Feature Story: ALPO Eclipse Section

Part 4: The 21 August 2017 Total Solar Eclipse – The Great American Eclipse

By Michael D. Reynolds,
Coordinator, ALPO Eclipse Section
Executive Director, the ALPO
m.d.reynolds@fscj.edu

Introduction

In this last in a series of four articles on the 2017 total solar eclipse dealing with site selection, weather prospects, observing the eclipse, and specific observing projects, I will provide the reader with an overview of eclipse imaging.

On 21 August 2017 the United States will experience its first total solar eclipse since February 26, 1979. All of the continental United States will experience at least a significant partial solar eclipse; the eclipse is being referred to as The Great American Eclipse.

For those fortunate enough to either live along the narrow track of totality or are able to travel to the path of totality, up to 2 minutes and 40 seconds under the shadow awaits observers. The partial phase of an eclipse never compares to totality; one should plan **now** to get to somewhere within the path of totality!

Eclipse imaging has been a main objective of both amateur and professional astronomers since the photographic medium became available.

The first suitable solar eclipse photograph was taken at the July 28, 1851 total solar eclipse by Julius Berkowski [Figure 1). A 6 cm refractor was used by Berkowski, who was located in his home city of Königsberg, Russia, at the Royal Prussian Observatory [Ref. 1]. His exposure of 84 seconds, which was started right after second contact (the instant when the total phase of an eclipse begins) was far longer than anything required with contemporary digital or even film medium.

Advances in film emulsion led to increasingly better — and significantly shorter — images of totality, as quality and sensitivities of photographic emulsion dramatically improved.

Charles Burckhalter, director of the Chabot Observatory in Oakland, California, ventured with a group of San Francisco Bay Area-based astronomers to Cloverdale, California, on January 1, 1889, to observe and image that eclipse [Figure 2].

At this location, totality lasted approximately two minutes. This eclipse and gathering was also the auspicious start of the Astronomical Society of the Pacific [Ref. 2].

Continued advances in both equipment and recording medium, as well as processing techniques and the switch from analog (film) to digital, has made eclipse imaging that much easier — and in some ways more challenging for today's eclipse photographer.

Equipment: Camera

Most experienced eclipse imagers will first recommend a DSLR, digital single lens reflex camera or a mirrorless ILC, interchangeable lens camera. DSLR's are available with various features and price points, if one does not already own a DSLR. One advantage of the DSLR is one can easily change lenses, from wide-angle to telephoto or direct to a telescope. DSLRs do not all have the same features; some have basic functions, whereas mid- and top-of-the-line DSLRs will support a variety of functions, such as lock-up mirror and

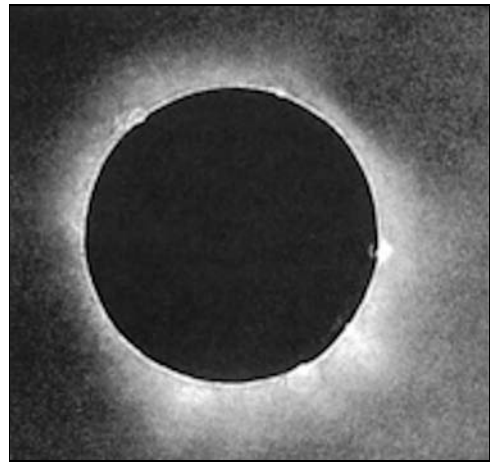

Figure 1. Julius Berkowski's 1851 84 second image of totality. *Image credit: Acta Historica Astronomiae*

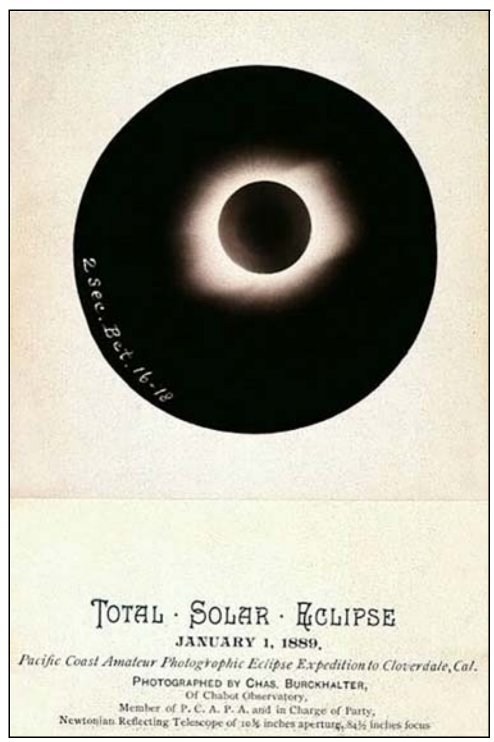

Figure 2. Charles Burckhalter's 1889 2 second image of totality. *Image credit: Chabot Space & Science Center, Eastbay Astronomical Society*

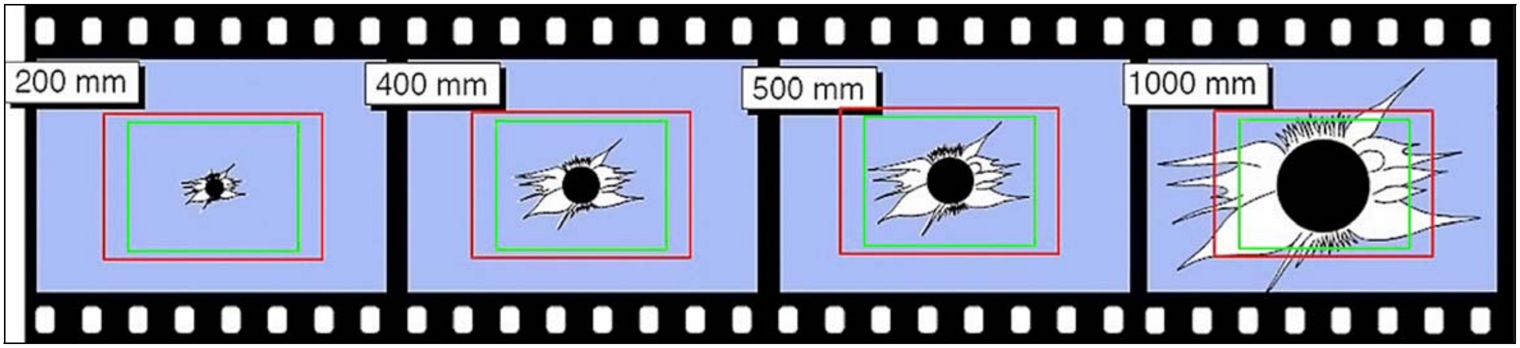

Figure 3. Image size vs. sensor type. Blue Rectangle: Full Frame DSLRs. Red Rectangle: Crop Sensor Canon and Nikon DSLRs. Green Rectangle: 4/3 Sensor Olympus and Kodak DSLRs. *Image credit: American Astronomical Society; adapted from an illustration by Fred Espenak [Ref. 3]*

exposure bracketing. Some of the latest models may also be controlled via the computer and specialized software, as well as direct image download to the computer.

Note that CCDs are not recommended here, especially for those who are imaging an eclipse for the first time. The field of view is limited. And the duration of totality does not allow for one to make adjustments, as with solar system or deep sky imaging.

An important consideration in purchasing a DSLR, or the DSLR you presently own, is the type of digital imaging sensor the camera employs. The sensor detects and sends the image that falls onto the sensor to be processed. The two types of sensors currently found include the full frame and the crop sensor. The full frame sensor is the size of a 35mm film frame; the term "full frame" is somewhat arbitrary. Also called APS-C DSLRs, the crop sensor is a smaller sized sensor. This relates to more noise and poorer low-light performance. Most crop sensor DSLR's do not have all of the available full frame DSLR features. And most importantly for the discussion of eclipse imaging: crop sensor cameras result in magnifying the image. Canon crop sensor cameras magnify by a factor of 1.6 and Nikon by 1.5 [Figure 3].

What To Image – and Equipment Needed

The DSLR's ability to accept a range of lenses and even directly attach to a telescope is an important feature of these cameras. The first decision one will need to make is what one would like to image. If you have multiple cameras, it is possible to image a variety of aspects of the eclipse, both the partial and total.

Table 1: Effective Lens Focal Lengths for Canon and Nikon APS-C Cameras

Lens f/l; Full Frame DSLRs	Canon APS-C 1.6x	Nikon APS-C 1.5x
16 mm	25.6 mm	24 mm
50 mm	80 mm	75 mm
135 mm	216 mm	202.5 mm
200 mm	320 mm	300 mm
400 mm	640 mm	600 mm
500 mm	800 mm	750 mm
1000 mm	1600 mm	1500 mm

The Partial Eclipse

One can image a projection of the partial eclipse, use a telephoto lens or a telescope with a proper solar filter to directly image the Sun, or even use a narrow-band filter (for example, hydrogen-alpha) to take unusual views of the partial phase, both prior to and after totality.

Right Before and After Totality

The Moon's oncoming shadow, colorful sunset-sunrise effect around the horizon, and possibly even shadow bands make

Figure 4. Projected view of the partial phase of the May 20, 2012 annular solar eclipse. *Image credit: Dr. Michael Reynolds.*

Table 2: Imaging Equipment Checklist

Item	Notes
Telescope or Telephoto lens	*Make certain your primary optic choice provides you with an eclipse image which allows you to see details, unless you are planning on high-magnification photography. However if you are not planning on high-magnification, too long a focal length could cut off the outer corona, if imaging the outer corona is one of your goals.*
DSLR Camera	*Full Frame or APS-C Crop Sensor; this also determines the photographic field of view.*
Camera to Telescope Mount	*T-ring for your specific DSLR and a T-adapter. Some companies make a single piece. Make certain you order the correct T-ring for your camera. (Not required if using a camera lens.)*
Mount: Tripod or Equatorial	*A tripod is recommended at a minimum. A mount which tracks should take one additional task away from your imaging procedures.*
Camera Remote	*Many prefer to use a remote, which takes the hand and finger off of the camera, reducing vibration. Some remotes can also be programmed to expose at specific intervals.*
Camera Batteries	*Assure a fully-charged battery; a charged back-up battery is a plus.*
Camera Medium	*Assure the medium is stable, with plenty of space and a fast upload speed.*
Solar Filter	*A white light solar filter for the front of your telescope or telephoto if you wish to image the partial phases*

for interesting photos. These also do not require any type of special lens, and most DSLRs can be automated to take a series of images.

Diamond Ring and Baily's Beads

Leading up to totality is a fairly-quick sequence that involves the last remnants of the Sun's photosphere — and the first light after totality. As the Moon covers the Sun, photosphere sunlight will leak through lunar valleys, producing a brilliant Diamond Ring and Baily's Beads. One must use some caution here while imaging; you are looking at unfiltered sunlight. Diamond Ring and Baily's Beads photos can be spectacular.

Totality!

There are a couple of options for imaging totality. One can photograph the eclipsed Sun as well as the foreground, such as the horizon, people, and/or landscape, by using a short focal length lens. One can also use a telephoto lens or attach the DSLR camera to a telescope to capture details, such as prominences, inner and outer corona, and coronal details.

Images taken through a telephoto lens or telescope will show detail, depending on the telephoto/telescope diameter and focal length. As one images at varying exposure lengths, different features of the totally-eclipsed Sun are readily captured [Figure 9].

There are other, more-advanced types of imaging one might try, such as the flash spectrum or the chromosphere. This usually takes a lot of experience, or just plain luck.

Camera Settings

There are several DSLR camera settings to consider. These include ISO, image quality, exposure length, and focus.

First: Focus, Focus, FOCUS! This is one of the most-essential of all of the camera-lens/telescope settings. I cannot overemphasize this; poor or soft focus cannot be eliminated through post-imaging processing.

If one is using a telephoto lens, do not use the lens' autofocus setting. Since the Sun is at infinity, for all practical purposes, the lens will search for the proper focus and will take few, if any, images. You need to accurately focus in advance. Many will use a piece of tape to temporarily hold the focus ring in place; an accidental twist right before totality could ruin one's images. Check the focus

Figure 5. October 23, 2014 partial solar eclipse; Solar View 50mm f/8 refractor with integrated Hydrogen-alpha filter with <0.7 nm bandpass, Celestron NexImage 5 camera; 177 stacked frames. *Image credit: Dr. Ron Brecher.*

as the day warms, and then cools due to the moon's shadow [Ref. 4].

One will also need to set the recorded image size. It is best to image at the camera's highest quality, usually RAW or at least large JPEG files. The higher quality will take more memory space, but will result in higher-quality images when enlarged. Make certain well in advance the memory card will hold all of the planned images.

ISO is a measure of the sensitivity of the DSLR's digital imaging sensor. The higher the number, the more-sensitive the imaging sensor, thus less light is needed to capture an image. One might think "the higher the sensitivity, the better." Yet as the ISO is increased, so is the noise also captured in the image. With film this is referred to as grain; high ISO film results were said to be grainy.

There are instances one might use a higher ISO, but total eclipse imaging is not one of those instances. I recommend 400 ISO maximum; I will set my DSLR's ISO to 100. Above 400 ISO begins to introduce noise in most cameras. One might need to image at a higher ISO if using poor mount or hand-holding the camera. A number of the newer DSLR cameras also employ a noise reduction feature; a valuable setting.

Other Considerations

First, there are other things and accessories to consider. For example I find a remote or remote timer useful. These attach to the DSLR or are connected through Blue Tooth. A remote allows for the taking of photographs without touching the camera – and introducing vibrations in the system.

Computer-control software, specifically designed for solar eclipses, is utilized by some during the eclipse. Such software allows one to input equipment details, such as telescope and DSLR. The software will control imaging during totality, taking the speculation out of exposure length or manual operation of the camera.

Additional camera batteries and memory media are both essential, as previously noted. As totality begins, one does not want to be staring at a dead camera or no capability to take a photo due to a full memory card. Nor does one want to be trying to put in a charged battery at second contact, or replacing a full memory card. Change out the battery and memory well-before second contact, if required. One might also want to consider using a battery pack or external power source, as well as a direct download to a computer or other memory device.

I always keep a red flashlight handy during the eclipse. As second contact approaches, it will get dark enough one will need some additional light. I might want to check something, say a cable connection, and the red flashlight gives me that opportunity. Consider how you observe at night.

Some like to use a digital tape recorder to record comments, observations, photo notes, or capture the excitement around totality. Others use it to record a checklist of what to do when, and then play it back during totality, such as look for Venus or check the camera's available memory.

Figure 6. Part of a 200 image series showing the Sun, sky, ocean, and cruise ship leading up to the November 13, 2012 total solar eclipse. Canon 6D and a Canon 16m-35mm zoom; 1/800 second at ISO 100. The camera was tilted to get the entire combination in the frame of view, due to the ship's orientation. *Image credit: Dr. Michael Reynolds.*

No matter where I go for an eclipse, I carry a small tool bag. I include items such as a slotted and Phillips screwdrivers, jeweler's screwdriver set, hex set, pliers, and a small adjustable wrench. I also carry a roll of duct tape. I usually never need any of these tools or supplies, but someone else always needs something.

I also bring something to cover my equipment, just in case of inclement weather. One can go as fancy as a tarp; a heavy duty garbage bag will work just as well. Be certain you can attach the cover so it doesn't blow away; bungee cords work well. Hopefully, we will not hear of any use for these items on August 21.

Other Imaging Options

- It seems that smartphones and tablets are everywhere. Some of these devices feature decent lenses. If one does not attempt to push the capabilities of these devices too far, some reasonable photos of the totally-eclipsed Sun, colors around the horizon, and people can indeed be captured. Electronic zooms usually produces poor results. Be certain to turn off the device's strobe. People will say that it bothers them during totality; usually the strobe flashes into their backs, not their faces. The smartphone would make for an easy-to-use video and audio device, too.

- Smartphone external auxiliary lenses can add telephoto or wide angle features, often with only fair results. Also available are mounts that allow attachment of a smartphone to the telescope's eyepiece. I have seen good success in using this method for imaging the moon.

- Point-and-shoot cameras gives one the flexibility of a reasonably-good optical system and more imaging options. The ISO and other camera features can easily be adjusted. By adjusting the point-and-shoot camera's sensitivity, aperture (f-stop), and exposure length, one can take a variety of exposures showing the Sun's inner and outer corona. The point-and-shoot camera employs a viewfinder, separate from the camera's imaging system. This camera type does not feature interchangeable lenses.

- Video camcorders offer another option for capturing the eclipse. From time-lapse during the partial phase, changes in the environment, people, and even totality, many will shoot video, allowing one to capture audio that occurs around totality. The audio is often a keepsake unto its own.

- Some note a film medium camera gives over digital imaging, especially with large format film cameras. The main drawback to the film camera is the limited number of images one can take. I would not want to discourage anyone with a film photographic resolved to pursue this type of eclipse imaging.

Figure 7. Second (left) and third contacts at the July 11, 2010 total solar eclipse on Easter Island. Explore Scientific 80mm APO and a Canon 5D Mark II DSLR; 2nd Contact: 1/2,000 second and 3rd Contact 1/800 second at ISO 100. *Image credit: Dr. Michael Reynolds*.

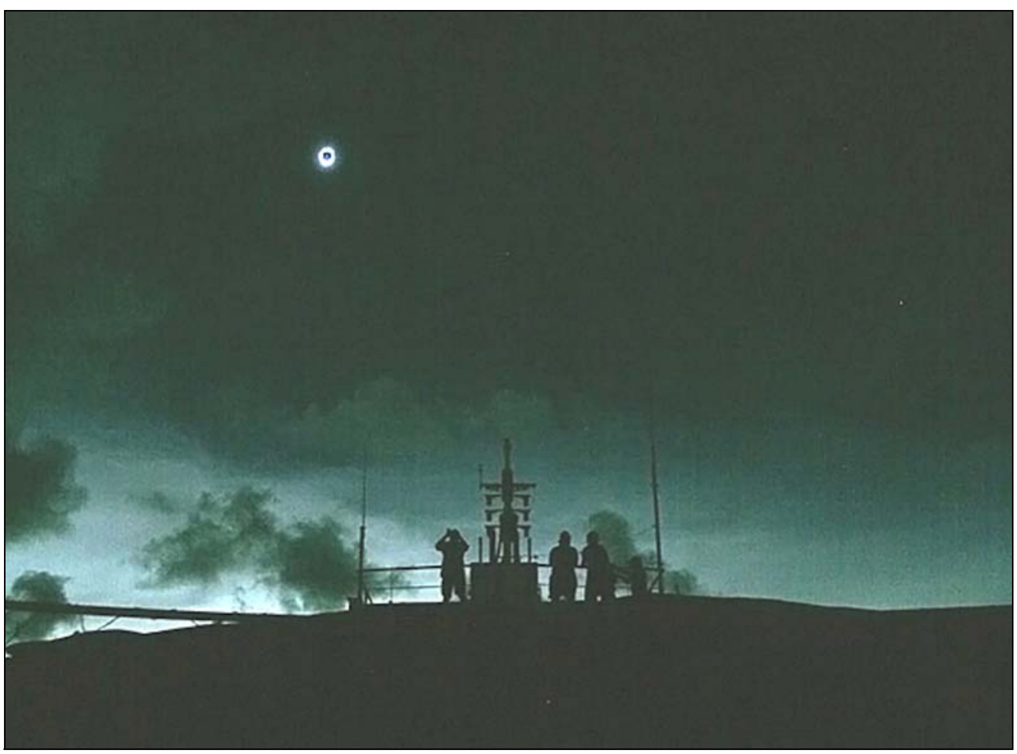

Figure 8. Totality at the July 22, 2009 total solar eclipse off of Kiribati. Canon 6D Mark DSLR and a 24-105 Zoom set at about 30mm; 1/100 second at ISO 100. *Image credit: Dr. Michael Reynolds*.

After the Eclipse

For some, this is where the work begins. From adjusting contrast to stacking images, post- processing takes a good image and makes it great. This is especially true for total solar eclipse photographs. As you look at images with different exposures, one will realize that none of the images truly capture what the eye sees. To produce such an image requires stacking of varying exposure lengths. This is also referred to as HDR, high dynamic range, and is a technique some of us have been using for a number of years. HDR has now become a mainstay in lunar photography as well as all types of photography.

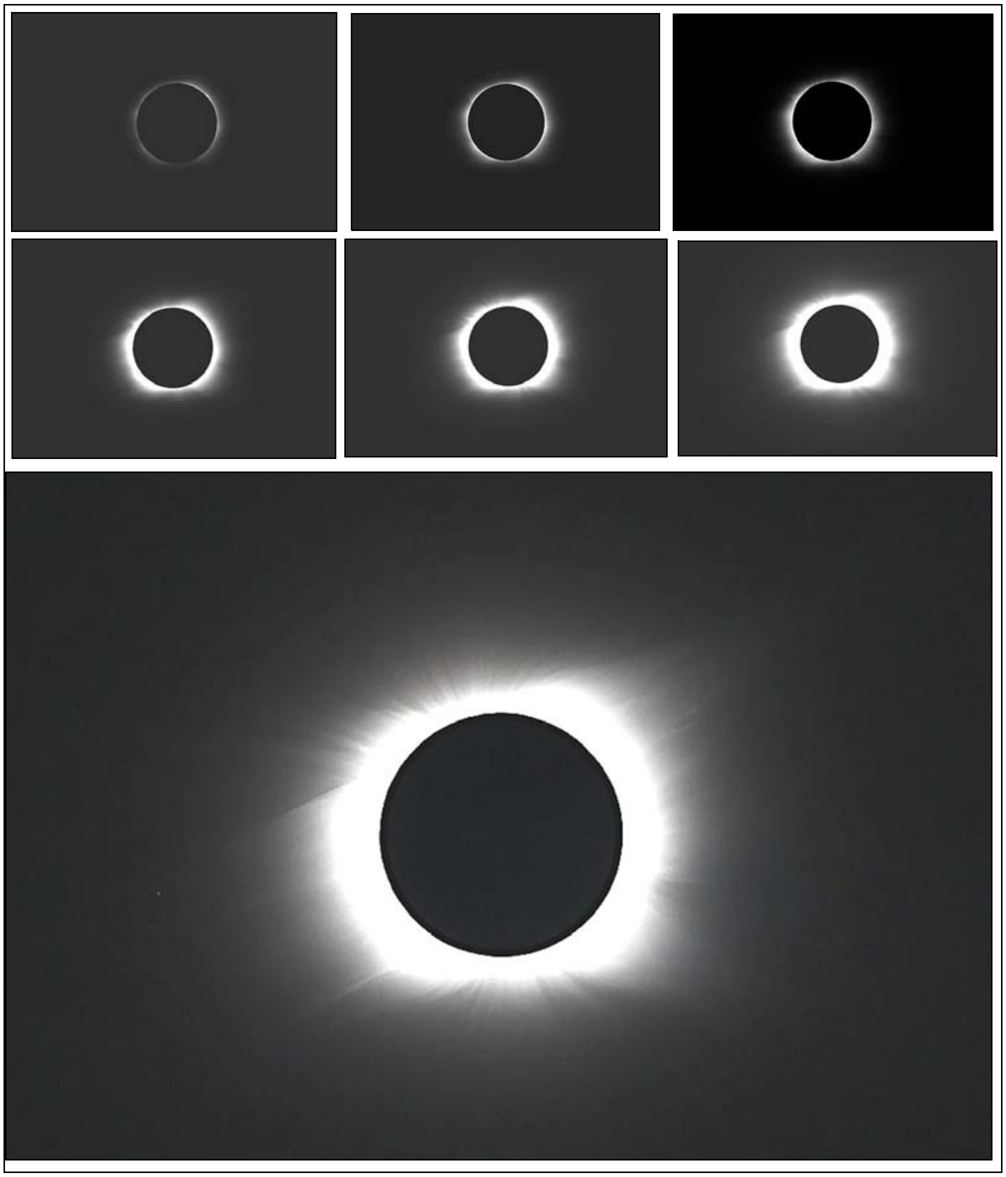

Figure 9. A series of totality images taken at the July 11, 2010 total solar eclipse, Easter Island. Explore Scientific 80mm APO with a Canon 5D Mark II DSLR at ISO 100.

Exposures, starting at the upper left Row 1: 1/8,000 second, 1/1,600 second, 1/800 second. Row 2: 1/500 second, 1/250 second, 1/125 second

Bottom image is 1/80 second. Note how one can see prominence details and inner corona in shorter exposures, outer corona detail in longer exposures. *Image credit: Dr. Michael Reynolds*.

Finally: Practice Makes Perfect!

Those who have successfully imaged eclipses already know how important checking out all of one's equipment and planned techniques are prior to eclipse day. I check my entire set-up and procedures several times. I like to practice on the Moon, specifically on the Full Moon. It is somewhat dark outside and will help one appreciate those nighttime imaging challenges. The Full Moon also provides one with a similar imaging scenario; both in size (minus the corona) and average exposure length. I also do several practice solar imaging sessions.

Regardless of how or even if you decide to image the eclipse, make certain you take some time to look at and experience the eclipse. Totality is something to be experienced, not just photographed!

Clear skies in the shadow,

Dr. Mike Reynolds
18 total solar eclipses … and counting

References

[1] Axel D. Wittmann and Reinhard E. Schielicke, On the Berkowski daguerreotype (Königsberg, 1851 July 28): the first correctly-exposed photograph of the solar corona, Acta Historica Astronomiae, vol. 25, p. 128-147.

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[3] American Astronomical Society, https://eclipse.aas.org/imaging-video/images-videos

[4] Reynolds, Mike and Richard Sweetsir. Observe Eclipses, Astronomical League, 1994

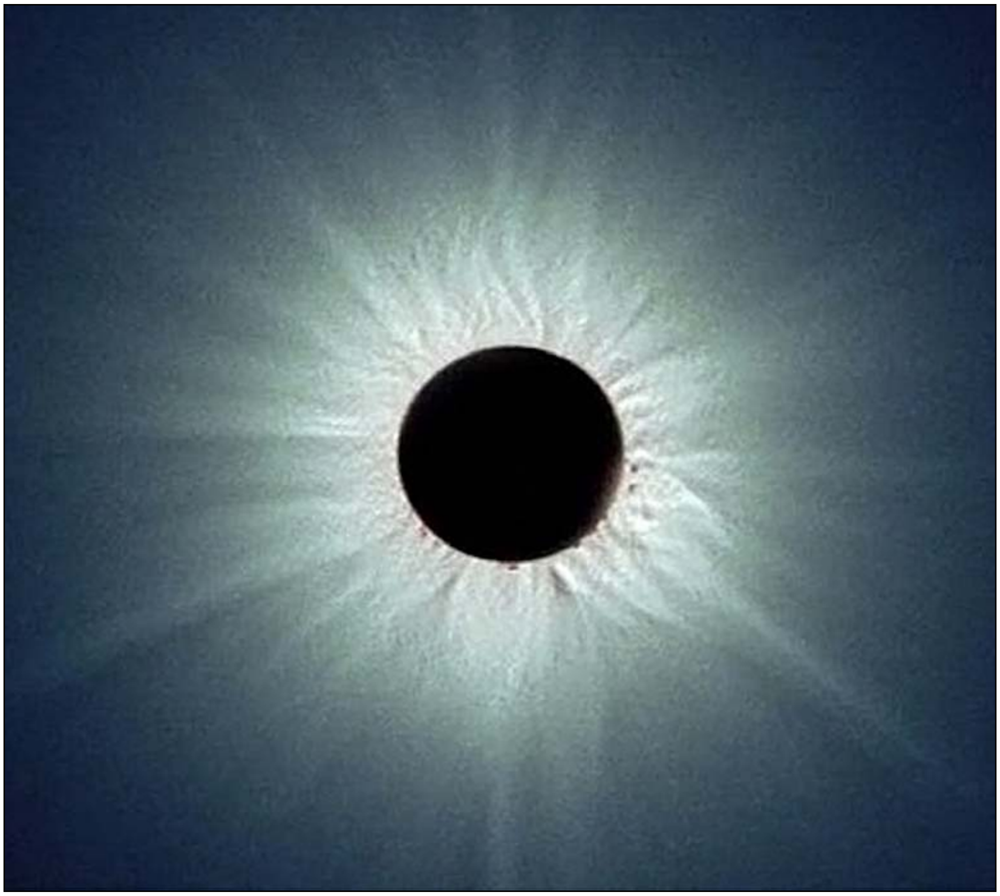

Figure 10. A stacked 10-image photograph of the June 21, 2001 total solar eclipse in Chisamba, Zambia. Canon AE1 and 400mm f/4 telephoto; 1/30 second to 1/1,000 second on Ektachrome film. *Image credit: Dr. Michael Reynolds*.

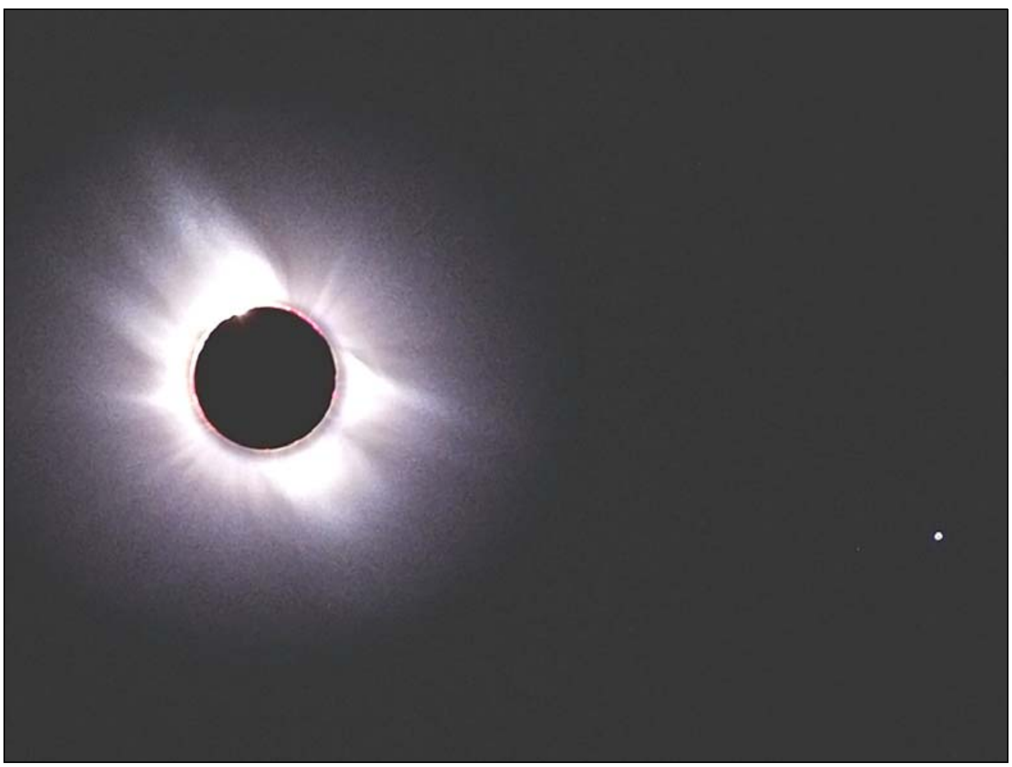

Figure 11. A stacked four-image photograph of the April 8, 2005 total solar eclipse. Four different telescope-cameras were used to capture the eclipsed Sun and Venus (to the right). The stacked image also shows the Sun's chromosphere. *Image credit: Fred Bruenjes, Dr. Michael Reynolds, Jen Winter, and Vic Winter.*