Imaging The 2017 Solar Eclipse

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Introduction

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I am interested in all aspects of amateur astronomy, and enjoy visual observing with my 18" Obsession Dob, and occasional deep sky imaging when I can get to some dark skies like the Okie-Tex Star Party where this picture was taken.

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My main interest however from early on has been observing and imaging the Sun. The Sun is one of the most dynamic objects you can observe, and unlike most other objects that you can observe with your telescope, features can change literally before your eyes, in a matter of minutes.

One of the first astrophotography awards I ever won was for a white light image of the Sun taken with a film camera. That picture looks horrible now in comparison to the images taken today with high frame rate video cameras.

Just as with planetary imaging, taking hundreds of frames, and then stacking the sharpest ones, when the atmosphere was steady, allows you to produce some pretty sharp high resolution images.

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Observing or imaging the Sun of course requires a safe solar filter on front of your telescope, and amateur astronomers basically have three types to choose from:

The first one, which is the cheapest, is a white light solar filter. White light filters allow you see the deepest into the Sun's atmosphere to the layer known as the photosphere. Here you can see sunspots, faculae, and granulation.

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There are basically three types of white light filters - ones made of coated mylar, ones made of coated glass,

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and for the highest resolution when imaging, a Herschel wedge.

The Herschel wedge uses an unsilvered diagonal to reflect a small amount of sunlight to the camera, with the rest of the sunlight being dissipated by a heat sink.

I need to point out that the Herschel wedge can only be used on small refractors, because you are allowing the full sun into the front of the telescope.

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The 2nd type of solar filter is the CaK filter. It is more expensive than a white light filter, and allows you see higher up in the Sun's atmosphere to a layer known as the lower chromosphere.

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Here you can still see the sunspots well, but other features come into view such as chromospheric emissions around the sunspots, as well as prominences. The prominences however are very faint.

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The third type of solar filter, and the most expensive, is the h-alpha filter.

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This type of filter allows you see the upper chromosphere, where you can see solar flares,

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dark filaments on the solar disk,

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and prominences in all their glory on the Sun's limb.

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During the partial phases of the eclipse next year, I plan to take images with all three types of solar filters just as I did for the Venus Transit in 2012, and as I do when there is no eclipse at all, with the exception that I will probably shoot fewer frames than normal to minimize the effects of the Moon's movement across the Sun.

When the eclipse is nearly total I plan to switch to my DSLR camera and a wide field refractor to capture the Sun's corona, which requires a much wider field of view.

Here then is how I plan to image the partial phases of the eclipse:

Taking and Processing H-alpha Solar Images

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1. To take h-alpha images, I use a monochrome camera that produces an AVI video file consisting of hundreds of frames, or takes hundreds of individual 16-bit TIF files for stacking.
2. Monochrome cameras, such as those made by The Imaging Source, Point Grey Research, and several other brands, work best for narrow band solar imaging.
3. You can shoot h-alpha images of the Sun with a color camera too, but you will find that you have to do extra processing to extract the detail from the red, green, and blue channels.
4. Early on, I used a Nikon Coolpix camera to do h-alpha imaging, and found that the red channel would be overexposed, the detail I wanted to capture was in the green channel, and the blue channel was very underexposed.
5. Therefore I ended up processing the green channel only, and throwing away the red and blue channels.
6. If you use a monochrome camera you will save yourself the extra work.

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7. The solar disk detail in h-alpha is usually much brighter than the prominences on the Sun's limb. Therefore it is best to shoot two separate AVI files, one exposed properly for the disk,

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and another exposed properly for the prominences, with the disk overexposed.

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The two images are then combined in Photoshop to produce a single image that shows both well. I usually try to shoot at least 300 frames per AVI file.

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8. Next I load the AVI file(s) into a program that can sort through the individual frames, sort out the best quality ones when the seeing was steady, and then stack them to create a high quality, low noise, image.
9. Programs that are popularly used for this include Registax, which is free, and AutoStakkert!2. These programs have other useful features that can be used to enhance the image such as wavelet sharpening.
10. In Registax, I load the AVI file I wish to process.
11. I Step through the individual frames to find and select a sharp frame when the air was steady, to be used as a reference frame for stacking.
12. I usually use 80% for the number of frames to keep.
13. Once stacking is complete, the screen for wavelet sharpening will appear.
14. For full disk images that have very small features, I only adjust the lowest slider, and not very much, to keep the image from looking over processed.

15. With higher magnification images, such as of individual sunspots, I start out by adjusting the lowest sliders first, and then the succeeding higher numbered ones, until the image is sharp, without looking over processed, or noisy. I then save the processed monochrome image as a 16-bit PNG file.

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16. Next, I load the PNG file(s) into an image editor, such as Photoshop, or the GIMP, which is a free program.
17. I use the clone stamp tool to edit out imperfections in the image, such as out of focus dust donuts, crop out unwanted parts of the image, adjust the brightness using curves and levels, and adjust the contrast.
18. To make a mosaic from several images that you would like to combine into one image, you can use the Photomerge function in Photoshop, and then crop off the uneven edges.

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19. Some people like to invert, or make a negative of the image at this point, because they believe it adds a 3D appearance to the detail on the disk. If you want to do this, make sure you do it before adding any false color. I personally prefer positive images however, because they look more natural.

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20. To add false color, use the curves tool. For the disk detail, I like a orange-yellow cast. Select the red channel, and pull the line up a bit in the center to give the image a reddish cast.

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21. Select the green channel, and pull the line down a bit in the center.

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22. Select the blue channel, grab the upper right end of the line and pull it down to the bottom. You should now have an orange-yellow image. Continue to adjust the curves until you are happy with the final color.
23. I save the processed file as a 16-bit PNG file. For e-mailing and posting on my website, I use Photoshop to convert the image to 8-bit, downsize it to no more than 1200 pixels wide, and save it as a JPG file.

Processing CaK Solar Images

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1. I use the same technique to process CaK images as I do h-alpha images, until the step where I add false color.
2. Some people like their CaK images to appear deep purple. I personally find it hard to make out the details on the disk however, using that color.
3. I prefer a blue color instead. Using curves again, select the red channel, and pull the line down a bit in the center to give the image a purple cast. Select the blue channel, and pull the line up a bit in the center to add blue. Select the green channel, and pull the line up a bit in the center. Continue to adjust the curves until you are happy with the final color.

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4. Prominences are visible in CaK, but they are much dimmer with respect to the brightness of the disk, than they appear in h-alpha images. To add the prominences to your image you would again need to shoot two sets of exposures, one exposed for the disk, and the other for the fainter prominences.

Processing White Light Solar Images

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1. I use a lot of the same techniques to process white light images as I do h-alpha images, except that only one AVI file is required, because no prominences are visible in white light.
2. When adding false color, I prefer a yellow color for the Sun's disk.
3. Again using curves, select the red channel, and pull the line up slightly in the center to give the image a reddish cast. Select the blue channel, and pull the line down a bit in the center to add yellow. Leave the green channel alone.
4. Continue to adjust the curves until you are happy with the final color.
5. Unlike h-alpha or CaK imaging, a color camera will work nearly as well as a monochrome camera to capture sunspots in white light, unless you use a green continuum filter to enhance the granularity. Then you will have to eliminate the green color cast in your image with your image editor.

Imaging Totality

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1. During totality the main goal is capture the corona of the Sun and the prominences. You will need a wider field of view to capture the whole corona. Your main challenge during this phase of the eclipse is that you will have only a couple minutes, before the Sun reappears.

2. The solar corona also exhibits a tremendous range in brightness which cannot be captured photographically in one single exposure.
3. Fortunately, your computer can assist you with this during processing, by combining a series of images taken at different exposures into a single composite image, which more closely resembles the corona's appearance as seen by the human eye.
4. The general procedure will be to take your solar filter off just before the start of totality.
5. Start your exposures of the total phase of the eclipse with the proper settings for capturing the diamond ring and Bailey's Beads just before second contact.
6. Then start increasing your exposure times by one stop increments until you reach your longest exposures at mid totality.
7. After totality, start shortening your exposures again in one stop increments until you again reach the correct exposure for the Bailey's Beads and Diamond Ring at third contact, which is the end of totality.
8. The series of exposures can then later be digitally composited together to reveal the full majesty of the corona during totality.
9. You can also go for a longer exposure at mid totality to record the maximum corona if you have a wide enough field of view with your setup, and possibly even record some Earthshine on the face of the Moon if you are lucky.
10. Be sure to replace your solar filter when totality ends to prevent damaging your camera!
11. It is important to remember with DSLR cameras, that the dynamic range goes down as the ISO goes up, so shoot at a slower speed such as ISO 100 or 200 if possible .
12. You also want to shoot in RAW file format for more control in processing later. Most DSLRs allow you to shoot both RAW and JPG images simultaneously. RAW format saves the image without the camera doing any internal processing or compression on it.

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13. During totality I would really like to observe the spectacle visually, rather than fussing with exposures on my camera, so my plan is to again use a computer to automate the exposures on my camera, using software such as Eclipse Orchestrator from Moonglow Technologies or another program called BackyardEOS for Canon cameras or BackyardNikon for Nikon cameras .
14. Eclipse Orchestrator takes control your camera during a solar eclipse so that you are free to concentrate on observing the event visually.
15. You can preprogram all exposures using a script wizard customized for your exact observing site coordinates and camera.
16. You enter your latitude/longitude coordinates and the software will automatically calculate the local eclipse event times for you. Then, all camera actions can be timed in reference to these specific eclipse events. All features are optional, so the program can be used for as little or as much as desired.
17. Your camera is connected to the computer with a USB cable.
18. Next, you build a script of exposures, listing when you want each exposure to occur, and with what settings such as shutter speed, ISO, aperture, and file type.

19. At the appointed time, Eclipse Orchestrator will send commands over the USB cable to the camera to execute those settings and trigger the exposure. The images will be saved to the camera's internal memory card, just as if you were there running the camera by hand.
20. The Script Generation Wizard for the free version of the software generates scripts to photograph Diamond Ring and corona.
21. The Pro version includes 8 additional scripts for capturing such phenomena as Baily's Beads, the chromosphere, Prominences, First and Fourth Contact, Earthshine on the Moon, and Partial Phases.
22. The software can also provide exposure compensation in case there is haze or thin clouds during totality.
23. If you want to use a Mac computer instead of a Windows one , there are a couple similar programs you can use for controlling your camera. One is called Eclipse Maestro, and the other is called Umbraphile.
24. The focal length of your lens or telescope will determine how big the Sun will appear and how much of the corona you will capture in your picture.

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25. A great online source for all aspects of observing and imaging eclipses is Fred Espenak's Mr. Eclipse website.
26. Here are some graphics from the website that show the field of view you can expect to capture with different lenses.

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27. Here is a table and formula for calculating the field of view for other lenses and telescopes.
28. Note that the field of view shown here for an SLR using 35mm film would also be true for a digital SLR that has a full frame sensor like the Canon 5D or 6D.
29. A DSLR with a smaller APC size sensor like a Canon 60D will give you a much smaller field of view.
30. In general, for the capturing detail in the corona and prominences, you will need to have a focal length greater than 300mm, or else the Sun's disk will be too small in the frame. I have been experimenting with several of my lenses and telescopes to see what will give me the best results.

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A free program download by New Astronomy Press, called CCD Calculator can also help you decide what the best combination of camera and telescope will work best for imaging the Sun as well as other astronomical objects, before you invest in new optics.
For the telescope, you enter the aperture, focal ratio, and whether you are using a barlow or focal reducer.

For the camera, you enter the pixel size and the array size.
Next, you choose the object you want to image from the library of objects in its database, and Then the program calculates the field of view and shows you how your chosen object will appear.
Here for example, is the field of view you would get with a 500mm F/6.3 mirror lens and a camera with an APC sized sensor.

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This is what the view looks like with a Celestron C6 SCT with a .63 focal reducer, giving you 945mm focal length. This looks pretty good field of view wise, but some sources online recommend that you not use any compound mirror lenses during totality, because you can get internal reflections showing up in your images. They suggest refractors are a better choice.

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Here is the field of view you will get with an 80mm refractor, and a DSLR camera with an APC sized sensor. 600mm focal length at F/7.5.

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If you use the same 80mm refractor with a DSLR camera that has a bigger full frame sensor, then you may want to add a 2X barlow to better fill the frame, increasing the focal length to 1200mm.

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With a 100mm F/9 refractor and a DSLR camera with an APC sensor, you get 900mm focal length and a bit tighter field of view than the 80mm scope.

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For my h-alpha shots during the partial phases, this is the field of view I will get with my Coronado Solarmax 60mm h-alpha scope, a 2X barlow, and my 6 megapixel PGR Grasshopper 3 camera.

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1. So, once you have figured out what camera and telescope combination to use, you need to figure out your exposure settings for that combination.
2. Once again, the Mr. Eclipse website comes to the rescue by providing a table and formula for calculating exposures.

3. These are of course approximate settings to start out with, and you will have to bracket your exposures to match the sky conditions on the day of the eclipse.
4. It is highly recommended that before the eclipse you practice your routine for taking the exposures, so that they become second nature to you when eclipse day arrives.
5. Remember you only have a couple minutes during totality to get all your exposures.
6. Also, don't forget to use another camera on a tripod to take pictures of the scene around you as the sky darkens, and the reaction of the people around you. I will probably set up a couple GoPro cameras for doing that.

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In February I started doing some testing with this portable imaging setup using my Ioptron IEQ45 Pro mount,

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With a double stacked Solarmax 60 h-alpha telescope, 2X Barlow, and Grasshopper 3 camera, an Orion 80mm refractor with 2X powermate, a Canon 60Da DSLR camera, and a Canon SL1 DSLR camera with a 500mm F/6.3 Phoenix mirror lens.

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To keep the Sun centered in the field of view, I will be using a Hinode Solar Autoguider, which you see here. It consists of two parts, the sensor, which you see here,

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and a hand controller.
Just like an autoguider for deepsky imaging, you do a short calibration routine, and then it starts sending commands to the autoguider port on the mount to track the Sun.
This comes in particularly handy if you did not do a very good job polar aligning your mount, which is a common problem when you set up during the daytime.

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Here is a shot of the Canon intervalometer I use. I can use it to take a series of exposures at different exposures, or just as a simple shutter release to avoid shaking the camera.

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This is a shot of a solar finder that I got from Scopestuff. The front portion has a pinhole that projects onto the target on the back portion. This greatly speeds up lining up the telescope on the Sun.

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This is a shot of the Sun in h-alpha taken with the double stacked Solarmax 60, 2X barlow, and Grasshopper 3 monochrome camera. I am pleased with this setup since it fills the frame nicely.

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I also plan to shoot some CaK images during the partial phases, using the 80mm refractor, Lunt B1200 CaK filter, and Grasshopper 3 camera.

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For white light images during the partial phases, I will be using the 80mm refractor with the Lunt white light solar wedge and the Grasshopper camera .

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Here is a white light test shot through the 80mm refractor with 2x powermate and my Canon 60Da. It provides ample room around the Sun's disk for capturing the corona.

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Here is a white light shot through the 500mm mirror lens. My thought was that I could use this lens to give wide field image of the corona. Unfortunately I am not too pleased with this image. The focus is very touchy on this lens.

I think instead of the 500mm lens, I will use my Canon 6D with the 80mm refractor.
This combination should provide a wide view of the corona.

I also plan to do some tests using a camcorder with a solar filter when I get a chance to see if that is worth doing.

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THE END
Questions?