

Chapter

15

To Be in the Moon's Shadow

In This Chapter

- ◆ Africa and Turkey may be clear in 2006
- ◆ Waiting for the big one
- ◆ Across amber waves of grain
- ◆ How to view and photograph eclipses

Reminiscing about past eclipses is fun. Members of a Solar Eclipse Mailing List on the Internet send messages back and forth all the time with images and reports. But planning for future eclipses may be even more fun.

What Does the Future Bring?

In this chapter, we discuss several total eclipses:

- ◆ November 23, 2003, in Antarctica
- ◆ April 8, 2005, in the Pacific
- ◆ March 29, 2006, in Africa and Turkey, and farther into Asia
- ◆ August 1, 2008, from northern Canada across Greenland, to Siberia, Mongolia, and China
- ◆ July 22, 2009, the longest eclipse in the saros
- ◆ August 21, 2017, the next total eclipse to cross the United States

Only in Antarctica

The Earth has seven continents, but even regular travelers usually don't visit more than six. The seventh, Antarctica, is remote and cold. But it has become an important scientific site. The continent is a high plateau in its middle, and the air over the South Pole is very dry, making it a desirable place to carry out certain kinds of astronomical observations.

The closer to the South Pole you get, of course, the longer the part of the year that has the midnight sun. Because, on the other hand, periods of 24-hour darkness also last longer, most scientists carrying out observations from Antarctica have to "winter over," spending six months or so there. Tourists can take a cruise in a week or so from the southern point of Chile to a peninsula that sticks up from Antarctica.

The total solar eclipse of November 23, 2003, will be visible only from Antarctica, but not from anyplace as easily accessible as the peninsula near Chile. Making things difficult, the path of the eclipse is on the opposite side of Antarctica.

A Russian icebreaker has been converted to a passenger cruise ship and regularly takes Antarctic cruises, usually out of Australia. It is scheduled for 28 days at sea to reach the location where the eclipse will be visible. I hear the Southern Ocean can be very rough. But I have a friend who has made over 10 Antarctic cruises because she thinks they are so wonderful. Whether the eclipse tourists will view the eclipse from the ship itself or from the adjacent ice is yet to be determined. The ship is to leave Port Elizabeth, South Africa; visit some islands en route; and wind up after the eclipse in Hobart, Tasmania, Australia.

The eclipse path doesn't cross any established outposts. It doesn't go too far from Russia's Mirny Station.

A couple of possibilities are arising for airplane tourists. One expedition will include several airplanes, which will land on the ice and then make short tourist trips around.

Much easier on the stomach than the 28-day-at-sea cruise will be a 1-day aircraft flights out of Perth, Australia, and out of Punta Arenas, Chile. Those who want to see the eclipse have to purchase the seats next to the windows on one side of the plane. The view from a plane is not as glorious as the view from the ground, but it will still be spectacular. And the planes can get near to the maximum point, where the eclipse lasts 1 minute and 57 seconds, and prolong the eclipse by 15 additional seconds or so.

Partial phases will be visible from the southern tip of Chile and Argentina, and also from Australia and New Zealand.

No Land—Maybe Just a Little

The eclipse of April 8, 2005, will be annular. The Earth won't be far past the tip of the Moon's shadow cone, so the track will be very narrow. The eclipse starts in the ocean southeast of New Zealand. At its end, it will intersect Central America. Even the maximum duration of annularity is only 42 seconds. But even more interesting, the eclipse will be total for a second or so in the middle of the Pacific Ocean.

We have to hope that there are enough umbraphiles to support a cruise ship going way out there for the event. At this writing, it is too early to know.

Turkey?

The next major total solar eclipse won't be until March 29, 2006, so there will clearly be a lot of eclipse tourists wanting to see it. The eclipse will start at the easternmost tip of Brazil and then will cross the Atlantic Ocean. It will hit West Africa in Ghana, Togo, Benin, and northern Nigeria. It then will go over Niger, east of the desert city of Agadez at the foot of the Sahara close to where the 1973 long eclipse crossed. Then the path will cross Chad and Libya and barely touch northwestern Egypt. Totality will peak at 4 minutes 7 seconds close to the border between Chad and Libya.

Off the center line, with diminished totality, it will cross the Greek island of Castellorizo. Perhaps the major viewing sites will be in Turkey; the path goes through Turkey's center, east of Ankara.

Then the eclipse will go up to countries that were formerly in the Soviet Union, crossing the top of the Caspian Sea into Kazakhstan. The eclipse will wind up in northeast China.

Partial phases of this eclipse will be visible from all of Europe, from the western part of Asia (up to the middle of Mongolia and to Bangladesh), and almost all of Africa, missing only the southernmost parts (which have been blessed with their own total eclipses, or at least partial phases, in recent years).

Way Up North, Plus

On August 1, 2008, in the prime of summer, a total solar eclipse will start in the islands of northernmost central Canada (Victoria, Prince of Wales, Somerset, Devon, and Ellesmere Islands) and then proceed over the northwestern tip of Greenland. It will cross northern oceans, where it will hit its peak duration of 4 minutes and 27 seconds. The eclipse then will hit land in northern Russia. It will cross western Mongolia and wind up in central China. I daresay that central Russia or China will be the places to view it from. Around sunset, it will reach near to Shanghai.

As Good as It Gets

As soon as one very long eclipse occurs, people start looking one saros later. The long eclipse of July 11, 1991, viewed especially in Hawaii and Mexico, will be followed 18 years 11½ days later on July 22, 2009. The eclipse's peak will be "only" 6 minutes 39 seconds, and it will be shorter from all viewing spots on land; the eclipses in this saros are now getting shorter than the 7 minutes they had been.

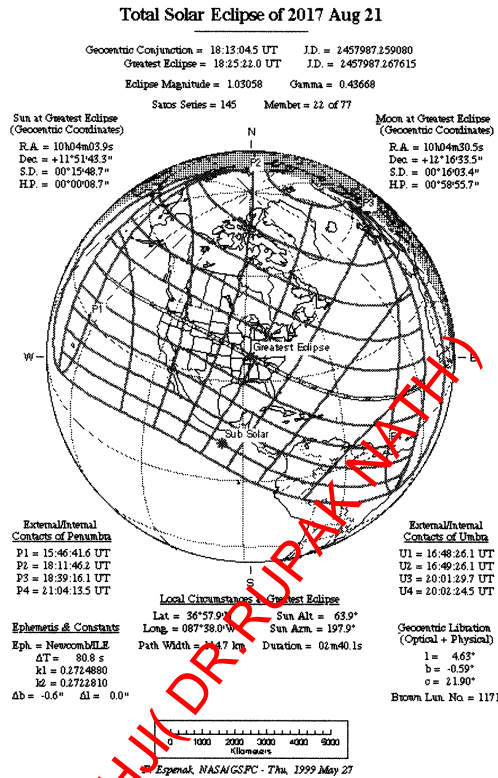
The eclipse will start at sunrise at India's west coast and will cross India and the eastern tip of Nepal. Totality also will cover parts of Bangladesh, Sikkim, Bhutan, northernmost Myanmar, and China. The eclipse will cross Shanghai, which will have over five minutes of totality, and then go out to the Pacific Ocean, passing not far south of Okinawa in southernmost Japan and crossing some of the smaller Ryukyu Islands. The peak totality duration occurs farther along in the Pacific.

The partial phases of this 2009 eclipse will be visible from not only India and the other countries mentioned, but also Russia, southeast Asia north of the middle of Sumatra and Borneo, and Papua New Guinea. Even the northern tip of Australia's Cape York will get a slight partial eclipse.

Home Again

Skipping ahead, let's discuss the next total solar eclipse that will be visible in the United States. On August 21, 2017 (one saros later than the eclipse that crossed Europe in 1999), totality will start in the north Pacific Ocean. It will hit land at northern Washington and cross central Idaho, mid-Colorado, mid-Nebraska, northern Missouri, southernmost Illinois, western Kentucky, middle Tennessee, southwestern North Carolina, and the heart of South Carolina. Maximum totality of 2 minutes 40 seconds will occur in Kentucky; the eclipse will exceed 2 minutes all along the center line in the United States.

All the United States will see a partial eclipse, ranging from over 60 percent in Southern California, to 80 percent in Florida, to 75 percent in New York City, to just under 60 percent in northernmost Maine. Hawaii will have 30 percent to 40 percent, and Alaska will have 35 percent to 70 percent. Northern South America, from the middle of Peru and Brazil upward, and all of Central America, Mexico, and Canada will also have a partial eclipse. The partial zone will include Greenland and Iceland, and will even reach to northwestern Scotland, which saw a partial or annular eclipse in 2003.



The path of totality at the August 21, 2017, total solar eclipse across the United States, with partial phases to the sides. For the partial phases, numbers show the percentage of the solar diameter that is covered.

(F. Espenak, NASA's Goddard Space Flight Center)

Once More, with Passion

After waiting nearly 40 years, from 1979 to 2017, for a total eclipse, people in the continental United States will have to wait fewer than 7 more for the following one. On April 8, 2024, a total solar eclipse will start over the Pacific and reach land in western Mexico. It will hit the United States at Texas and will cross eastern Texas, eastern Oklahoma, southeastern Missouri, southern Illinois, most of Indiana, and northwestern Ohio. It will then clip northwestern Pennsylvania, northern New York, Maine, Vermont, and New Hampshire as it moves across northern Maine into eastern Canada at New Brunswick.

The maximum duration of the eclipse in Mexico, will be 4 minutes 28 seconds, though U.S. durations won't be much shorter. All of the United States excluding Alaska, as well as all of Canada, Mexico, the Caribbean, and Central America, will have a partial eclipse.

The Dregs

Some eclipse fans who would travel halfway around the globe for a total eclipse say they wouldn't even go out their doors for a partial one. But I don't mind getting a glimpse (through a filter for the partial ones) of them all.

October 14, 2004

This eclipse is never total or annular on Earth, but up to 93 percent of the Sun will be covered. The partial phases will be visible in Japan, northeastern Siberia, western Alaska, and the Aleutian Islands. The zone of eclipse extends barely to Hawaii.

April 8, 2005

This one is really the dregs in the United States, since you could go see the annular eclipse in Costa Rica, Panama, Colombia, and Venezuela. In any case, partial phases will be visible from about half the United States. Everyone south of a line extending roughly from San Diego to Denver, to Chicago, to Philadelphia will see a partial eclipse.

Eclipse Viewing and Photography

An eclipse is so glorious to see, with the sky changing dramatically around you even as the diamond rings and corona become visible overhead, that people often say that they wish they weren't taking photographs and could just relax and look at it. So, my first recommendation to eclipse tourists is just to relax and look around. After all, many others of us are taking photographs, and you can easily arrange to get copies. But if you want to take your own photographs, here are some hints.



Sun Safety

Remember that as long as the Sun isn't totally eclipsed, you can't look at it without a special filter. During the partial phases, you can use a filter, project a solar image onto a screen using a telescope or binoculars (without looking up at the Sun through them), or make a simple pinhole camera. But during totality, none of those methods will allow you to see the eclipse. You must look at the totality directly.

Still Photography with Film

The size of the Sun and the corona on 35-mm film with an ordinary camera lens is pretty small—only a couple of millimeters across. Such a photograph isn't usually interesting, unless you can put the Sun at the top of your frame and put some foreground objects in the rest of the frame. It is best to use a tripod and a cable release so that your camera doesn't shake.

Eclipse photographs centered on the Sun start to get interesting with telephoto lenses about 300 mm or longer. Then the Sun and the corona take up a substantial part of the frame. I recommend taking a few photographs during the diamond-ring effect and then, during totality, bracketing widely. That is, take one frame at every conceivable exposure. With my f/8 500-mm telephoto lens, I start at $\frac{1}{125}$ s and take a photograph at each click-stop of shutter speed: $\frac{1}{60}$, $\frac{1}{30}$, $\frac{1}{15}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, and 1 second, using film between ISO 100 and ISO 400. Using faster film than that usually hurts more than it helps because the grain is worse for the faster films.

The following table lists the field of view for various lenses when used with 35-mm cameras. The Sun and the Moon are about 0.5° across; allowing for 1 solar radius of corona on each side of the Sun gives a desired field at least 1.5° across.

Field of View

Focal Length (mm)	Diagonal Size	Field of View
20 mm	125°	$100^\circ \times 70^\circ$
28 mm	81°	$73^\circ \times 50^\circ$
50 mm	50°	$41^\circ \times 28^\circ$
200 mm	12°	$10^\circ \times 7^\circ$
500 mm	5°	$4^\circ \times 3^\circ$
1,000 mm	2.5°	$2^\circ \times 1.4^\circ$



The Solar Scoop

The size of the Sun on film depends on the focal length of your lens. It is about the same size on the film in millimeters as the focal length of your lens divided by 109—and it is good enough to just divide by 100, which is easy to do in your head. So, a 1,000-mm telephoto lens gives an image about 10 mm across. A 50-mm lens, which is a normal lens for a camera, gives an image only 0.5 mm across, too small to be attractive by itself.

The corona falls off in brightness so rapidly—a factor of 1,000 in the first 2 solar radii outside the edge of the Sun—that a mere difference of a factor of 2 or 4 in exposure time shows you a little more corona or a little less corona but doesn't ruin your picture. So, in some sense, eclipse photography is easy, since every exposure is good. The key things to watch are the focus and the steadiness.

You should have a solar filter on your lens before totality so that you can focus carefully through it, whether or not you take photos of the partial phases. It is particularly useful to focus on the sharp horns of the solar crescent. Note that when you look through an ordinary filter, which is made of flat glass, the focus doesn't change when you take it away.



Solar Scribblings

If you are using a point-and-shoot camera, put a piece of black tape over your flash. It may try to go off automatically, and you don't want to ruin photographs your neighbors may be taking or damage their eyes' dark adaptation.

Don't leave your camera on any automatic setting. In particular, if you leave the focus on automatic, the camera may well "hunt" through the whole eclipse—that is, go back and forth through the focus, never finding the right focus—and never take any pictures at all!

Exposure Times for Prominences

Focal Ratio	ISO 100	ISO 400
f/2	1/1,000	1/4,000
f/4	1/250	1/1,000
f/8	1/60	1/250

Exposure Times for Diamond Ring and Inner Corona

Focal Ratio	ISO 100	ISO 400
f/2	1/125	1/500
f/4	1/30	1/125
f/8	1/8	1/30

Exposure Times for Middle Corona

Focal Ratio	ISO 100	ISO 400
f/2	1/30	1/125
f/4	1/8	1/30
f/8	1/2	1/8

Still Photography with a Digital Camera

Digital cameras work quite well at eclipses. Make sure that you don't have to download images during totality. To guarantee your not having to do so, empty your storage medium before the eclipse or at least 10 minutes before totality.

Again, if you have only a normal lens, you are better off taking photographs that have the eclipse near the top of the frame and other features in the foreground. Be sure to take off all automatic settings. The auto focus may hunt, never finding a good focus because the image of the corona in the sky is so small. And the automatic exposure may do one or both of the following:

- ◆ Overexpose the corona, since it is measuring largely black sky and trying to bring it to a gray level
- ◆ Stay open much too long, taking up much of the eclipse with a single frame

The more megapixels you have, the better, to give good resolution on your images. Cameras with at least 5 megapixels (that is, millions of pixels) match the resolution of 35-mm film and enable you to make enlargements of your images. (These cameras have about $2,000 \times 2,500$ picture elements, making 5 million in all.)

Fun Sun Facts

The era of film is ending, both for home photography and astronomical photography. Both professionals and amateurs are now using charge-coupled devices (CCDs) instead of film. These devices are much more sensitive than film. The intensity of light hitting each individual picture element ("pixel") is read off into a computer. A CCD with 3,000 rows of 2,000 pixels in a row has $3,000 \times 2,000 = 6$ million pixels, or 6 megapixels.

Take off all automatic functions. Choose one exposure time for the several exposures during the diamond-ring phase (you don't want to be changing things during this brief interval), and then take exposures at many different values during totality. Be sure that the camera is mounted steadily on a tripod. And use a cable release to minimize shake.

Eclipse Videography

Video cameras have lower resolution than still cameras, but you can still make some nice movies of a total eclipse. The partial phases change so slowly—taking over an hour—that it is boring to just let the video camera run during those phases. Many cameras have ways of taking a burst of a few seconds; do so every five minutes or so.

Then let the camera run starting a minute or two before totality.

The DV cameras take digital video, as opposed to earlier cameras such as Hi-8 that take video in analog fashion. Digital video has higher resolution.

Image Size on a 13-Inch Diagonal Television Screen (Camcorder Lens)

Focal Length	Size of Sun	
	(<i>1/2-inch CCD</i>) mm (in.)	(<i>2/3-inch CCD</i>) mm (in.)
50 mm	20 (0.8)	17 (0.7)
100 mm	40 (1.6)	34 (1.3)
200 mm	80 (3.2)	68 (2.7)
500 mm	200 (7.9)	170 (6.7)
1,000 mm	400 (15.8)	340 (13.5)

If you want to take a close-up view using a telephoto lens or use your camera on maximum optical zoom, it is best for you to obtain a mount that tracks the Sun. After all, the Sun moves its own diameter across the sky in only about two minutes. So during a reasonably long eclipse, it could just move out of your field of view if you are using an ordinary tripod. Mounts like that are available at stores (brick-and-mortar or online) that sell telescopes.

Wide-angle movies during an eclipse can be very nice because they show not only the corona in the sky, but also the changes in the atmosphere below. Be sure to turn off the automatic exposure function, or it will compensate perhaps too much for the darkening sky effect that you want to record.

Be sure to turn off the automatic focus and to set your focus for infinity (or focus in advance on the Sun through a solar filter or on some very distant object). Otherwise, your camera may go back and forth through the focus throughout totality and never get a clear image.

Many things can go wrong when you are trying to photograph an eclipse. Be sure that you have checked the following:

- ◆ Your battery is charged.
- ◆ There is film, tape, or a digital card in the camera, as appropriate.
- ◆ Your filter or lens cap is off for totality.
- ◆ You can get your filter off easily without shaking the camera as totality starts.
- ◆ The Sun doesn't drift out of the field of view during totality.

- ◆ You don't make the camera vibrate in your exuberance to snap the shutter.
- ◆ The REC symbol really shows, if you are using a video camera, so that you know that you are recording.
- ◆ Nobody trips on the power cord if you are plugged into an electrical outlet.
- ◆ Nobody bumps into your tripod.

The Least You Need to Know

- ◆ Interesting eclipses can be seen about every 18 months somewhere in the world.
- ◆ The next eclipses that will be subject to the most eclipse tourism will be those in Turkey in 2006 and China in 2009.
- ◆ The next total eclipses visible in the United States will be in 2017 and 2024.
- ◆ It isn't hard to photograph an eclipse, but you must be careful in various ways to observe safely and get a good image.

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