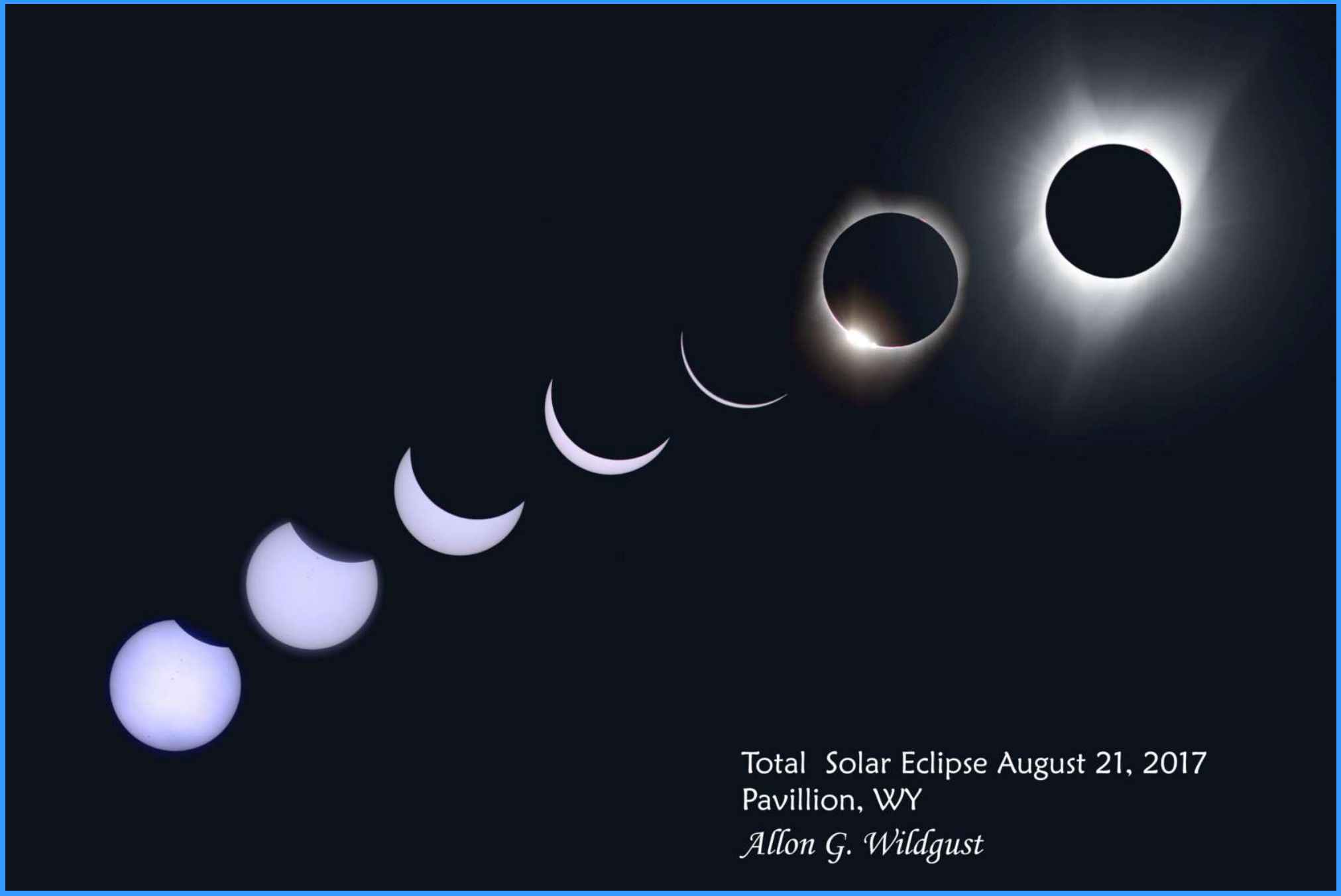
Imaging a Solar Eclipse

by Paul Walker of the Vermont Astronomical Society

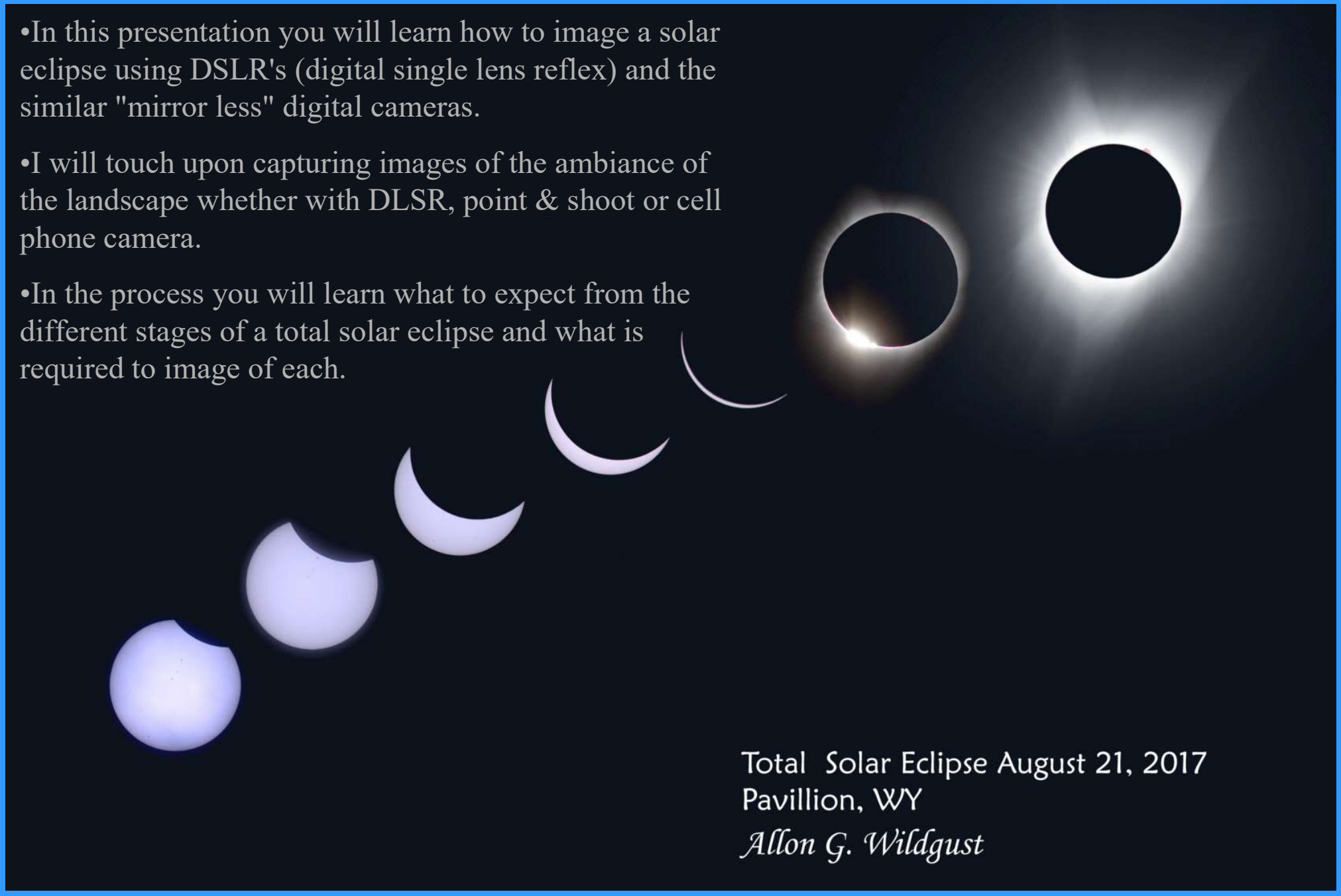


Imaging a Solar Eclipse

•In this presentation you will learn how to image a solar eclipse using DSLR's (digital single lens reflex) and the similar "mirror less" digital cameras.

•I will touch upon capturing images of the ambiance of the landscape whether with DLSR, point & shoot or cell phone camera.

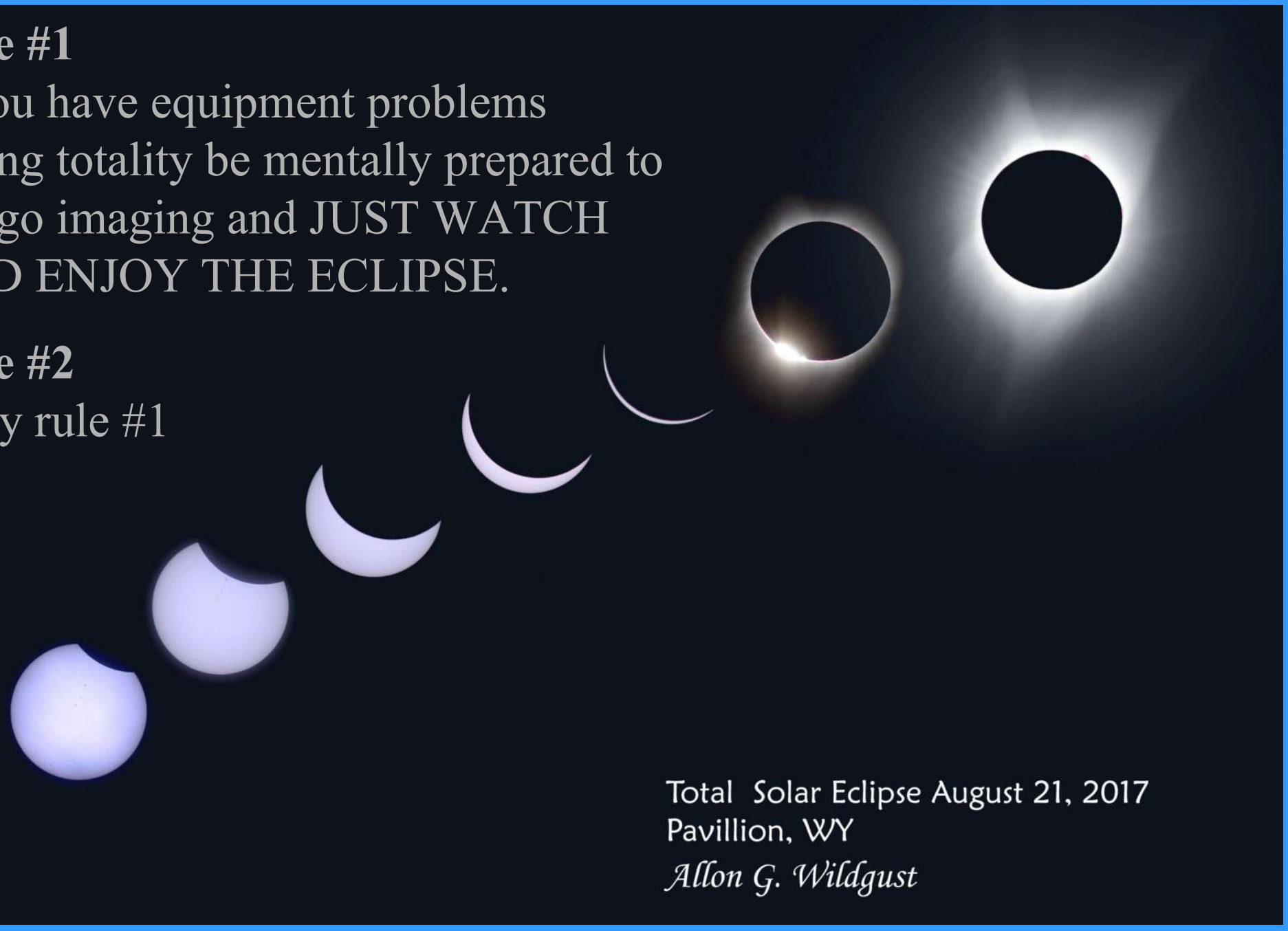
•In the process you will learn what to expect from the different stages of a total solar eclipse and what is required to image of each.



Imaging a Solar Eclipse

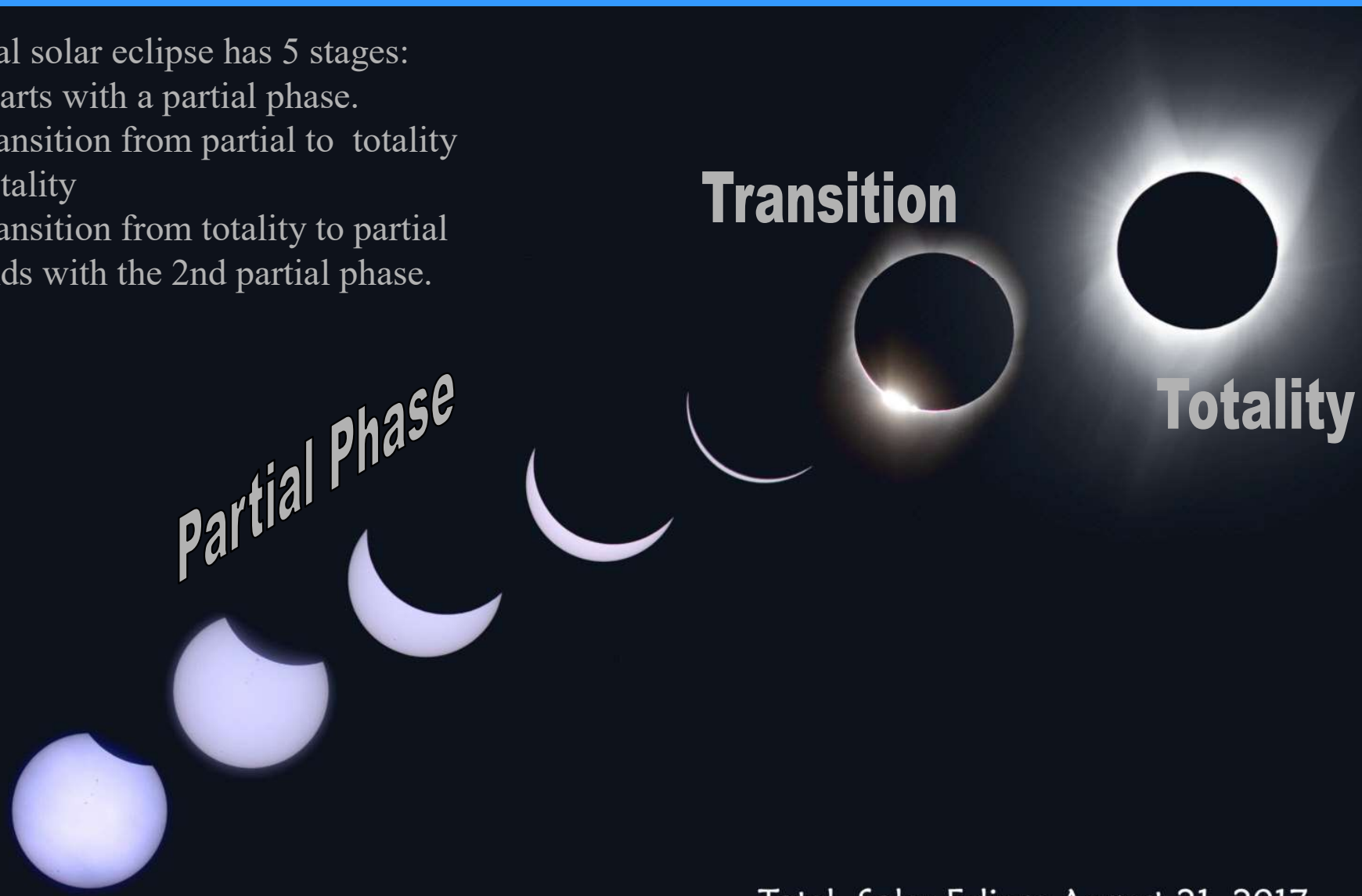
Rule #1
If you have equipment problems during totality be mentally prepared to forego imaging and JUST WATCH AND ENJOY THE ECLIPSE.

Rule #2
Obey rule #1

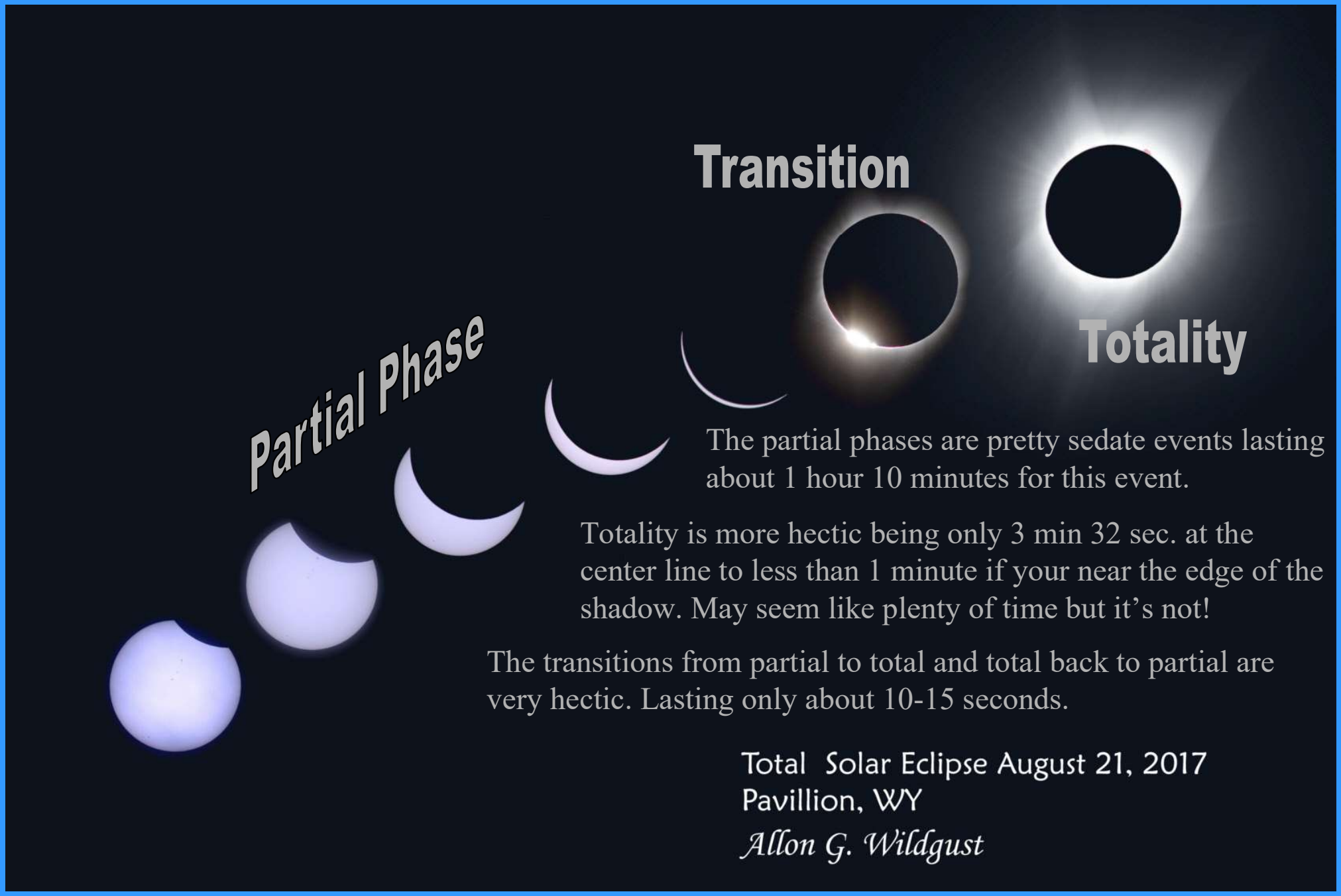


Stages of a Solar Eclipse

A total solar eclipse has 5 stages:
1) Starts with a partial phase.
2) Transition from partial to totality
3) Totality
4) Transition from totality to partial
5) Ends with the 2nd partial phase.



Stages of a Solar Eclipse



Partial Phase

To be totally safe, any time other than during totality you will need to use a filter that blocks 99.999% of the Sun's light.

You will need a proper solar filter.

Recommended brands are:

Baader (some sizes may still available at B&H Photo Video out of NY City)
Orion
(Celestron (EclipSmart Universal Solar Filter)
DayStar (their "Universal Lens Solar Filter", works but they have a lot of internal scatter which reduces the contrast, some sizes may still available at B&H Photo).
Spectrum Full Aperture Solar Filter: Threaded Film (less internal scatter than the DayStar filter, available from sectrumtelescope.com/product-category/threaded-camera-solar-filters and optcorp.com)

Image Credit: Paul Walker

Partial Phase

The best range for a telephoto lens is 300-800mm (effective focal length) This will show some sunspots, get some detail of prominences on the edge of the Sun and fit all or most of the Sun's corona in the field.

Do trial shots of the Sun well before the eclipse using the filter to determine the best camera settings.

As many of you know, judging an image in the daylight is difficult. It helps to increase the brightness of the view screen. Using dark T-shirt over your head and camera helps a lot.

You can use the histogram if your camera has that feature. However, with the Sun comprising a small percentage of the total pixels it may, those pixels may be hard to see on the histogram.

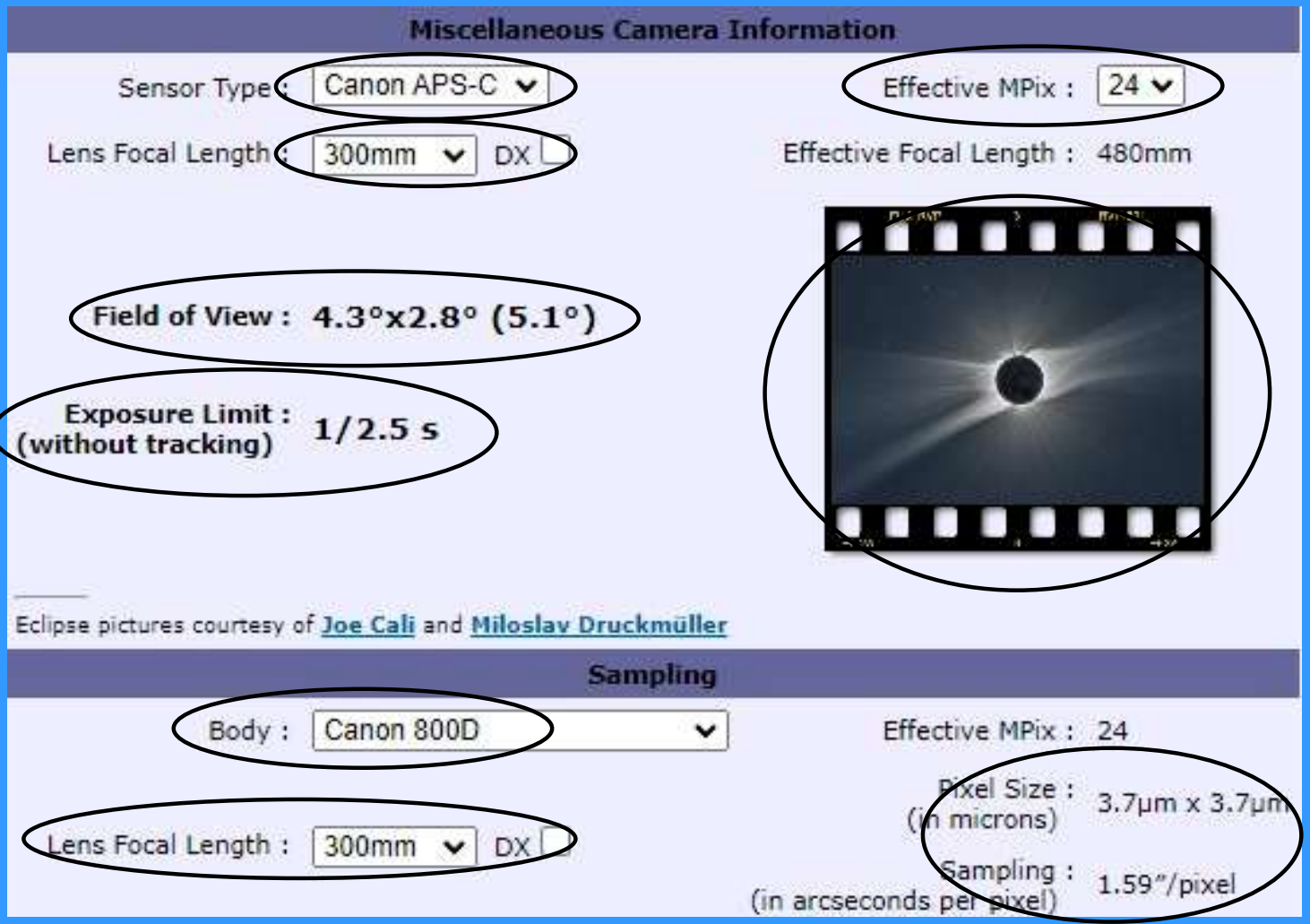
675mm E.F.L

It is better to under expose the partial phase. I have found that with images showing the whole disk of the Sun, an exposure that puts the brightest pixels at about the 60-75% position will show sunspots the best.

Image Credit: Paul Walker

Camera/Lens Field of View Calculator for Solar Eclipses

http://xjubier.free.fr/en/site_pages/SolarEclipseExposure.html



Credit: http://xjubier.free. fr (your site for all things solar eclipse, including interactive maps for this and future eclipses)

Shutter Speed Calculator for Solar Eclipses

http://xjubier.free.fr/en/site_pages/SolarEclipseExposure.html

Calculated exposure for the partial phase using a ND 5 filter, the lens set to f/7.1 and camera to ISO 200 (the focal length doesn't matter)

Top half This is split in 2 Bottom half

Altitude of the Sun	Elevation of the Observer
40 °	0 m

Eclipse Event		Camera Settings
Partial phase — TO SolarLite™ filter (ND 5.6)	○	Sensitivity (ISO) : 200
Partial phase — 1/100000th filter (ND 5.0)	◉	
Partial phase — 1/10000th filter (ND 4.0)	○	
Baily's Beads (annular - with ND 5.6 filter)	○	Lens aperture (f/Number) : 7.1
Baily's Beads (annular - with ND 5.0 filter)	○	
Baily's Beads (annular - with ND 4.0 filter)	○	
Baily's Beads (total - without filter)	○	

Chromosphere	○
Prominences	○
Lower corona (<0.1 solar radius)	○
Diamond Rings (±6s 2nd & 3rd contact)	○
Inner corona (<0.2 solar radius)	○
Inner corona (<½ solar radius)	○
Middle corona (<1 solar radius)	○
Upper corona (<2 solar radii)	○
Outer corona (>3 solar radii)	○
Outer corona (>4 solar radii)	○
Outer corona (>8 solar radii)	○
Earthshine	○

Suggested shutter speed :

1/2000 s

With atmospheric extinction :

1/1600 s

Brightness (Q) :

10.8

Exposure Value (EV) :

17.4

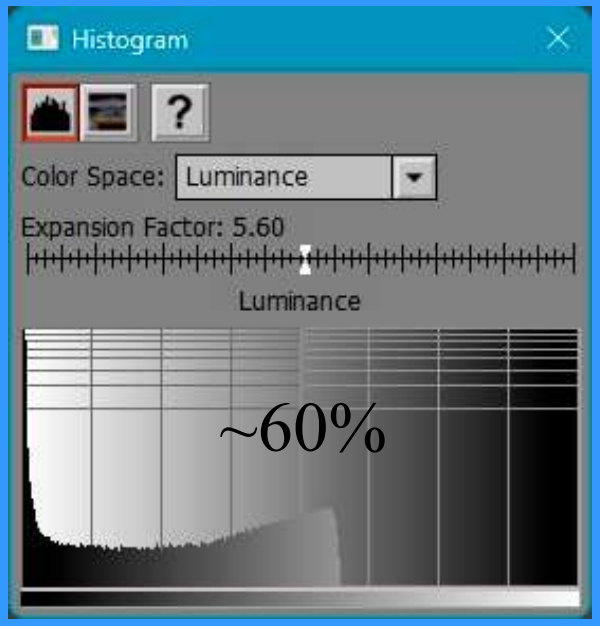
Credit: http://xjubier.free. fr (your site for all things solar eclipse, including interactive maps for this and future eclipses)

Partial Phase

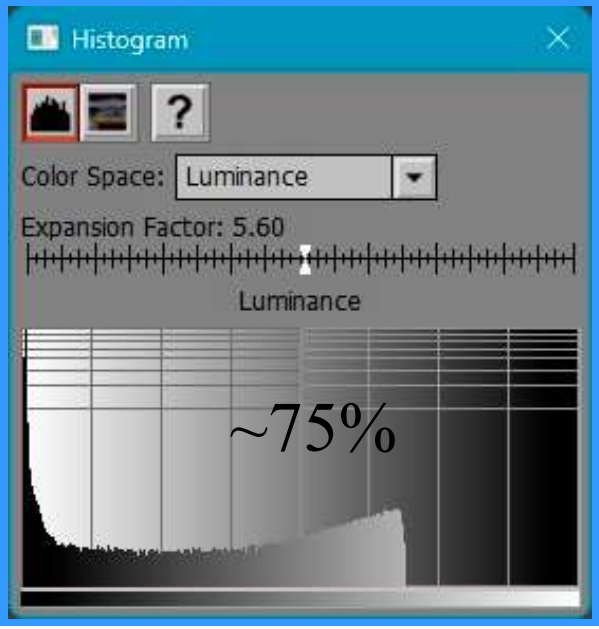
Because the calculation is an estimate and your filter probably won't exactly match the selection, you will want to do some test images:

cropped- 75-300 mm @ 300mm

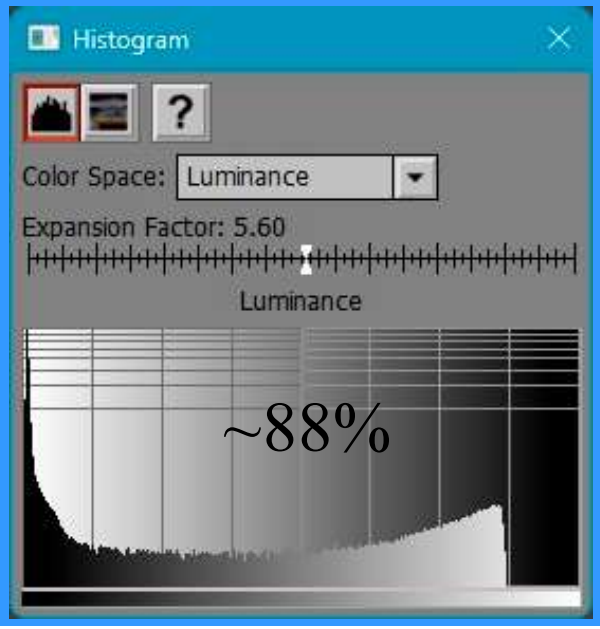
1/1600 sec f/7.1 ISO 200



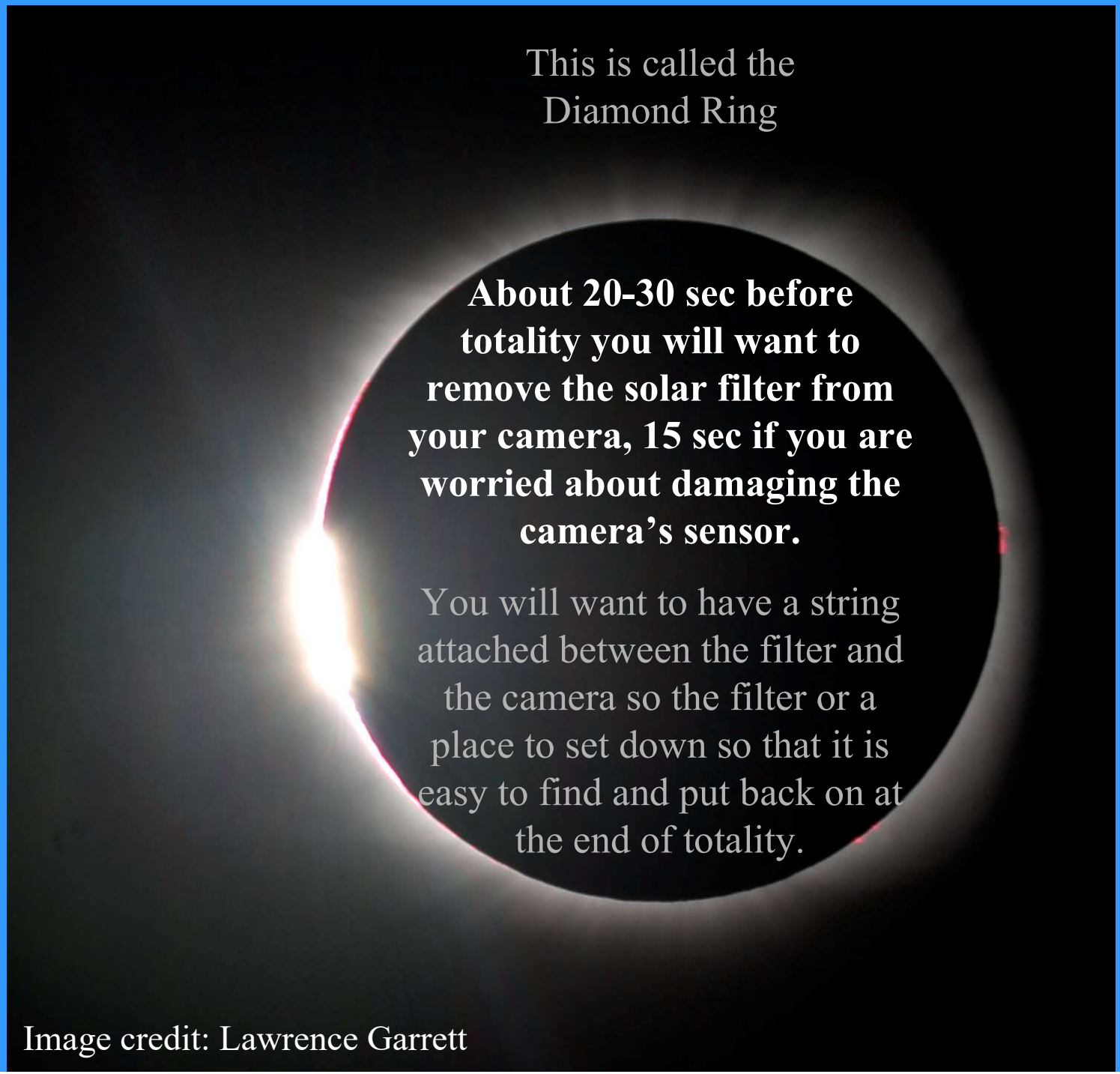
1/1000 sec f/7.1 ISO 200



1/500 sec f/7.1 ISO 200



Transition from Partial to Total



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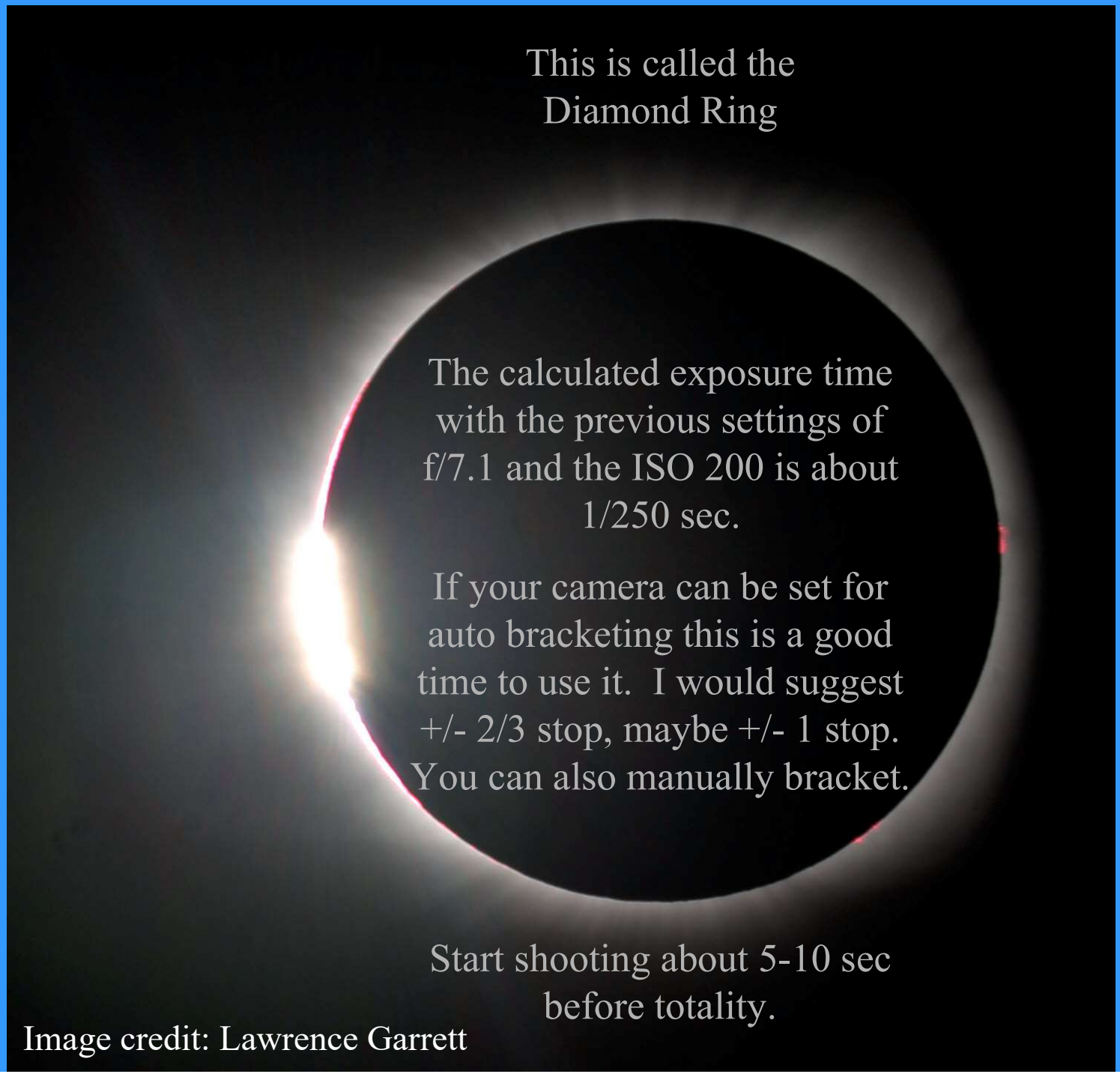
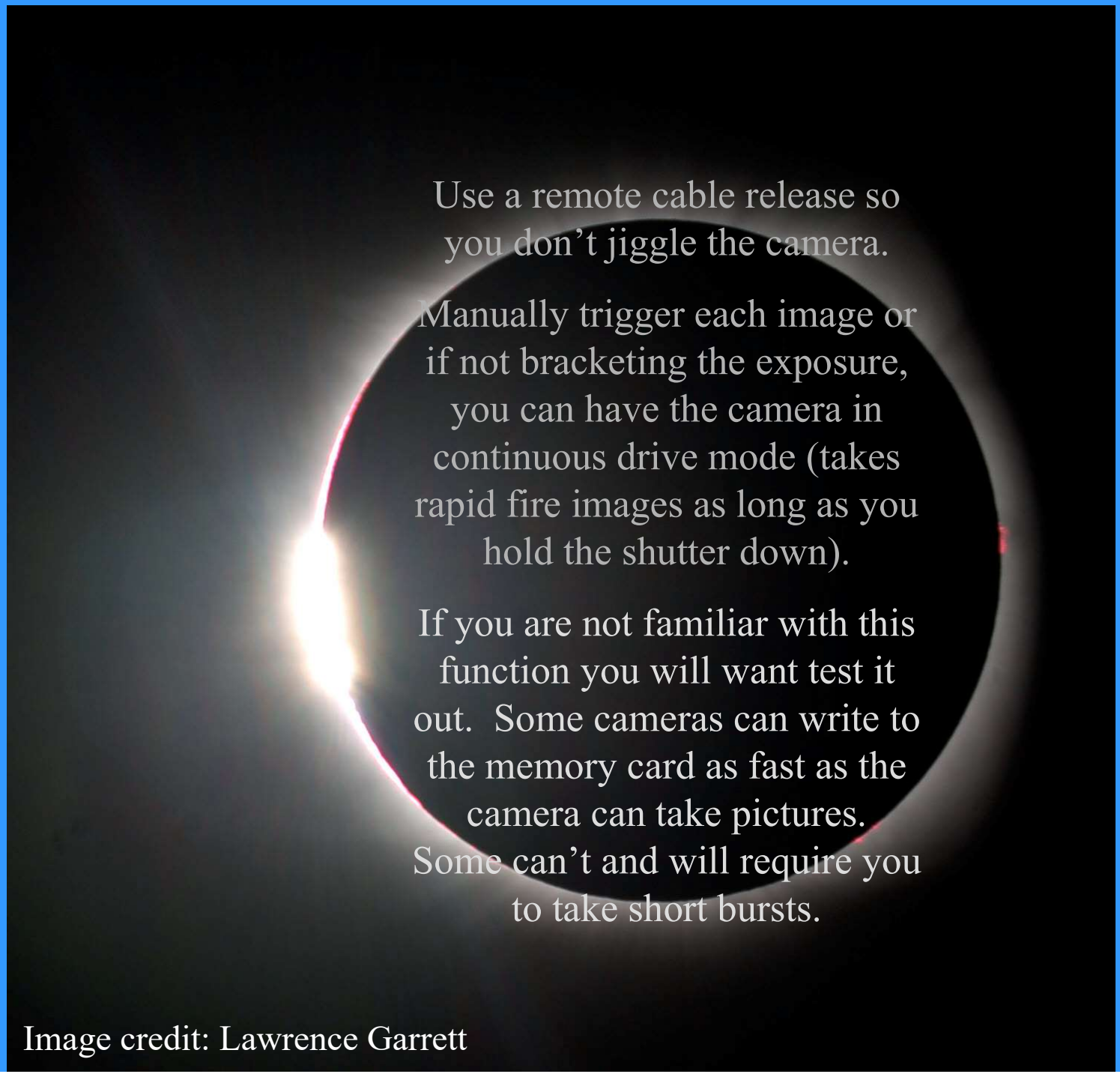


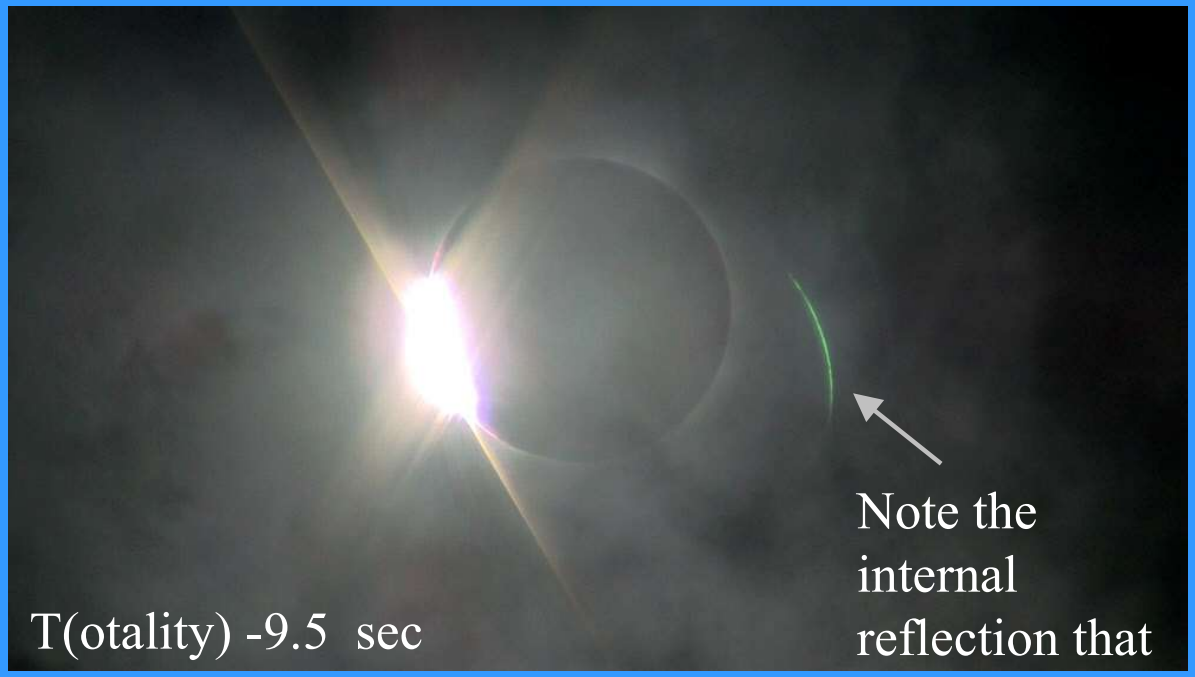
Transition from Partial to Total



Transition from Partial to Totality

This sequence will give you an idea of what the transition looks like and how quickly it progresses.

These are frames from a High Definition (HD) digital camcorder at 15x optical zoom and using a 2x screw-on teleconverter.



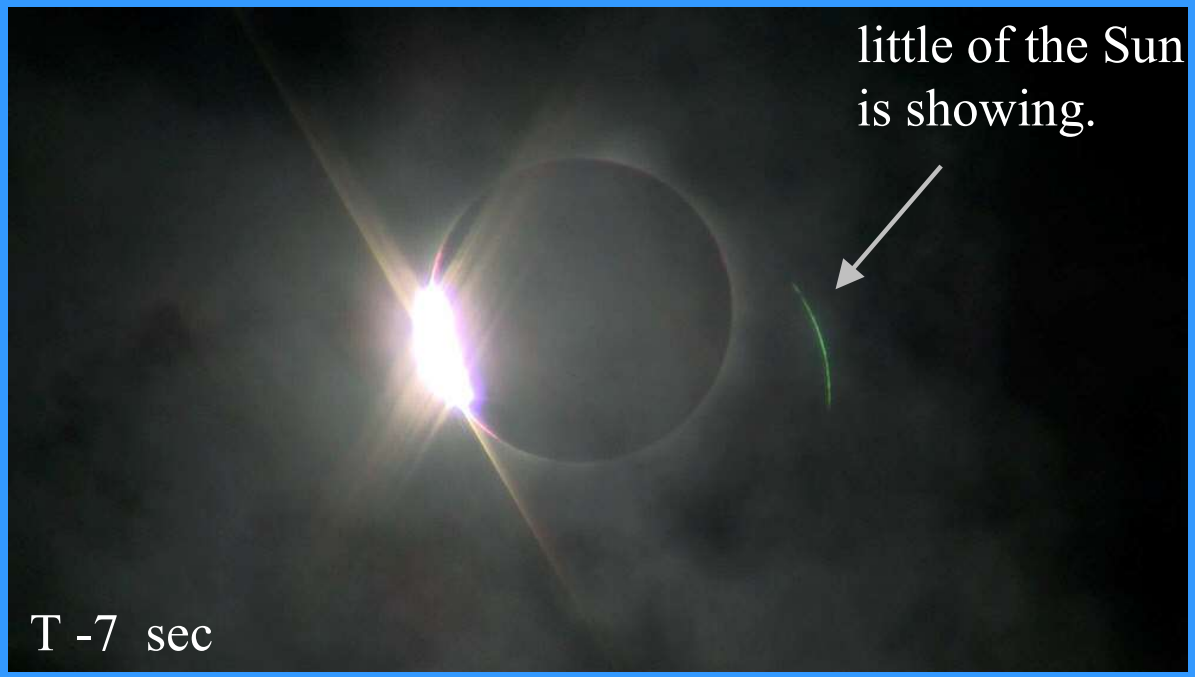


Image credit: Paul Walker

Transition from Partial to Totality

This sequence will give you an idea of what the transition looks like and how quickly it progresses.

These are frames from a High Definition (HD) digital camcorder at 15x optical zoom and using a 2x screw-on teleconverter.

Notice the parallel streaks of light. They are cause by the mountains and valleys along the edge of the Moon breaking up the sliver of Sun into many separate spots of light.

Image credit: Paul Walker

Transition from Partial to Totality

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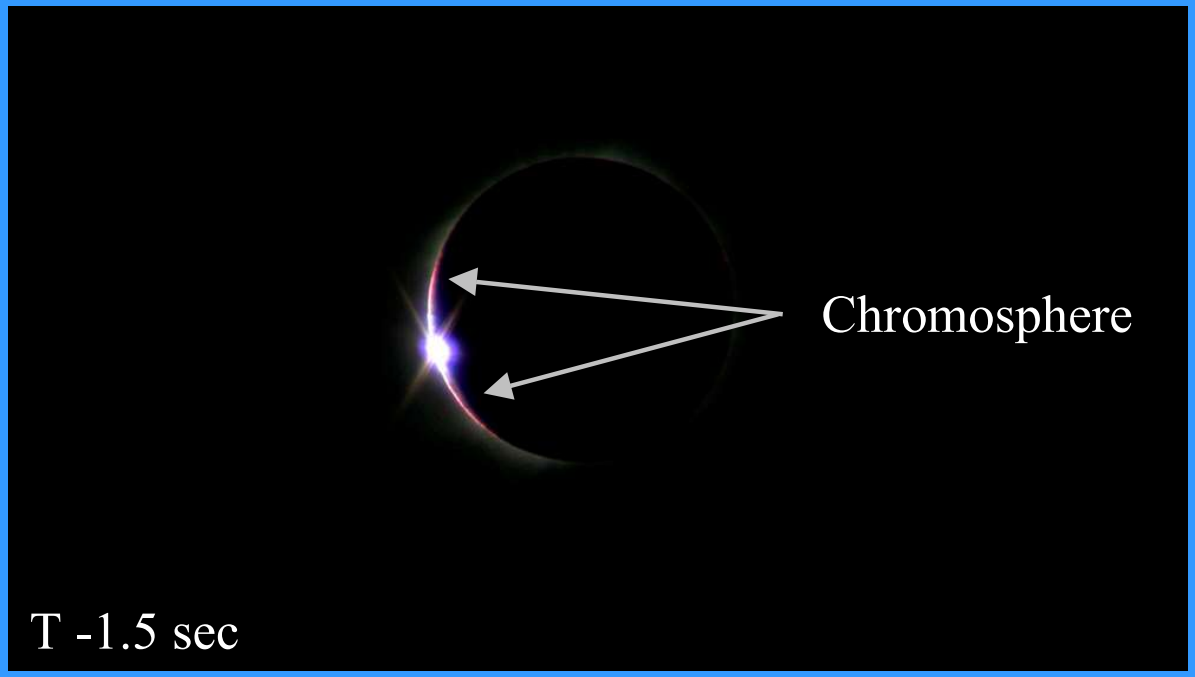
Notice the parallel streaks of light. They are cause by the mountains and valleys along the edge of the Moon breaking up the sliver of Sun into many separate spots of light.

Check out the red line showing above and below the last speck of the Sun, revealing the red chromosphere.



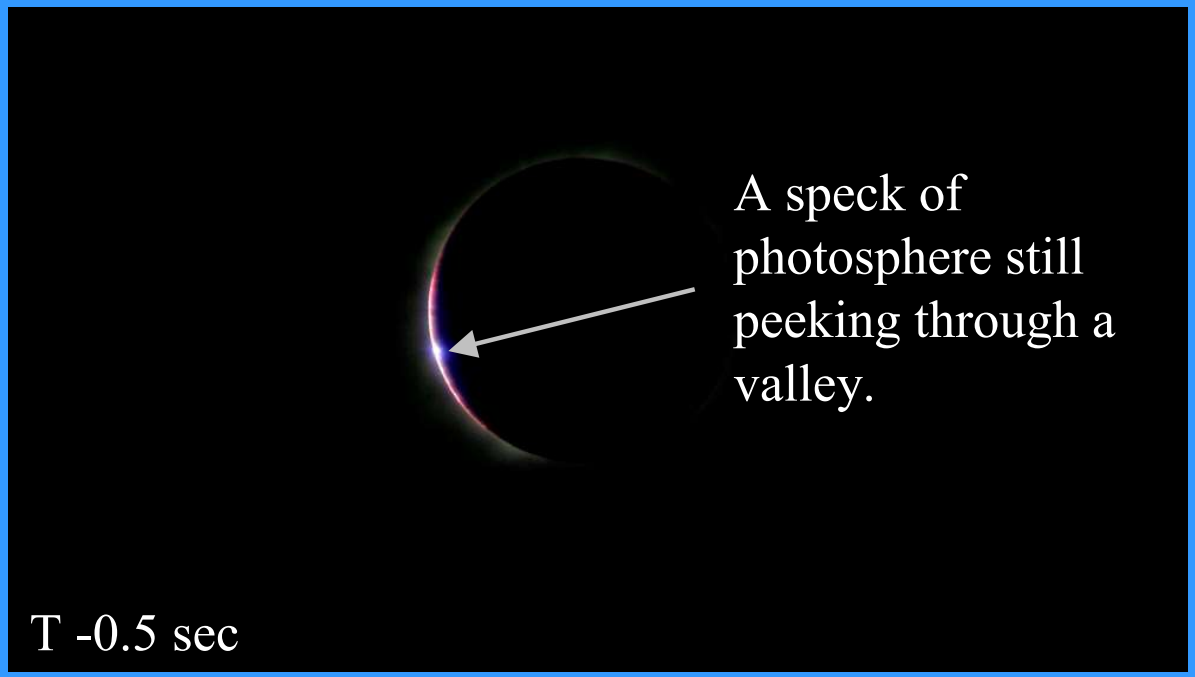


Image credit: Paul Walker

Totality, the whole point of being in the shadow.

Image Credit: Joe Comeau

Take your solar glasses off. We are now at totality where the pearly white corona becomes visible. However, for about 7-10 seconds you will see a bright red band (shown on previous image) where the Sun disappeared and probably some red "flames" on the edge of the Sun. These are called the Chromosphere and Prominences respectively.

These are ionized hydrogen gas (the primary constituent of the Sun). The Prominences are huge plumes of ionized hydrogen gas elevated above the Sun's surface by magnetic loops. Normally only visible using special telescopes.

Totality

Image Credit: Joe Comeau

The exposure time, based on the the previous settings of f/7.1 and ISO 200 is 1/6400 sec. for the Chromosphere and 1/3200 sec. for the Prominences.

This is also a good time for auto bracketing exposures. As you only have about 7 seconds to change the exposure and get off a few shots of the Chromosphere. You may be better off just looking and not trying to image the Chromosphere.

The Prominences will be visible for a longer time. Some maybe for the whole length of totality.

Totality

This image also shows solar prominences on the left side and the inner corona.

The pace slows down but you will find totality ending way too soon.

During totality you will want to take a series of shots over a wide range exposures to get images showing the full range of the corona from the inner to the outer corona.

Use the exposure calculator to find the right settings for your setup. Try to find settings that require you to only change the exposure time through the whole eclipse. You don't want to be wasting time changing the f/ratio and ISO if you don't have to.

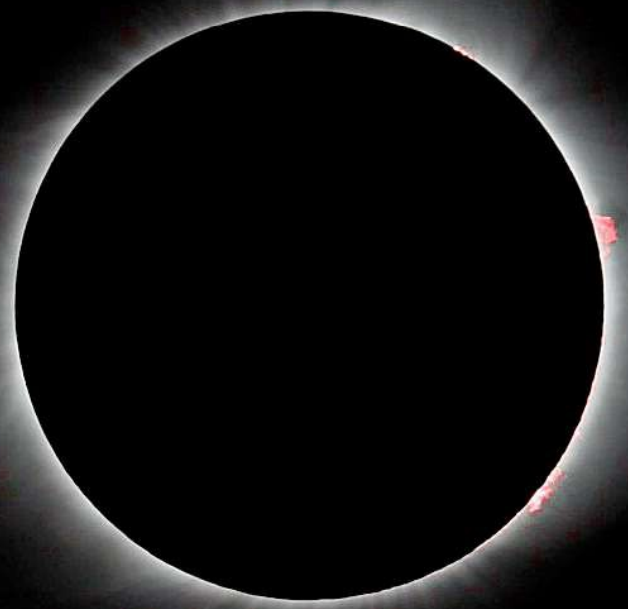


Image Credit: Steve Yerby

Coronal Streamers

The exposures for the corona will range from about 1/3200 sec to about 1/2 sec.

Here you can get away with changing the exposure by 2 stops. But that's still a lot of different exposures (about 14).

If you are auto bracketing you may not want change from bracketing to not bracketing during the eclipse, depending on how quick it is to change and whether or not you plan to use it at the end of totality.

Image Credit: Steve Yerby

More of the Corona is visible in this wider angle image
The planet, Venus, is visible in the lower left corner.

This is a high dynamic range (HDR) image. This is one reason to take series of images over a wide range of exposures.

This is it for totality. If you missed getting images that include the Chromosphere or the diamond ring earlier or want to use different exposures than you used at the transition to totality you are in luck as it all plays out in reverse at the end of totality. But you have to be ready and have your camera settings set up.

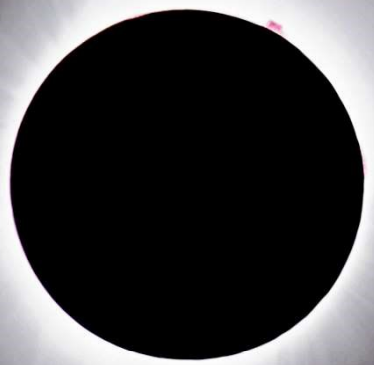


Image Credit: Allon Wildgust

Capturing the Scene

Whether with a DSLR, point & shoot or the camera in your smart phone, during most of the partial you can take pictures as you normally would.

Image credit: Paul Walker

Capturing the Scene

But as it gets darker you will need to set the “EV” control to the negative side to take a darker image that more closely matches the visual appearance. A tripod recommended. A good option is to take a video. As a bonus it will of course record your excitement. You can share screen shots of any frame you want. That’s what I did from the August 2017 eclipse. Based on my video being extra bright before and after the eclipse I must have actually set the EV to the plus side but I don’t remember by how much. I must have experimented before hand with the point & shoot I used.

Image credit: Paul Walker

Record the Camera Settings You Plan to Use.

Use the ***Field of view and camera settings calculator*** for Solar Eclipses to make a list of the camera setting you plan to use for each phase of the eclipse.

Make a time-line for the eclipse of when you are going to change the setting(s) on your camera for the next phase.

Add the settings to the time-line.

Practice with you camera setup on your tripod and/or other equipment you will be using. Aim the camera in the direction that the Sun will be for the eclipse. This way you can see how the camera will be oriented and where the camera buttons will be. Most of you use you cameras pointing down and/or more or less level. For this event it will be pointing quite high in the sky. And for anyone using a telescope mount or other star tracking device the camera will likely be tipped to the side. Run through several dry runs to get used to this different orientation, taking the solar filter off and putting it back on and how long it actually takes you to this and how long it takes you to changes the settings.

Keeping Tracking the Time

It is of course hard tell *exactly* when the Sun will be completely covered ahead of time just by looking and even harder to tell *exactly* when the Sun will reappear. For imaging the event it especially helps to know. The link to the ***Interactive map*** in the last slide will give you that information but you don't really want to be watching the clock, you want to be watching the eclipse.

For those with smart phones there is and app for that. **Solar Eclipse Timer** (https://www.solareclipsetimer.com/) available for iPhone and Andriod phones will talk you through the whole sequence of the eclipse.

Though, again, not what you really want to be doing but an alternative is keep one eye on a clock that **displays time to the second and is synchronized to actual time**. Write down on a piece of paper the important times. Like 1 min before totality (time to check your camera settings), 30 sec, 15 sec, mid-totality (good time to change the cameras settings for the 2nd diamond ring), 30 sec and 10 sec before the end of totality. This will be better then nothing.

Not having a smart phone, in 2017 I used a small digital voice recorder to create and play back carefully choreographed instructions to myself. It worked well, though it took a few takes to create and I almost missed starting the playback on time. This year a plan to create a video my video editing software. I will record the a digital clock that displays the seconds starting a few minutes before the start of totality. I'll add in text at precise times, than add a voice track while watching the video and reading off the text. I can then play this on my laptop. It should be easier to create than the voice recording. And if I miss the start time I can simply skip ahead, pause, then hit the play again when the actual time matches the clock in the video. I have a self-synchronizing digital clock that displays seconds that I will use at the eclipse for accurate time.

Rules for Imaging

Slightly different rules then I put at the beginning

Rule #1

Put in your plan time for
WATCHING AND ENJOYING THE ECLIPSE

Rule #2

If you have equipment problems during totality be mentally prepared to forego imaging and
JUST WATCH AND ENJOY THE ECLIPSE.

Recap, Odds and Ends, and Links.

- The best range for a telephoto lens is **300-800mm (effective focal length)**.
- **Use a tripod**, the best one you have.
- Use some type of **gear head** to fine tune aiming the camera and follow the Sun as it moves across the sky.
- A zoom vs. a telephoto lens will allow you to zoom out to find the Sun.
- During the Partial phase the solar filter needs to always be on the camera.
- During the Partial to Totality transition the filter needs to be off to catch the diamond ring.
- For the chromosphere, prominences and corona the filter needs to be off.
- **One thing I have not mentioned. It likely will be at least partly cloudy which means your calculated exposures will be wrong and you'll have compensate on the fly.**
- Bring a **spare battery** and **spare memory** card.
- Get a **large capacity** card with a **fast write speed**.

- ***Field of view and camera settings calculator*** for Solar Eclipses:
  http://xjubier.free.fr/en/site_pages/SolarEclipseExposure.html

- ***Max exposure*** time without too much movement of the Sun for a tripod mounted camera. Note that the site above has a calculator for this that takes into account the physical size and mega pixels of the camera sensor and produces a different answer than the rule of thumb below.

The rule of thumb is: max exposure in seconds = 500 / the effective focal length

24Mp "Full Frame" camera with 800mm f.l. lens - 500/800= 0.62 sec

24Mp APS-C camera (1.6 x form factor) with 500mm f.l. lens - 500/(500x1.6)= 0.62 sec

- ***Interactive map*** that will give you exact start time of each phase of the eclipse:
  http://xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2024_GoogleMapFull.html