2017 Eclipse Across America

Photographing the 2017 Total Solar Eclipse
Date: August 21, 2017
By: Joseph Novotka

Photographing a Total Solar Eclipse

AGENDA

- Introduction
- Photographing the Sun
- Differences in Solar Eclipse Types
- Photographing the Solar Eclipse
- Locations and Times for 2017
- Summary

NASA Total Solar Eclipse WEB Page

- NASA WEB Page: https://eclipse2017.nasa.gov/

History and Quick Tips for Solar Eclipse

- The last time the contiguous U.S.
- saw a total eclipse was in 1979.
- The last time one crossed North America was in 1918.
- Eclipse Tips
  - Plan your Trip and Gear for the Eclipse (Lenses, Filters, Batteries, Tripod, Telescope w-a Tracking Equatorial Mount) and test you setup on the Sun before going.
  - A Partial Eclipse requires the same white light filter as viewing the total Sun (Welding Glass #12 to #17)
  - *** Do not remove your Solar Filter until the Total Eclipse starts (<u>after Baileys Beads</u>). Return to the Solar Filter <u>before Baileys Beads</u> occur.
  - Exposure setting are 10 stops of difference (256 times difference) (1/8000 to several seconds) from full Sun to Total Solar Eclipse.
  - Use Time-Lapse or Video (avi video will allow you to stack video frames)
  - Zooming into the Sun/Moon so that the FOV is 1.5 to 3 degrees
  - The more cameras you use the better for capturing great images
  - Exposure setting for Baileys Beads and Corona is best at 1/80 secs
  - Using Bracketed and Composited imaging will help you capture the shot you want

Looking at the Sun during a Solar Eclipse

Always inspect your solar filter before use; if scratched or damaged, discard it. Read and follow any instructions printed on the package of the filter.
<u>Always supervise children using solar filters.</u>

Photographing the Sun

- Looking at the Sun is the same as looking at a Partial Solar Eclipse (don’t look at the Sun or Partial Eclipse).

- Photographing the Sun is the same as photographing Partial Solar Eclipse, yes but the Suns brightness is very slightly less during a Partial Solar Eclipse (in the Penumbra). The apparent visual magnitude of the Sun is -26.74. A Total Eclipse magnitude is about 12.

TURN OFF YOUR FLASH

Photographing the Sun

- Magnitude of the Sun during a Partial Solar Eclipse

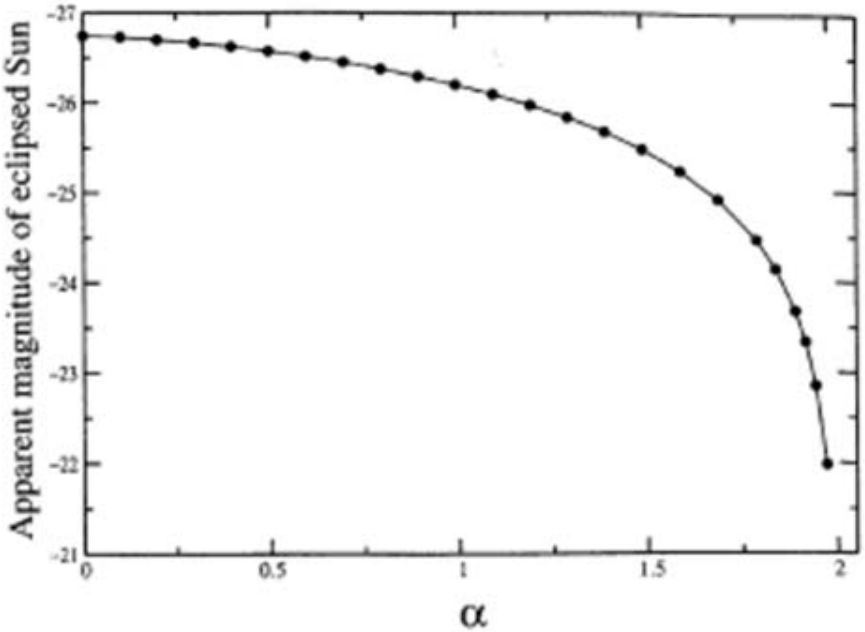


Figure 3. The apparent magnitude of the uneclipsed Sun is –26.74. The graph shows how the apparent magnitude varies during the eclipse. The tick marks on the abscissa occur every 0.25 in α, i.e. every 8 minutes.

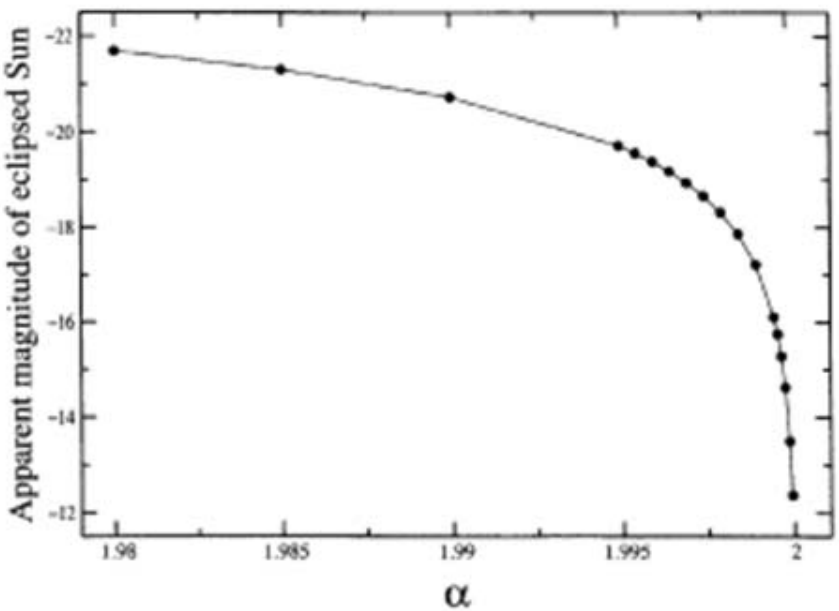
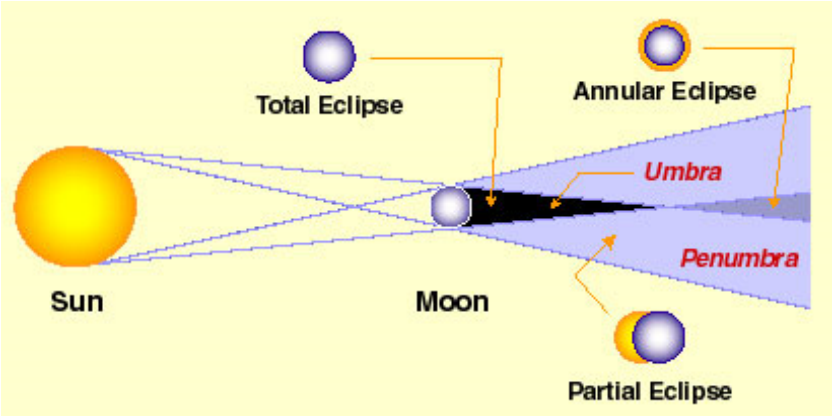


Figure 4. Totality starts when α = 2.00. The apparent magnitude of the eclipsed Sun changes drastically in the half minute before totality. For the Cornish eclipse, α = 1.98, 1.985, 1.99 and 1.995 are respectively 38.4, 28.8, 19.2, and 9.6 seconds before the onset of totality.

Title: Brightness during a solar eclipse
Authors: Hughes, D. W.
Journal: Journal of the British Astronomical Association

Differences in Partial & Total Solar Eclipse

- A solar eclipse only happens during a new moon.
- The moons orbit is tilted by 5 degrees from the earths Orbit.
- The Earth, the Moon and the Sun must be in a straight line for a solar eclipse to occur.
- The geometry of Solar Eclipses is associated with the moon position, shown in the figure on the right (which is not to scale).



- **Total solar eclipse** occurs when the Moon manages to completely obscure the Sun <u>as seen on earth</u>.
- **Annular solar eclipse** occurs when the Moon is far from us or when the Sun is near to us so that the Moon's apparent size is smaller than the Sun.
- A **partial solar eclipse** is seen when you are in the <u>Penumbra</u> region of the moons shadow. A Total solar eclipse can be seen only if you are in the <u>Umbra</u> region of the moons shadow.

Timing of a Total Solar Eclipse

- The <u>whole Eclipse experience</u> lasts a maximum of 3 hours and 2 minutes in Carbondale, IL and 2hrs and 55 minutes in Hopkinsville, Ky.
- The <u>Total Solar Eclipse</u> on Monday, August 21, 2017 will last 2 minutes and 40 seconds maximum.

36° 52' 15.00" N <-> 36.87083° 2m 40.0s (total solar eclipse)
87° 25' 45.12" W <-> -87.42920° 2m 40.9s (lunar limb corrected)
Help

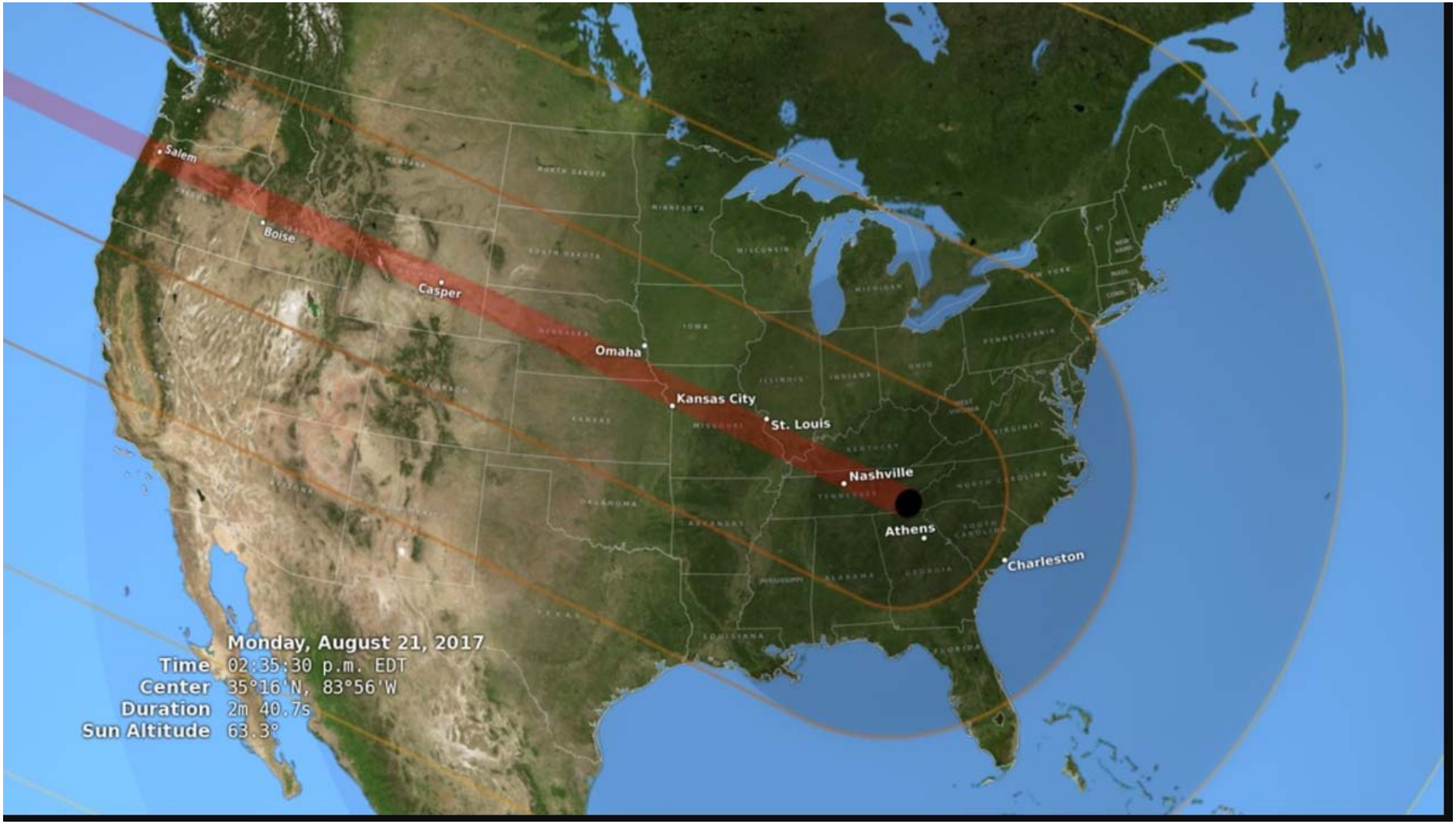
Umbral depth : 98.44%
893m (2931ft)
Path width : 114.6km (71.2mi)
Obscuration : 100.00%

Magnitude at maximum : 1.01505
Moon/Sun size ratio : 1.03058
Umbral vel. : 0.647km/s (1448 mph)

Event (ΔT=68.8s)	Date	Time (UT)	Alt	Azi	P	V	LC
Start of partial eclipse (C1) :	2017/08/21	16:56:39.3	+62.0°	149.6°	293°	01.4	
Start of total eclipse (C2) :	2017/08/21	18:24:48.3	+64.0°	198.1°	113°	08.7	-2.0s
Maximum eclipse (MAX) :	2017/08/21	18:26:08.4	+63.9°	198.8°	204°	05.6	
End of total eclipse (C3) :	2017/08/21	18:27:28.3	+63.8°	199.6°	295°	02.6	-1.1s
End of partial eclipse (C4) :	2017/08/21	19:51:48.2	+53.4°	234.6°	114°	09.6	

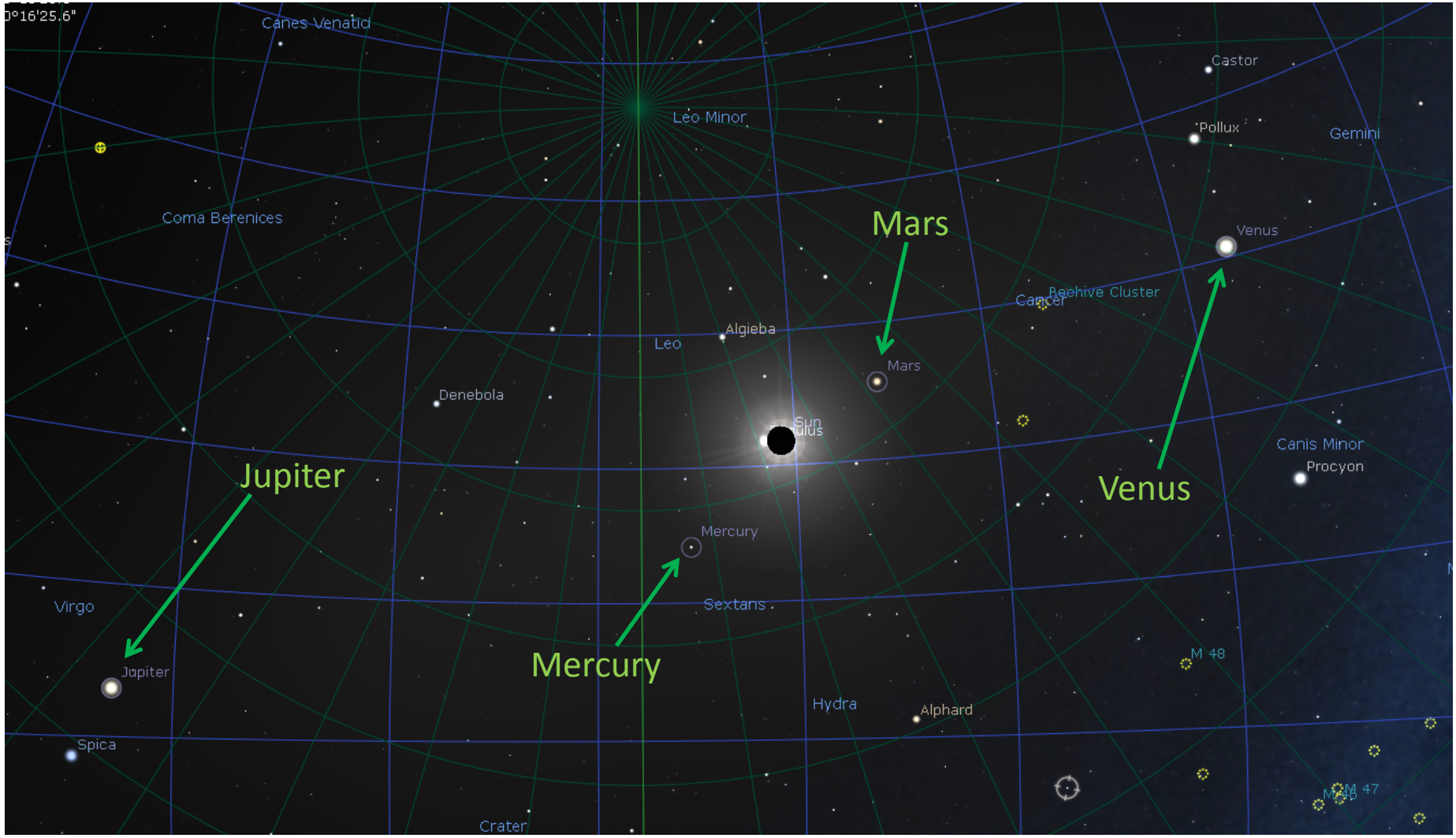
- During totality, <u>Planets</u> (Jupiter, Mercury, Mars and Venus) and <u>Bright Stars</u> will be visible.
- A solar eclipse occurs whenever the Moon's shadow falls on the Earth. This only happens during a New Moon when the Moon passes between the Sun and Earth. The Moon's orbit is tipped 5 degrees to Earth's orbit so the Moon's shadow misses Earth during most of the New Moons.

2017 Solar Eclipse Umbra & Penumbra Regions



The Sky during a Total Solar Eclipse

During the Eclipse in the eastern Sky, Mercury and Mars will be visible as shown below. Venus not shown is farther west of Mars.



Photographing the Total Solar Eclipse

- Some tools and equipment to bring
  - Looking at the Sun is different than photographing the Sun, as a camera can have its exposure be very short. A solar filter for staring at the SUN is the cardboard Solar Glasses recommended by NASA or Welding Glass #14 for viewing.
  - Camera with Lens (e.g., Lenses from 200mm to 1000mm)
  - Some people like a large field of view (< 200mm `provides a smaller Eclipse in the image) but you can get the feel of the excitement around your area.
  - 1000mm is best, usually a telescope (obtain 1 to 3 degrees) w/equatorial mount
  - Filters to bring are Solar Filters; i.e. - Baader Solar Filter, Welders Glass 12to14, or a Neutral Density Filter (minimum 10-stop), a nice to have is a Hydrogen-alpha (10nm band) for the corona and prominences. Another nice to have filter is a Calcium & Sodium filter if you have them.
  - The Total Solar Eclipse on Monday, August 21, 2017 will last two minutes and 40 seconds near Hopkinsville Ky.
  - For finding times of the Eclipse Start and End and Durations try using the Google Map Link below: http://xjubier.free.fr/en/site_pages/solar_eclipses/TSE_2017_GoogleMapFull.html

Photographing a Total Solar Eclipse

How to View the 2017 Solar Eclipse Safely

On Monday, August 21, 2017, a solar eclipse will be visible (weather permitting) across all of North America. The whole continent will experience a partial eclipse lasting 2 to 3 hours from coast to coast.

Anyone within the roughly 70-mile-wide path of totality from Oregon to South Carolina will experience (https://go.nasa.gov/2pC0lhe) the total eclipse, when the moon blocks total Sun face. Totality turns day into night and makes visible the otherwise hidden solar corona (sun's outer atmosphere). Bright stars and planets will become visible. *Credit: Rick Fienberg, TravelQuest*

Looking directly at the sun is unsafe except during the brief total phase of a solar eclipse ("totality"), when the moon entirely blocks the sun's bright face, which will happen only within the narrow path of totality (https://go.nasa.gov/2pC0lhe).

The only safe way to look directly at the uneclipsed or partially eclipsed sun is through solar filters, such as "eclipse glasses" or hand-held solar viewers. To date four manufacturers have certified that their eclipse glasses and handheld solar viewers meet the ISO 12312-2 international standard for such products: Rainbow Symphony, American Paper Optics, Thousand Oaks Optical, and TSE 17.

Always inspect your solar filter before use; if scratched or damaged, discard it. Read and follow any instructions printed on or packaged with the filter. Always supervise children using solar filters.

Stand still and cover your eyes with your eclipse glasses or solar viewer before looking up at the bright sun. After glancing at the sun, turn away and remove your filter — do not remove it while looking at the sun.

Duration of a Total Solar Eclipse

When Can You See It?

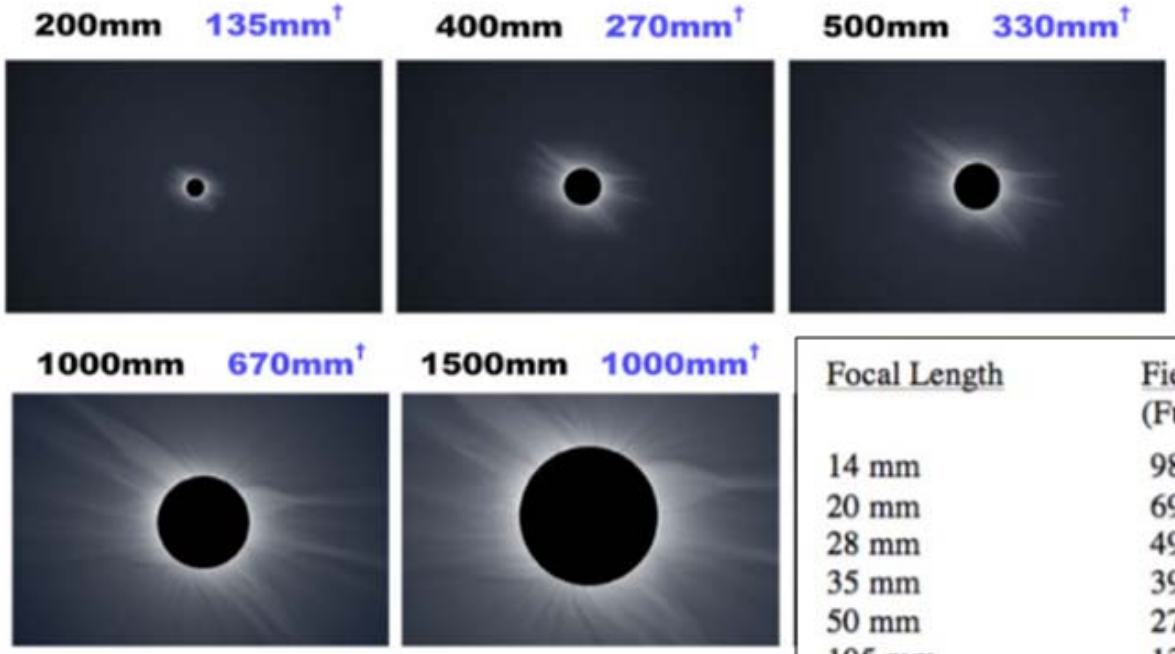
Times for partial and total phases of the eclipse vary depending on your location. This interactive eclipse map will show you times for the partial and total eclipse anywhere in the world.

	Eclipse Begins	Totality Begins	Totality Ends	Eclipse Ends	
Madras, OR	09:06 a.m.	10:19 a.m.	10:21 a.m.	11:41 a.m.	PDT
Idaho Falls, ID	10:15 a.m.	11:33 a.m.	11:34 a.m.	12:58 p.m.	MDT
Casper, WY	10:22 a.m.	11:42 a.m.	11:45 a.m.	01:09 p.m.	MDT
Lincoln, NE	11:37 a.m.	01:02 p.m.	01:04 p.m.	02:29 p.m.	CDT
Jefferson City, MO	11:46 a.m.	01:13 p.m.	01:15 p.m.	02:41 p.m.	CDT
Carbondale, IL	11:52 a.m.	01:20 p.m.	01:22 p.m.	02:47 p.m.	CDT
Paducah, KY	11:54 a.m.	01:22 p.m.	01:24 p.m.	02:49 p.m.	CDT
Nashville, TN	11:58 a.m.	01:27 p.m.	01:29 p.m.	02:54 p.m.	CDT
Clayton, GA	01:06 p.m.	02:35 p.m.	02:38 p.m.	04:01 p.m.	EDT
Columbia, SC	01:13 p.m.	02:41 p.m.	02:44 p.m.	04:06 p.m.	EDT

Table 1 – Example of eclipse times for cities in the path of totality.

Photographing a Total Solar Eclipse

Lens Focal Length vs. Image Size – Solar Eclipses



†Focal lengths in **BLACK** are for Full-Frame DSLRs
Focal Lenghts in **BLUE** are for Crop-Sensor DSLRs.

www.MrEclipse.com/SEphoto/SEphoto.html ©2017 Fred Espenak

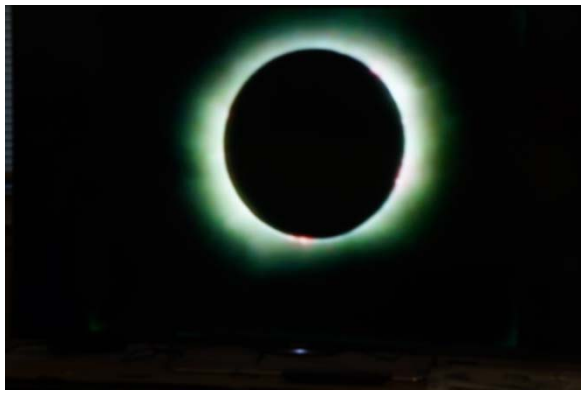
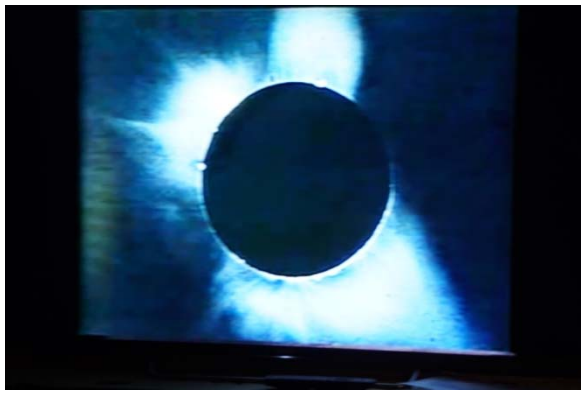
Blue is for a APS-C Sensor type

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

Photographing a Total Solar Eclipse

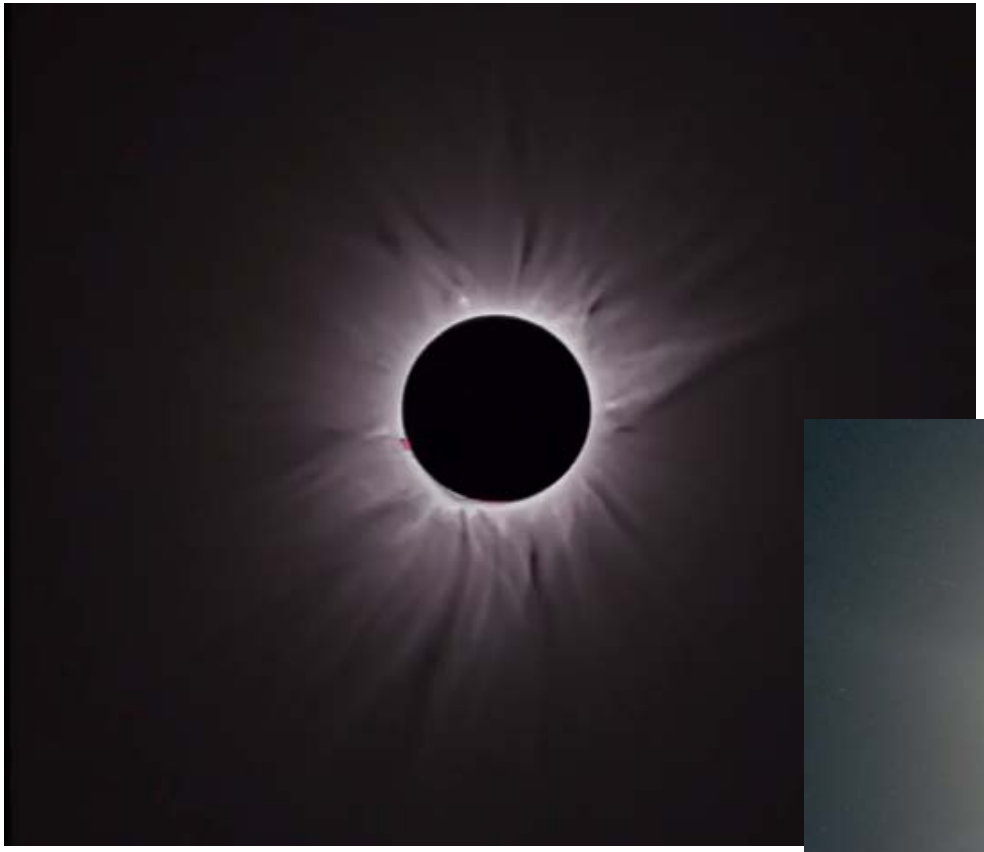
TURN OFF YOUR FLASH

From Rob Hawley

Examples of the type of total eclipse's corona that you may encounter during the Eclipse. Decide on what FOV you want to capture the data/image you plan to capture. Decide on the exposure you will be using it will provide the Corona to brighten or capture Baileys Beads

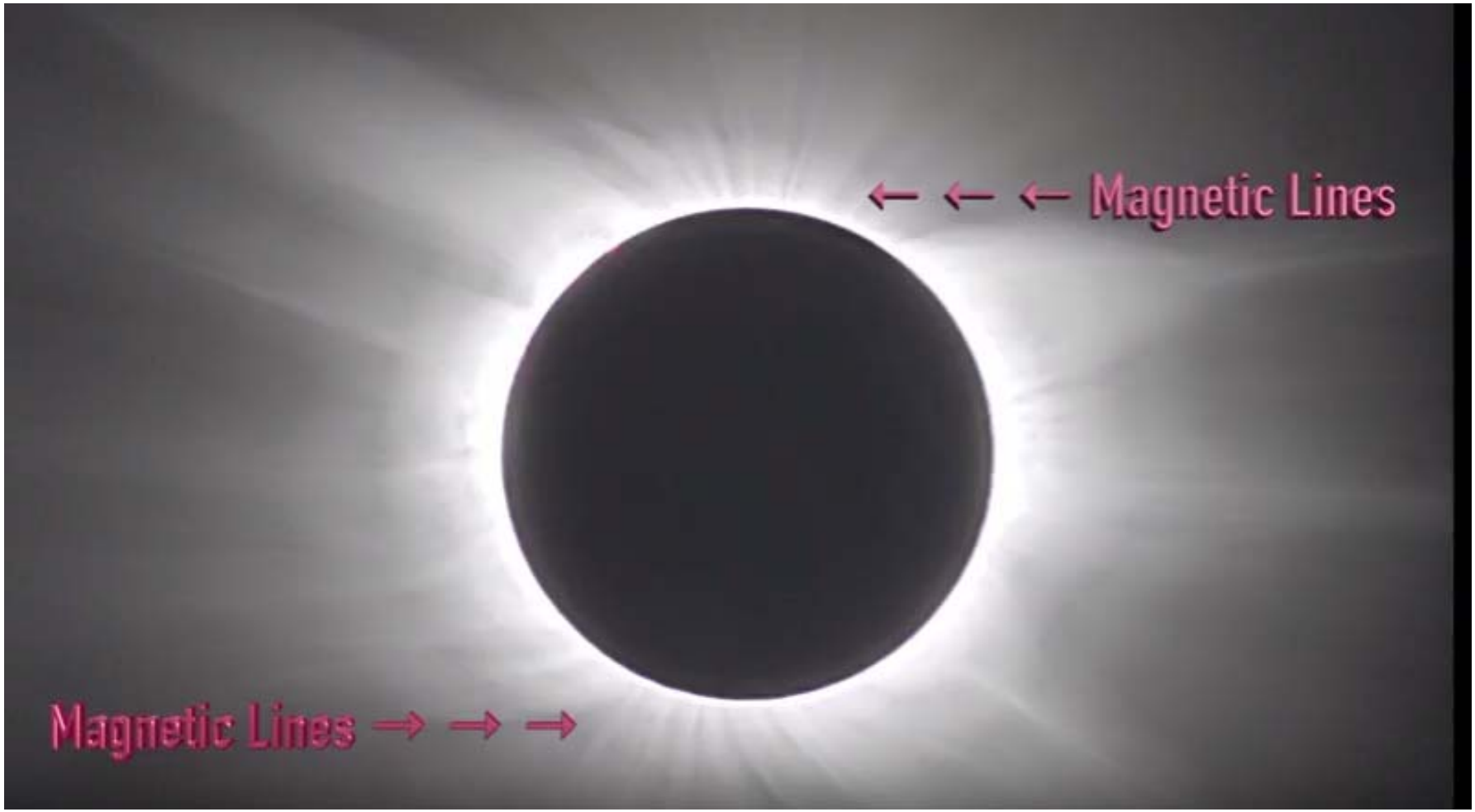
Photographing a Total Solar Eclipse



Decide on what FOV you want to use to capture the data/image you want. The Corona ranges from 1 degree to 3+ degrees. Process your images for possible effects that you may be able to obtain by staking images.

Photographing a Total Solar Eclipse

Magnetic Field Lines in the Corona are possible to capture.



Photographing a Total Solar Eclipse

Solar Eclipse Exposure Guide

ISO	f/Number								
25	1.4	2	2.8	4	5.6	8	11	16	22
50	2	2.8	4	5.6	8	11	16	22	32
100	2.8	4	5.6	8	11	16	22	32	44
200	4	5.6	8	11	16	22	32	44	64
400	5.6	8	11	16	22	32	44	64	88
800	8	11	16	22	32	44	64	88	128
1600	11	16	22	32	44	64	88	128	176

Eclipse Feature	Q	Shutter Speed								
Partial[1] - 4.0 ND	11	—	—	—	1/4000	1/2000	1/1000	1/500	1/250	1/125
Partial[1] - 5.0 ND	8	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15
Baily's Beads[2]	11	—	—	—	1/4000	1/2000	1/1000	1/500	1/250	1/125
Chromosphere	10	—	—	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60
Prominences	9	—	1/4000	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30
Corona - 0.1 Rs	7	1/2000	1/1000	1/500	1/250	1/125	1/60	1/30	1/15	1/8
Corona - 0.2 Rs[3]	5	1/500	1/250	1/125	1/60	1/30	1/15	1/8	1/4	1/2
Corona - 0.5 Rs	3	1/125	1/60	1/30	1/15	1/8	1/4	1/2	1 sec	2 sec
Corona - 1.0 Rs	1	1/30	1/15	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec
Corona - 2.0 Rs	0	1/15	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec	15 sec
Corona - 4.0 Rs	-1	1/8	1/4	1/2	1 sec	2 sec	4 sec	8 sec	15 sec	30 sec
Corona - 8.0 Rs	-3	1/2	1 sec	2 sec	4 sec	8 sec	15 sec	30 sec	1 min	2 min

Instructions

Choose the ISO speed in the upper left column. Next, select the f/number of the lens or telescope (on same line as ISO). Finally, drop straight down to the bottom table to get the correct exposure for each feature of the solar eclipse.

Note that the brightness of the corona varies dramatically with distance from the Sun's edge. All exposure values in this guide are estimates. For best results, use them only as a guide and bracket your exposures.

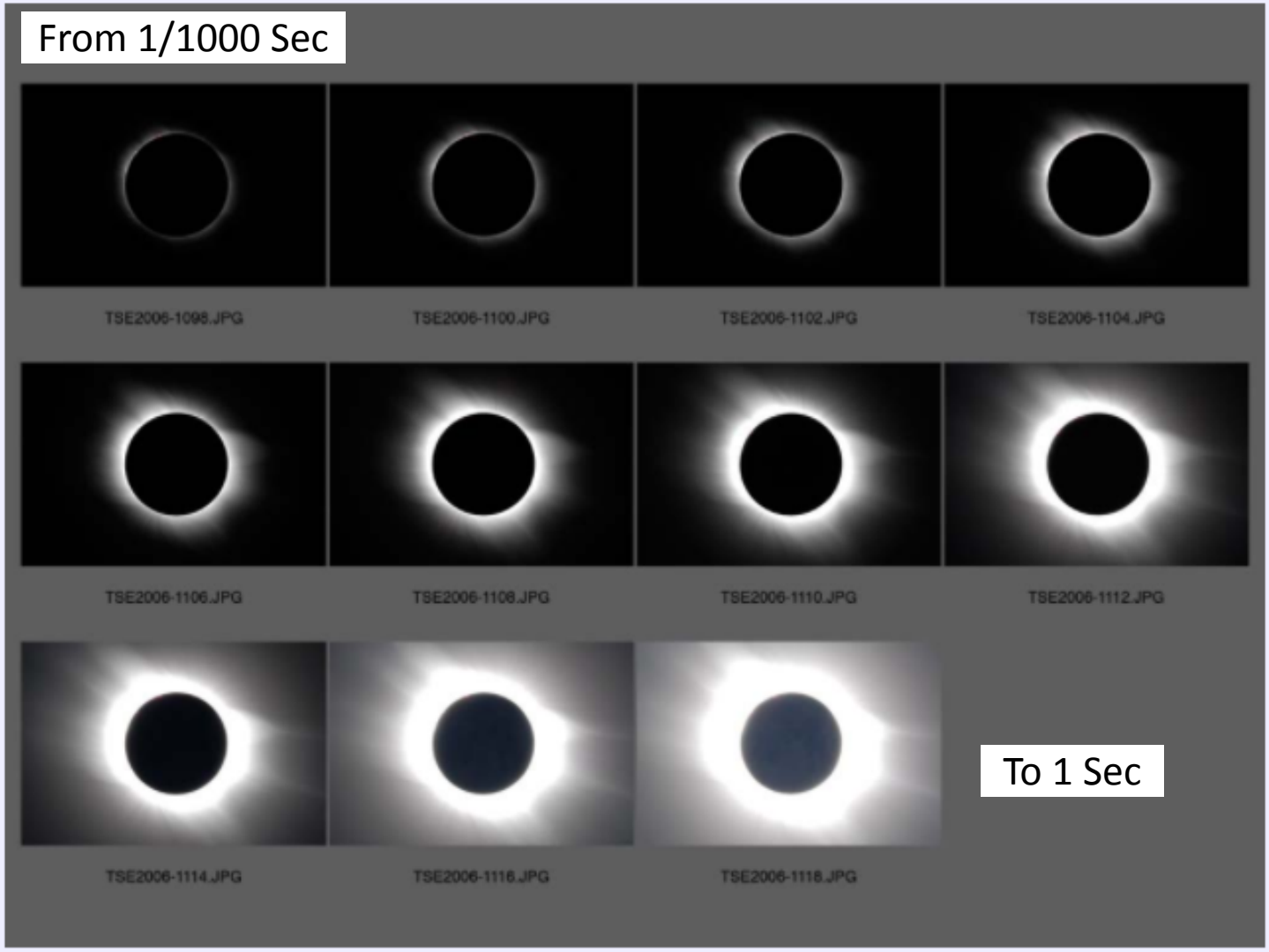
Exposure Formula: $t = f^2 / (I \times 2^Q)$

where: t = exposure time (sec)
f = f/number or focal ratio
I = ISO film speed
Q = brightness exponent

Abbreviations: ND = Neutral Density Filter.
Rs = Solar Radii.

Notes: [1] Exposures for partial phases are also good for annular eclipses.
[2] Baily's Beads are extremely bright and change rapidly.
[3] This exposure also recommended for the *Diamond Ring* effect.

Photographing a Total Solar Eclipse



Exposure Bracketing Sequence
The sequence above was made by shooting a series of bracketed exposures ranging from 1/1000 to 1 second (ISO 200, f/9) total solar eclipse of 2006 Mar 29 from Jalu, Libya.

The next two Total Solar Eclipses

BACKUP

BACKUP INFO

Photographing a Total Solar Eclipse

Neutral density filter reduces the amount of light going into the lens, so you can take long exposures even when the light is bright. Or you can take photos of extremely bright objects like the Sun. These types of filters usually costs up to $200 (especially on larger diameter lenses), but with this simple hack, you can make it for only $5 using Welding Glass.

The welding glass can be purchased online or at any welding supply store for about $5. Most pieces of welding glass are tinted a blue or green, you can get rid of the tint in post processing. How you construct your filter is up to you. One method on line is to secure it with rubber bands, like the thick blue rubber bands from a produce store.

Compose your shot before you put on the welding glass, (you won't be able to see out of your viewfinder) after it is installed. Take your lens hood, put it on the camera lens backwards, and pull the rubber bands around the lens hood. Shown to the right. →

You can cover the camera with a opaque cloth, at least 24"x24", over the camera only.

Test your exposure setting for the setting you like while taking photos of the Sun.

Telescope and Binocular Solar Filters

- The first consideration is buy a good full aperture solar filter from a reputable dealer and manufacturer. They come made of Mylar and also coated glass. For my eyes, the glass ones are the only way to go. They are more expensive, but my eyesight is priceless. I personally think that plastic sheeting is just too easy to damage.
- Even a tiny hole in the plastic or in the coating can let dangerous levels of light through. Therefore, an important consideration is to check it EVERY TIME BEFORE you use it.
- Solar filters come in different types. A filter that blocks 99.99% of the incoming light is fine for photography, but NOT for visual observing. The most common type of solar filters block 99.999% of the sun's light and work for visual observation. This is the type that telescope manufacturers typically offer. But there are also filters that block 99.9999% of the light and are very safe. (This is the same level of protection as the #15 Welder's Glass –see the next page.)
- Why go full aperture? Well there are two reasons. First, do you want all that intense solar radiation focusing on small areas inside your telescope? It can cause serious damage. And related to that, but much more serious, it is not uncommon for the image of the sun to get so hot that it will crack the solar filters that are not full aperture. If that happens while you are looking through it, you will instantly permanently damage your eye; not even enough time to react.

Welder's Glass as Solar Filters

- You can buy a pair of "eclipse glasses" or you can use #15 Welder's Glass. Well I went out to buy some, and #15 is very hard to find. The people at the welding shops did not understand how you can combine two or more pieces to still get a safe value.
- The astronomy literature says you can't do it, but you can do it if you understand the formula behind the glass. You MUST NOT just add the Glass numbers.
- First the short form of the solution, for those not mathematically inclined. What you need to do is buy two pieces that total #16, or three that total #17. For every additional piece, add 1.

- #15 Welder's Glass blocks 99.9999 % of the light. This also means it only lets 0.0001 % of the light through. This is the level of transmission (T) that is quite safe. So this is the level we want. To calculate the Shade Numbers (SN) use this formula:
- $$SN = 1 + (7 / 3) * (-\log (T))$$

- If we start with the SN values, then the formula is: $\mathbf{T = 10^{(-(SN-1)*3/7)}}$
- If you do the math, you will see that two pieces of glass of SN = 8 and SN = 8 equal the same T value as one piece of SN = 15, and for three pieces of SN = 5 and 6 and 6.

Welding Glass and Neutral Density Filter

Welding Shade Number	ND1 Number Notation	Neutral Density (Lee/ Tiffen)	Neutral Density (Cokin/ Hoya)	Lens Opening Fraction 1/	F Stop Reduction	Luminous Transmittance				Max Effective Far-Ultraviolet Average Transmittance	Max Infrared Average Transmittance
						Filter	Welding Shade				
						Average %	Maximum %	Nominal %	Minimum %		
Clear				1	--	100	100	--	85	--	--
1.5					--		67	61.5	55	0.1	25
1.7	ND101	0.3	ND2	2	1	50	55	50.1	43	0.1	20
2							43	37.3	29	0.1	15
2.5	ND102	0.6	ND4	4	2	25	29	22.8	18	0.1	12
3	ND103	0.9	ND8	8	3	12.5	18	13.9	8.5	0.07	9
4	ND104	1.2	ND16	16	4	6.25	8.50	5.180	3.160	0.05	5
5	ND105	1.5	ND32	32	5	3.125	3.160	1.930	1.180	0.02	2.5
	ND106	1.8	ND64	64	6	1.563					
6		2.0		100	6 2/3	1	1.180	0.720	0.440	0.01	1.5
	ND107	2.1	ND128	128	7	0.781					
	ND108	2.4	ND256	256	8	0.391					
		2.6	ND400	400	8 2/3	0.25					
7	ND109	2.7	ND500	512	9	0.195	0.440	0.270	0.164	0.007	1.3
8	ND110	3.0	ND1000	1024	10	0.098	0.164	0.100	0.061	0.004	1
	ND111	3.3	ND2048	2048	11	0.049				0.003	.9
9	ND112	3.6	ND4096	4096	12	0.024	0.061	0.037	0.023	0.002	.8
		3.8	ND6310	6310	12 2/3	0.016					
10	ND113	3.9	ND8192	8192	13	0.012	0.023	0.0139	0.0085	0.001	.6
		4.0	ND10000	10000	13 1/3	0.01					
11		4.2		16384	14		0.0085	0.0052	0.0032	0.0007	.5
12		4.5		32768	15		0.0032	0.0019	0.0012	0.0004	.5
13		4.8		65536	16		0.0012	0.00072	0.00044	0.0002	.4
		5.0	ND100000	100000	16 2/3	0.001					
		5.1		131072	17						.3
14		5.4		262144	18		0.00044	0.00027	0.00016	0.0001	.3
		5.7		524288	19						
		6.0		1048576	20						