went up in a balloon to measure the sun's radiation, cosmic rays do not decrease when the sun is blocked. But many other energies do indeed vanish.) Solar ultra-violet energy drops to zero. So does infrared radiation, whose absence starts to be felt long before totality arrives. With the drop in infrared energy, clouds, rocks, and the air just above the ground are suddenly cooled. This chill creates a pressure difference that manifests itself as a haunting eclipse wind. Moreover, the decreasing temperature as the sun is steadily blocked can shrink the gap between the temperature and the dew point, allowing clouds to suddenly form. That's what happened during the Siberian eclipse of the 1980s, with exasperating consequences, as the large international party of professional astronomers who had gathered to observe the event saw nothing when thick clouds materialized. They had meticulously planned for what the sun's visible rays would do—but they'd neglected its invisible rays!

When the eclipse is over, observers immediately start thinking about how they can get to the next one. So don't even think of being anywhere else but in the narrow ribbon of totality on August 21, 2017, and on April 8, 2024. Be sure to factor in likely cloud cover. For example, eastern Idaho is a safer bet than the Pacific Northwest for the 2017 event, whereas in 2024, you'd be better off staying in the dry parts of southern Texas than in the Buffalo, New York, area. Also know that, in most places, midmornings tend to be clearer than midafternoons. When an eclipse offers a long track, as the one in 2017 does, one could choose a late morning event in Idaho or a midafternoon totality in Nashville; the odds somewhat favor the former.

I know someone who went to seven total eclipses but was clouded out of four of them. There are even several people who, on August 11, 1999, inexplicably chose to view the eclipse from Cornwall, England (overcast and drizzling), instead of from Turkey (crystal clear). This is a case in which considerations of convenience—or, perhaps, having friends or relatives in a particular location—can steer us wrong.

1Correction appended 8:26 ET 08/07/17: This story has been updated to reflect the correct state.2 Correction appended 7:15 ET 08/14/17: This story has been updated to reflect the correct width.
