Total solar eclipse – October 1995

On October 24 this year, the track of totality of a solar eclipse will cross a 40–55 km wide strip of land in northern India Total eclipse may be seen from any location within this strip, which will stretch from Rajasthan in the west to West Bengal in the east. The beginning of the eclipse will be over Iran at sunrise, and will end over the Pacific Ocean at sunset. In India, the total phase will be visible between 8.30 and 8.50 in the morning as the shadow will sweep over the country; the duration of totality on the centre line will range from 45 s over Rajasthan to about 80 s in West Bengal. Full details of the visibility of the eclipse have been calculated and given in the NASA Reference Publication No. 1344 (ref. 1). Weather conditions over the path are expected to be favourable[2].

One point about total solar eclipses often missed is that the view of the totally eclipsed sun cannot be obtained from outside the track of totality; what one can see is only a partially eclipsed sun. A few accompanying features such as considerable diminution of daylight, perhaps even a view of a few bright stars and planets may be seen, but most of the spectacles, the chromospheric flash, the glorious view of the corona, etc., will be missed. But these views are so rare that many who had stayed outside the track do not even realise what they have missed. I have come across many persons who claim to have witnessed a total eclipse, but on scrutiny it has come out that they have witnessed only a partial phase of the total eclipse. The records in such cases reveal that the track of totality of that particular eclipse did not pass through the city where they were located.

The chances of an eclipse track passing over a particular spot are very rare; statistical calculations indicate that on an average the chances are roughly once in 350 years We may check the rate by comparing the visibility chances at a few particular spots. This year the track will pass slightly south of the city of Calcutta; the last time such an event was seen from this locality was on 10 May 1575 during the reign of Akbar, the Mogul. The last time an eclipse track passed within 50 km of Bangalore was on 5 July 1293; the city was not even founded. The next time it will be on 5 July 2168, a really long wait indeed!

But as in all statistical figures, certain extremes are unavoidable. In recent history, two eclipse tracks crossed over Newfoundland in the eastern coast of Canada within two years and four months, i.e. on 7 March 1970 and 10 July 1972. Still more strange is a spot in Siberia, where three eclipse tracks passed over within eleven years, viz. 1941, 1945 and 1952.

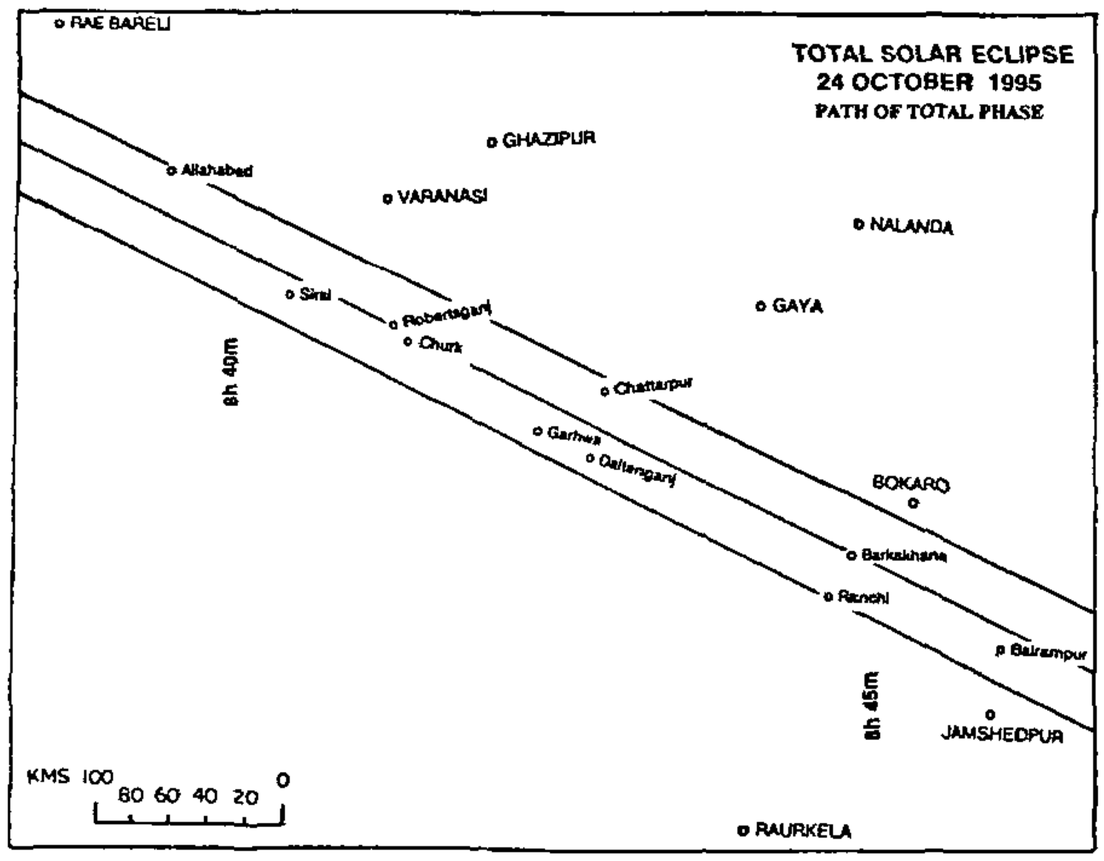
As far as the subcontinent of India is concerned, calculations reveal that during the twentieth century, eclipse tracks should pass over part of it just five times. Three events are already over; two, including the one this year, are yet to happen. The first was on 21 August 1914, when the track ended over the Rann of Kutch at sunset. The second, a similar one on 30 June 1954 had the path of totality slightly north, which again ended at sunset over the Rajasthan desert. The third one was the best among the five; its duration was about 3 min and the totality path crossed over Karnataka, Andhra Pradesh, and Orissa, and again over a short stretch over Mizoram. It happened in the afternoon with the sun still high in the sky and provided a unique opportunity of viewing the beauty of totally eclipsed sun to millions on its track. It is beside the point that countless numbers deprived themselves of this chance because of blind superstition.

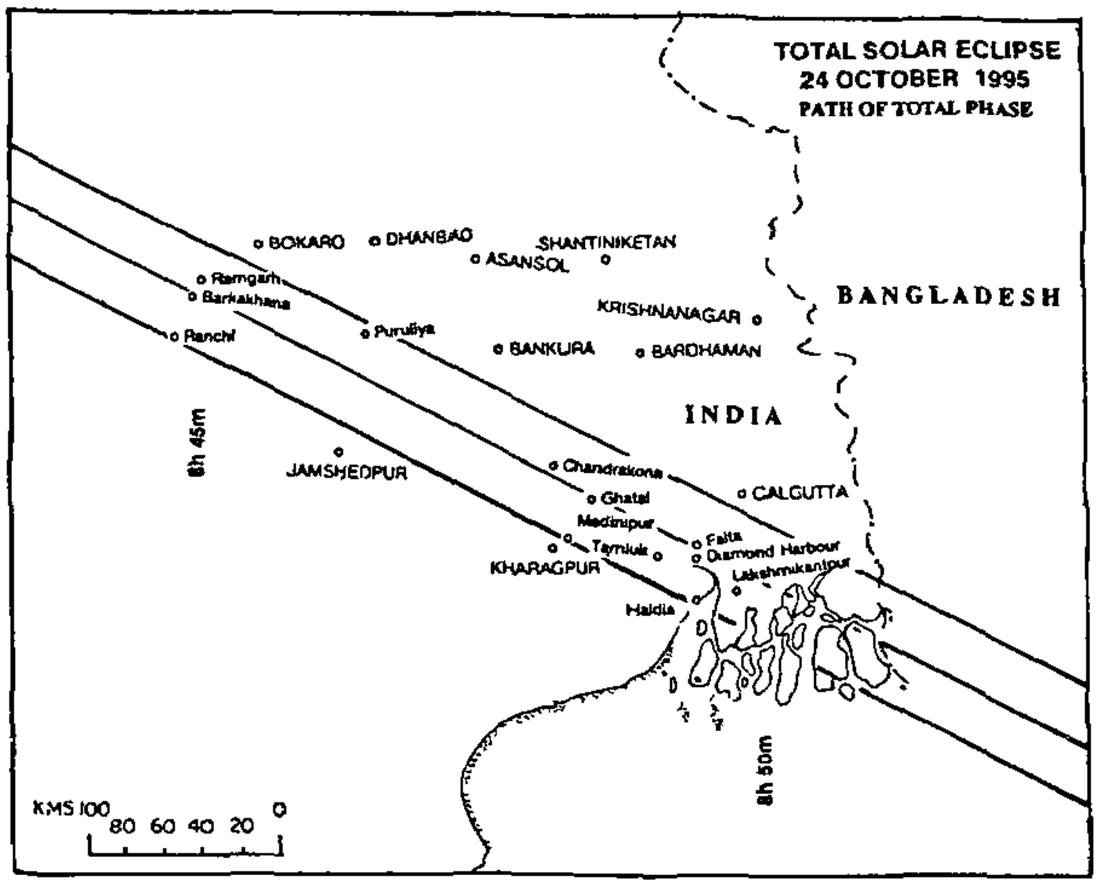
For this year's eclipse, detailed maps showing the eclipse path in India have been given by Singh[3]. I am giving only some important points about the event from the viewpoint of observers from India. The first glimpse of totality will be from a village Anandgarh on the Indo-Pak border at 0830 IST, with the sun 20° above the horizon; its duration will be about 45 s. Two fairly big towns in Rajasthan, Alwar and Bharatpur will fall in the eclipse path though not on the centre, as a result of which the duration of totality for viewers located at these places will be reduced. The cities of Agra and Etawah will fall just outside the path, while Allahabad and Mirzapur will be just inside; but to get a good view of the eclipse the viewers will have to move some 10–15 km to reach the centre of the eclipse path. In Bihar, both Ranchi and Hazaribag will fall a few km outside, so also the metropolis of Calcutta, whose southern suburban area will be just inside the eclipse path Duration here on the centre of the track will be about 80 s, with the sun's altitude about 40° at mid totality.

After this year's eclipse, one more eclipse track will cross over India in the late afternoon of 11 August 1999. The course of the shadow will cross Gujarat, Madhya Pradesh and Andhra Pradesh and will end at sunset over the Bay of Bengal. But considering the seasonal chances of monsoon clouding over the eclipse path and the lower altitude of the sun in that event, this year's eclipse appears to be the last good chance for Indian scientists in this century for arranging experiments which will hopefully produce some vital clues to the mystery of the sun.

The scientific explanations for the occurrences of total eclipses and various observable events are available in the literature; scientific experiments undertaken during such events are also extensively covered in some review articles[4]. We may skip those points to avoid unnecessary repetition and concentrate on various features observable by amateur astronomers and general viewers. We may carefully note one warning: looking at the bright disc of the sun without protection is hazardous. During an eclipse event, most of the time the uneclipsed part will be visible, it may only be viewed through a heavily darkened filter. The type of goggles which the welders use are quite suitable; they cut down the brightness to about 10^{-4}, which is essential. An alternative can be prepared by exposing black and white photographic films to daylight (not direct sun) and developing them fully in the dark room. The films can then be fixed in hypo, washed and dried in air. One layer may not provide the extinction needed; two or three layers mounted together may be necessary. The sun through this composite may look brownish and can be viewed without any discomfort.

Once armed with this device, we can venture to view an eclipse event . Let us imagine that we are located at the centre of the path of totality. The invisible moon will be approaching the sun from the west; the first contact will appear as





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an almost unnoticeable dent in the solar disc. Minute by minute the eclipse will grow; slowly we will be able to recognize the dark shape of the moon. The moon appears here as pitch dark, even though considerable light reflected from the earth illuminates its face. This appearance is purely due to contrast to the uneclipsed part of the bright photosphere.

Not very spectacular things seem to have happened as yet: there is a gradual decrease in general illumination and the air temperature starts falling, and this can be felt. I have been told that confusion can be noticed among flocks of birds and herds of cattle at the untimely appearance of the dusk, but am unable to describe in proper sequence from my own experience, because whenever I faced such a situation in the past, I was much too occupied and worried about my experiments to pay attention to these details. But one does not miss some amount of eerieness in the atmosphere at that time

Something noticeable happens in the shadows cast by obstacles. If we have a tree nearby then through some gaps in the foliage tiny bits of sunlight fall on the ground. In normal times these take the form of diffuse circles of light but now one may clearly notice sickle-shaped light spots instead. In fact, these are pinhole images of the partially eclipsed sun through the narrow openings in foliage. It is as expected from the laws of physics, but nevertheless quite striking in appearance.

Now let us turn our attention to the sun; the sun is already in a crescent form, something similar to the crescent moon, only the edges are much sharper. They get thinner and thinner and ultimately break up into a string of bright beads; these are called Baily's beads after the scientist who first described the phenomenon in 1836. The appearance is due to unevenness of the lunar limb; the photosphere may shine through small valleys for a few seconds more after almost the entire disc has been covered by the moon. Sometimes the presence of a deep valley may produce a 'diamond ring' event, when just one very bright point as if mounted on a ring of pink chromosphere may be seen. Any idea of the beauty of this diamond ring is difficult to convey to a person who has not seen it.

One more interesting piece of observation may be made at this juncture; bands of light and shadow may be seen on the ground, rippling all over. There are different appearances of these shadow bands, and in that unreal atmosphere the observers imagine different things. Some see them as if standing in a snake-pit with vipers crawling all around, and some see the event as faint shadow ripples passing under their feet. The phenomenon is similar to the twinkling of stars and owes its origin to the irregular refraction by atmospheric eddies. The only difference is that shadow bands cast in the light of bright stars are not detectable in reflected light, but the tiny Baily's beads are much brighter and the bands created in their light are easily detected by unaided eye.

The pink chromosphere flashes out as soon as the photosphere is covered; if the sun is active, a few prominences, plumes of glowing solar gas stretching out of the limb may be seen. The view lasts for one or two seconds only, but this short stretch of time is most eagerly awaited by solar physicists, ever since Janssen and Tennant did the pioneering experiments on the tobacco fields of Guntur on the morning of 18 August 1868, when a new element helium was discovered, 27 years before it was detected in a British laboratory by William Ramsey.

For amateurs and general eclipse viewers I may safely recommend an interesting observation. The only instrument one will need is a pocket-sized direct vision spectroscope. One should keep looking through this instrument at the thinning crescent sun; the protective dark filter should be removed; the spectroscope will disperse sunlight automatically bringing down its intensity to a safe level. One will see dark Fraunhofer lines clearly; the moment the photosphere is covered by the moon, all dark lines will flash into an array of vividly coloured emission lines. This experiment was first performed by C. A. Young of Princeton University during the eclipse of 22 December 1870, and ever since it has been repeated almost in all eclipses, not only for the valuable information about the detailed structure

of the solar chromosphere but also for the sheer magical beauty of the event.

As the moon will cover up the thin chromosphere, the pink light will fade and be replaced by the pearly white glow of the solar corona. I must repeat that the protective dark filter will have to be removed during totality, otherwise all of these interesting views will be missed. The size and shape of the corona varies from eclipse to eclipse, depending upon the phase of the solar activity cycle. At sunspot maximum the corona will be extensive and covers all sides, while at minimum it generally avoids polar regions and extends mainly over the solar equator. This year's eclipse will be near a sunspot minimum and the latter shape is expected. But even then, the glow of the corona will prevent the sky from becoming totally dark; there will be almost as much light as that from a full moon, but it will be more mysterious, more ethereal, spinning a web of fantasy over the whole atmosphere.

The pictures of the solar corona we see on the pages of astronomy textbooks are far from inspiring, most of the intricate beauty being lost in the recording process. But the eye can perceive many details of streamers and rays, and catch the subtle display of light and its variations over the precious seconds of totality. Of course, the new recently developed techniques of scientific processing of the coronal photographs in the laboratary can bring out part of the lost information, though not the beauty of the grandest spectacle of nature.

The totality ends rather suddenly, with a brief appearance of chromospheric glow, Baily's beads and, if lucky, with a diamond ring event; then one can see even the moon's shadow racing away, and daylight reappearing like a flood. The eclipse is over, although the crescent sun will take almost an hour more before assuming the normal full disc form.

It is indeed a pity that many persons refuse to see the total eclipse because of superstitious ideas. Some think that harmful radiations emanate from the sun during eclipses; some even go to the extreme of imagining that poisonous gases pervade the earth's atmosphere. The unusual happenings in the sky used to strike terror in the minds of primitive men, who imagined demons devouring the sun and eventually destroying everything, the customary penances and ritual baths after the event are remnants of the original feeling of terror. The ideas of a demon devouring the sun have largely disappeared, but the fear of the unknown persists. I know persons who not only refused to observe the eclipse, but kept their entire families locked indoors to prevent them coming under the influence of the eclipse; even tiny holes in their windows were plugged to stop the light from the eclipsed sun to enter their homes. It is difficult to explain to them that nothing happens to the sun during eclipses; the shadow cone cast by the moon is always floating in space, and this just goes over the earth's surface during eclipses. Even the idea of generation of poisonous gases or bacteria in the shadow cone is unscientific; the earth also carries its own shadow cone on the night side, everyday we are living in it for twelve hours. It is futile to point out that these ideas are totally based on ignorance and have no trace of scientific logic. The persistence of the feeling is aided by the extreme rarity of the phenomenon; for people rooted to their homestead, the chance of viewing a total eclipse comes *once in fourteen generations.*

Many point out the occurrence of eclipse blindness which had totally spoilt the eyesight of many persons in the past. This fear is genuine but need not be attributed to any strange unnatural phenomena during eclipses. The real reason lies in the extreme brightness of the sun; if any person keeps on looking at the sun, his retina will also get burnt out, causing blindness. In normal times physiological reflexes prevent such mishaps but during the penultimate minutes just prior to totality, general illumination falls and human iris opens up to collect as much light as possible in the rapidly darkening surroundings. But the crescent sun retains the same intrinsic brightness per unit area, and its image focused on the retina with the fully opened eye-lens burns out a sickle-shaped area of the sensitive tissue. The dangerous aspect of this accident is that the observer does not feel any pain, and the damage is done without the viewer's knowledge. Prevention of such happenings is simple and has been prescribed earlier in this article. Nothing happens to the skin or any other part of the body by exposure to the eclipsed sun.

To conclude, I may say that this is a rare opportunity for many to witness an event which I may call as Nature's grandest spectacle. I am still to meet any person who has gone and witnessed a total solar eclipse, and repented the trouble and extra effort needed for his adventure.

On the eve of the total solar eclipse of 16 February 1980, Dr M. K. V. Bappu had addressed the Osmania University faculty and the students; I feel his concluding advice may be retold now. An excerpt below gives beautifully what I wish to convey to all enthusiastic viewers:

'I now think of the man who enjoys some of the nice sights of Nature, one who has got an aesthetic sense of feeling of appreciation of beauty, who enjoys a good sunset, who finds a feeling of delight at hearing the roaring waters of a waterfall or of a gurgling stream as it passes by, who delights in a good rainbow or takes a fancy for seeing the well-spun cobweb of a spider on a dewy morning; in short, an individual who is alert to his environment and who enjoys different aspects of it. I think there is much for him in witnessing one of these rare sights of the total eclipse of the Sun. I hope that he would just travel down not very far, just even twenty miles south of Hyderabad and take with him, probably a minimum of equipment, just his own eyes, and go through this delectable feast that is really only a feast of the Gods.'[5]

I have only to substitute the city of Hyderabad by a chain of cities in North India for this year's eclipse; otherwise, the advice remains the same for millions who do not wish to miss an opportunity of a lifetime.

1 Espenak, F. and Anderson, J., NASA Reference Publication No 1344, 1993

2 Singh, J., *Bull Astron Soc India*, 1994, **22**, 339–354

3. Singh, J., *Bull Astron Soc. India*, 1995, **23**, 3–12.

4 Bhattacharyya, J. C., *Indian J Radio Space Phys*, 1990, **19**, 525–533

5 Bappu, M. K. V., Contr Nizamia & Japal Rangapur Observatories Contribution, No 10, 1979

J. C. Bhattacharyya, Indian Institute of Astrophysics, Bangalore, India.