How to Photograph the Great American Total Eclipse of 2017

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(For 2017 eclipse photography webinar participants only. Not for general distribution)

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Eclipse Photography

Almost any kind of camera can be used to capture images of a rare total solar eclipse. However, Digital Single Lens Reflex (DSLR) cameras offer a distinct advantage since they take interchangeable lenses. A lens with a fairly long focal length (or a small telescope) is required to produce an image of the Sun of acceptable size.

DSLRs generally come in two sensor sizes. Most consumer DSLRs use an APS-C or Crop sensor (Canon: 22.2 x 14.8 mm; Nikon and others: 23.5-23.7 x 15.6 mm). The more expensive professional market DSLRs use a larger Full Frame sensor (36 x 24 mm). Cameras with either sensor size are capable of taking excellent eclipse photos. However, the sensor size plays an essential roll in determining the size of the Sun's image with any particular lens.

Figure 1: Lens Focal Length Vs. Image Size for Eclipse Photography

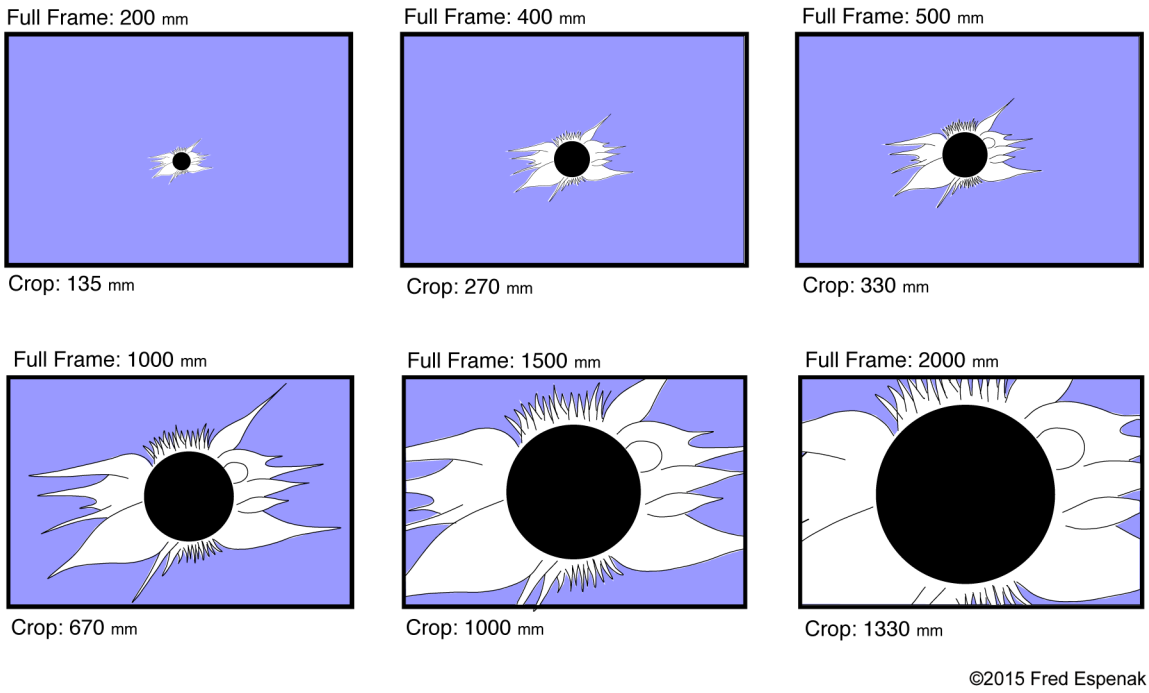

Figure 1 illustrates the size of the Sun and solar corona ats six different focal lengths for Full Frame DSLRs (top labels) and Crop sensor DSLRs (bottom labels). To capture the entire disk of the Sun, the focal length of the optics must not exceed 2500 mm with a Full Frame DSLR (1700 mm with a Crop sensor). Longer focal lengths permit photography of only a magnified portion of the Sun's disk. In order to photograph the Sun's corona during a total eclipse, the focal length should be no longer than about 1500 mm with a Full Frame DSLR (1000 mm with a Crop sensor). However, a shorter focal length of 1000 mm Full Frame (700 mm Crop sensor) requires less critical framing and can capture some of the longer coronal streamers.

For any particular focal length, the diameter of the Sun's image is approximately equal to the focal length divided by 109 (Table 2). This table also provides the field of view of a range of lenses with both Full Frame and Crop DSLRs. This information is useful in planning wide-angle images capturing time sequences of the entire eclipse from 1st to 4th contact.

Table 2: Field of View & Sun Size for Various Photographic Focal Lengths

Focal Length	Field of View *(Full Frame)*	Field of View *(Crop)*	Size of Sun
14 mm	98° x 147°	65° x 98°	0.2 mm
20 mm	69° x 103°	46° x 69°	0.2 mm
28 mm	49° x 74°	33° x 49°	0.2 mm
35 mm	39° x 59°	26° x 39°	0.3 mm
50 mm	27° x 40°	18° x 28°	0.5 mm
105 mm	13° x 19°	9° x 13°	1.0 mm
200 mm	7° x 10°	5°x 7°	1.8 mm
400 mm	3.4° x 5.1°	2.3° x 3.4°	3.7 mm
500 mm	2.7° x 4.1°	1.8° x 2.8°	4.6 mm
1000 mm	1.4° x 2.1°	0.9° x 1,4°	9.2 mm
1500 mm	0.9° x 1.4°	0.6° x 0.9°	13.8 mm
2000 mm	0.7° x 1.0°	0.5° x 0.7°	18.4 mm

Image Size of Sun (mm) = Focal Length (mm) / 109

Solar Filters

A solar filter is needed to view and photograph the partial phases of the eclipse. It is only during totality when the Sun's bright disk is completely obscured that it is safe to view without a solar filter. In fact, the filter MUST be removed to see and photographs the Sun's faint corona.

The use of a solar filter also allows you to safely aim your camera and focus carefully on the partial phases in preparation for totality. About 10 seconds before the total phase begins, remove the solar filter and shoot a rapid series of images to capture the diamond ring effect. Remember that it is *NOT safe* look at the Sun through the optical viewfinder of the camera until totality has begun.

A list of sources for solar filters appears on page 5.

ISO Speed and Exposures

A medium speed ISO (200 to 400) is recommended for photographing a total solar eclipse. For best results, you must use a tripod to steady your camera. The following table offers approximate exposures (in seconds) for a given ISO to photograph the partial phases through a

solar filter, prominences during totality (no filter), and the outer corona (no filter). If you use a digital point-and-shoot camera with no manual controls, just let the camera determine the best exposure.

Close-Ups of the Corona

The most spectacular and awe-inspiring phase of the eclipse is totality. For a few brief minutes, the Sun's pearly white corona, red prominences and chromosphere are visible. The great challenge is to obtain a set of photographs, which capture aspects of each of these fleeting phenomena. The most important point to remember is that during the total phase, all solar filters must be removed! The corona has a surface brightness a million times fainter than the photosphere, so photographs of the corona are made without a filter. Furthermore, it is completely safe to view the totally eclipsed Sun directly with the naked eye. No filters are needed and they will only hinder your view. The average brightness of the corona varies inversely with the distance from the Sun's limb. The inner corona is far brighter than the outer corona. Thus, no one exposure can capture its the full dynamic range. The best strategy is to choose one aperture or f/number and bracket the exposures over a range of shutter speeds (i.e. - 1/1000 down to 1 second). Rehearse this sequence since the great excitement accompanying totality offers no time to think. If your DSLR shoots in RAW format, by all means use that setting. You will get fewer but better quality images on your memory chip.

Additional Suggestions

If you don't have a powerful enough telephoto or zoom to get close-ups of the corona, there are a number other interesting subjects to photograph. During totality, try shooting people silhouetted against the twilight sky with the eclipsed Sun above. Since the Sun's altitude will be fairly high during the 2017 eclipse you will need to get down low to the ground. A wide-angle lens works especially well for this since you can capture both the eclipse and people bathed in the eerie twilight colors of totality.

Use a tripod to steady your camera because it gets as dark as twilight during totality. Set the camera to auto-exposure. A cable release helps prevent camera shake. You should also disable the electronic flash so it doesn't interfere with the photography of others. Check the camera manual for directions. Failing that, just tape a piece of stiff cardboard over the flash.

During the partial phases, the ground under nearby shade trees is covered with small images of the crescent Sun. The gaps between the tree leaves act like pinhole cameras and each one projects its own tiny image of the Sun. You can duplicate the effect by forming a small aperture with your hands and watching the ground below. The pinhole camera effect becomes more prominent with increasing eclipse magnitude. Virtually any camera can be used to photograph the phenomenon, but automatic cameras must have their flashes turned off.

Video Imaging the Solar Eclipse

The total solar eclipse makes a natural subject for video. Successfully capturing the eerie twilight, the Sun's awesome corona and the excited reactions of your companions makes a wonderful record of the experience to be shared many times. Most still cameras from the humble cell phone to a sophisticated DSLR can also shoot video. But don't overlook a dedicated video camera since dedicated HD video cameras are quite small and portable with articulated viewing screens.

Video imaging eclipses is not difficult, but it does require some planning and preparation. Although many people fear damaging their cameras during eclipses, their concerns are unjustified. You can safely point your camera directly at the Sun in the seconds preceding totality to capture the fabulous diamond ring effect. I've done just that at recent eclipses by removed my protective filter 20 seconds before totality without harming my camera.

Most dedicated video cameras are equipped with a zoom lens having a power of 20x. Some models even sport 50x or more optical zooms. Beware of the bloated claims of digital zooms. While they are capable of magnifying hundreds of times, the image quality drops drastically with increasing magnification. Stay within the "optical" zoom range of your video camera for best results. To determine the apparent size of the Sun's disk in your video camera, just put a solar filter on your lens and shoot some video of the Sun on any clear day.

A good camera support is mandatory. Since the Earth rotates 15 degrees per hour, the Sun will slowly drift through the camera field by one Sun diameter every 2 minutes. You need to use a low enough magnification to keep the Sun in the viewfinder or else move your camera during totality. A motorized equatorial mount will track the Sun throughout the eclipse.

Video imaging the partial phases requires the same type of solar filter used for still photography. Check for internal reflections between the filter and the many lens surfaces. Once again, use a good tripod to hold your camera steady.

The crucial task in an eclipse imaging (both still and video) is to remove the solar filter in time to capture the diamond ring effect. Since CCD's are more-or-less impervious to damage, you can remove the filter ~20 seconds before totality as the first diamond ring forms. Replace the filter about ~20 seconds after totality ends in order to capture the second diamond ring. Of course, no solar filter is used during totality itself.

Some video camera has manual exposure controls that can be used to emphasize and differentiate between the prominences, the inner and outer corona. Gain controls, manual diaphragms and variable shutter speeds can be adjusted during totality while monitoring their effects in the viewfinder.

While high-magnification zooms are great for capturing the corona, wide-angle videos are also fascinating. They show the approach of the Moon's shadow and the shape of the shadow cone during totality as well as the sunset effect surrounding the horizon. Although shadow bands can be recorded, their low contrast can make them challenging. The sound track recorded with the video images captures the excitement of totality. You can also recite details of camera settings as you change them and record any verbal descriptions, impressions, or observations.

It's crucial to become thoroughly familiar with your equipment by setting it up and rehearsing for the eclipse. Remember to put in a freshly charged battery within a half hour of totality and make sure that the camera is recording. Finally, plan to take some time out and actually watch the eclipse with your own eyes!

Sources for Solar Filters

The following is a brief list of sources for filters that are specifically designed for safe solar viewing with or without a telescope. The list is not meant to be exhaustive, but is a representative sample of sources for solar filters currently available in North America and Europe. For additional sources, see advertisements in *Astronomy* and or *Sky & Telescope* magazines.

Sources in the USA:
American Paper Optics: www.3dglassesonline.com/
Astro Hutech IDAS Solar Filters: www.sciencecenter.net/hutech/idas/solar/
Astronomics: www.astronomics.com/
Celestron: www.celestron.com/
DayStar Filters: www.daystarfilters.com/
Lunt Solar Systems: luntsolarsystems.com/
Meade Instruments: www.meade.com/
OPT Telescopes: www.optcorp.com/
Orion Telescopes and Binoculars: www.telescope.com/
Rainbow Symphony: www.rainbowsymphony.com/
Seymour Solar: www.seymoursolar.com/
Spectrum Telescope: www.spectrumtelescope.com
Thousand Oaks Optical: www.thousandoaksoptical.com/

Sources in Canada:
Kendrick Astro Instruments: www.kendrickastro.com/
Khan Scope Centre: www.khanscope.com/
KW Telescope: www.kwtelescope.com/

Sources in Europe:
Baader Planetarium: www.baader-planetarium.com/
First Light Optics: www.firstlightoptics.com/solar-filters.html
Rother Valley Optics: www.rothervalleyoptics.co.uk/
Solar Scope: www.solarscope.co.uk/

Recommended Exposures for Imaging a Total Solar Eclipse

SUN - full disk or partial eclipse
Through full aperture Solar Filter

Film Speed - ISO

f/	50	100	200	400	800
2.8	1/2000	1/4000	-	-	-
4	1/1000	1/2000	1/4000	-	-
5.6	1/500	1/1000	1/2000	1/4000	-
8	1/250	1/500	1/1000	1/2000	1/4000
11	1/125	1/250	1/500	1/1000	1/2000
16	1/60	1/125	1/250	1/500	1/1000
22	1/30	1/60	1/125	1/250	1/500
32	1/15	1/30	1/60	1/125	1/250

SUN - total eclipse: prominences
No filter

Film Speed - ISO

f/	50	100	200	400	800
2.8	1/4000	-	-	-	-
4	1/2000	1/4000	-	-	-
5.6	1/1000	1/2000	1/4000	-	-
8	1/500	1/1000	1/2000	1/4000	-
11	1/250	1/500	1/1000	1/2000	1/4000
16	1/125	1/250	1/500	1/1000	1/2000
22	1/60	1/125	1/250	1/500	1/1000
32	1/30	1/60	1/125	1/250	1/500

SUN - total eclipse: inner corona (3° field)
No filter

Film Speed - ISO

f/	50	100	200	400	800
2.8	1/250	1/500	1/1000	1/2000	1/4000
4	1/125	1/250	1/500	1/1000	1/2000
5.6	1/60	1/125	1/250	1/500	1/1000
8	1/30	1/60	1/125	1/250	1/500
11	1/15	1/30	1/60	1/125	1/250
16	1/8	1/15	1/30	1/60	1/125
22	1/4	1/8	1/15	1/30	1/60
32	1/2	1/4	1/8	1/15	1/30

SUN - total eclipse: outer corona (10° field)
No filter

Film Speed - ISO

f/	50	100	200	400	800
2.8	1/4	1/8	1/15	1/30	1/60
4	1/2	1/4	1/8	1/15	1/30
5.6	1 sec	1/2	1/4	1/8	1/15
8	2 sec	1 sec	1/2	1/4	1/8
11	4 sec	2 sec	1 sec	1/2	1/4
16	8 sec	4 sec	2 sec	1 sec	1/2
22	15 sec	8 sec	4 sec	2 sec	1 sec
32	30 sec	15 sec	8 sec	4 sec	2 sec

These exposure tables are given as guidelines only. The brightness of prominences and the corona can vary considerably. You should bracket your exposures to be safe.

Table adapted from: *Totality: Eclipses of the Sun* (3rd Edition) by Mark Littmann, Fred Espenak, and Ken Willcox and (see: http://www.mreclipse.com/Totality3/Totality3.html).