Mirror projection:

A small hand mirror provides an effective way of watching the eclipse safely. We use it to project an image of the Sun onto a suitable surface such as a wall.

Pinhole camera:

One safe way of enjoying the Sun during a partial eclipse or anytime is a "pinhole camera," which allows you to view a projected image of the Sun. There are fancy pinhole cameras you can make out of cardboard boxes, but a perfectly adequate (and portable) version can be made out of two thin but stiff pieces of white cardboard. Punch a small clean pinhole in one piece of cardboard and let the sunlight fall through that hole onto the second piece of cardboard, which serves as a screen, held below it. An inverted image of the Sun is formed. To make the image larger, move the screen farther from the pinhole. To make the image brighter, move the screen closer to the pinhole.

Telescope & binocular projection:

A better technique is to project an image of the Sun using a telescope or binoculars. Place a sheet of cardboard around the objective (the big end) of the telescope or binoculars, to act as a shade for a second sheet positioned behind the eyepiece, about a foot away.

The whole thing should be adjusted by trial and error; you can adjust the focus by means of the focusing knob, and by moving the screen. Again, do not look through the binoculars/telescope. Line it up using its shadow on the screen; when the shadow of the telescope is a circle, it should be about right. You should cover or remove any finder scope to avoid temptation. Again, it might be a good idea to set up a large sheet of card or a blanket around the projector, to create a shaded area in which the projected image can be seen more clearly. Setting this up can be a little fiddly, especially as the Sun is moving -- you will discover that the Sun actually moves quite quickly across the sky.

Eclipse Photography:

Does not use a simple "point and shoot" camera aimed at the Sun, as looking at the Sun through the viewfinder will blind you? Rather use it to photograph the scene around you as the eclipse develops. For the same reason take great care with a digital camera or video camera. Also check that the detectors in your digital or video camera will not be damaged by direct sunlight entering the lens.

To photograph the eclipse itself, use a 35 mm SLR camera, as follows:

- Turn off the flash or put black tape over it
- Use a solar filter when the eclipse is partial
- Do not use a solar filter when the eclipse is total
- Use a lens of 200 mm to 1000 mm focal length for a reasonable image size
- Use fast film such as ISO 400 to minimise the movement of the Sun during each exposure
- Pre-focus the lens at infinity
- Set the camera on a tripod and use a remote release (cable or infrared)

(Sources: NASA & MrEclipse.com)

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Overview on SOLAR ECLIPSE

PROGRAMME ON SOLAR ECLIPSE FOR SCHOOLS, 29TH MARCH 2006

Supported by NRDMS Division,
Deptt. of Science & Technology, Govt. of India, New Delhi

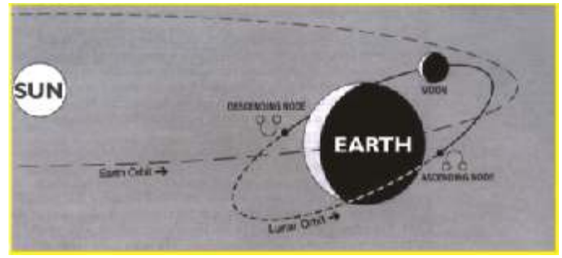
Solar eclipse is probably the most spectacular astronomical event that most people will experience in their lives. There is a great deal of interest in watching eclipses, and in the days and weeks before an eclipse occurs, there are often news stories and announcements in the media, providing information on what will happen, and how to watch the eclipse safely.

Solar eclipse:

A solar eclipse is a fascinating phenomenon - our Sun, which is normally so reliable, is suddenly stained black by the Moon. Any solar eclipse is an interesting event, but a ***total solar eclipse*** is the most spectacular astronomical phenomenon that you'll ever see. In the middle of the day, a shadow moves over the Sun - for a brief minute or two, the sky darkens to the same level as on a moonlit night; animals and birds are silent; everything seems to be in suspension. The Sun may be vanished, but its outer atmosphere - the corona - is visible as a ghostly halo around the black disc of the Moon, with streamers and ribbons of faint light trailing off for millions of miles in the Sun's magnetic field.

Reason and frequency:

Since the Moon cycles through its phases every 29 1/2 days or one synodic month, one would expect an eclipse to occur during each conjunction with the Sun. If the Moon's orbit around the Earth were in the same plane as the Earth's around the Sun, this is precisely what would happen. However, the Moon's orbit is inclined 5° to the Earth's. Our planet's natural satellite passes through the ecliptic only twice a month at a pair of points called the nodes (northward-crossing one is known as the ascending node and southward is known as the descending node). The rest of the time the Moon is either above or below the plane of the Earth's orbit. Since an eclipse can only occur when the Sun, Moon and Earth lie in the same plane, these conditions are met when new Moon takes place at one of the nodes. In any one calendar year, there are at least 2 and as many as 5 solar eclipses. On the other hand, there can be no more than 3 lunar eclipses per year and it's quite possible to have none at all. Combining both solar and lunar eclipses, it's possible for one calendar year to contain a maximum of 7 eclipses. However, they can only occur in the combinations of 5 solar and 2 lunar or 4 solar and 3 lunar. In either case, the solar eclipses must all be partial. As a point of interest, 1982 happened to be one of the rare years containing 7 eclipses. What made it even more remarkable was the fact that all 3 lunar eclipses were total.



This will not happen again until the year 2485 AD.

An examination of the geometry of the nodes yields further clues on the subject of eclipse recurrence. Since the Sun and Moon both subtend significant angles, neither one has to be exactly at the nodes for an eclipse to occur. In addition, an observer's position on the surface of the Earth introduces a sizable parallax of 2° in ecliptic latitude. These factors make a solar eclipse possible whenever the Sun is within 18.5° of a node. The Sun travels along the ecliptic at about 1° per day and requires about 37 days to cross through the eclipse zone centered on each node. New Moon occurs every 29 1/2 days and thus guarantees at least one eclipse during each of the Sun's node crossings. The period during which the Sun is near a node is called an eclipse season and there are two eclipse seasons each year.

If the line of nodes were fixed in space, then eclipse seasons would occur six months apart and at the same time each year. Actually, the line of nodes slowly drifts westward at the rate of 19 degrees per year. As a result, eclipse seasons occur every 173.3 days. Two eclipse seasons constitute an eclipse year of 346.6 days. This is 18.6 days short of a solar year and is equal to the time required by the Sun to cross the same node twice. In order to find a periodicity in the mechanics of solar eclipses, we must search for a commensurability between the synodic month and the eclipse year. Fortunately, 19 eclipse years are almost exactly equal to 223 synodic months; they differ by only 11 hours. The coincidence is all the more remarkable when compared to a period known as the anomalistic month. This is the time required for the Moon to pass from perigee to perigee and is approximately 27 1/2 days. The anomalistic month is important because the Moon's geocentric distance is the primary factor determining the annular or total nature of a solar eclipse. As unlikely as it may seem, 239 anomalistic months are also equal to 223 synodic months to within 6 hours. This is the origin of the

famous Saros cycle of 6585 1/3 days or 18 years, 11 days and 8 hours. Any two eclipses separated by one Saros cycle share very similar mechanical characteristics. They occur at the same node with the Moon at the same distance from Earth and at the same time of year. Because the Saros does not contain an integral number of days, its biggest drawback is that subsequent eclipses are visible from different parts of the globe. Although the 1/3 day displacement shifts the eclipse path 120° westward with each cycle, the series returns to the same geographic region every 3 Saroses or 56 years and 34 days.

A Saros series doesn't last indefinitely because the various periods are not perfectly commensurate with one another. In particular, 19 eclipse years are 1/2 day longer than the Saros. As a result, the node shifts eastward by about 0.5° with each cycle. A typical Saros series begins when new Moon occurs about 18 degrees east of a node. If the first eclipse occurs at the Moon's decending node, the Moon's umbral shadow will pass 3500 km below the Earth and a partial eclipse will be visible from the south polar region. On the following return, the umbra will pass about 300 km closer to the Earth and a partial eclipse of slightly larger magnitude will result. After ten or eleven Saros cycles (about 200 years), the first central eclipse will occur near the south pole of the Earth. Over the course of the next 950 years, a central eclipse will occur at each Saros but will be displaced northward by an average of 300 km. Halfway through this period, eclipses of long duration will occur near the equator. The last central eclipse of the series will occur near the north pole. The next ten eclipses will be partial with successively smaller magnitudes. Finally, the Saros series will end some 13 centuries after it began at the opposite pole. A typical series may be comprised of 70 to 80 eclipses, about 50 of which are central. If a Saros series begins near the ascending node, the first eclipse will be partial from the northern polar region and the previous sequence of events is reversed. Since at least two solar eclipses occur every year, there are obviously many different Saros series in progress simultaneously. For instance, during the later half of the twentieth century, there are 41 individual series and 26 of them are producing central eclipses. As old series terminate, new ones are always beginning and take their places.

Types of solar eclipse:

There are four different types of solar eclipse, such as:

Partial:

Partial eclipses occur when the umbral shadow of the Moon does not touch the Earth and only the penumbral shadow touches the earth. These eclipses occur when a new Moon falls close to the outer limits of the eclipse window

Annular:

Sometimes, the Moon is too small to cover the entire Sun's disk. To understand why, we need to talk about the Moon's orbit around Earth. That orbit is not perfectly round but is rather oval or elliptical in shape. As the Moon orbits our planet, its distance varies from 221,000 miles to 252,000 miles. This 13% variation in the Moon's distance makes the Moon's apparent size in our sky vary by the same amount. When the Moon is on the near side of its orbit, the Moon appears larger than the Sun. If an eclipse occurs at that time, it will be a total eclipse. However, if an eclipse

occurs while the Moon is on the far side of its orbit, the Moon appears smaller than the Sun and can't completely cover it. Looking down from space, we would see that the Moon's umbral shadow is not long enough to reach Earth. Instead, the 'antumbral' or negative shadow reaches Earth. The track of the antumbra is called the path of annularity. If you are within this path, you will see an eclipse where a ring or 'annulus' of bright sunlight around the Moon's disk for anything from a few seconds to up to 12 minutes, called annularity eclipse.

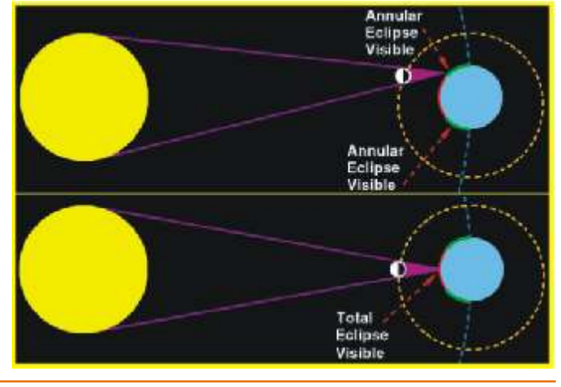
Total:

During a total eclipse of the Sun, the Moon appears bigger in the sky than the Sun. Therefore the bright rays of Sunlight are blocked by the Moon, and we are able to see the Sun's much fainter corona, the only time when this is visible and the Moon's dark umbral shadow sweeps across Earth's surface, then a total eclipse of the Sun is seen. The track of the

Moon's shadow across Earth's surface is called the Path of Totality. It is typically 10,000 miles long but only 100 miles or so wide.

Hybrid:

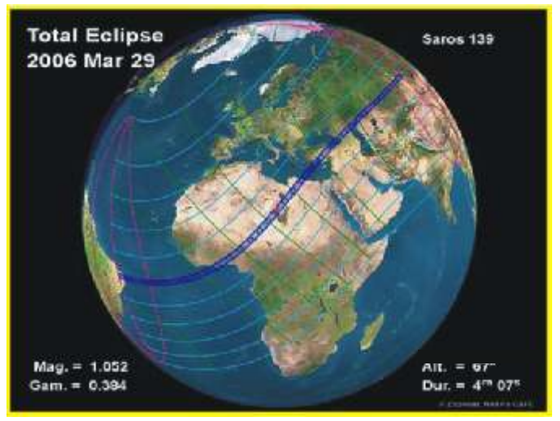
This type of eclipse is fairly rare and is also known as an annular/total eclipse. The eclipse begins as an annular



eclipse with the Moon's umbral shadow just short of the earth's surface. But, because of the Earth's curvature, in the centre of the eclipse path, the Moon's shadow is just long enough to "touch down" on the surface of the earth and the eclipse becomes total. The eclipse will remain total until near the end of the eclipse path when the shadow is once again too short to reach the surface and the eclipse once again becomes annular. These eclipses always have short duration of both the annular and the total phase. Therefore the width of the path of annularity/totality is very small.

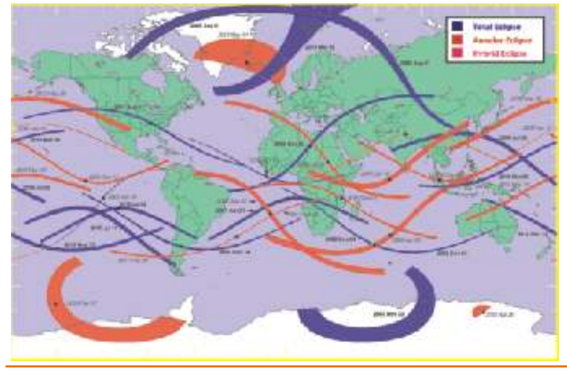
Total Solar Eclipse of 29th March 2006:

The ***Total Solar Eclipse of 2006 March 29*** is another "must see" - touching exotic locations in pristine Africa. The eclipse begins at local sunrise on the coast of Brazil and then sweeps across the central Atlantic Ocean, before making its next landfall on the Ivory Coast/Ghana border. The path then curves through Togo and Benin, before



entering Nigeria. Exiting Nigeria, the path crosses central Niger, gaining in duration all the time before sweeping across the northwestern tip of Chad. Maximum Eclipse of 4m 07s is reached just across the Libyan border, and the umbra leaves land on the border of Egypt and Libya. After crossing the Mediterranean Sea Turkey is swiftly crossed and then Russia, where the umbral shadow leaves earth at local sunset.

Umbral path of solar eclipses, 1999 to 2020:



Eclipse observation:

Warning!

- Never look directly at the Sun with your eyes or through a telescope, binocular or any other optical aid. If you look at the Sun through the normal telescope or binoculars, the situation is even much more dangerous to the human eye because the lenses of the telescopes and binoculars intensify the effects of the heat and light coming from the Sun.
- Looking directly at the Sun can cause a retinal burn (damage) or seriously affect eyesight, It may even cause total blindness
- The Sun (during eclipses or in normal conditions) can be observed only with certain conventional methods and taking the necessary precautions.
- Even if up to 99% of the disk of the Sun is eclipsed, the remaining 1% of the solar disk is still as harmful to the human eye as ever
- Only during the brief totality phase of a total solar eclipse the totally eclipsed Sun can be viewed safely with the unprotected eye.
- The observer should know precisely when totality ends in order to protect his eyes before the Sun reappears again.
- Never observe directly any other solar phenomenon, e.g., the transits of the planets Venus and Mercury.

Safe viewing:

Eclipse viewers:

The eclipse viewers are made of a special metallised foil or

black polymer and have been tested for eye safety when viewing the Sun. They block the harmful infrared and ultraviolet light that we cannot see. To avoid eye straining Sun may be looked at for not more than 10 seconds.

No. 14 Welders' Goggles:

Welders' goggles or the filters for welder's goggles with a rating of 14 or higher are safe to use for looking directly at the Sun. They are also relatively inexpensive. Warning! *Do not attempt to use these filters behind a pair of binoculars or telescope* (that is, between your eyes and the binoculars or telescope**).** If you wish

to observe the eclipse with binoculars or a telescope, you must use *a specially designed solar filter* on the front end (or Sun-side) of the instrument.