Registered with the Registrar of Newspapers of India: R.N. DELENG/2002/8668

VIPNET NEWS

A monthly newsletter of Vigyan Prasar Network of Science Clubs - VIPNET

April-May 2012 | Vol. 10 | No. 4-5 | Price: 2.00

Special Issue on Transit of Venus 06 June 2012

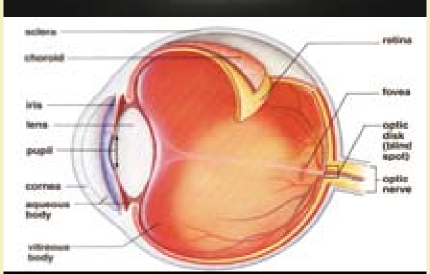
National Mathematical Year 2012

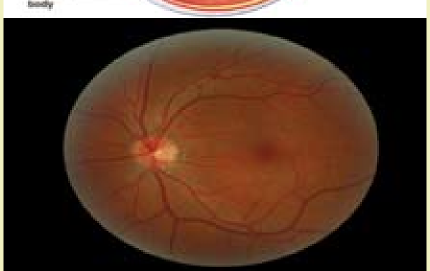
Inside

Transit of Venus 2012

The Sun

Eye, Vision and Venus Transit

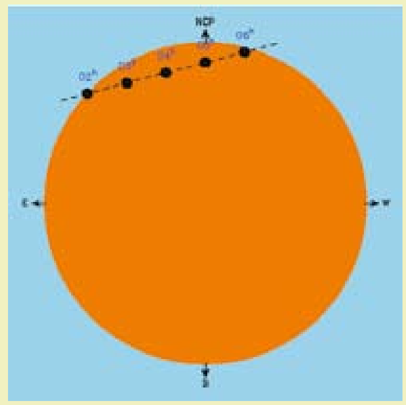




If you miss this Transit - You miss it for ever

Transit of Venus 6 June 2012

Since its inception Vigyan Prasar has been utilizing major celestial events like total and annular solar eclipses and transits of planets for triggering an interest in science in general and in astronomy in particular. Such celestial events by their very nature and rarity stir the imagination of all. Nobody can remain unaffected by a total solar eclipse, which is a life time experience or a Transit of Venus which come in pair after a span of over hundred years. Such events raise many questions in the minds of those who are not familiar with the scientific basis of such phenomena. These events also provide opportunities to students and researchers of science to observe and experiment. So it is natural that Vigyan Prasar have been utilizing these celestial phenomena for taking up large-scale science communication programmes in the country. Vigyan Prasar also utilizes these opportunities to locate and train resource persons, to develop institutional linkages, to prepare innovative resource materials and to reach out the unreached ones.



Venus Transit as observed in 1874 in one of the expeditions

The idea behind organizing nation-wide activities around the celestial events is not simply to explain the science behind these phenomena but to make the audience familiar with the method of science and lead them on the path of scientific exploration by encouraging them to ask questions and to search answers. Above all the idea is to raise curiosity in the minds of the youngsters.

The Venus Transit on 8 June 2012, is the 8th transit of Venus since the invention of the telescope. Historically, the Venus transits have played an important role in the advancement of our knowledge, so far as our solar system is concerned. If you have seen the last transit of Venus which occurred on 8 June 2004, you will be indeed most fortunate to see the transit which is occurring on 6 June 2012. If you miss the forthcoming transit you will miss it forever because the next transit will occur only after a long gap of 105.5 years.

On the occasion of the Venus Transit-2012 Vigyan Prasar has planned a number of activities and programmes to be organized all over the country including training programmes of master resource persons, development of books, activity kits, films, posters, exhibitions, power point presentations and live telecast/webcast of the event.

(Continued on page 6)

> *Venus (planet) may be a cautionary tale for our technical civilization, which has the capability to profoundly alter the environment of our small planet.*
>
> — Carl Sagan

Transit of Venus 2012

Transits - What are they?

On October 24, 1995, June 11, 1999, and 22 July 2009, we had a rare opportunity of witnessing a Total Solar Eclipse from India, when millions observed and enjoyed one of the most spectacular phenomena of nature. When Moon comes in between the Earth and the Sun, a solar eclipse takes place. Total solar eclipse takes place when the Moon is close enough to the Earth and hence its angular diameter is large enough to cover the disc of the Sun. However, it could happen that the Moon is rather far away from the Earth (and the Earth close enough to the Sun) making the apparent diameter of the Moon smaller than that of the Sun. The Moon then cannot cover the entire disc of the Sun. Under such circumstances, an annular eclipse of the Sun takes place, as was witnessed on 15 January 2010 from many parts of the world including India. We then see a bright ring around the Sun with Moon positioned inside the disc of the Sun. However, when the inner planets Mercury or Venus come in between the Sun and the Earth, it is called a transit. Their angular sizes being much smaller than that of the Moon, we only see a black dot (rather than a dark circle as during the annular solar eclipse) passing across the disc of the Sun. However, the transit phenomena are rare. Mercury transit takes place some 13 to 14 times in a century. Transits of Venus, however, are even rarer taking place with intervals of over a century. Incidentally, there was no transit of Venus in the entire 20th century!

Transits of Venus

As stated earlier, transits of Mercury can be seen 13 to 14 times in a century. The first transit of Mercury in the 21st century took place on 07 May 2003 which was visible in the entire country. However, transits of Venus across the disk of the Sun are among the rarest of planetary alignments. Indeed, only seven such events occurred since the invention of the telescope and till the beginning of the 21st century (1631, 1639, 1761, 1769, 1874, 1882 and 2004). In the 21st century, the transit of Venus took place on 06 June 2004 after a gap of 121.5 years, the earlier one having taken place on 06 December 1882. The next will occur on 06 June 2012. We may note that in the present epoch the Venus transits occur in pairs with each pair separated by over a century; and show a clear pattern of recurrence at intervals of 8, 121.5, 8 and 105.5 years. The next pair of Venus transits will occur on 11 December 2117 and 08 December 2125.

Incidentally, the pattern of 105.5, 8, 121.5 and 8 years makes a basic cycle of 243 years. However, this is not the only pattern that is possible within the 243-year cycle. This is due to the fact that there is a slight mismatch between the times when the Earth and Venus arrive at the point of conjunction (either at the ascending node or the descending node) when a transit could take place. Prior to 1518, the pattern of transits was 8, 113.5 and 121.5 years, and the eight inter-transit gaps before the AD 546 transit were 121.5 years apart. The current pattern will continue until AD 2846, when it will be replaced by a pattern of 105.5, 129.5 and 8 years. Thus, the 243-year cycle is relatively stable, but the number of transits and their timing within the cycle will vary over time.

The discs of the planets Mercury or Venus, as seen from Earth, are much smaller than that of the Moon as stated earlier. Therefore they make no more than a small black dot when they move in front of the face of the Sun. With every transit, depending on the geometry involved, this dot may traverse a different path across the face of the Sun. You will see that Ingress - the point of entry of the solar disc - for Mercury and Venus is always from the east and exiting on the western edge. The plane of the Earth's orbit round the Sun is known as the ecliptic. Since we are on the Earth, the ecliptic is the apparent path followed by the Sun through the stars. The orbits of other planets round the Sun are tilted at small angles to the ecliptic and hence planets will usually be either above (north) or below (south) the ecliptic. Transits of the Sun will occur if the inferior conjunction occurs within a day or two of the date at which the planet crosses the ecliptic.

History of Transits

In 1609, the astronomer Johannes Kepler (1571-1630) demonstrated mathematically that planets move around the Sun in elliptical orbits. On the basis of his calculations, Kepler predicted that a transit of Venus would occur on 6 December 1631. Pierre Gassendi, who was familiar with Kepler's Astronomical tables, observed a transit of Mercury that happened in November of the same year (also predicted by Kepler). However the Venus transit of that year was not visible from Europe and no expeditions had been organized to observe it from elsewhere. By 1639, Jeremiah Horrocks, an English cleric and astronomer, reworked Kepler's calculations and concluded that transits of Venus occurred in pairs spaced eight years apart roughly every 120 years. Horrocks and his friend William Crabtree observed the 24 November 1639 transit, and, from these observations, Horrocks calculated the Earth-Sun distance as about 56,000,000 miles (90,123,000 kilometres).

Edmund Halley realized that transits could be used to measure the Sun's distance from the Earth. Kepler's laws gave relative distances between all the planets and the Sun, but, the absolute distances were not known. Halley did not live to see Venus transits in his lifetime, but, his efforts gave rise to many expeditions in 1761 and 1769 to observe the transits of Venus which gave astronomers their first good value for the Sun's distance from Earth.

Captain Cook had observed a transit of Venus from Tahiti in June of 1769 and one of Mercury from Mercury Bay in New Zealand in November of the same year, during his exploration of the coastline of New Zealand. In fact, the first trip of Captain Cook, in the Endeavor, had been commissioned for the observations of the 1769 Venus Transit from Tahiti. In India too, there had been some observations of transits, but, unfortunately, no rigorous measurements were made to be of much scientific value. The earliest recorded use of telescope in India was by an Englishman, Jeremiah Shakerley. He was one of the earliest followers of Kepler and viewed the transit of Mercury in the year 1651 from Surat.

Observations were planned from Pondicherry, for the Venus transit of 1761 by Le Gentil of France. He set out on a long sea voyage to India, in order to be in time for this transit. Unfortunately, Britain and France were at war during this period and when he was about to land in Pondicherry it had been taken over by British forces and he was forced to change his course leading to his observing of the 1761 transit from the sea under conditions that were not conducive to doing accurate measurements. He planned to stay on for the June 3rd 1769 Venus transit and spent the time in studying the flora and fauna of these regions. Tragically, he was prevented from observing this event due to clouds that moved in front of the Sun just during the transit! However, there were several successful observations of the 1761 and 1769 transits, from widely separated locations, geographically. Observers had to be sent to widely separated places on the World map because, the longer the baseline between them, the more accurate would have been the calculated Earth-Sun distance. Charles Mason and Jeremiah Dixon were chosen by the Royal Astronomical Society of England, to study the 1761 Venus Transit from Sumatra. However, an attack by a French frigate found them at the Cape of Good Hope during April of that year, it being too late for them to sail for Sumatra. They, did observe the transit successfully from the Cape of Good Hope. Alexandre-Gui Pingré observed the 1761 transit from Madagascar.

Captain Cook and Sir Joseph Banks made successful observations of the 3 June, 1769 Venus transit from Tahiti. Chappe d'Auteroche, had observed

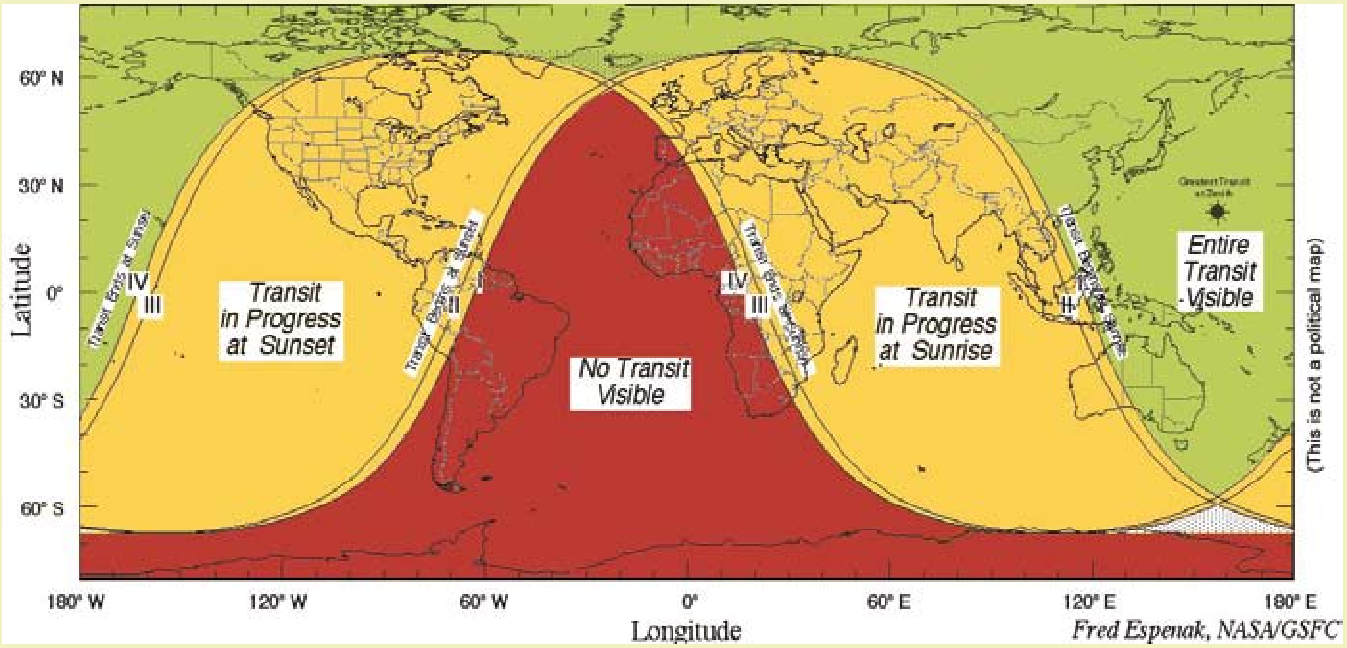


Figure 1: Global Visibility of the Transit of Venus 05/06 June 2012 (Courtesy NASA, 2012 Transit of Venus)

the 1761 transit from Siberia and was sent by the French government to observe the 1769 transit from Baja, California. Chappe d'Auteroche was successful in observing the transit, but, the expedition ended in tragedy later when many of its members including Chappe d'Auteroche contracted fever and died. John Bevis was a Physician and Amateur Astronomer who had discovered the Crab Nebula. In 1769 he observed the Venus Transit from Richmond and published his observations in Philosophical Transactions. William Crawford observed the 1874 transit from Mauritius. Ernst Emil Becker of the Berlin Observatory made observations of the 1874 transit from an expedition to Isaphan. The first scientific observations made by the Yale Heliometer, in its time, the largest in the world, were of the 1882 Venus transit.

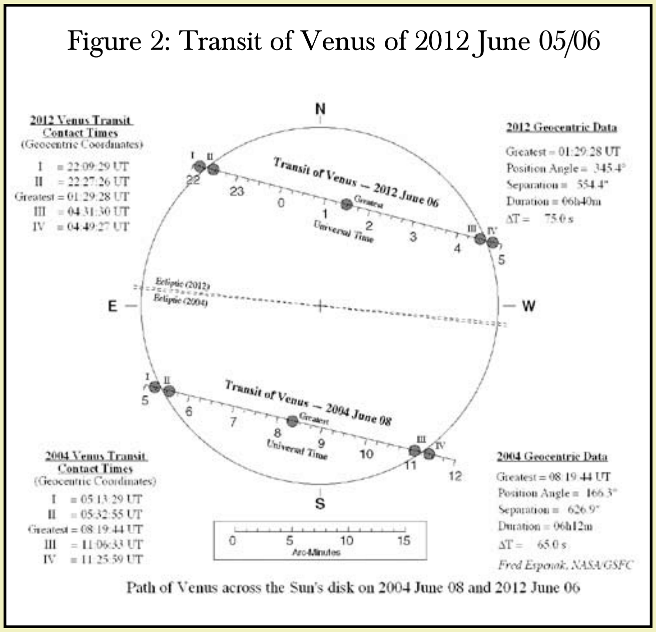


Figure 2: The Figure shows the path of Venus across the Sun's disk and the scale gives the Universal Time of Venus's position at any point during the transit events of 2004 and 2012 respectively (Courtesy: GSFC, NASA). Mark the contact points during ingress (I and II) and egress (III and IV).

Venus Transit 2012: From Where and When Will It Be Seen?

The entire event of the Venus Transit of 06 June 2012 will be widely visible from the western Pacific, Eastern Asia and Eastern Australia as shown in Figure 1. Most of North and Central America, and northern South America will witness the beginning of the transit (on June 5) but the Sun will set before the event ends. Similarly, observers in Europe, western and central Asia, eastern Africa and Western Australia will see the end of the event since the transit will already be in progress at sunrise from those locations. In India too, the transit would already be in progress at sunrise on 06 June 2012 would be visible almost till 1030 hrs.

The Four Contacts

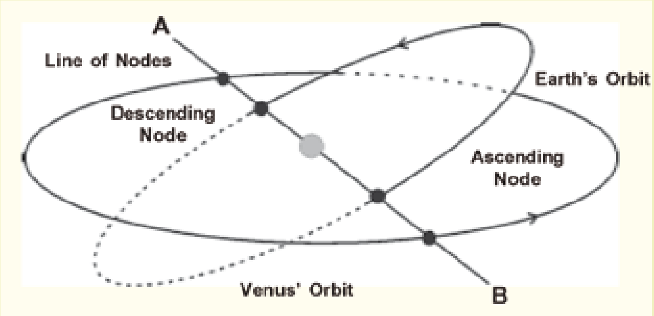
The transit begins with contact I, the instant the planet's disk is externally tangent to the Sun. Shortly after contact I, the planet can be seen as a small notch along the solar limb. The entire disk of the planet is first seen at contact II when the planet is internally tangent to the Sun. Over the course of several hours, the planet slowly traverses the solar disk. At contact III, the planet reaches the opposite limb and once again is internally tangent to the Sun. Finally, the transit ends at contact IV when the planet's limb is externally tangent to the Sun. Contacts I and II define the phase called ingress while contacts III and IV are known as egress. Figure 2 shows the transit paths along with the four contact points for the events of 08 June 2004 and 06 June 2012 respectively.

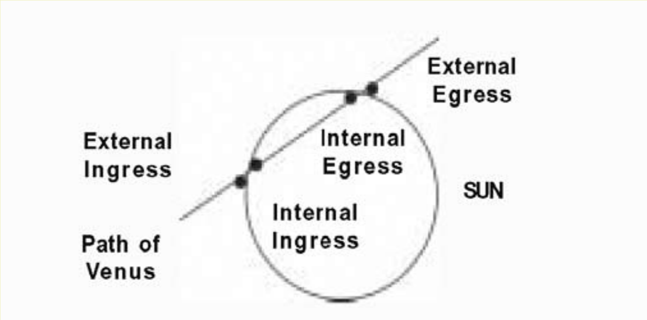
> "Note: Never try to look at the disk of the Sun directly, this could lead to blindness - the only safe way of viewing this event will be to project the image of the Sun on to a screen and view the projection. One will need a moderate aperture telescope to be turned towards the Sun and its image projected on to a screen, preferably some darkening provided around the projection area. Alternatively, you may use a safe solar filter to be made available by NCSTC and Vigyan Prasar through which you may look at the Sun directly and witness the transit."

The Astronomical Unit (AU) or the Sun-Earth Distance

What we need to do, if we wish to calculate the exact Earth-Sun distance, is to estimate what is called the Solar Parallax. What is this quantity? It is the angle subtended by half a diameter of the Earth at the Sun. If this angle and the radius of the Earth can be estimated, we can use simple trigonometry to calculate the Earth Sun distance. A transit will start and end at slightly different times when viewed from different places on the Earth. By timing the events from various places on the Earth and the "parallax" involved in these measurements, the distance to the Sun can be determined. More accurate methods are available now, but careful measurements in the 18th and 19th centuries gave distances to within one per cent of that currently accepted value.

To begin with, we must determine





the length of the chord followed by Venus during transit exactly. Also, time of Ingress and egress must be measured accurately. In making this estimate, it is necessary to make corrections - not only as regards the motion of the Earth and Venus in their orbits, but also due to the rotation of the Earth. Similar observations are taken from two stations situated at different latitudes on the Earth and separated as much as possible. For

Transit of Venus 6 June 2012 CIRCUMSTANCES FOR INDIA						
Location	Sunrise	Transit Contacts				
		Contact I External Ingress	Contact II Internal Ingress	Maximum Transit	Contact III Internal Egress	Contact IV External Egress
	h m s	h m s	h m s	h m s	h m s	h m s
Delhi	05:22:56	03:39:20*	03:57:08*	07:02:27	10:05:08	10:22:28
Srinagar	05:19:17	03:38:42*	03:56:29*	07:02:11	10:05:24	10:22:43
Shimla	05:17:19	03:39:07*	03:56:54*	07:02:19	10:05:10	10:22:29
Chandigarh	05:19:43	03:39:07*	03:56:54*	07:02:20	10:05:12	10:22:31
Jaipur	05:32:27	03:39:23*	03:57:12*	07:02:33	10:05:14	10:22:34
Ahmedabad	05:53:23	03:39:30*	03:57:20*	07:02:47	10:05:27	10:22:48
Bhopal	05:33:40	03:39:49*	03:57:35*	07:02:42	10:05:02	10:22:22
Dehradun	05:15:43	03:39:14*	03:57:02*	07:02:21	10:05:05	10:22:24
Lucknow	05:11:57	03:39:44*	03:57:32*	07:02:28	10:04:47	10:22:06
Patna	04:57:53	03:40:06*	03:57:55*	07:02:26	10:04:22	10:21:41
Gangtok	04:40:17	03:40:10*	03:57:57*	07:02:16	10:04:05	10:21:24
Kolkata	04:51:18	03:40:35*	03:58:24*	07:02:29	10:03:59	10:21:19
Guwahati	04:30:21	03:40:27*	03:58:14*	07:02:14	10:03:45	10:21:07
Shillong	04:30:56	03:40:31*	03:58:18*	07:02:15	10:03:43	10:21:03
Imphal	04:24:21	03:40:42*	03:58:30*	07:02:13	10:03:30	10:20:50
Aizawl	04:31:33	03:40:44*	03:58:32*	07:02:18	10:03:35	10:20:55
Agartala	04:37:02	03:40:39*	03:58:27*	07:02:21	10:03:44	10:21:04
Kohima	04:21:55	03:40:38*	03:58:25*	07:02:10	10:03:30	10:20:50
Itanagar	04:20:28	03:40:28*	03:58:15*	07:02:07	10:03:35	10:20:55
Ranchi	05:01:54	03:40:20*	03:58:09*	07:02:32	10:04:17	10:21:37
Bhubneswar	05:05:52	03:40:38*	03:58:29*	07:02:39	10:04:09	10:21:30
Raipur:	05:20:52	03:40:16*	03:58:07*	07:02:43	10:04:35	10:21:56
Daman	05:57:39	03:39:44*	03:57:36*	07:02:54	10:05:23	10:22:44
Mumbai	06:00:16	03:39 51*	03:57:43*	07:02:57	10:05:21	10:22:42
Panaji	06:02:24	03:40:13*	03:58:07*	07:03:05	10:05:11	10:22:32
Thiruvanathapuram	06:02:58	03:41:03*	03:58:59*	07:03:17	10:04:40	10:22:03
Bangaluru	05:52:31	03:40:43*	03:58:37*	07:03:07	10:04:45	10:22:07
Hyderabad	05:40:55	03:40:24*	03:58:16*	07:02:56	10:04:48	10:22:08
Channai	05:41:42	03:40:54*	03:58:48*	07:03:04	10:04:30	10:21:52
Puducherry	05:45:39	03:40:58*	03:58:52*	07:03:07	10:04:30	10:21:52
* Events are not visible at these locations						

both the stations, the chords followed by the transiting Venus would be obviously different. Using geometry, and Kepler's laws of planetary motion, it is then possible to determine the perpendicular distances between the two chords both in minutes and kilometers. This would also tell us how much 1 arc second corresponds to in terms of kilometers at the distance of the Sun. It is then easy to deduce the solar parallax leading to the Sun - Earth distance (1 AU or 1 Astronomical Unit) in terms of kilometres.

This then, was the excitement that underlay all the expeditions in the 17th and 18th centuries to observe Venus transits. The outcome involved was of paramount importance and hence all out national efforts from England, France and later from America. Now we know the Earth Sun distance accurately and yet, there is still the thrill of participating in all out global efforts to re-measure this historic quantity and participate in Global togetherness through scientific efforts! So keep your rendezvous with Venus in on 06 June 2012 !

The apparent diameter of Venus is nearly 1 arc-minute. Hence, it is just possible to observe the planet without any optical magnification as it crosses the Sun. We must, however, use the solar filter protection. Venus appears to be only 1/32 of the Sun's apparent diameter so a pair of binoculars or a small telescope would offer a good view. However, all binoculars and telescopes must be suitably equipped with adequate solar filters to ensure safe solar viewing. Amateurs and even students could make a scientific contribution by timing the contacts at ingress and egress.

A Great Opportunity for Science Communicators In association with leading research institutions in the country, National Council for Science and Technology Communication (NCSTC) and Vigyan Prasar have planned a comprehensive countrywide campaign to make people aware of the phenomena related to astronomy in general and transits in particular.

While a transit of Mercury or Venus offers a great opportunity to the scientists to measure the planetary distances from the Sun, it provides a great occasion to science communicators to utilise the spectacular event to communicate the basic scientific aspects related to several astronomical phenomena in particular, and science & technology (S&T) in general to the members of the community.

The main objective of the proposed programme is to utilise the event of Venus Transit for triggering an interest in S&T especially among children in S&T in general and in Astronomy in particular. A spate of activities would involve students/teachers/general public and active association / collaboration of Government/ non-Government / voluntary organisations.

T-Day

Transit-day, or the T-day: June 06, 2012 is our date for rendezvous with Venus. The next transit would take place only after a long gap of 105.5 years. What is more, this was an historical event that helped measure the distance of the Earth from the Sun, and consequently of all the planets. This event would offer science communicators a great opportunity to popularise astronomy, and address unscientific beliefs and superstitious at the same time associated with celestial events. As during the Total Solar Eclipses of 1995 and 1999, the annular solar eclipse of 2010, and the last Venus transit of 2004, this would be an event in which students, teachers, general public, and Government/non- Government organisations, would be involved. We do hope you would be a part of this great event.

■ **V.B. Kamble**
vinaybkamble@gmail.com

Continued from page 1

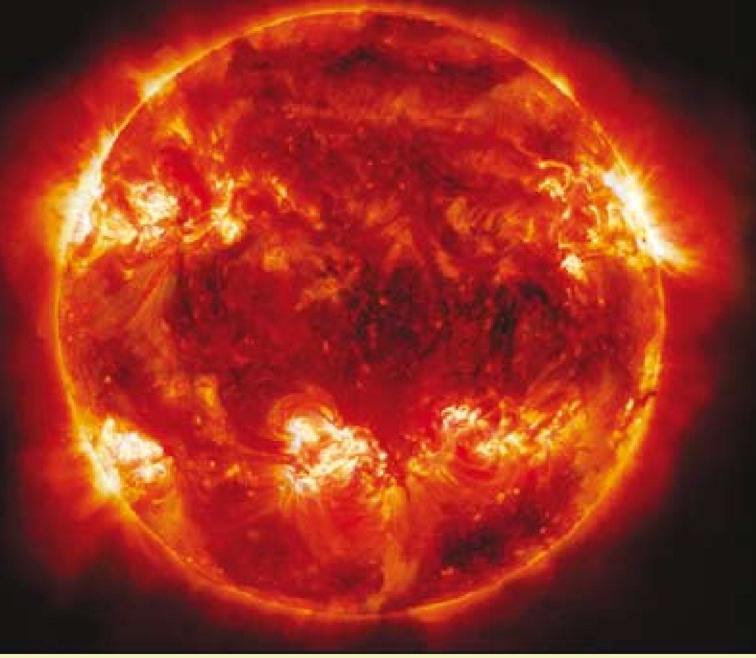
(Transit of Venus 6 June 2012)

As in the past, Vigyan Prasar has planned a comprehensive countrywide campaign built around the forthcoming Transit of Venus on 6 June 2012 to make people aware of the phenomena related to astronomy in general and transits in particular. This event also offers a great opportunity to science communicators and science clubs to not only initiate activities on astronomy but also address unscientific beliefs and superstitions associated with celestial events.

VP has also created a special link on its website www.vigyanprasar.gov.in. On this link all the resource material and three films has been uploaded for your convenience with downloading facility. You are free to duplicate this resource material at your end and circulate among the schools, science clubs, science communicators and other agencies associated with S&T popularization activities in your areas. In this issue of VIPNET, we are presenting three resource articles i.e. on Transit of Venus 2012, The Sun and Eye, Vision and Transit of Venus.

It is expected that coordinators of science clubs may use this material to give lecture and demonstration to popularize astronomy and address unscientific beliefs and superstitions associated with celestial events. So, Transit-day or the T-day – June 6, 2012, will be our date for rendezvous with Venus.

■ **B.K. Tyagi**
bktyagi@vigyanprasar.gov.in



The Sun

The Sun is the nearest star and the source of most of the energy which we need and consume on the earth. It is a huge ball of gas. Due to very high temperature, there is no material in the Sun in the solid or liquid form. It is a fireball with a diameter of nearly 1.4 million km. Its angular diameter is about ½° of arc. Its temperature at the core is about 15×10^6 Kelvin. Its surface is at a relatively lower temperature, about 6000 Kelvin.

> "Never look at the Sun with naked eye, it could cost you your eye-sight."

Salient Physical Features

When the Sun's disk is totally covered by the moon (as it happens during a total solar eclipse), one can see a faint halo around the Sun. This is called the solar corona, or the solar atmosphere (Fig.1)

Fig. 1: Solar corona visible during a total solar eclipse

The principal physical characteristics of the Sun are summarized in Table 1. The density of the Sun's core is about 150 gm/cm^3, i.e. it is about 150 times heavier than water when measured on earth. This happens due to the high gravitational compression of the Sun leading to a very high pressure, density and temperature in the core. The mass of the Sun is estimated to be approximately 2×10^{30} kg., which works out to nearly 333000 times that of the Earth. The Sun rotates around itself once in about 25 days. Since it is not a solid body (it is gaseous), its different parts rotate with different speeds. There are times when the Sunspots (cooler and hence darker areas on the surface of the Sun) could be seen using a solar filter. By noting the shift of their positions on a day-to-day basis, one can easily convince oneself that the Sun is in fact rotating about its own axis. The axis of rotation of the

Table 1: Principal physical characteristics of Sun

Characteristics	Value
Mean distance from Earth (one astronomical unit)	(1.4960±.0003)X10^{8}km
Radius	(6.960±.001)X10^{5}km
Mass	1.991±.002)X10^{33}g
Mean density	(1.410±.002X g/cm^3
Surface gravity	(2.738±.003)X10^{4}cm/sec^2 (28xterrestrial gravity)
Total energy output	3.86±.03)X 10^{33} erg/sec
Energy flux at surface	(6.34±.07)x10^{10}erg/cm^2 (sec)
Effective surface	temperature 5780^0±50^{0}k
Stellar magnitude (photo visual)	-26.73±.03
Absolute magnitude (photo visual)	+4.84±.03
Inclination of axis of rotation to ecliptic	7^0
Period of rotation	About 27 days. The Sun does not rotate as a solid body: it exhibits a systematic increase in period from 25 days at the equator to 31 days at the poles.

Sun is inclined to the plane of the ecliptic by about 83°, that is inclined to the normal to the plane of the ecliptic by about 7°. The Sunspots are described later in the article.

Structure and Composition

Unlike the earth, the Sun is gaseous throughout and so does not have any solid surface. The structure of the Sun can be thought of as a series of concentric spherical shells or layers, each characterized by a unique combination of physical processes. At the center of the Sun is the nuclear burning core, as illustrated in Fig.2. Traveling outward, one encounters first the radiative

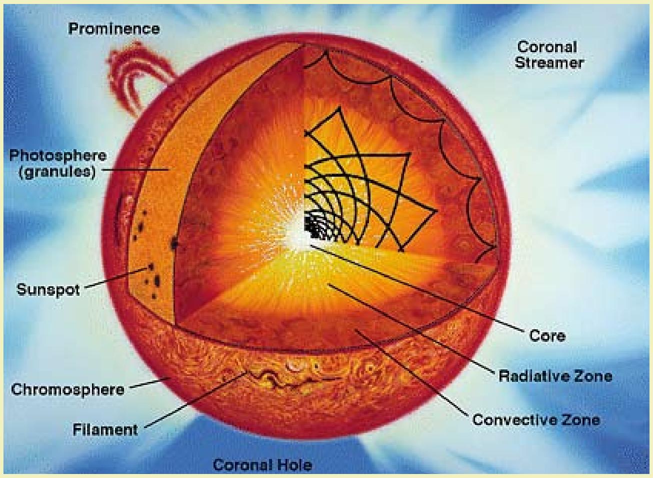


Fig. 2: Inner layers of the Sun, with solar corona in the background

zone, then the convection zone, then the photosphere, the chromosphere, the transition zone, and finally, the corona. All of these regions are powered by a nuclear burning core from which energy is transported outward through successive layers by radiation and convection. The temperature is 15×10^6 K, in the core and decreases monotonically outward to a minimum of approximately 4×10^3 K in the chromosphere. The transition from radiative to convective energy propogation occurs in the region in which the temperature drops below 2×10^6 K, whereby convection becomes a more efficient transport mechanism than radiation. This defines the boundary between radiation and convection zones.

The innermost layer of the Sun that can be observed in visible light is called the photosphere. The photosphere is more luminous than the optically thin outer portions of the solar atmosphere and defines the size of the Sun as observed in visible light. The height, temperature, and density of various layers of the solar atmosphere are given in Table 2.

The atmospheric layer that lies just outside the photosphere is the chromosphere. The visible emissions from the chromosphere are over-powered by the full

Table 2: Characteristics of the Solar Atmosphere

Region	Height above of Photosphere (Km)	Base Temperature	Density (atoms/m^2)
Photosphere	0-320	6500-4500	10^{23}-10^{22}
Chromospheres	300-2000	4500-28000	10^{21}-10^{16}
Transition zone	2000	10^5	10^{16}
Corona	7×10^6	1.8×10^6	10^{12}

light of the photosphere when observed without special filters andare blocked by the moon during the totality of a solar eclipse. They are, however, visible with the unaided-eye as a flash of red light just before totality. This red light, known as H emission, is emission at a wavelength of 656 nm due to an atomic transition in hydrogen (1nm=10-9 m). Prominences are large-scale chromospheric features with an arch-like structure, visible in Hµ at the edge of the solar disk against dark sky. Because these structures absorb light from the underlying photosphere, they appear as dark features when observed on the solar disk. (Fig. 2)

Perhaps the most puzzling feature of the outer solar atmosphere is its temperature structure. Instead of a continued decrease in temperature with distance outward, an increase is observed. The gradual increase observed in the chromosphere becomes a steeply rising increase in the transition zone, so named for the abrupt change in the thermal gradient. The temperature continues to rise well out into the corona. While this temperature increase in the corona appears to violate the elementary thermodynamic principle that a body cannot supply heat to a hotter body without external work being done, the paradox is resolved with the understanding that the photosphere heats the corona from the non-thermal source of energy stored in its magnetic fields. Two mechanisms are thought to be involved: One is currents generated by changing magnetic fields; the other is magnetohydrodynamic waves. The relative importance of these two mechanisms is presently the subject of intensive investigation.

What elements is the Sun made of?

In specifying the chemical composition of the Sun, one can be at leaset 98% correct by saying “Hydrogen and helium”. In spite of the fact that these are the two lightest elements in the periodic table, this statement is true not only for abundance by number of atoms but also for abundance by weight. The next most abundant elements, in decreasing order, are oxygen and carbon (Table 3). The rest comprise less than 1% of the Sun by weight and less than 0.03% by number. It may be of interest to note that the element Helium was discovered

Table 3: Major elements on the Sun

Element	Percentage by mass
Hydrogen (H)	70.52
Helium (He)	27.57
Oxygen (O)	0.96
Carbon (C)	0.31
All other elements put together	Less than 1%

on the Sun during spectroscopic observations of the solar corona during the event of total solar eclipse in 1968 from the tobacco fields of Guntur in Andhra Pradesh. It may also be interesting to note that Helium was discovered much later on the Earth, in the year 1895 to be precise!

What is the source of energy in the Sun?

The Sun has been shining for about 5 billion years radiating 4×10^{26} watts of power, and may continue to shine for another 5 billion years! How does the Sun (or any other star) produce such vast amounts of energy? According to current belief, a star contains mainly hydrogen, some helium and a small fraction of other chemical elements. Incidentally, the composition of an average star is like that of the Sun.

The large mass of the Sun results in a high gravitational pull and gives rise to a high pressure at the centre. This can be balanced on by the temperature in its central parts becoming high, (say, about 15×10^6 k). At such high temperatures, hydrogen nuclei get converted into helium nuclei. This is called a thermonuclear reaction. Four hydrogen nuclei get fused to form a helium nucleus in this reaction releasing vast amounts of energy. Hence it is also called a fusion reaction.This fusion reaction in the core of the Sun converts about 4.25 million tonnes of hydrogen into helium every second! This is the mechanism responsible for the energy produced in the Sun, or in any other star.

Hydrogen in the Sun is depleted every moment and helium is formed. When the hydrogen in the Sun will get exhausted, there will be no more fusion and the Sun will stop supplying the energy it now does. This would mark the death of the Sun (and also of the Earth!). When the hydrogen supply is exhausted, it would swell, become cooler and expand to become a red giant. The Sun will probably grow to about 250 times its present size taking in Mercury, Venus and Earth in the process. Then it will get small again, turning atoms of helium into heavier atoms, releasing further energy. The Sun would grow so small that finally all its matter will be packed into space not much larger than the Earth, it would then be called a white dwarf. With the passage of time, the white dwarf will stop shining and finally become a dead black dwarf. It is believed that the Sun has existed for about five billion years and will continue to exist for another ten billion years.

Sunspots

Observation of the Sun shows several dark spots on its surface. The number of spots and their sizes vary from year to year [Fig. 3 (A) and 3 (B)].

It has been observed that the growth of Sunspots occurs in a periodic cycle of 11 years. Every eleven years, the Sunspot activity would be at a maximum. It may be of interest to note that 1990 was a year of solar maximum. The region of the Sun near a high magnetic field gets cooler and, therefore, appears dark against a bright background giving the appearance of a spot.

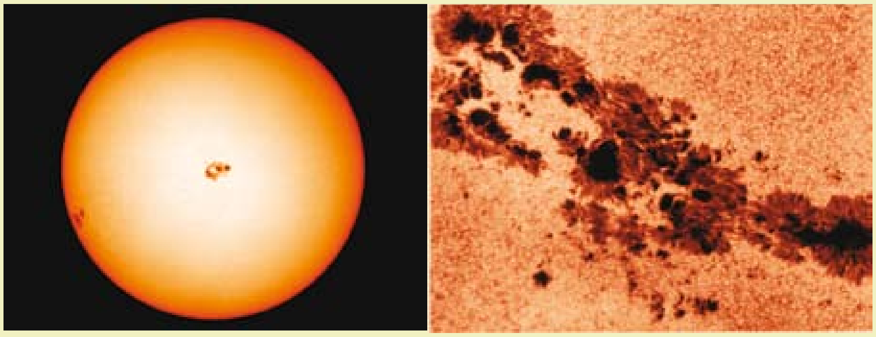


Fig. 3 (A) : Sunspots on the surface of the Sun. The side figure is the magmified view of the sunspots observed in the surface of Sun

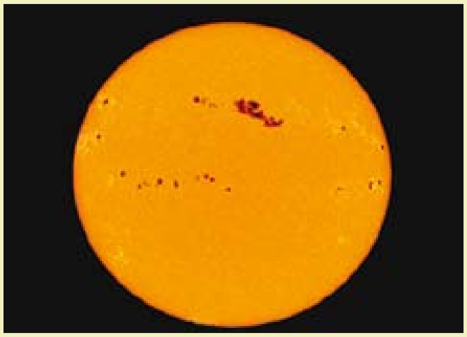


Fig. 3 (B) : Sunspots when the solar activity is high

In a magnetic field and at high temperatures, the charged particles like electrons, protons and ions of various atoms move along complex paths. In addition, there is the eleven year cycle of Sunspots, i.e. the magnetic activity. As a result the shape and size of the solar corona changes from time to time. When the magnetic activity on the star is high, the corona is symmetric (Fig.1). However, when the magnetic activity is low, the corona consists of streamers. The streamers appear due to the Sun's magnetic fields and extend far into the interplanetary space. The nature of Sunspots and magnetic field of the Sun are not yet very well understood.

Observing the Sun

The Sun cannot (and should not) be observed with naked eyes due to its brilliance. Hence, different techniques have been developed by physicists to learn about the various aspects of the Sun.

One can observe some features of the Sun with simple telescopes. However, one should never look at the Sun through a telescope unless fitted with a proper solar filter. Otherwise, there is every chance of damaging the eyes. The best way to view the Sun is to project the image of the Sun as an illuminated disk with Sunspots on it, (if they are there!), by holding a white screen about a metre away from the eye-piece of a telescope.

The Sun can also be observed in infrared and ultraviolet radiation, as well as radio waves with instruments sensitive to a particular kind of radiation.

Observations of the Sun during a total solar eclipse have their own importance. They give information on the solar emissions from its atmosphere. That is why scientists from all parts of the world flock, along with their instruments, to a suitable place from where the total eclipse can be observed surely and easily.

Several manned and unmanned spacecrafts have also been used to study the Sun. Observations from a spacecraft have the advantage that radiation falling on it does not have to pass through the Earth's atmosphere. During the total solar eclipse of October 24, 1995, MiG 25, Canberra and AN-32 aircraft of the Indian Air Force carried on board several scientific experiments chasing the umbral shadow and took pictures of solar corona.

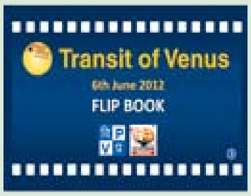
References

1. Our Solar System, Avinash Wasudeo Joshi and Narayan Chandra Rana, published by Wiley Eastern Limited, 1992.
2. Encyclopaedia of Science & Technology, McGraw Hill (Vol. 13).
3. Encyclopaedia Britannica.
4. Encyclopedia of Astronomy and Astrophysics Edited by Robert A. Mayers, Academic Pres Inc (1989).
5. Photographic Atlas of the Solar Chromosphere, Ashok Ambastha and Arvind Bhatnagar, Udaipur Solar Observatory, Udaipur (1985).

V.B. Kamble
vinaybkamble@gmail.com

Activity Kit on Transit of Venus 06 June 2012

VP has develop a activity kit on Transit of Venus comprises about 8 activities, posters and a solar filter. The kit has been design as part of countrywide campaign on Transit of Venus, 6 June 2012. It aims to encourage the people to view the transit safely and to undertake some astronomical activities associated with event. The kit has been develped in association with Gujarat Science City, Ahmedabad in English and Hindi.



Director, Vigyan Prasar
A-50, Institutional Area , Sector-62. NOIDA (201309)
Phone: 91-120-240 4430,35 Fax: 91-120-2404437
e-mail : info@vigyanprasar.gov.in Website : http://www.vigyanprasar.gov.in

Eye, Vision and Venus of Transit

The transit of Venus will take place on 06 June, 2012 and will be seen throughout the country. Surely, it would be a great occasion to witness it. True several websites would webcast the entire transit live, and sitting in front of the monitor of your computer would be the 'safest' way to observe the transit! However, watching the Venus transit directly requires sufficient safety measures so as not to damage our eyes- temporarily or permanently. Smoked glass or sunglasses are not at all safe. It is not at all safe to look at the Sun without safe filters. It is only during the totality phase that it is safe to look at the Sun directly.

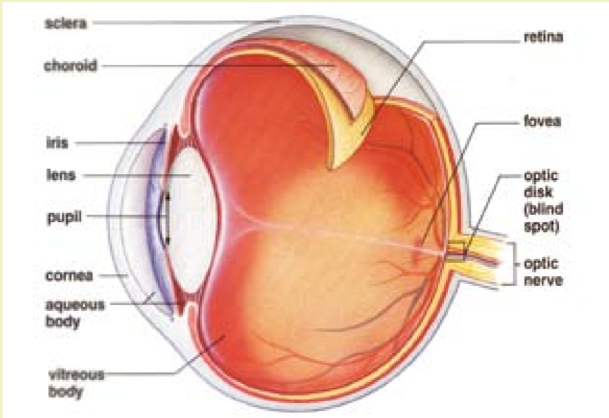


Figure 1: Structure of the eye

In this article, we shall review the important factors leading to injury to the eyes by naked viewing of the Sun and the means for their prevention. We shall need to have a look at the structure of the yes and the light radiations affecting it. We shall then consider the injuries caused to the eye especially by viewing at the Sun either with naked eye or though unsafe devices like smoked glass, sun glasses etc., methods of viewing the Sun safely; and the measures to prevent injury to the eye.

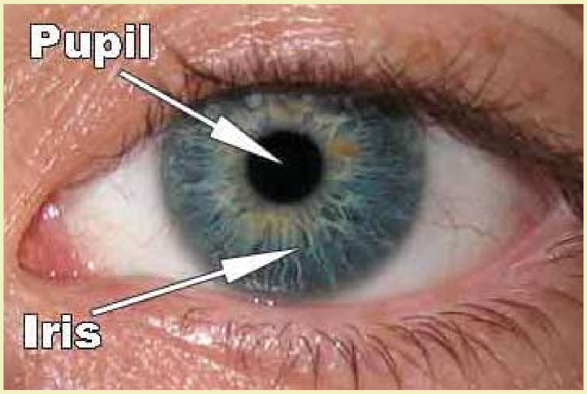
Structure of the Eye

The eye does not actually see objects. Instead, it sees the light they reflect or give off. The eye can see in bright light and in dim light, but it cannot see in no light at all. Light rays enter the eye through transparent tissues. The eye changes the rays into electrical signals. The signals are then sent to the brain, which interprets them as visual images.

The visible parts of the eyeball are the white sclera and the coloured iris, shown in Figure 1. A Membrane called the conjunctiva covers the sclera. The sclera is the white part of the eye. The clear cornea lies in front of the iris. The lens is connected to the ciliary body. Inside the eyeball which underlies the choroid, changes light rays into electrical signals. The optic nerve carries the signals to the brain. The fovea centralis, a pit in the macula lutea (explained later), is the area of sharpest vision.

The iris is the coloured disk that lied behind the cornea. At the center of the iris is a round opening called the pupil, which looks like a black circle, shown in Figure 2. The pupil regulates the amount of light that enters the eye. Two muscles in the iris automatically adjust the size of the pupil to the level of light. In dim light, the dilator muscle enlarges the pupil. As much light as possible can then enter the eye. In bright light, the sphincter muscle makes the pupil smaller, which prevents too much light from entering the eye. The pupil also becomes smaller when the eye looks at a nearby object, thus brin ging the image into sharp focus.

The ciliary body encircles the iris. It is connected by strong fibres to the crystalline lens, which lies directly behind the iris. The lens is a flexible structure about the size and the shape of a aspirin table. Like the cornea the lens is transparent because it has bo blood vassals and is relatively dehydrated. The muscles of the ciliary body make constant adjustments in the shape of the lens. These adjustments produce a sharp visual image at all times as the eye shifts foci between nearby distant objects. The ciliary body also produces a clear watery fluid called aqueous

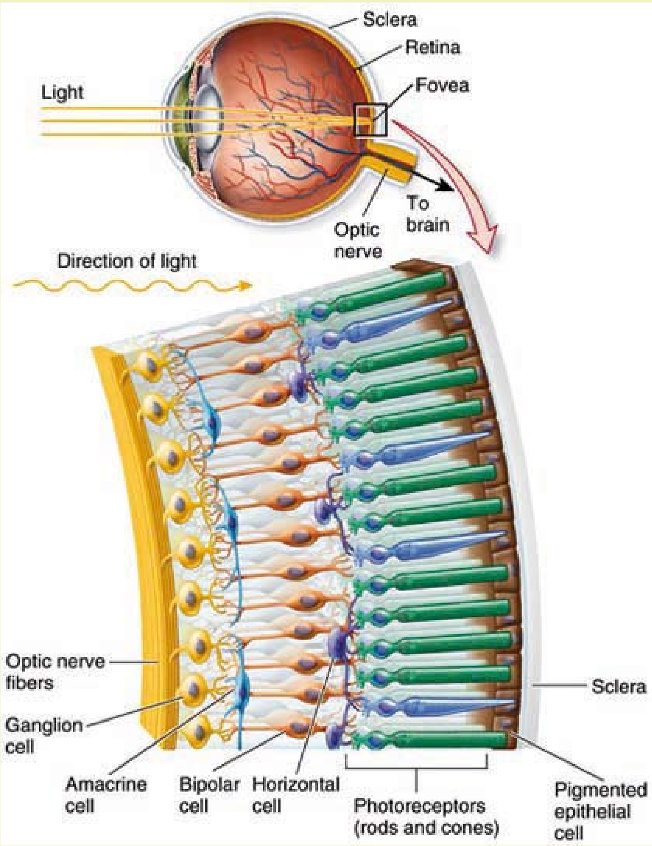


The iris has a round opening called the pupil, which regulates the amount of light that enters the eye. In dim light, the dilator muscle pulls the pupil open wider. In bright light, the, sphincter muscle tightens around the pupil and makes it smaller. Figure 2: The Iris humor. This fluid nourishes and lubricated the cornea and the lens, and it fills the area continuously. The old fluid is drained out as the new fluid takes its place.

The choroid forms the back of the uveal tract (the iris, the ciliary body and the choroid considered as one structure). It looks and feels like a blotting paper soaked with black ink. The choroid has many blood vessels. Blood from the choroid nourishes the outer part of the retina.

The retina makes up the innermost layer of the wall of the eyeball. It is about as fragile as a piece of wet tissue paper. The retina is made up of two types of light-sensitive cells-roads and cones. The cells are named for their shape. The retina has about 120 million roads and about 6 million cones, which absorb light rays and change them into electrical signals (Figure 3).

Near the center of the retina is a round area called the macula lutea or macula. The macula consists chiefly of cones. It produces a sharp image of scenes at which the eyes are directly aimed, especially in bright light. The rest of the retina provides peripheral vision-that is, it enables the eyes to see objects to the side while



The retina has cells called rods and cones, which absorb light rays and change them into electrical signals. There are more cones than rods in the central area of the retina. The cones are concentrated in the fovea centralis. Nerve fibres attached to the rods and cones join to form the opticss nerve. Figure 3: Retina

looking straight ahead. Most of the roads lie in this part of the retina. Because rods are more sensitive in the dark than cones, faint objects often can be seen more clearly if the eyes are not aimed directly at them. For example, looking to the side of a dim star makes its image fall on the part of the retina that has the most rods and provides the best vision in dim light.

Nerve fibres attached to the roads and cones join at the center of the retina and form the optic nerve. This nerve consists of about a million fibres. It serves as a flexible cable that connects the eyeball to the brain. In act, the optic nerve and the retina are actually extensions of the brain. The optic nerve carries the electrical signals produced in the retina to the brain, which interprets them as visual image.

How we see?

Light rays that enter the eye must come to point on the retina for a clear visual image to form. However, the light-rays that objects reflect or give off do not naturally move toward one another. Instead, they either spread out or travel almost parallel. The focusing parts of the eye-the cornea and the lens-blend the rays toward one another. The cornea provides most of the refracting (bending) power of the eye. After light rays pass though the cornea, they travel through the aqueous humor and the pupil to the lens. The lens bends the rays even closer together before they go through the vitreous humour and strike the retina. Light rays from objects at which the eyes are aimed come together at the fovea centralis, a tiny pit in the center of the macula (Figure 3). This is the area of sharpest vision Light rays from ob jets to the sides strike other areas of the retina.

Adaptation to light and dark is partly controlled by the pupil. In strong light, the pupil may become as small as a pinhead and so prevent the eye from being damaged or dazzled by too much light. In the dark, it can get almost as large as the entire iris, thus letting in as much light as possible. However, the most important part of adaptation to light and ark occurs in the retina.

Optically important regions in the electromagnetic spectrum

Different sources of radiation emit electromagnetic energy in different parts of the electromagnetic spectrum, say radio frequency, infrared, visible, ultraviolet, X-rays or gamma-rays. The wavelength of light is measured in the units of nanometers (nm), where 1nm=109 meter. The electromagnetic spectrum is shown schematically in Figure 4.

The solar spectrum at Earth chiefly comprises of infrared rays (say from 6500 nm-723nm), visible light

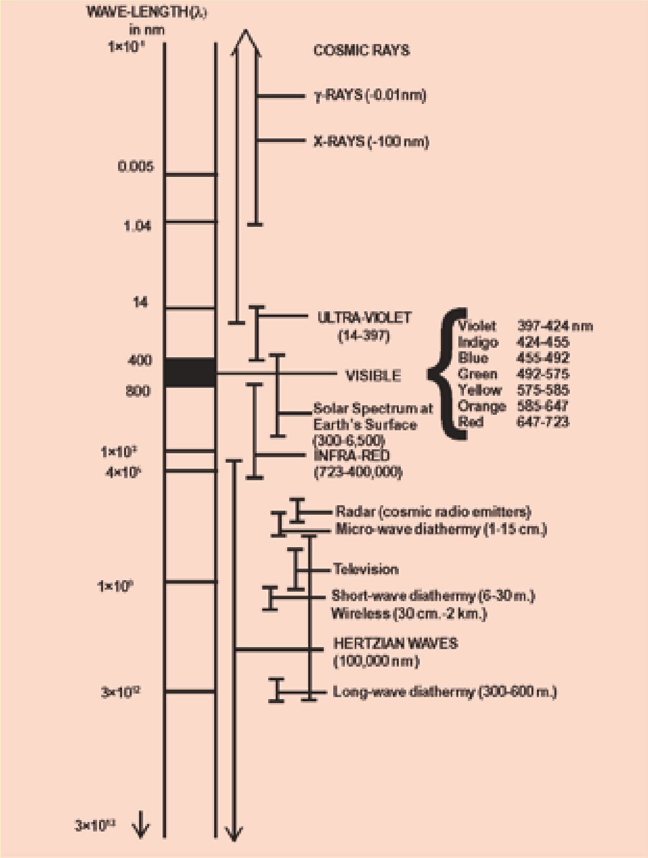


Figure 4 : The Electromagnetic Spectrum

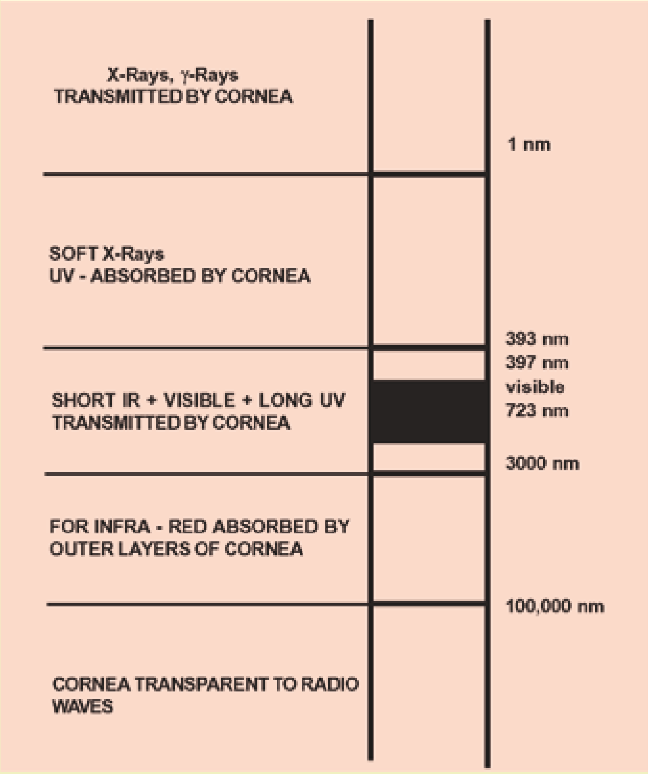


Figure 5 : Optically Important Regions of the Electromagnetic Spectrum

(from 723 nm-399 nm), and ultraviolet rays (from 397 nm-100 nm). It would be interesting to note that the sunlight contains about 58% infra-red radiation, 40% visible and 2% ultraviolet.

The optically important regions are middle (i.e., from 3000 nm-393nm) which includes infrared, visible and long ultra-violet rays and the shortest wavelength in the electromagnetic spectrum (i.e., less than 1 nm). These are schematically shown in the Figure 5.

Light transmitted through different parts of the eye

The ocular tissues, like the other tissues of the body, are transparent to the longest waves in the electromagnetic spectrum: like other tissues they are opaque to the longer infra-red radiations which are readily absorbed by water and are thus absorbed by the outer layers of the cornea. Below 3,000 nm, however, in the shorter infra-red, transparency again begins and throughout the middle regions of the spectrum the limits of absorption and transmissibility vary considerably until, in the long ultra-violet, all radiations bellow 393 nm are again cut off by the cornea. Another band of opacity exists throughout the short and extreme ultra-violet a region wherein much of the radiation in absorbed by water and some by air; but at the level of 1.0 nm, through the bands of soft and hard x-rays and y-rays. The two regions of the spectrum, i.e; the middle and the shortest, are of biological significance.

Different parts of the eye, i.e., aqueous (i.e. through aqueous humour between cornea and iris), lens, vitreous and retina transmit light of different wavelengths in different proportions. This is shown in Figure 6.

Below 3,000 nm and increasing proportion of infra-red radiation is transmitted through the cornea;

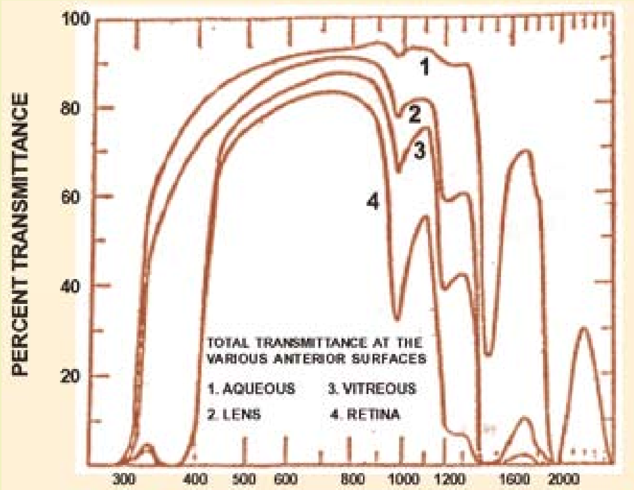


Figure 6: How direct and scattered light is transmitted through the entire eye.

there are bands of relatively high absorption in the neighborhood of 2,000 and 1,00 nm to which this tissue is relatively opaque, but 25% of the incident radiation is transmitted though it at 2,300 nm, 65% at 1,650 nm, 80% at 1,200 nm, and almost 100% at 1, 000 nm. To this wavelength in the short infra-red, the cornea is more transparent than to visible red rays (750 nm). Most of the visible radiation, however, in transmitted until absorption become apparent and increases steeply in the long ultra-violet: at 370 nm 90% at 330 nm 80%, at 305 nm 50%, at 300 nm 25%, and at 290 nm only 2% of the radiation incident on the cornea is transmitted into the inner eye to be largely absorbed by the aqueous humor. Of the remaining 98% of this spectral band, half is absorbed by the corneal epithelium and half by the stroma; and at 230 nm practically all (97.3%) of the incident energy is cut off by the epithelium.

The radiation that traverses the cornea is absorbed in part by the ocular tissues while some 10% of the incident energy is dissipated by diffusion. Most radiation which falls upon the pigmentary layers of the iris and the retina, whether infra-red, visible or long ultra-violet, is absorbed and converted into heat. Of the long-wave radiation which traverses the transparent media, the aqueous humour absorbs all the infra-red above 2700 nm and partly at lower wavelengths. The lens absorbs all radiations longer than 2300 nm, but, below it, it shows two bands of selective absorption near 1900 nm and 1500 nm. At the lower limits of the visible spectrum, the most actively absorbent tissue is the lens. The lower limit of transmissibility varies considerable proportion of ultra-violet rays down to 305.5 nm may pass through this tissue, in the adult the effective zone of partial absorption is from 400- 350 nm, although a feeble transmissibility down to 320 nm may exist, and in the aged all rays below 450 nm in the violet may be absorbed.

The concentration of radiant energy in the eye

The concentration of radiant energy within the eye is obviously of considerable importance in the study of its effects upon the ocular tissues. The longest (radiowaves) and shortest (X- and Y-rays) radiations traverse the ocular tissues without deflection, but radiations belonging to the infra-red, visible and ultra-violet regions of the spectrum are retarded in their passage through the media and thus suffer refraction to a degree depending on the optical density of the tissue and the wavelength in question; and shorter violet waves are the most refrangible, while refraction becomes progressively less towards the red end of the visible spectrum and the

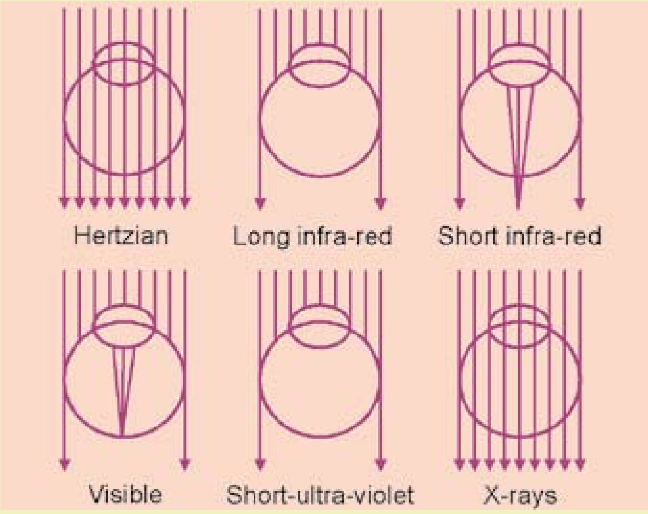


Figure 7: The permeability of the eye to the electromagnetic spectrum

infra-red. This is schematically shown in Figure 7. With a small source emitting radiations of middle spectral distribution, the density of energy is approximately uniform through the anterior half of the globe, since absorption and dispersion in the media counterbalance fairly exactly the concentrating effect of refraction; but in the posterior part of the globe where the beam is brought to a focus, the latter effect becomes the more prominent. It follows that with a small source (a point source or with small angular diameter) of energy damage may be caused at the retina while the anterior structures are left unaffected. This occurs, for example, in sun-blindness owing to the refraction of the infra-red and visible rays as shown in Figure (8). The effect of concentration, however, is limited by the imperfections of the optical system of the eye.

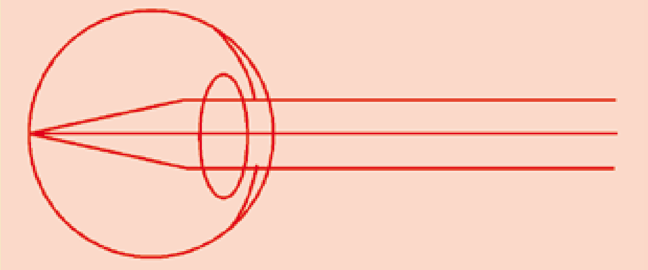


Figure 8: The concentration of radiant energy in the eye

Hazards from UV Radiation

UV radiation refers to the part of the electromagnetic spectrum subdivided into ultraviolet (UV) rays with wavelengths of l= 100-380 nm. UV radiation is further subdivided into UV-C (l = 100-280nm), UV-B (l = 280-315nm), and UV-A (l = 315-380nm).

In general, the shorter the wavelength the more energetic the radiation making it damaging the plants and animals. UV-C can do great damage but fortunately poses no risk to life on Earth. It is completely filtered out by oxygen and ozone in the stratosphere. Ozone also plays a vital role in filtering UV-B, the ultra violet radiation i.e. the greatest threat to life on Earth. But even a fully functioning ozone layer does not absorb all the UV-B rays. UV-A surpasses the stratosphere virtually unfiltered. But compared to the shorter wavelengths, UV-A causes little harm and even plays an important role synthesizing Vitamin D in humans. So, in discussing the harmful effect of ultra violet radiation we are mainly talking about UV-B. Too much exposure to this type of radiation can lead to skin cancer, cataract and suppressed immune system. UV radiation accounts for 20% of cataract cases, and 90% of all skin cancer. Cumulative exposure over a person's life exacerbates wrinkling and discolors the skin. The penetration of UV radiation in the eye is shown in Figure 9.

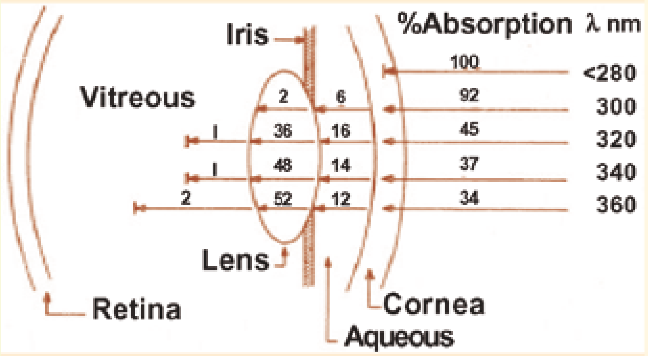


Figure 9 : Depth of penetration of UV into the eye

Radiation can have the greatest effect on the parts of the eye that absorb them. How deep the rays can penetrate into the eye depends on their wavelength. Yet the dividing lines are not quite so distinct. A more accurate distinction is made by considering how easily the different wavelengths pass through the components of the eye. The eye's translucence also depends on a person's age. In early life, the frontal part of the eye is more translucent than it is in old age.

Damage can also occur in places where the eyes are subjected to high intensity UV radiation, say during electric arc welding or in snowy zones under clear skies. One long term effect of UV radiation is a certain clouding of lens or formation of cataract. Certain proteins, so-called crystalline, are altered in the lens cells by photochemical reaction in connection with other factors, such as diabetes. This can cause a pigmentation of the cells and clouding of the lens. This process progresses over time until vision is sharply impaired or even blindness occurs. Since the lens tissue in contrast to other tissues in the body - does not grow the new cells, the damage is irreversible. Yet, modern surgical technology does allow the clouding the lenses to be replaced by artificial lenses. The radiation responsible for this condition is UV-A and UV-B which cause the damage. The intensity of the radiation that causes this disease is well below the intensity that can cause an acute inflammation of the cornea or conjunctiva. What is most important is the cumulative length of exposure, mostly extending over several decades. Indeed, the disease can also be caused by artificial UV radiation sources. Plain sunlight can also cause the cataract but this often effect people who work a lot outdoors, such as farmers or seamen. Disease can effect practically anyone. The common form occur in people nearing the end of their seventies. The rate of cataract disease in the population increases with the age.

Retinal Burns

Chorioretinal (i.e., involving choroid and retina) burns are most usually produced after looking at the Sun;

Box 1: Why Looking at the Sun Directly is Dangerous?

The size of the image of the Sun at the retina is of the order of 0.2mm. Hence the energy available at retina is concentrated approximately in at area of circle within radius 0.1 mm.

Solar Energy indicence on Earth = 1.36 kw/m^2

= $1.36x10^{-4}$kw/cm^2

Area of pupil (radius 1mm) = 0.03 cm^2

Thus power incident on the pupil = $1.36x10^{-4}x0.03$kw

= $0.040x10^{-4}$kw

= $4x10^{-6}$kw

70% of this energy is available at retina, i.e., power incident at retina = $4x0.70x10^{-6}$kw/cm^2

= $3x10^{-6}$kw

The size of the image being of diameter 0.2 mm, the energy absorbed in the retina is concentrated in area

= 0.03mm^2= 0.03x 10^{-2} cm$^{2.}$ = $3x10^{-4}$ cm^2.

Hence the concentration of solar power in area in which image is formed

= $3x10^{-6}/3x10^{-4}=10^{-2}$ kw/cm^2 = 100 kw/m^2

Which is about 100 times more than the solar energy incident on Earth and quite powerful to cause retinal burns even if viewed for only a few seconds!

occasionally they occur after accidental exposure to lightening, or the short-circuit of a high-tension current or, more rarely, after gazing into a strong artificial source of light such as a carbon arc. Sometimes, following subliminal exposures, only temporary subjective symptoms appear. Following severe exposures, a destructive burn causes permanent damage - a serious matter when, as is usually the case, the macula is involved. A solar choriorentinal burn (sun blindness or photoretinities) is an injury of this type.

Let us consider the Sun as black body at temperature 60000 K. The energy available in its radiation will be about 1.36 kilowatt/m2 at the Earth's surface. If the pupil is strongly contracted to about 2 mm, as is the case when the Sun is observed directly, about 3% of this energy will enter the eye. Slightly over 30% of the energy that enters is lost in its passage through different inner parts of the eye. We make use of this information to estimate the concentration of energy on the retina while observing objects like the Sun (Box1).

Symptoms - In case of an accident

The subjective symptoms (after looking at the Sun without adequate protection) are characteristic; and their severity bears little relation to the retinal appearances. In most cases nothing abnormal is noticed immediately except the dazzling sensation; but shortly thereafter a diffuse cloud floats with irregular undulations before the eyes, associated usually with irritating after-images, photophobia (fear of light), and occasionally photopsia (flashes of light) and chromatopsia (disturbance in colour vision). After 24 hours, this diffuse cloud contracts into a dense scotoma (a blind spot or area of depressed vision) which may last for weeks or months or even permanently. The scotoma is typically central and reduces the visual acuity to an average of 6/12 (what a person with normal eyesight may see from 12 feet would be seen by the affected persons from 6 feet) but not infrequently to 6/60 (what a person with normal eyesight may see from 60 feet would be seen by the affected person from 6 feet) or less; it is discovered by the blurring or disappearance of small objects or test letters and in the early weeks, it often undergoes flickering or rotatory movements. Metamorphosia (larger or smaller images of objects rather than their normal sizes) may appear in the central field due initially to displacement of the retinal elements with oedema and eventually to degenerative changes. Do not take chances! Rush to an ophthalmologist in case of any symptoms mentioned above! To avoid this situation, follow the guidelines for viewing the Sun safely given later in this article.

The objective signs are typical, but even when the subjective symptoms are marked, the fundus may occasionally appear normal. Initially in the slighter cases, the macula seems somewhat darker than usual, a change doubtless due to choroidal congestion; in the more severe cases the central area may be raised and oedematous, showing perhaps a grey appearance and minute haemorrhages or a dark central spot surrounded by an oedematous retinal detachment. The typical appearance which rapidly develops at the fovea is that of one or more yellowish-white spots, oval in shape or sometimes crescentic, surrounded by an irregular zone of mottled pigmentation fading gradually into the background of the fundus (Figure 10 and 11). This appearance corresponds to the lesions

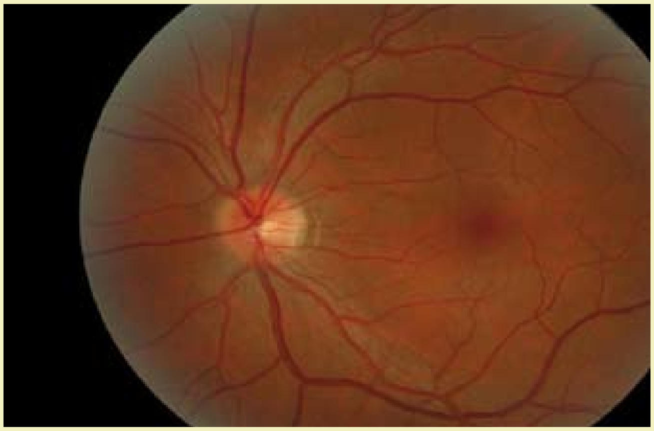


Figure 10 : This photograph is the back of the eye of a man who viewed the partial solar eclipse of 1966 without eye protection. The arc-shaped scars are typical of an eclipse burn, and the vision in this eye has been reduced to 20/30 (6/9). Source : BBC News http://news.bbc.co.uk/1/hi/sci/tech/ 1376184.stm

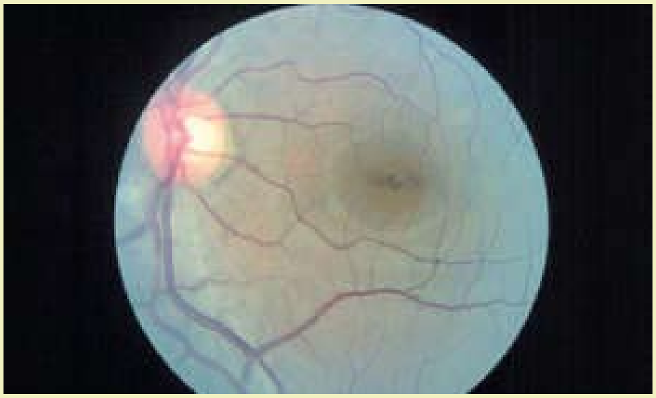


Figure11: This picture shows a more extreme form of solar retinopathy in the left eye of a young man who stared unprotected at a partial eclipse of the Sun. Several crescent-shaped burns can be seen in the central retina, and these have resulted in blindness in this eye, with his vision reduced to below 20/400 (6/120).Source : BBC News http:// news.bbc.co.uk/1/hi/sci/tech/1376184.stm

seen experimentally: careful ophthalmoscopic focusing suggest that the central spot is a burnt-out hole in the pigmentary epithelium, while the surrounding stippled ring represents an aggregation of pigment. In the worst cases a typical macular hole may develop.

Vision after retinal burns

In the majority of cases the vision improves within the first month or two and the scotoma, if it persists, tends to become relative sufficiently small; correspondingly the red zone with its yellow spots at the macula may become grayer and also disappear. Few records are available of patients who have been injured for more than a year and fewer and fewer after several years. Improvement may occur over several months but in the majority of cases some disability persists.

The return of the visual acuity to 6/6 does not necessarily mean recovery of normal vision because in some cases small residual central or paracentral scotomata may persist and particularly if these are bilateral, they may lead to permanent impairment of reading or the ability to perform fine work. In most cases with a permanent macular lesion, particularly a hole, a small area of central vision may be permanently lost. After a few years, however, the visual capacity may increase considerably and the resultant scotoma becomes small. Indeed the vision may appear to be unaffected and the minimal disability is unnoticed by the patient - a happy result which unfortunately is by no means invariable. The moral is - Never look at the Sun directly, even during partial solar eclipse.

Viewing the Sun

Never view the Sun directly, eclipse or no eclipse, without safe, tested filters, otherwise temporary or permanent damage could be caused to your eyes. The Sun can be viewed safely with the naked eye only during the few brief seconds or minutes of a total solar eclipse. It is emphasised that even when 99% of the sun's surface is obscured during the partial phases, the remaining photospheric crescent is intensely bright and cannot be viewed safely without sufficient eye protection. Hence, Do not attempt to observe the Sun directly, even during the partial (or annular) phases of any eclipse with naked eye. Unless appropriate filters are used, it may result in permanent eye damage or even blindness! It is, therefore, necessary to follow certain guidelines for safe viewing of the (partial or annular) solar eclipse. The fact that the Sun appears dark in a filter such as smoked glass, sun glasses, coloured film, photographic neutral density filters etc. does not guarantee that your eyes would be safe. Damage to the eyes comes predominantly from invisible infra-red wavelengths. Avoid all unnecessary risks.

Observing a transit is like observing the Sun on any day. It is necessary to reduce the intensity of Sunlight at least by a factor of 100,000 or more for safe viewing. Any filter which reduces the intensity of a standard 60 Watt incandescent frosted electric bulb such that the printed code is no longer readable would be safe enough. To prepare an effective filter, put together two

BOX 2: DOs AND DON'Ts FOR OBSERVING THE VENUS TRANSIT

DOs

- Project the image of the Sun on a shaded wall through a pin hole.
- A small telescope or binoculars can be used to project the image of the Sun on a white card / screen / wall. If binoculars or telescope has any plastic parts, take necessary precautions to protect them from heating and melting by sunlight.
- Direct viewing of the partially eclipsed Sun should be done only using a scientifically tested filter certified to be safe. A dark welder's glass (No.14) is ideal. The filter provided in the Vigyan Prasar kit can also be used. Always, use only one of your eyes to view the eclipse. In all cases, please examine the filter before use. A filter with pin holes / scratches must not be used. Don't touch, fold or wipe the film with your fingers, under any circumstances. Any scratch or fold on the film would render it unsafe for viewing the eclipsed Sun.
- Look at the Sun only intermittently.

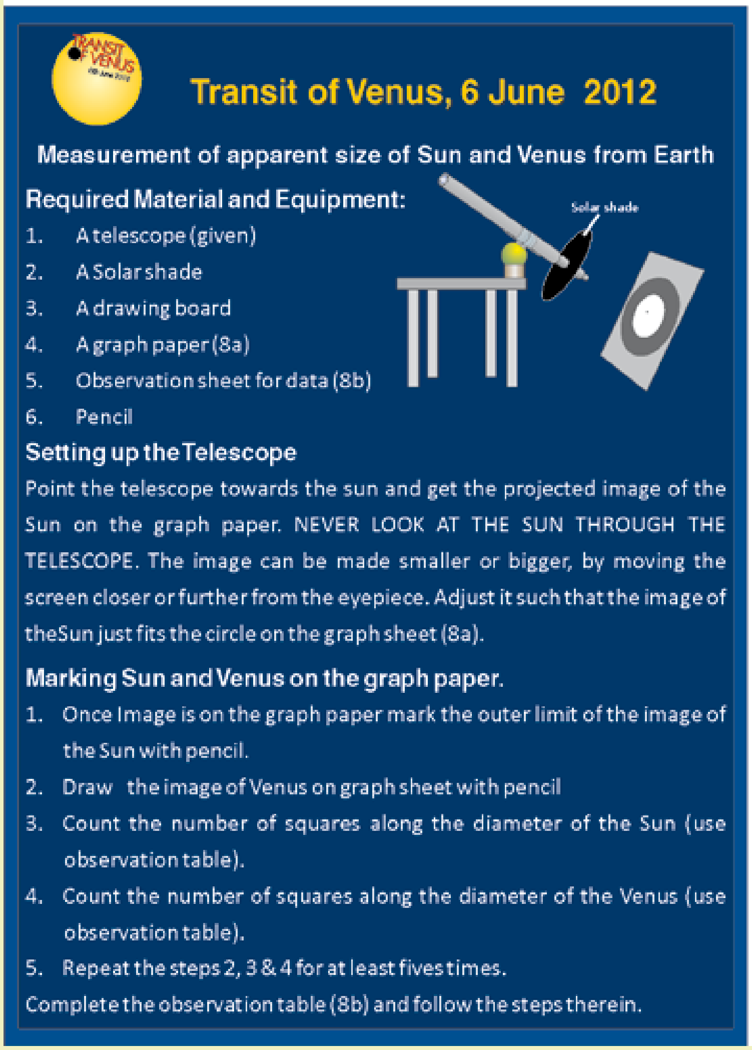
DON'Ts

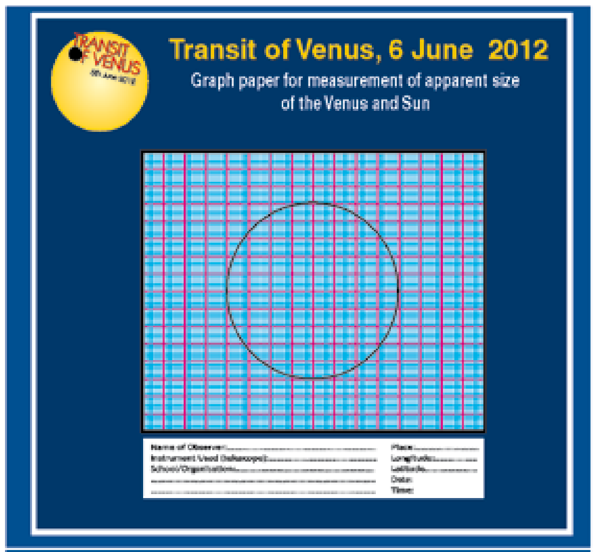
- Don't attempt to observe the Sun with naked eyes.
- Never look at the Sun through a telescope or binocular without a proper filter.
- Don't use any filter that simply reduces the visible intensity of the Sun. Fifty-two per cent of the Sun's rays are in the infra-red region of the spectrum. Damage to the eye is predominantly caused by this invisible infrared energy.
- Don't use smoked glass, colour film, sunglasses, non silvered black & white film, photographic neutral density filters and polarizing filters. They are not safe.
- Don't use solar filters designed to thread into eye pieces and often sold with inexpensive telescopes.
- Don't look at a reflection of the Sun from coloured water.

or more thicknesses of over exposed black and white photographic or X-ray film (slower films are best) until a density is obtained which just abolishes the readability of print on a 60-watt bulb (Ref. Archives of Ophthalmology, 70 (1964) 138). The light of the bulb in a dark room will then appear as a glow similar to that of full moon on a moderately bright night. The metallic silver contained in the film emulsion is the protective filter. However, black and white film even if fully exposed to light is likely to be unsafe, since they often use dyes instead of silver. A popular inexpensive alternative is aluminized mylar sheet (without any microholes) manufactured specifically for solar observation. Ordinary mylar sheet may not be safe. Dark Welder's glasses (shade No. 14) could also be safely used. As a further precaution, do not view the Sun even through these filters continuously beyond a few seconds. It is however, emphasised that no legal liability for these recommendations could be accepted since even with best of precautionary warnings, there is every likelihood that accidents will occur with direct viewing of the Sun. Smoked glass, colour film or sunglasses are not safe. Safest ways are viewing Sun's projected image through a pin-hole on a card-board held at a distance of about 1 meter in a shaded room. DOs and DON'Ts to observe the Sun safely are given in Box 2.

V.B. Kamble
vinaybkamble@gmail.com

Activity to be undertaken during the Transit





Published and Printed by Mrs. K. Dasgupta Misra on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016
Printed at Delhi Sales Corporation, D-39, Sector - 2, Bawana Industrial Area, Bawana, Delhi - 110039

Editor : **B. K. Tyagi**
Associate Editor : **Rakesh Kumar Upadhyay**
Layout & design : **Pradeep Kumar**
Typing : **Ajeej Ahmed Azad**