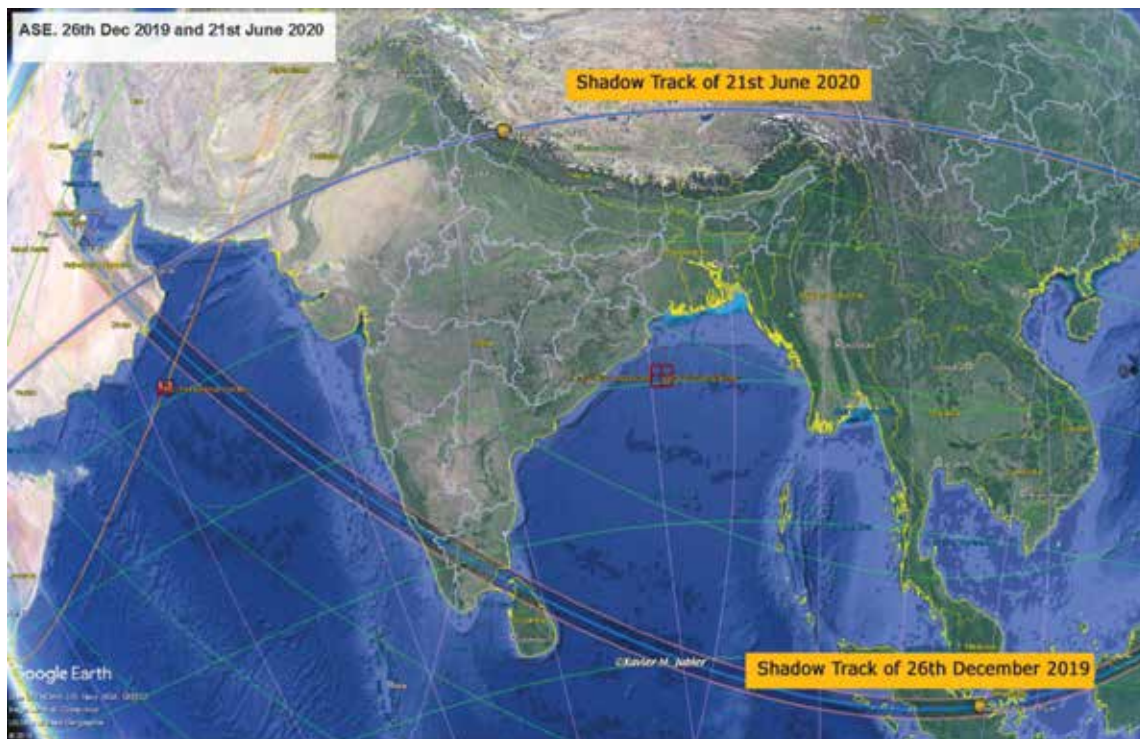


# “RING of FIRE”

## Double Bonanza for India

Debasis Sarkar

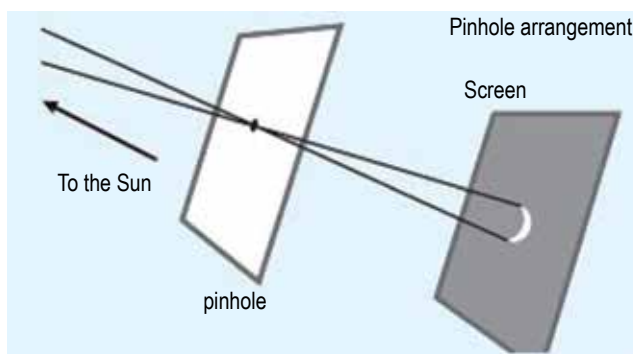


Shadow Track of ASE 26<sup>th</sup> December 2019 and 21<sup>st</sup> June 2020. Credit: Xavier Jubier

**I**NDIA is the lucky recipient of a bonanza of two solar complete eclipses in a span of just six months. On the first of this eclipse pair, Moon’s 118 km wide shadow will swipe over south India on 26 December 2019. Following that, Moon will draw its much narrower 21 km wide footprint over North India on the 21<sup>st</sup> of June 2020. People within these shadow tracks will get to see all the phases of these eclipses including grand ‘Annularity’ that offers ‘Ring of Fire.’ During this few-seconds-long Annularity, the Sun appears as a dazzling ring with Moon obscuring its central portion. Those living out of the shadow tracks will miss the Annularity, but get the partial phase.

In India, we are getting Solar Eclipse after almost 10 years and will need to wait till 2031 for the next one after this pair. Naturally, you cannot afford to miss it.

Since the last Solar Eclipse in India on 15 January 2010, digital photography has taken a quantum jump. While DSLR or Mirrorless bodies and large focal length lenses have become easily available, cell phone cameras have become smart enough to give stunning output even in solar eclipses. Naturally, shooting an Eclipse is no more confined to the domain of experts. The ‘Ring’ is no more for the ‘Lords’ only.



This is the first time Indian amateur sky enthusiasts will watch and shoot the solar eclipse through H-Alpha optics – highly sophisticated equipment that can show turbulence on the solar surface, gigantic fire flames coming out of the Sun, its filaments, flares, etc.

### The Annular Solar Eclipse

Solar Eclipse takes place on a New Moon day when the Moon comes between the Sun and Earth in a straight line. This causes the Moon’s shadow to touch and swipe the Earth’s surface creating a solar eclipse.



Shadow Track of ASE 26 December 2019 (118 km side)



Shadow Track of ASE 21 June 2020 (21 km wide)

But, not every New Moon can create an eclipse.

The Moon's orbit around the Earth is tilted with relation to the Earth's orbital plane by 5 degrees with two intersecting points – 'Ascending Node' and 'Descending Node.' Thus, despite the Moon being between the Earth and Sun on every new Moon, the three do not always come on a straight line or cause an eclipse. Interestingly, these nodes also rotate around the Earth once in 18 years. In this way, if a new Moon takes place when a node is also between the Earth and Sun, the three come in a straight line and an eclipse takes place.

The apparent visible size of the Sun and Moon (around 0.5 degree) always keeps on changing due to the elliptical shape of the Earth's orbit around the Sun and the Moon's orbit around the Earth.

If a Solar Eclipse takes place when the Moon appears slightly smaller than the Sun, it cannot cover the entire solar disk and leaves the Sun's bright outer edge visible as a 'Ring of Fire'. This is called the Annular Solar Eclipse. This is the only time when one can find two shadows for everything in all the sides under the sunlight because the light source during Annularity is a giant illuminating ring.

On the other side, when an eclipsing Moon appears bigger than the Sun, it obscures the entire bright disc of the Sun; this is called Total Solar Eclipse – the only time when a much fainter outer corona of the Sun becomes visible.

### Cycle of Solar Eclipse

Solar eclipses follow a definite cycle in a repetitive chain. Every eclipse is a member of a 1226 to 1550 years long chain known as Saros series. Each series gives us 69 to 87 eclipses. Two consecutive eclipses of the same series are separated by a period of 18 years 11 days and 8 hours (6,585.3 days). This is called a Saros. Interestingly, more than one Saros series continue simultaneously giving us two solar eclipses almost every year.

### Phases of Annular Solar Eclipse

An ASE comes with five distinct points in its entire duration:

- **1st contact:** Lunar disc touches the Sun. Moon's silhouette starts engulfing the solar disk beginning Partial phase.
- **2nd contact:** Moon's silhouette gives birth to 'Annularity.' For a few seconds, we get to see 'Bailey's Beads.' This is a thin fragmented ring caused by passage of sunlight through the rough edge of the Moon.
- **Maximum eclipse (E-Max):** Midpoint of Annularity. The 'Ring of Fire.'



- **3rd contact:** Annularity ends. Once again, we get Bailey's Beads.
- **4th contact:** The Moon comes out of the solar disk ending the partial phase and the eclipse.

A complete ASE can last over 3 hours. But the duration of Annularity ranges from just less than a second to over 12 minutes.

### Viewing/Shooting

Location is vital. A place closer to the centerline of the shadow track will give the longest duration of Annularity and uniform shape of the ring. Long duration cloud coverage study suggests west coast as the preferred choice for the December eclipse. And for June 2020 eclipse in Northern India, Western Rajasthan is the definite choice.

### Eye Safety

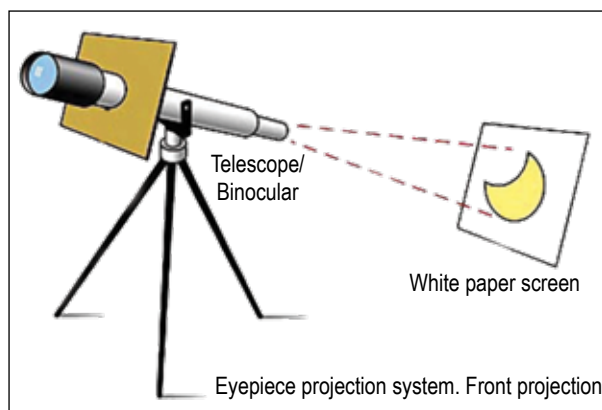
**Observing or shooting the Sun without proper protection is dangerous. Severe irreversible eye damage may take place with improper viewing for even seconds.**

The Sun is too bright to see or shoot directly. We must bring down this brightness to 1/1,00,000th using special solar filters of Density 5. Fortunately, quality solar filters are now available in India. Optometry expert Dr B.R. Chou suggested Welder Glass of (W14) as a safe alternative. Specialized sun goggles meeting ISO 12312-2:2015 international standard are safe for direct viewing.

Traditional items like used X-ray plates, smoked glass, CD, floppy disks and cheap unapproved sun goggles are very unsafe. They may attenuate the visible portion of the sunlight (wavelength 400 nanometre to 700 nanometre) but cannot reduce the energy factor of invisible infrared or ultraviolet portion adequately.



Telescope eyepiece projection system (Back Projection) projecting Sun during Transit of Venus in 2004. The white circle is Sun and small black dot at 6 hr position is Venus



### Shooting the Solar Eclipse

1. **Direct Method:** Viewing or shooting through optics like telescope, spotscope, binoculars or monocular with suitable solar filters.
2. **Indirect method:** By creating an image of the Sun through a telescope, binocular, pinhole camera or solar projector and then shooting that image.

### Mobile or Compact Cameras

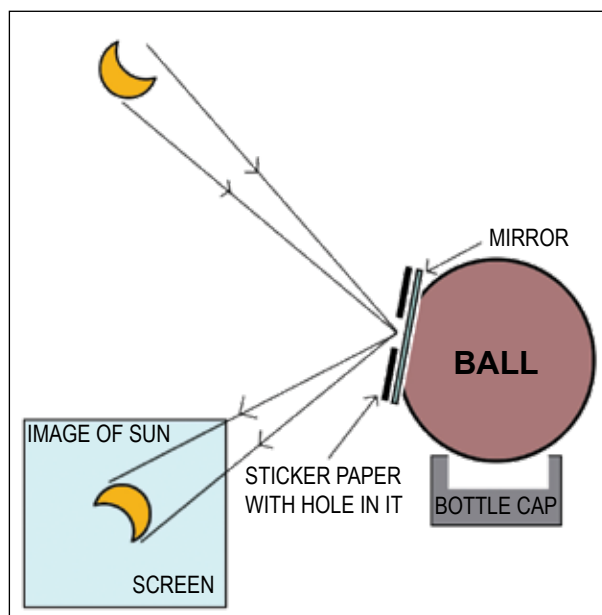
Since we had the last solar eclipse in India, mobile phone cameras have taken a quantum jump in quality and features. Some models come with even 10x optical telephoto power that makes them quite good to shoot ASE. Compact cameras offering 10x or 20x optical zoom are also good enough. Do not count or use digital zoom.

Mobiles or compacts with low optical zoom can be attached to external optics like monocular, spotscope, binocular or telescope to obtain large images. This is called Afocal arrangement. A 10x monocular coupled with a mobile of optical 2x tele-power can offer  $10 \times 2 = 20 \times$  magnification.

First put the solar filter on the mouth of the monocular, spotscope, telescope or on one side of the binocular (other side sealed). Look at the Sun through the eyepiece. Ensure best possible focus. Now, take the camera or mobile and set focus at an infinite distance. Adjust exposure seeing preview on LCD panel. If the camera or mobile doesn't support manual focus or exposure override, let those be in 'Auto' mode. It's a WYSIWYG ('What You See Is What You Get'). Simple couplers to physically attach mobiles or cameras with optics are easily available online.

### Using DSLR or Mirrorless Cameras

DSLR or Mirrorless cameras are the best. A 500 mm or 600 mm lens is good enough optic. Or any Reflector, Refractor or Cassegrain telescope of even higher focal length can be used as optic. It is known as Direct Objective arrangement where a camera body is directly coupled with a telescope without any eyepiece or camera lens in between. To accommodate a bigger solar image with 1500mm or higher focal length telescopes, full frame cameras should be preferred.



Sun projector

### Suggested exposure settings for both Afocal or Direct Objective. Actual exposure duration may vary.

	ISO 200	ISO 400	ISO 800	ISO 1600
f/4.5	1/2000	1/4000	1/8000	-
f/5.6	1/1000	1/2000	1/4000	1/8000
f/8	1/500	1/1000	1/2000	1/4000
f/11	1/250	1/500	1/1000	1/2000
f/16	1/125	1/250	1/500	1/1000

Shutter speed (in second) at different ISO and f/ ratio settings.

Focal ratio (f/\*) of the optic is an important factor to determine the shutter speed. We can calculate the ratio by dividing the focal length of the telescope by the diameter of its front element. Example: An optic of 1000 mm effective focal length and 100 mm diameter will have ratio of f/10 (1000/100). Solar filter must be attached at the front of the optics.

### Indirect Methods

**Pinhole Camera:** Cut the smaller side of a shoe box. Cover this with butter paper. Make a tiny hole using a pin at the centre



H Alpha Image of Sun.

Photo: Debasis Sarkar, Janmejy Sarkar



Double shadow during Annularity of ASE 2010.

Photo: Debasis Sarkar



Monocular attached to a cellphone using coupler.

Photo: Debasis Sarkar

### Time Chart for different cities near shadow track

Place	Eclipse Duration	Annularity Duration	C1	C2	E-max	C3	C4
<b>26 December 2019</b>							
Kanhagad	179 min, 54 sec	186 sec	8 04 41	9 24 15	9 25 47	9 27 21	11 04 35
Tirupur	185 min, 25 sec	186 sec	8 06 30	9 28 24	9 29 58	9 31 30	11 11 55
Arvakkurichi	186 min, 50 sec	187 sec	8 07 00	9 29 31	9 31 05	9 32 38	11 13 50
Pudukottai	189 min, 1 sec	183 sec	8 07 48	9 31 19	9 32 52	9 34 22	11 16 49
Artantangi	189 min, 34 sec	170 sec	8 08 02	9 31 44	9 33 19	9 34 54	11 17 36
<b>21 June 2020</b>							
Sirsa	205 min, 40 sec	24 sec	10 16 52	11 56 02	11 56 14	11 56 26	13 42 32
Kurukshetra	206 min, 21 sec	30 sec	10 21 16	12 01 36	12 01 51	12 02 06	13 47 37
Yamunanagar	206 min, 29 sec	27 sec	10 22 18	12 02 57	12 03 09	12 03 24	13 48 47
Dehradun	206 min, 31 sec	18 sec	10 24 02	12 05 09	12 05 18	12 05 27	13 50 33
Joshimath	206 min, 47 sec	27 sec	10 27 49	12 09 47	12 09 59	12 10 14	13 54 36

Timechart for different places near centerline for timechart for other places may be obtained by sending Lat Long of the location to author through E mail. debasislg@gmail.com skywatchersindia@gmail.com

of the opposite side. Face the pinhole towards Sun and look at the butter paper screen from the other side. You should get a small image of the Sun (around 3 mm in dia). The box can be made of any other size. Bigger the box, bigger the image but weaker the brightness.

**Eye-piece Projection:** Fix your telescope or binocular on a stand, without any solar filter. Look at the Sun. Allow sunlight to enter through the front end of the optics and come out through the eyepiece to get projected on a white screen. A little bit of focusing of the eyepiece will make the image sharper. It can be a front projection on open screen or a back projection in a closed box. For Binoculars, one side must be kept sealed. Extreme precaution must be taken to ensure that the beam of Sunlight always comes out through the eyepiece instead of falling inside for long. That can cause severe damage to the equipment.

**Sun Projector:** Safest and easiest. Take a piece of mirror and a sticker paper. Cut a circular hole of 1.5 cm dia in the sticker. Stick it on the front surface of the mirror. Fix it on a rubber ball of around 7–10 cm dia. Place the ball on a bottle cap so that it can be oriented in any direction. Place it under the Sun to project a circular image of the Sun inside a darkened room.

All these three indirect viewing setups will need constant reorientation during the eclipse as the Sun will keep on moving. Any camera can be used to photograph these indirect images.

### Points to remember

- Keep a black cloth to cover yourself and your camera monitor. Viewing LCD panel under sunlight is a nightmare.
  - Stable tripod is a must.
  - All the gadgets will need continuous re-orientation.
  - Experienced users, avoid using eyepieces with cemented lens elements like Kellner, Plossl or Nagler class. Rather use Huygen or Ramsden type.
  - Sun goggle should be used over usual spectacle.
  - Sun goggle is must for both Partial and Annular phases of ASE.
  - It is economical to buy solar filter sheets and then cut it to size to frame and mount.
  - Hold solar filter pieces at the corners only to avoid damage while mounting them. Damaged filter must be discarded.
  - Unlike Total Solar Eclipse, sun filter must be kept on for the entire duration of ASE.
  - During annularity, the sky does not become completely dark as it happens during totality phase of Total Solar Eclipse.
  - Enjoy own shadow just before or after Annularity. Razor sharp but faint. It never happens so except Solar Eclipse.
  - Do not miss taking pictures of own shadow during Annularity. This will be double at all sides.
  - Cross fingers. Allow sunlight to pass through the tiny holes in between them and fall on a wall or floor. Instead of usual solid round images of Sun, there will be rings.
  - Enjoy a sharp decline in atmospheric temperature just before Annularity. And rise immediately after Annularity. (This will be more noticeable during June 2020 ASE.)
  - In case of any technical glitch with the camera during annularity, just leave it. Put your sun goggle on and look towards the 'Ring of Fire'. Shoot the heavenly view with the best camera one can think of. Eyes.
- Wishing all a clear sky.

Mr Debasis Sarkar is a journalist with a passion for astronomy & photography. He was selected as one of the 24 members of the Trans-continental Coronal Observing Network lead by Mr. Fred Clett, Director of Royal Observatory of Belgium during 1999 Total Solar Eclipse; Chosen by National Film Board of Canada as one of the four global subject persons for its 58-minute long documentary movie on Total Solar Eclipse 1999 *Shadow Chasers*. Address: Sky Watchers Association of North Bengal, "Subarna Kutir" 57, Aban Tagore Sarani, Deshbandhu Para, Siliguri, West Bengal-734004. Email: skywatchersindia@gmail.com & debasislg@gmail.com