

Total Solar Eclipse 22nd July 2009

Aamod Karkhanis

I will be going out of town on 22nd July. What about you?

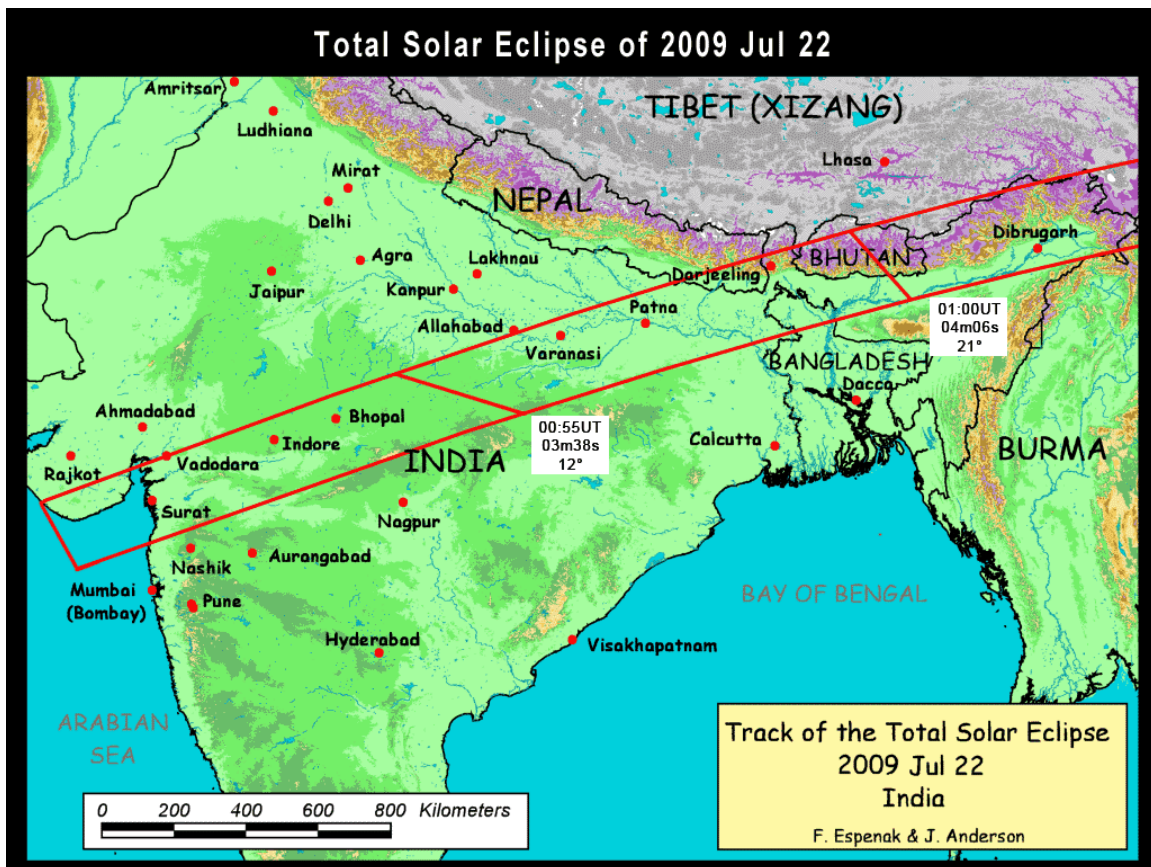
You must have thought, what is so special about 22nd July that I have to start the article with the statement that I will be going out of town – why and where.

Well, I stay in Mumbai. July is not the best time to be in Mumbai. The monsoon will be at its peak and in Mumbai it not just rains, it pours; it may rain a few hundred millimeters of rain in one single day.

But the rains is not the reason I am going to be away from Mumbai on July 22nd.

I do not want to be in Mumbai on that day .. I have not decided where I should be going but it will be either Surat, Indore, Bhopal, Vidisha, Vaanasi, Patna or anywhere near the region.

What is so special about these places and what is so special about 22nd July?
See the chart below and you will get an idea ..



Eclipse Predictions by Fred Espenak, NASA's GSFC

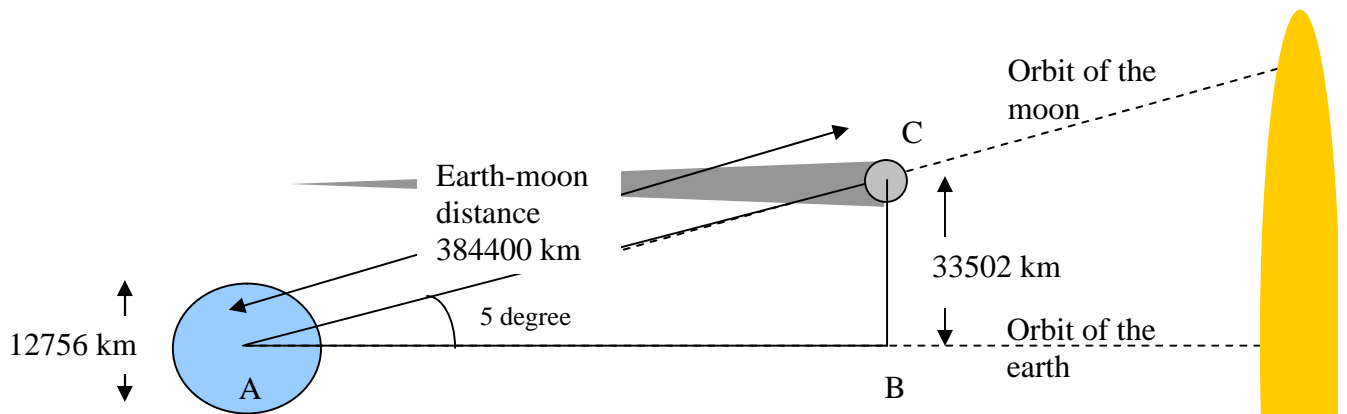
There will be a total solar eclipse on 22nd July. The figure above shows the region where the totality will be visible, Surat, Bhopal, Indore, Varanasi, Patna all are in the path of totality. Total solar eclipse is a rare phenomenon; the next total solar eclipse that we can see in India will be in 2034. The last solar eclipse was in Jan 2009 but that was not total. I do not want to miss this one, so am all set to go and be somewhere from where I can experience this celestial drama.

Why do eclipses occur? We all know the answer, we have learned in the school. The solar eclipse occurs because of moon coming between the sun and the earth, when sun, moon and earth are in the straight line. And perhaps with just this information our brush with Astronomy in the school gets over. Actually astronomy is a very old science, eclipses are such dramatic events that they have been attracting attention of all. Any change from normal causes fear. The eclipses have been associated with ill omen or with bad things in all civilizations and cultures. The early astronomers looked at the entire world from an earth centric point of view. They found that the eclipses occur only when Sun is at a certain place (with respect to Earth). The common man's story was there are two demons Rahu and Ketu who swallow the sun and cause eclipse; the astronomers understanding was that the moon comes between earth and sun at two points. The question remains why only at these two points and what sort of mathematics does one need to predict the eclipses?

Actually it is quite easy. We know the earth revolves round the Sun in a somewhat elliptical orbit. This orbit lies in one plane. This plane is called the 'ecliptic'. If the Moon was to rotate in this plane itself we would have had solar eclipses every no moon day and lunar eclipse every full moon day.

Fig 1

But as shown in the figure above, the plane of moon's orbit around the earth does not coincide with the plane of orbit of the earth around the sun. It is inclined at a small angle, approximately 5 degrees. 5 degree appears to be a small angle but considering the relative sizes and distance of the earth and moon it is sufficient for the moon shadow to miss the earth.



The above figure is greatly exaggerated but should serve to understand the trigonometry. The angle between the earth's orbit and that of the moon is 5 deg.

Here in triangles ABC, angle CAB = 5 degree, CA = earth moon distance = 384,400 km. (sin ? = ht / hypotenuse)

$$\sin(5 \text{ deg}) = 0.0871 = \text{CB}/\text{CA} \Rightarrow \text{CB} = \sin(5 \text{ deg}) * \text{CA}$$

$$\sin(5 \text{ deg}) * 384,400 = 33,502 \text{ km.}$$

Diameter of the earth is 12,756 km

So just a tilt of 5 degrees and the shadow of the Moon misses the earth by large amount.

So normally an eclipse should not occur. But look at the first figure again .. when the earth was at position C the situation was as described above, the shadow of the moon missed the earth. But what about when the earth is at point B?

The ellipse describing the orbit of moon cuts the Earth's orbit at two points. These points are called nodes. When the earth is at point C and even if the moon is in the node points it is not a no moon day – no eclipse.

But what happens when the earth is at point B?

If the moon is at the node facing the sun – the sun, the moon and the earth all are in the same line. This time the shadow of the moon will fall on the earth and we will have an eclipse.

We will have a similar situation on the other half (at point A). The ancient Indian astronomers called these points Rahu and Ketu.

Every time the earth passes thru these two points there is a possibility of an eclipse. We know the earth completes one rotation in one year so we should have an eclipse exactly every six months.

But that does not happen ..

Things are not as straightforward .. the lunar month is 29.5 days. One year has 365 days. 365 is not exactly divisible by 29.5. This means we do not get full moon or no moon on the fixed days in a year, this also means we may not have a no moon day when the earth is crossing the Rahu, Ketu points.

Actually even if there is a no moon day while the earth is nearby the Rahu-Ketu points we may get an eclips, may be a partial one. If a no Moon occurs within +/- 5° of a Node, we will get a total or annular eclipse.

Once we know the angle of inclination (of moon's orbit) the nodal points at which the three can come in a straight line are fixed. The earth will cross these points on the same day each year. So all eclipses should always fall on either of the two days. But that too is not the case.

The plane of the Moon's orbit round the Earth is not fixed in space, but swivels round with respect to the Ecliptic (the plane of Earth's orbit). It goes thru a complete cycle every 18 years.

In the figure below the bottommost plane is the ecliptic. The plane shown by the pale grey rectangle is the plane of orbit of moon round the earth. This is inclined at an angle of 5 degrees. If you swivel this rectangle along the axis AA' we get a different plane .. shown by the dark grey rectangle. Note this new plane is still inclined to the ecliptic by 5 degrees. Now the new plane will cut the ecliptic in a different line, slightly shifted to right...

This swiveling angle is changing slowly – it will go on increasing, reach a maximum, go on reducing, reach a maximum on opposite side and again start swinging in opposite side .. all in a cycle of 18 years. So every year the Rahu, Ketu points shift and will occur at a different time. (the Rahu, Ketu points will shift by 9.82 days each year) But the entire cycle will repeat every 18 years; 18 years, 11days and 6 hours to be precise.

Now we have a way to predict when the next eclipse will occur, all that we have to do is to check last 18 years record and simply repeat. This period was known to the ancient astronomers. This period is known as Saros.

We have had a partial solar eclipse just about 6 months ago, on 2009 Jan 26. Adding 18 years, 11 days we predict there will be a solar eclipse on $2009 + 18 = 2027$ Jan 26 + 11days = Feb 6 ..We should expect an eclipse on Feb 6 2027.

Similarly the 22nd July 2009 situation will repeat on $2009 + 18 = 2028$, July 22 + 11 = Aug 02. (Aug 02 2028)

NASA charts corroborate our results. Unfortunately both will not be visible in India.

You must be knowing the story of Jayadratha. Arjun had vowed to kill him for his sins before end of the day else he would kill himself. And Jayadratha went into hiding. The noon approached and Jayadratha was not found. It was now nearing evening and still no clue about his whereabouts. Arjuna started preparations to immolate himself. And the light started dimming, the yellow glow of the evening was set. Jayadratha from his hiding place saw the light dimming and now feeling safe came out of hiding. And to everyone's surprise the sun started shining bright again...

If the story is based on historical event, even with all mythical elements, distortions and exaggerations in all probability it describes an event that happened on a total solar eclipse day.

As we have seen total solar eclipse do not occur dime a dozen. After the 22nd July one, the next total solar eclipse that you can see in India will happen on year 2034. The Jayadratha story is a total solar eclipse that could be seen in India, Hastinapura in particular, and that too sometime later in the afternoon, is likely to be quite a unique. The noted freedom fighter Bal Gangadhar Tilak was an astronomy scholar. He was in the jail at Madale (now in Mynamar). An idea struck him. Why not try to deduce the period of Mahabharata based on different astronomical information given while describing the events of Mahabharata. One such data point he had was the story of Jayadratha and rare occurrence of the eclipses; another one is the constellation position described while the Bhismacharavay was lying on the ground. And interestingly his estimates were quite close to today's estimates.

Since we are on the topic let us look at some more numbers and see if we can find something interesting ..

The Sun happens to be 400 times the Moon's diameter, and 400 times as far away. That coincidence means the Sun and Moon appear to be the same size when viewed from Earth. But the Moon's orbit is not exactly circular. It is slightly elliptical. The moon's Perigee is 363,300 km and Apogee is 405,500 km. If the solar eclipse happens when the moon is at its apogee (that is when it is further away from us) we may not see the moon shadow covering the entire sun and we see an annular solar eclipse. When the eclipse happens when the moon is at Perigee the moon's shadow will cover the entire Sun and we see a total solar eclipse.



Actually when the moon is at the perigee it appears just a little bigger than the Sun. On July 22 it will be at a distance such that it will be 1.008 times the apparent size of the sun. So we will have a total solar eclipse that will last for about 3 to 4 minutes.

Coming back to our story, there will be a total solar eclipse on 22nd and I do not want to miss this opportunity. What about you?

Whatever you do, one thing you must not, is to be afraid of the eclipse and sit at home missing out on this lifetime experience!!

Aamod Karkhanis

An additional Box .. not related with the article, but may be interesting to the reader.

Box

But yes, do NOT view the sun with naked eye.

And yes, carry your camera. It is most convenient if you have a digital camera. You can look at the sun at the LCD screen, it is not harmful but not directly as in an SLR viewfinder.

Better to take a sufficiently big memory card, then you can keep the camera in continuous mode and if lucky, will be able to get some great shots of the diamond ring. It is very difficult to get the diamond ring shot without the continuous mode as by the time you see and click the Sun had come up further.

If you have a ultra violet filter on the camera use it, otherwise the sun will not be sharp. If your camera does not have one do not despair, try keeping the white balance so that the excess red is cut down.

As for the focus, keep to infinity or if using autofocus try focusing distant horizon.

Most cameras now a days have very good auto mode that will adjust shutter speed, aperture and film sensitivity. You should keep the setting to underexposed by at least 1.5 to 2 stops.

(Original, Unedited version)