Registered with the Registrar of Newspapers of India: R.N. 70269/98

ISSN : 0972-169X
Postal Registration No. : DL-11360/2004

DREAM 2047

February 2004 Vol. 6 No. 5 Price: Rs. 5.00

VP News

Padma Bhushan for Shri M. V. Kamath

Shri M. V. Kamath, President, Vigyan Prasar Society, has been conferred Padma Bhushan by Government of India for the year 2004 for his services to the nation. He is one of the seniormost journalists of the country and highly respected for his analytical commentaries. He is also Chairman, Prasar Bharati. Vigyan Prasar heartily congratulates him for the honour bestowed on him. It was he, who mooted the idea of Vigyan Rail.

Inside

Vigyan Rail — on the move

The response to Vigyan Rail has been really overwhelming. At every halt, at least 20-30 thousand people have been visiting Vigyan Rail everyday. People from far-flung areas are coming to see this unique science exhibition on wheels. The school students are showing a keen interest. At all places, the event is widely covered by print and electronic media wherever the Vigyan Rail goes.

Vigyan Rail reached Bareilly on January 06, 2004 and was stationed there upto January 08, 2004. Shri Bachi Singh Rawat, Hon'ble Minister of State, Science & Technology inaugurated the exhibition. Shri Santosh Gangwar, Hon'ble Minister of State, Heavy Industries, was also present as Chief Guest. Over two lakhs people visited the exhibition. Some 130 schools brought their students. Due to heavy rush, the exhibition was kept open from 8.30 a.m. till 11 p.m.

Vigyan Rail then travelled to Lucknow where it was stationed from January 9, 2004 to January 13, 2004. Dr. Nanith Sehgal, DM, Lucknow and Shri R.K. Singh, DRM, North Central Railway jointly inaugurated the exhibition. Over 1.5 lakh people including students from schools visited the exhibition at Lucknow.

Shri Santosh Gangwar, Minister of State, Heavy Industries and Shri Bachi Singh Rawat, Minister of State, Science & Technology visiting Vigyan Rail at Bareilly

A section of the audience at the inaugural session of Vigyan Rail at Allahabad

contd. on page...23

... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

Published and Printed by Dr. Subodh Mahanti on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 & Printed at Saurabh Printers Pvt. Ltd., B-280, Okhla Industrial Area, Phase - I, New Delhi - 110 020

Editor : Dr. V.B. Kamble

Roving on Mars

In 1877, Giovanni Virginio Schiaparelli (1835-1910), an Italian astronomer, produced the first "modern" map of Mars, on which he showed a system he termed *canali*. *Canali* in Italian means "channel" and the word was translated into English as "canal" implying intelligent design! In 1910, Percival Lowell (1855-1916), an American astronomer and discoverer of the planet Pluto, painted a compelling portrait of a dying planet, whose inhabitants had constructed a vast irrigation system to distribute water from the polar regions of Mars. Further, his idea of an "Earthlike" Mars proved more exciting.

At the dawn of the space age, Mars was considered to have an atmosphere about a tenth the density of Earth's, water ice polar caps that waxed and waned with the seasons, and an annual "wave of darkening" that was often interpreted as growing plant life. However, in the 1960s, observations from Earth and flyby spacecraft signalled the beginning of the end for Lowell's Mars. The *Mariner 4, 6*, and *7* missions of USA returned images of a moonlike, heavily-cratered surface. The atmosphere was found to be almost pure carbon dioxide and only a hundredth the density of Earth's, and the polar caps proved to be almost entirely frozen carbon dioxide. The first global views of Mars, returned by the *Mariner 9* orbiter in 1972, revealed that the planet was far more complex than the earlier flyby missions had shown, with huge volcanoes, an enormous canyon system, and evidence of running water *at some point in the past*. But the wave of darkening was shown to be the result of seasonal redistribution of wind-blown dust on the surface. The atmosphere's composition and density were confirmed, and most of the evidence for an Earthlike Mars was swept away.

But despite all these blows, the possibility of organisms on the surface could not yet be ruled out. For this reason, in 1976 the USA *Viking* landers – *Viking 1* and *Viking 2* - carried a sophisticated instrument to look for possible life forms on the Martian surface. Both the landers had experiments to search for Martian micro-organisms. The landers provided detailed colour panoramic views of the Martian terrain. They also monitored the Martian weather. They, however, could not detect any traces of life on the two landing sites which were widely separated and different in character. As of today, the chances that life exists on Mars do not seem very good. However, there are reasons to believe that Mars may have been significantly wetter, perhaps with a denser atmosphere, earlier in its history. If so, there is the possibility that life arose on Mars, only to die out as conditions on the planet worsened. This is why some scientists have suggested that future searches for life on Mars be shifted to focus on *extinct* life rather than *extant* life.

Nearly two decades after the *Viking* missions, there has been a spurt of activity on the Martian surface once again. *Mars Pathfinder - USA Lander* and *Surface Rover* arrived at Mars on July 4, 1997, and two days later a six-wheel rover, named *Sojourner*, rolled onto the Martian surface. *Mars Pathfinder* returned thousands of images from the lander as well as more than 15 chemical analyses of rocks and extensive data on winds and other weather factors. NASA's twin robot geologists - *the Mars Exploration Rovers* - were launched toward Mars on 10 June, 2003 and 7 July, 2003 respectively, in search of answers about the history of water on Mars. "*Spirit*" landed on its surface on 03 January, 2004, while "*Opportunity*" landed on 24 January, 2004. Spirit fell sick for a few days, but was healthy once again! *Spirit* and *Opportunity* would roll out, collect rock and soil samples and analyse them for clues to past water activity and determine whether life ever arose on Mars. They would also characterize the climate and geology of Mars, and prepare for human exploration in the years to come.

The big science question for the *Mars Exploration Rovers* is how past water activity on Mars has influenced the red planet's environment over time. While there is no liquid water on the surface of Mars today, the record of past water activity on Mars can be found in the rocks, minerals, and geologic landforms, particularly in those that can only form in the presence of water. That's why the rovers are specially equipped with tools to study a diverse collection of rocks and soils that may hold clues to past water activity on Mars.

The spacecraft are targetted to sites on opposite sides of Mars that appear to have been affected by liquid water in the past. The landing sites are at Gusev Crater, a possible former lake in a giant impact crater, and Meridiani Planum, where mineral deposits (hematite) suggest Mars had a wet past.

Meanwhile, NASA Mars orbiters - *Mars Global Surveyor* launched on 07 November, 1996 and the *2001 Mars Odyssey* launched on 07 April, 2001 – continue to orbit Mars carrying out important observations and providing support to the rovers. *The Mars Express* – Mars orbiter and lander - launched by European Space Agency on 01 June, 2003 met only with partial success. Its lander *Beagle 2* did not return any signals after it separated from the spacecraft. *Mars Express*, however, continues to orbit Mars and transmit valuable data to the Earth. Indeed, Mars never saw such a feverish activity when five spacecraft simultaneously had a brush with it!

What is important to note is that it took nearly 37 missions spread over 5 decades of concerted efforts to land the rovers on Mars. It may be a few more decades before humans set

Contd on page...36

Editor : **V.B. Kamble**

Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016; Tel : 26967532; Fax : 26965986
e-mail : vigyan@hub.nic.in
website : http://www.vigyanprasar.com

Venus Transits and the Astronomical Unit

❒ V. B. Kamble

Astronomical Unit

In the history of modern science, basic constants have always been lavished with great care - atomic weights, the velocity of light, the constant of gravitation, elementary charge, to name a few. They serve as keys to the closed doors of nature. They represent a measure of constancy in a world of change! We shall briefly narrate the story of the attempts during the 18th century to calculate one of the natural constants of physical astronomy, the Sun's mean distance from the Earth - the Astronomical Unit or AU. Expressed as a mean radius of the Earth, the astronomical unit becomes the standard measure for the universe - a celestial meterstick. Kepler's Laws of planetary motion and Newton's mechanics involved dynamic consideration which were independent of the actual dimensions of the system for which they were established. As a result, it was sufficient to know the relative position of one planet with respect to another. It did not allow us to find the exact distance. The adoption of some arbitrary values in Kepler's laws for the distance between the Earth and the Sun would make possible only the determination of the *relative* positions of the other members of the solar system. But this is like expressing the distance between New Delhi and Chennai without knowing the length of the meter! Hence, a major scientific aspiration during the 17th century was that of solving the problem of the actual scalar dimensions of the solar system.


Johannes Kepler

A golden opportunity

The astronomers of the 18th century were presented with a golden opportunity to fulfil this ambition. The transits of Venus of 1761 and 1769 provided the necessary celestial mechanism for determining the most accurate determination of the solar distance that could be obtainaed down to the middle of the 19th century. Indeed, the very infrequent transits of the Venus across the face of the Sun were not observed until the 17th century. As a matter of fact, only 5 such events have been observed in the history of astronomy – those of 1639, 1761 and 1769, and 1874 and 1882. The transit of 1631 was not observed. These events have a regular cycle of 243 years, made up of 4 irregular intervals which are alternatively short and long – the short ones are always 8 years apart and the long ones alternatively 121½ and 105½ years. The interesting phenomenon that transits occur in pairs at intervals of 8 years, when they do occur at all, arises from the fact that the time for 7 revolutions of the Earth is equal to 13 for Venus.


Edmond Halley

The transits of the 18th century took place at the time of the most fruitful union of mathematics and observational astronomy that had occured then. It may be interesting to note that this age also was called the age of reason and enlightment. The enlightened interest and scientific practice also gave rise to the international co-operative scientific expeditions in modern history. We shall trace briefly the scientific aspects of the transits of Venus and its applicability to the problem of evaluating the solar distance in this article.

Transits – what are they?

When Moon comes in between the Earth and the Sun, it is the solar eclipse. However, when either Mercury or Venus – either of the interior planets - comes between the Sun and the Earth, it is called a transit. In a few months from now, we shall have the good fortune of watching Venus move across the disc of the Sun.

The discs of the planets Mercury or Venus, as seen from Earth, are much smaller than that of the Moon. 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. The transits do not take place frequently because the orbits of both Mercury and Venus are tilted at small angles to the ecliptic (the average plane of Earth's orbit around the Sun – the planets are always seen close to it). Hence they will usually be either above (north) or below (south) the ecliptic. This is also the reason why we do not have solar eclipse on every new Moon day, or lunar eclipse on every full Moon day – the Moon may be somewhat above or below the ecliptic. Likewise, a transit will occur if the inferior conjunction of the planet (Mercury or Venus) occurs within a day or two (that is, the Sun, planet and the Earth coming on the same line with the planet in between) of the date at which the planet crosses the ecliptic.

The transits of Mercury can be seen 13 to 14 times in a century. Incidentally, the first transit of Mercury in the twenty first century took place on May 07, 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 six such events have occurred since the invention of the telescope (1631, 1639, 1761, 1769, 1874 and 1882). *It is interesting to note that there is no person living today who has witnessed a Venus transit before, the last transit having taken place on 06 December, 1882.* **The next two transits of Venus will occur on June 08, 2004 and June 06, 2012.** The entire transit of June 08, 2004 will be visible from Europe, Africa (except western parts), Middle East, and most of Asia (except eastern parts). India is ideally suited to observe the entire sequence of the transit. We are very fortunate indeed.

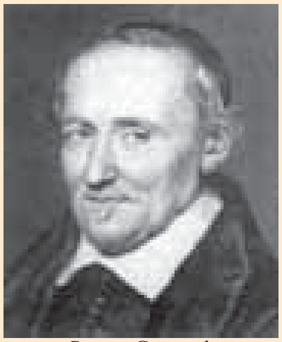
Halley explains significance of transits

What is the significance of transits? Edmond Halley (1656-1742) realized that transits could be used to measure distance of the Sun from the Earth (discussed later). As stated earlier, Kepler's laws gave relative distances between 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. By timing the events from various places on the Earth and using elementary geometry, 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 1% of that currently accepted.

Ptolemy

Actual scale of the astronomical world – Some History

The problem of determining the actual scale of the astronomical world has a history of its own. The first evaluation of the solar distance was derived in the sixth century B.C. by Anaximander, who speculated on both the distances of the Sun and the Moon from the Earth put the former at a distance of 27 times the diameter of the Earth and the latter at 19 times the diameter of the Earth. Apparently, there was no geometric calculation behind these figures - probably these values were arrived at through some sort of "number mysticism". Eudoxus (408 B.C.-355 B.C.) in Greece is supposed to have arrived at a relative distance between the Sun and the Moon of nine to one. From about the middle of the 4th century B.C., numerous studies were made of the sizes and distances of the planet. Aristarchus of Samos (310 B.C.-230 B.C.) was able to obtain a ratio between the distance from the Earth to the Sun and the distance from the Earth to the Moon. Apparently, his calculations showed that the distance from the Earth to the Sun proved to be 18-20 times greater than the distance from the Earth to the Moon. He arrived at the conclusion that the solar distance from the Earth to be 180 times the Earth's mean diameter, or about 2.2 million kilometres - rather small by modern estimates. The closest to the truth and boldest of all the estimates down to modern times was that of Posidonius (135 BC - 51 B.C.) who placed the Sun at a distance of 6545 times the Earth's diameter, or about 83 million kilometres. Hipparchus established the solar distance as 1245 times the Earth's diameter. Ptolemy derived a figure of 605 Earth's diameters.



Pierre Gassendi

At this stage, it is important to note when the notion of "parallax" came into being. The recognition of the concept of parallax in astronomy seems due to Archimedes (C.287-212BC), at least with respect to the parallax of the Sun. The solar parallax could broadly be described as the angular size (i.e. in terms of the radius or diameter) of the Earth as seen from the Sun. Indeed, the solar parallax is defined as the angle subtended at the center of the Sun by the Earth's radius (Figure 1). We shall discuss this in more detail later.

Ptolemy (2nd century AD) evaluated the solar parallax and expressed in angular measure as 3 minutes of arc. This value of solar parallax was accepted to the time of Tycho Brahe (1546 - 1601). Even Nicolaus Copernicus differed only slightly from Ptolemy setting the distance of the Earth from the Sun at 750 time the Earth's diameter. Tycho Brahe made no attempt to re-evaluate the solar distance, but Johannes Kepler (1571-1630), the brilliant co-worker of his last years, took it upon himself to re-examine the problem. *Kepler concluded that Ptolemy's estimate of the solar parallax was much too large and that the parallax could not be greater than one-minute, and was very likely much below that upper limit.* In 1627 Kepler completed the Rudolphine Tables (Box 1). Based on these Tables, he was able to predict with considerable accuracy the motions of Mercury and Venus. A precise knowledge of the motion of the inner planets, i.e. Mercury and Venus, he felt, would make it possible to decide just when they would pass across the face of the Sun and be visible from the Earth during the passage - that is to say, just when they would transit. Two years later he published a pamphlet in which he predicted the transit of Mercury on 07 November, 1631, and the transit of Venus on 06 December, 1631, though without connecting the latter to the question of the solar distance.

Tycho Brahe

It was Pierre Gassendi (1592-1655) who observed the transit of Mercury on 1631 at Paris, thereby becoming one of the first individuals ever to witness the transit of a planet. For this purpose, he used the principle of the camera obscura. Let us briefly describe his method. He admitted the solar light into a darkened room through a small opening in the window. The image of the Sun was then received upon a white screen and a circle drawn corresponding to its exact outline. Axes were constructed to divide the circle into four equal parts, and the circle itself was divided into 360 degrees. To obtain the time at the moment of observation, Gassendi placed an assistant in the room above him, whose duty was to observe the altitude of the Sun with a 2-foot quadrant whenever Gassendi signalled by stamping his foot! When the transit took place, Gassendi was able to track its path across the Sun by drawing a chord corresponding to the movement of Mercury's image across his screen. In addition, he was able to estimate its apparent diameter (about 20 seconds of arc) and determined the observed time of transit. By all counts it was a successful scientific observation. Gassendi attempted to repeat his success with Mercury transit for that of Venus. However, an error in the Rudolphine's Tables prevented him from doing so. Venus crossed the face of the Sun during the European night between 6 and 7 December of 1631. Consequently, no observation of 1631 transit of Venus was made!

BOX 1
The Rudolphine Tables

The Rudolphine Tables of planetary positions were published by Kepler in 1627 in Ulm and dedicated to Tycho Brahe's and Kepler's deceased patron, Rudolph II. The Rudolphine Tables were the first to make use of Kepler's newly formulated laws on planetary motions, calibrated using Tycho's store of accurate planetary observations. They received a spectacular validation on November 7, 1631, when the French philosopher and astronomer Pierre Gassendi (1592-1655) observed a transit of Mercury across the solar disk, as predicted by Kepler. Kepler's prediction of this event was far more accurate than those based on the Copernican Tables. This success paved the way for the general acceptance not only of the Rudolphine Tables, but also by extension, of Kepler's three Laws of planetary motions. The Rudolphine Tables predicted a transit of Venus in 1631, but not in 1639. It predicted that in 1639 Venus would be too far south to pass before the Sun.

Box 2
Again and Again, I recommend....

"I happened to observe with the utmost care, Mercury passing over the Sun's disk: and contrary to expectation, I very accurately obtained, with a good 24-foot telescope, the very moment in which Mercury, entering the Sun's limb, seemed to touch it internally ... forming an angle of internal contact. Hence I discovered the precise quantity of time ... of Mercury ... within the Sun's disk, and that without an error of one single second of time.I ... On observing this I immediately concluded, that the Sun's parallax might be ... determined by such observations .... Therefore, again and again, I recommend it to the curious strenuously to apply themselves to this observation."

- Edmond Halley (1691)

What did Edmond Halley say about a transit?

"There remains therefore Venus's transit over the Sun's disk, whose parallax, being almost four times greater than that of the Sun, will cause very sensible differences between the times in which Venus shall seem to pass over the Sun's disk in different parts of our Earth. From these differences, duly observed, the Sun's parallax may be determined, even to a small part of a second of time; and that without any other instruments than telescopes and good common clocks, and without any other qualifications in their observer than fidelity and diligence, with a little skill in astronomy. For we need not be scrupulous in finding the latitude of the place, or in accurately determining the hours with respect to the meridian; it is sufficient, if the times be reckoned by clocks, truly corrected according to the revolutions of the heavens, from the total ingress of Venus on the Sun's disk, to the beginning of her egress from it, when her opaque globe begins to touch the bright limb of the Sun; which times, as I found by experience, may be observed even to a single second of time."

- Edmond Halley (1716)

The Rudolphine Tables had predicted that the next transit of Venus after that of 1631 would take place in 1761, and that in 1639 it would be too far south to pass before the Sun. Jeremiah Horrox (1619-1641), (also spelt Horrocks) while studying the errors in these Tables, discovered that the transit of Venus would indeed take place in 1639. This is how Horrox was induced to observe the 1639 transit with great attention! He used much the same technique which Gassendi had employed for the transit of Mercury eight years earlier. *However, instead of simply admitting the solar light into the darkened room through an apperture in the shutter, he substituted the telescope at the opening.* In this way he could bring the image of the planet to a sharp focus on the screen. His observation was a complete success. From these observations, Horrox was able to collect several elements in the theory of the planet's motion. He could state with confidence that the diameter of the Venus could not be greater than one-minute. Although he was not equipped to calculate the solar parallax with any degree of accuracy, he estimated that it could not exceed 14 seconds of arc. It was a bold conclusion in view of Kepler's one-minute evaluation for the solar parallax. The results of the 18th century transit of Venus observations were to prove Horrox much closer to the truth than Kepler. Newton praised him most highly. Besides the work on the transit of Venus and the Moon's orbit, he worked on the detection of the inequality for the mean motion of Saturn and Jupiter. He wrote an essay on the nature and movement of comets, and an incomplete study on tides. No doubt, it is an impressive list for a man of 22, though isolated and unsung in his own day.

Jeremiah Horrox

Some twenty years passed by after the work on Horrox before the first scientific calculation of the Sun's distance was obtained – without a transit of Venus! Giovanni Domenico Cassini (1625-1712) together with Jean Richer at Cayenne made simultaneous observations of the parallax of the planet Mars in the background of stars while the planet stood in opposition. From the results thereby obtained, Cassini deduced the solar parallax of 9.5 seconds, corresponding to the Sun - Earth distance to 139 million kms. Indeed, the estimates by other observers ranged from 10 seconds to 20 seconds.

Cassini

Theoretically, the transits of both Mercury and Venus could be used to determining the dimensions of the solar system. But the development of a practical method for performing the task had to wait till the efforts of Edmond Halley. Halley's interest in the possibility of utilising the transit of Venus for determinig the solar parallax arose from his trip to St. Helena to observe the stars of the south pole and the transit of Mercury of 1677 (Box 2). He announced in 1691 that by the observation of the transit of Venus, the distance of the Sun from the Earth might be determined. He presented a definite plan by which to obtain an accurate knowledge of its value. He published in 1716 a paper which outlined a practical programme of observation with the promise of definitive results (Box 2). His reputation as an astronomer helped to inspire scientists from all corners of the world to prepare for the rare opportunity presented by the forthcoming transits of 1761 and 1769.

Solar Parallax

In astronomy, discussion of the solar distance makes use of the much more suitable term - solar parallax. *The word parallax in general means, the difference between the direction of the heavely body as seen by an observer and as seen from some standard reference point.* If the Earth's centre is taken as the standard reference point – a point on the Earth's centre and its circumference as the observer's position, then the parallax of an object may also be said to be the angular separation of the Earth's centre and its circumference as seen from the object. Hence, the solar parallax is an angle formed at the Sun by lines drawing from the centre of the Earth and from the observer's station on the Earth's surface. It is useful to define a special kind of parallax when the Sun is at the horizon. And this horizontal parallax is simply the radius of the Earth as seen from the Sun. Indeed, solar parallax is the angle subtended at the centre of the Sun by the Earth's radius. If this angle is known and the radius of the Earth can be measured, then the distance to the Sun can be deduced by simple calculation (Figure 1).

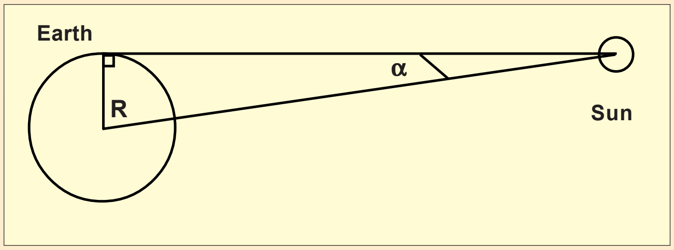


Figure 1 : The solar Parallax

What is the connection between the solar parallax and solar distance anyway? Suppose an observer is placed on the Sun, and armed with an instrument capable of measuring the angular separation between two points and a knowledge of the Earth's diameter as well. By measuring the angle formed by the Earth's diameter as seen from the Sun and knowing its actual length, the problem of determining the distance between the Sun and the Earth now becomes the simple trigonometric one of calculating the altitude of an isosceles triangle where the base length and the angle between the equal sizes are known. *Conversely, for a terrestrial observer to whom the Earth's diameter is known, the problem becomes one of evaluating the angle of parallax.*

Measuring the Solar Parallax

Let us see how the transit of Venus could be used for determining the distance of the Sun. When a surveyor desires to ascertain some inaccessible distance, say the width of a river, he measures a baseline on his side of the river, and also the angles between this baseline and the lines running to the desired point. With these data, he can readily compute the required distance. A plan similar to this is employed when the astronomer desires to determine the distance of the Moon. The baseline which he uses in his computation is the radius of the Earth, and the angle subtended and the Moon by this radius is called the parallax. These two being once known, the distance may be readily found. But this method utterly fails when applied to a body as distant as the Sun. The Sun's distance is so great that the angle subtended at it by the Earth's radius becomes inappreciable. Halley's method enables the astronomers to employ, instead of the parallax of the Sun, the parallax of Venus at her nearest point. Venus revolves in an orbit within that of the Earth completing a revolution in about 224 days, while the Earth requires 365. In Figure 2, E represents the Earth and its orbit; V, Venus and its orbit; S, the Sun; and AB, the line of nodes of the planet formed by the orbits of Venus and the Earth. The orbit of the Venus is inclined at an angle of about 3 degrees and 23½ minutes. Hence, an inferior conjunction (i.e. Sun, Venus and Earth coming in a single line with Venus in between) of the two planets will be a rare phenomenon. It can occur only when the Earth and Venus are both present on the same side of the sun along the line of nodes AB. Let us note in passing that the Earth is always at position A in June and at position B in December, so that all observed transits will occur in these months. On the line of nodes when Venus lies on the opposite side of the Sun it is called superior conjunction. Two consecutive conjunctions (either inferior or superior) occur at intervals of about 584 days. When Venus is at the inferior conjunctions, her distance from the Earth is much less than that of the Sun, and her parallax consequently much larger. In fact, the distance from the Earth to Venus is only about one quarter as much as that to the Sun, and, therefore, her parallax almost 4 times more. It was precisely to take advantage of this greater parallax that Halley's method was proposed. The only difficulty is that Venus is rarely visible at her inferior conjunctions. The light of the Sun is so great that the brightest stars in its vicinity are lost to sight. It is only on this rare occasions, when Venus chances to come so exactly in line that her disc is projected as a black dot against the Sun's disc, that Venus becomes an object for rigid observation.

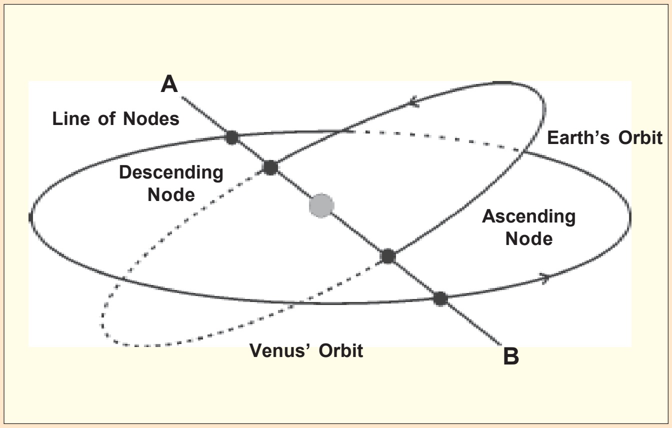


Figure 2 : Geometry for transits

How is it that we cannot employ Mercury transits to measure solar parallax though they take place 13 to 14 times a year? In principle we can. But, the Mercury is too close to the Sun and hence much further away from the Earth. Hence its parallax would be much smaller than that of the Venus and hence even more difficult to measure!

Let us now describe the method to determine the solar parallax using Venus transits. In Figure 3, A and B represent two observers on the Earth, V the planet Venus in its orbit; CD

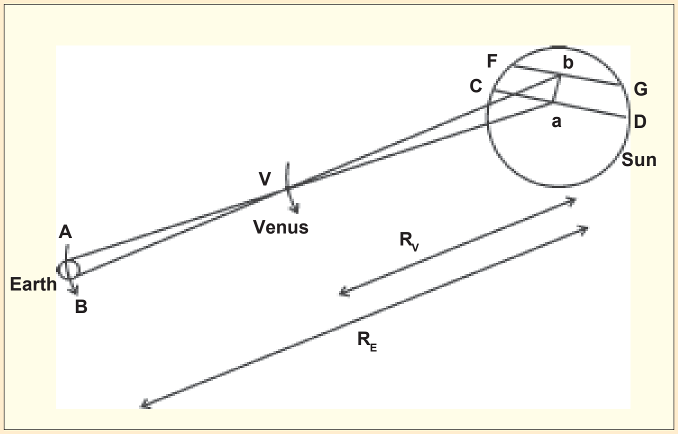


Figure 3 : Measuring solar parallax

and FG the paths of Venus across the face of the Sun as seen from A and B respectively. Kepler's third law then allows us to determine the relative positions of Venus and the Earth with respect to the Sun. Let the planet Venus move in her orbit at V between the Sun and the Earth. We may further assume that the Earth is stationary and that the Venus moves with a velocity equal to the difference between her own and that of the Earth. Let the two observers watch the phenomenon - the one at A at a point near the north pole and the other at B at a point near the south pole. It is evident that to these two observers the transit would appear to take place on different lines. Thus, the observer at A would see planet crossing in the line CD while the observer at B would see it on the line FG. Further apart the two stations A and B could be taken, the greater would be the interval 'ab' between the two paths. Now, Kepler's laws of planetary motion tell us how much further it is from V to a than from V to A. Since the location of the two observers at A and B is known, their distance apart in kilometres can be found and thus using elementary geometry we have at once the distance 'ab' in kilometres . It only remains to find out what part 'ab' is of the entire diameter of the Sun and then we should know this diameter in kilometers. We do know the angular diameter of the Sun, i.e. we know the angle made by two lines drawn from the eye to the two ends of the Sun's diameter. Its average value is about 32 minutes of arc, a little more than half of a degree. If the observer at A had timed with great precision the ingress of the planet at C and its egress at D, he would know the time taken in traversing the line CD. Then knowing the rate at which the Earth and the Venus move in the orbit - not in kilometers but in minutes - he can tell the exact length CD in minutes. For making this estimate he must take into account, not only the motion of the planets in their orbits, but also the effect produced by the Earth's rotation. Similarly, the length of the line FG can be determined in minutes. From these lengths it is easy to derive the length of 'ab', the distance between the two lines in minutes. But we already know 'ab' in kilometers, and from these two values we can ascertain how many kilometers are due to each minute or second or arc at the distance of the Sun. It works out to about 735 kilometer in each second of arc. Hence the angle subtended by the Earth's radius at the centre of the Sun, or the parallax of the Sun must be quotient of 735 kilometres contained in the Earth's radius and works out to about 8.7". The calculations involved are outlined in Box 3.

This is virtually although not precisely the process by which the Sun's parallax is derived utilising the transit of Venus. Surely, the observers are not two, but any number. Further, the calculations are by no means so simple in practice as indicated here. Every circumstance which can possibly affect the results must be taken into account and avoid instrumental and other errors. From the observations on the transits of 1761 and 1769, the computed value of parallax of the Sun was 8.5776" corresponding to a distance of 152×10^6 km. approximately, though it was not accepted as final. There were discrepancies and irregularities in these observations. Currently, the accepted value of the solar parallax is 8.794148 seconds of arc.

Frequency of Transits of Venus

As remarked earlier, transits of Venus have a peculiar pattern made up of four irregular intervals of 8,121.5,8 and 105.5 years (Box 4A). How do we explain this strange pattern? If at time 0 the Earth, Venus and the Sun are in line at the ascending node (Figure 2) – i.e. a perfectly central transit occurs, then this will occur again only when Venus has

Box 3

How far is the Earth from the Sun, then?

Let us refer to Figure 3. We know that diameter of the Sun = 31'30", that is 1890."

It is obvious that, $ab / AB = aV / VA = R_V / (R_E - R_V)$

where R_V and R_E are the orbital radii (semi diameters) of Venus and Earth respectively.

Thus, $ab = AB (R_V / (R_E - R_V))$

Hence, $ab = AB ((R_V / R_E) \div (1 - (R_V / R_E))$. But, how do we know R_V / R_E?

From Kepler's third law of planetary motion, we have,

$T_V^2 / T_E^2 = R_V^3 / R_E^3$

Thus, $R_V / R_E = \sqrt[3]{(T_V^2 / T_E^2)}$

We need to compute ab in the angular measure. Since the location of the two observers A and B is known, their distance apart in kilometers can be found. Thus we have at once the distance ab in kilometers. We know the angular diameter of the Sun, which is 31'30" or 1890". If A had timed with great precision the ingress of the planet at "C", and its egress at 'D', he would know the time occupied in traversing the line CD. Knowing the rate at which the Earth and Venus move in their orbits, he can tell the exact length CD not in kilometers, but in minutes. In the like manner, the length of the line FG can be determined in minutes. From these lengths, it is easy to derive the length of ab, the distance between the two lines, in minutes.

But, we already know ab in kilometers, and from these two values, we can readily ascertain how many kilometers are due to each minute or second of arc at the distance of the Sun. It turns out to be about 735 kilometers for each second of arc.

We can now readily calculate the solar parallax. It is the quotient of 735 kilometers contained in the Earth's radius. Hence, solar parallax α = 6400 / 735 = 8.7" approximately.

It is now child's play to calculate the distance of the Sun from the Earth.

Now, α = Radius of the Earth / Orbital radius of the Earth. Hence, 1AU = Radius of the Earth / α. Here α will have to be in the angular (radian) measure and when 8.7" is converted to angular measure, we get 4.2×10^{-5} radians. We also know that radius of the Earth is abut 6400 kilometres. Thus, 1AU = 6400 ÷ (4.2×10^{-5}), or 151×10^6 kilometres approximately. We can now have the dimensions of the solar system.

completed an integral number of orbits and the Earth too has completed an integral number orbits. Let us call these integral numbers n, N respectively. Now, Earth takes 365.25636 days to complete one orbit while Venus takes 224.701 days to complete one orbit.

Hence, 224.701n = 365.25636N. Surely, these expressions are not commensurable and consequently the equation is never exactly satisfied. However, equality "almost" occurs for the specific values of n, N for 'ascending' node near alignment as shown in Box 4B.

The gaps between the two alignments are too large to explain the dates of *all* Venus transits given apart. But, we must remember that alignments can also take place at the descending node. When should *these* transits occur? These must occur at an integral number of orbits (of Earth and Venus) *plus* a half orbit after passing the ascending node at time 0. The second equation is then:

$$224.701(n + ½) = 365.25636 (N + ½)$$

We now have a corresponding list of near equalities for transits at the descending node as shown in Box 4C.

Box 4 B and Box 4 C for transits at the ascending node and the descendind node respectively, between them, fit the sequences of dates of Venus transits given. One may also note that the ascending node transits take place in December while the descending node transits take place in June. We assume here that the orbit of Venus has negligible eccentricity – i.e. her orbit is near circular and hence the time between the ascending and descending node is exactly half a sidereal period of Venus, i.e. relative to stars. In addition to assuming that the orbits of Earth and Venus are concentric circles, we also assume that the positions of the nodes do not change with time. None of these assumptions is strictly true. However, the above figures are only illustrative in nature.

Box 4A

Frequency of Transits of Venus

Transits of Venus may be seen at first sight to have a strange periodicity. The transits from 17th century to 21st century are as follows:-

Year	Date	Node	Gap in years from last transit
1631	07 December	Ascending	-
1639	04 December	Ascending	8
1761	06 June	Descending	121½
1769	03-04 June	Descending	8
1874	09 December	Ascending	105½
1882	06 December	Ascending	8
2004	08 June	Descending	121½
2012	06-07 June	Descending	8

Box 4B

Earth Orbits	Venus Orbits	Difference (hours)
0	0	0
8	13	22.5
235	282	12.9
243	395	9.6
478	777	3.3

Box 4C

Earth Orbits	Venus Orbits	Difference (hours)
113½	184½	17.7
121½	197½	4.8
356½	579½	8.1
364½	592½	14.4

It's not all that easy!

The method of obtaining the solar parallax which Edmond Halley presented in 1716 was basic to the transit of Venus observation of 1761 and 1769. Though geographical errors were discovered in his proposals before they were put into practice, and some modifications were made in the method itself, **Halley's plan remained fundamental to the 18th century calculation of the solar distance.** The distinct effective feature of Halley's method lies in the manner of determining the separation between the apparent paths CD and FG in Figure 3. The path farthest from the Sun's centre FG is shorter

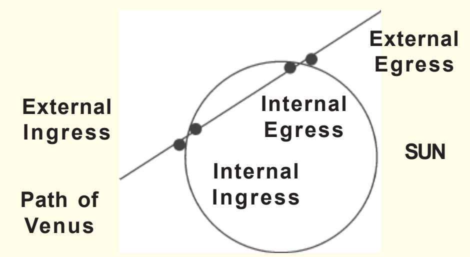


Figure 4 : Circumstances of a transit

than the other, so that Venus will appear to pass across the Sun more rapidly when observed from a station in the southern hemisphere than when observed from a station in the norther one. Halley, therefore, proposed that the time which Venus would appear to spend on the surface of the Sun be measured, the instruments required being only a telescope and a good timepiece. The difference in time noted by observers at different stations in the two hemispheres would then supply means for calculating the difference between the parallax of the Venus and the Sun. His plan, therefore, required that both the beginning and the end of a transit be exactly determined. This demanded four very precise measure in pairs or themselves, the moments of external and internal contact at ingress, egress (Figure 4).

The rotation of the Earth introduces additional factors into the problem. It introduces an increment or decrement in transit duration depending upon the position of the observer and the direction of the Earth's rotation. Secondly, the rotation of the Earth raises the obvious problem of how to place observers in the best possible geographical position to witness the phenomenon. To be effective, Halley's technique required that the duration of the entire transit be measured; and to make this possible the widest northern and southern separation of observers within the cone of visibility of the phenomenon was required. This was to make the difference between observed duration as large as possible in order to keep the errors as small as possible.

Observations on the Sun involve some difficulties which are peculiar. The Sun is intensely hot and intensely luminous. Its surface, instead of being a smooth, unchanging globe, is constantly in a state of the most fearful agitation. The edges

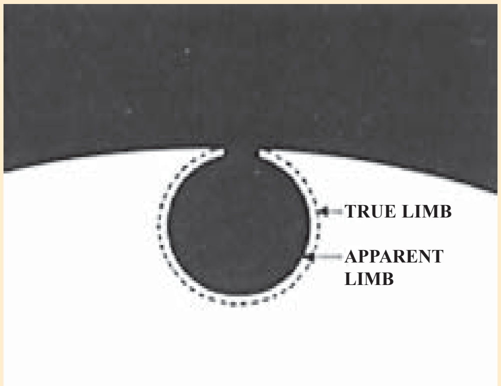


Figure 5 : The Black Drop Effect

of its disk, therefore, at which we are to observe the ingress and egress in a transit, are ragged and irregular. Besides this, the planet having its dark face turned toward us, cannot be discovered until the contact actually begins so that the observer is apt to allow some seconds or fractions of a second to elapse before he recognizes the planet. This difficulty makes the observations for external contact notably uncertain and unreliable. But when the phases of internal contact are selected for observation, a new class of difficulties is encountered. It is found that long after the planet would seem to be clear of the line of the limb, it still clings fast to it by a dark ligament (see Figure 5). Gradually the ligament grows thinner and thinner, until finally it breaks. This is what is known as the famous (or infamous!) Black Drop Effect. This effect becomes the limiting factor in determining the Astronomical Unit via transit timings.

We may remark that in the 17th century, the transit of Venus had been observed in isolation by Jeremiah Horrox and his friend Crabtree. The usefulness of the phenomenon for determining the solar distance was then unknown and an interest in science was yet to spread. By 1761 and 1769 the enthusiasm was enormous. For example, contrast the limited success of Horrox and Crabtree in merely seeing the transit of Venus and the catalogues of 120 observers from 62 separate stations who observed it in 1761, and 138 observers from 63 stations who observed it in 1769. We shall briefly describe the expeditions to observe Venus transits of the 18th century and 19th century in a forthcoming article.

References

1. The transit of Venus : A study of Eighteenth Century Science by Harry Woolf, Princeton University Press (1959).
   The present article draws considerably on the book. A wonderful account of the efforts in 18th Century to measure the solar parallax.
2. The transit of Venus by David Murray, December 06, 1874 http:// home.att.net/~o.caimi/VENUS.pdf
3. Transits of the Sun by Fred Espenak http://sunearth.gsfc.nasa.gov/eclipse/transit/transit.html
   The most authentic account of transits by a veteran astronomer engaged in predictions and circumstances for decades.
4. A new method of determining the parallax of the Sun by Edmond Halley (Phil.Trans.Royal Soc. Vol.XXIX, 1716 pp.454-464. Available on http://sunearth.gsfc.nasa.gov/eclipse/transit/HalleyParallax.html
   A highly inspiring paper. A must for anyone interested in learning about the historical aspects of transits.
5. Http://www.dsellers.demon.co.uk/venus/ven-eh5.htm
   Information on frequency of transit in the present article is drawn from this article.

Glossary

Ascending Node : Also known as northbound node. The point at which a planet or comet crosses to the north side of the ecliptic.

Astronomical unit : Abbreviated AU. A measure for distance within the solar system equal to the mean distance between Earth and Sun, that is, about 149,598,000 kilometers.

Black drop : As seen through a telescope, an apparent dark elongation of the image of Venus or Mercury when the planets' images are at the sun's limb.

Descending node : That point at which a planet or comet crosses the ecliptic from north to south.

Ecliptic : 1.The apparent annual path of the sun among the stars; the intersection of the plane of the Earth's orbit with the celestial sphere.

2. The plane of the Earth's orbit around the Sun.

Egress : The departure of the Moon from the shadow of the Earth in an eclipse, or of a planet from the disk of the Sun.

Ingress : The entrance of the Moon into the shadow of the Earth in an eclipse, of a planet into the disk of the Sun.

Parallax : Parallax can be defined as the angular distance between two points as seen from a third point in space, such as the radius of the Earth's orbit can be seen from a Star.

Radian : The central angle of the circle determined by two radii and an arc joining them, all of the same length.

Solar parallax : The Sun's mean equatorial horizontal parallax p, which is the angle subtended by the equatorial radius r of the earth at mean distance a of the sun.

Transit : Passage of a smaller celestial body across a larger one.

Roving on ..... *Contd. from page...43*

their foot on the Red Planet and take a "small step" on its surface. Mars is a spectacular place, and will remain so even if it is finally proved to be lifeless. Nearly a year ago, 01 February, 2003 to be precise, the Space Shuttle *Columbia* disintegrated on its return journey when it was just 16 minutes away from the Earth. The entire crew of seven astronauts perished. Kalpana Chawla - the citizen of the Universe - was one of them. Spirit and Opportunity roving on the surface of Mars are a fitting tribute to these martyrs who helped push the frontiers of our knowledge. Today, we may not be sure if there is or ever was life on Mars. But one thing is certain - one day, there will be!

❒ **V. B. Kamble**

Father Eugene Lafont

A Selfless Missionary of Science in India

❑ Subodh Mahanti
e-mail: mahantisubodh@hotmail.com

Indeed in addition to his sterling qualities as an educationist, Father Lafont was a born popular scientific lecturer, and had a peculiar facility for putting dry facts in a popular way and an equal facility for making his lectures interesting by experimental illustration.

Nature, May 14, 1908, p.35

The most significant aspect of Lafont's personality was that he belonged to religion and tried to synthesise science with religion. God and God's positive works, according to him, are inseparable, since truth of one kind cannot be basically opposed to another kind. We would emphasise that his synthetic view was widely shared by the contemporary intellectuals.

Arun Kumar Biswas in his book, *Father Eugene Lafont of St. Xavier's College, Kolkata and the Contemporary Science Movement*, The Asiatic Society, Kolkata, 2001.

All the pupils of Father Lafont, so long Professor of Physics in that college (St Xavier's), recall his teaching influence as truly educative. His wealth of experiments and vivid clearness of exposition of them, made his class the most interesting in the college…"

Patrick Geddes in his book, *An Indian Pioneer of Science: The Life and Work of Sir Jagadish C Bose.* Longmans, Green and Co, 1920.

Though a Catholic and Priest, I hail with delight and pursue with love any advance of true science, the only thing that frightens me being the pretended discoveries of men who are not satisfied with facts, but put in their stead, and erect into scientific dogmas, the ill-digested lucubrations of their imagination.

Father Eugene Lafont

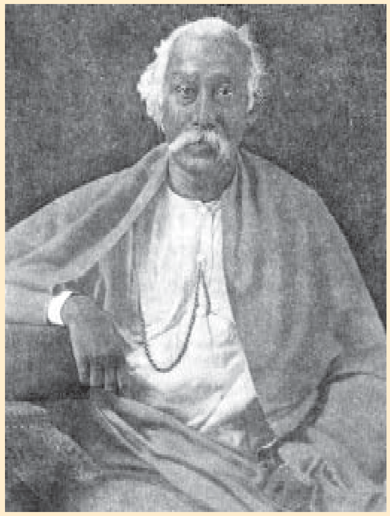
Father Eugene Lafont occupies a unique place in the history of modern science in India. Father Lafont came to Kolkata (then Calcutta) in 1864 at the age of thirty-four. Father Lafont joined the St Xavier's College on December 07, 1865 and he was associated with it for 43 years (1865-1908). At St. Xavier's Father Lafont 'taught science, preached science (alongwith religion of course) and practised science'. He taught here Jagadis Chandra Bose, regarded as the first scientist in modern India and many other illustrious students. Under the guidance of Father Lafont, St. Xavier's College established meteorological and astronomical observatories and a physical laboratory. Father Lafont played an instrumental role in persuading the Calcutta University in initiating undergraduate course in science. He, alongwith Mahendra Lal Sircar, was the co-founder of the Indian Association for the Cultivation of Science. The Association, which was established in 1876, was the first institution of scientific research to be established and managed by the natives of India. Father Lafont is rightly considered as one of the architects of modern Indian science. "Lafont and Mahendralal were genuine path-finders in the Indian science movement of the `nationalist' hue as contrasted with `colonial' variety. Quite fittingly, they were called the twin fathers of modern science in India. J. C. Bose, C. V. Raman etc. were deeply indebted to their leadership," writes Arun Kumar Biswas. Lafont established meteorological and astronomical observatories at St. Xavier's College. It was his public popular scientific lecture-cum-demonstrations in which he excelled over all his other activities. His first popular scientific demonstration to the public of Kolkata on September 18, 1868 and he continued to lecture till his death.

Father Eugene Lafont

Father Lafont was a man of religion but he did not find any contradiction in dedicating his life for teaching and 'preaching' science. He also practised religion with equal zeal. Father Lafont vehemently opposed the idea that science and religion cannot go together. He believed that truth of one kind cannot be opposed to truth of another kind. He put mind or soul at higher pedestal than matter. Father Lafont advocated a balanced commitment for science and religion. Along with teaching and giving popular science lectures, Father Lafont continued his theological studies. His sermons at St. Thomas Church, where he was the Vicar, were so popular that they even attracted non-Catholics as well

Father Lafont was born at Mons, a little town in the southern-most part of Belgium, on March 26, 1837. His father

Pierre Lafont was an army officer. His early education was at St. Barbara's College at Ghent (or Gent), where his father was posted. He joined the Society of Jesus in December 1854. After receiving the necessary training of the Order, Father Lafont joined the Namur College for studying Philosophy and Natural Sciences. Father Depelchin, who later established the St. Xavier's College at Kolkata in 1860, was the minister of the Namur College. Within five years of the establishment of St. Xavier's College, Father Depelchin requested for the services of Father Lafont for teaching physics. Father Lafont arrived at the St. Xavier's College on December 07, 1865. His first assignment was to teach the 5th year or Pre-entrance class of the school. When in 1867, the BA class was opened at St. Xavier's Father lafont was promoted from the school department to take charge of the Natural Philosophy division in the college. He also taught Mental and Moral Philosophy. In 1871 Father Lafont became the Rector of the St. Xavier's.



Dr. Mahendralal Sircar

Father Lafont is often referred to as the teacher of the first scientist in modern India, Jagadis Chandra Bose. It was Father Lafont who inspired Bose in experimental science. Thus Patrick Geddes, the biographer of Bose, wrote: "…and his (Father Lafont's) patient skill, his subtelity, as well as brilliance of experimentation, were appreciated by this young student above all. Here was Bose's first discipline towards that combination of intellectual lucidity with wealth of experimental device and resource by which he has all the more fully represented and honoured his old master by surpassing him." Since the beginning Father Lafont thought very high of Bose. In a certificate given to Jagadis Chandra Bose on April 12, 1880 Father Lafont wrote: "I certify that Baboo Jagadis Chunder Bose B.A. was my pupil in Physical Science for a period of four years and gave some proof of very great proficiency in that branch of study. I consider him to be one of the best students we had in our College Department." Father Lafont believed that Bose had a priority over Marconi in inventing wireless transmission. This is clear from a letter he wrote to Bose sometime in August 1897. Lafont wrote: "I would like to give a public lecture at St. Xavier's College Hall on "Telegraphy Without Wires", but as the instruments you so kindly gave me are not in working order and as I would like to take this opportunity to vindicate your rights to priority over Marconi, would you assist me in my lecture with your presence and work your own instruments. Let me know as soon as possible as I intend inviting the Lieutenant Governor…" Bose always gratefully remembered his extraordinary teacher.

Sans Souci : Theatre Converted into St. Xavier's College

Father Lafont was not a creative research scientist. But then he was something more than a popular science lecturer. Thus Arun Kumar Biswas wrote: "The manner with which Lafont grasped and interpreted the latest scientific discoveries spoke of his command over the frontiers of science. The high proficiency which he attained in the study of physics gives evidence that had he remained in Europe, he would have won a very conspicuous place in the world of Science. He however devoted himself to the cause of Bengal Mission as `the needs of Bengal were many"'. His contribution to the development of a scientific ethos in the country was very significant. He expanded the scientific emphasis of the St. Xavier's College. At his request priests `with scientific learning' were sent to Kolkata from Belgium. He established a fully equipped laboratory at the college. He built this laboratory largely based on contributions received by him and entry fees for attending his lectures. Commenting on the laboratory the house magazine of the college, The Xaverian (Vol. 1, No.2. 1904, p.61) wrote: "...The first thing that strikes the visitor on entering the Physical Science Laboratory, apart from the vast proportions of the hall, is the magnificent array of almirahs all filled with instruments, that surround the place, and increase in number, dimensions and importance as he proceeds towards the further end of the room. This is the place for mute astonishment…As regards the scientific equipment, the laboratory is fully up to date, and to quote, the words of the inspectors appointed by the University of Calcutta: "Its collection of apparatus…is far above the actual requirements of the ordinary University courses."

In 1875, he built a small astronomical observatory in the college. This created lot of interest among the people about scientific matter. It was the Italian astronomer Pietro Tacchini (1838-1905), who influenced Father Lafont to build the observatory. Tacchini came to India as the leader of the Italian expedition to observe the transit of Venus in December 1874. The other members of the expedition team were the Jesuit Angelo Secchi (1818-78), director of the Observatory of the Collegio Romano; Alessandro Dorna (1825-86) of the Observatory of Turin and Antonio Abetti (1846-1928) of the Observatory of Padua. At the instance of F. Lamouroux, Italian Consul of Calcutta, Tacchini selected Madhupur as their site of observation. Lamouroux had consulted Lafont while selecting observation station for Tacchini. Lsafont was also invited to join the expedition. As a member of the expedition team, Lafont, alongwith Prof. Dorna, carried out visual observations. The spectroscopic observations were carried out by Prof. Tacchini and Abetti. Though the weather hindered the observations, Prof. Tacchini's team could obtain important results. Father Lafont wrote an interesting account of the expedition and got it published. Here we quote from Father Lafont's account:

"As the time approached when the first contact was expected, the clouds gathered more numerous around the sun, as if determined to hide it, and we had great difficulty in securing a view of its bright edge through the openings left between these obnoxious screens. However, Prof. Dorna and myself succeeded in taking down with tolerable accuracy the two first contacts. Those who understand the spectroscopic method must have guessed already that our talented chief and his companion could not have seen these two first phases of the transit, since absolute purity of the atmosphere is a necessary condition of success in these delicate researches. Fortunately, soon after, the sky gradually became clearer, and during the transit Prof. Tacchini discovered in the atmosphere of Venus unmistakable the sign vapour of water. This result, corroborated by Prof. Abetti, is in itself a very valuable addition to our knowledge of the planet. Encouraged by this unforeseen discovery and the better state of the atmosphere, we all resumed our places at the eye-piece of our instruments, and had the great satisfaction of catching, all of this time, the two last contacts. Here again, the ordinary method of observation gave us times agreeing very closely, whilst our companions of the spectroscope had the good fortune of establishing upon experimental proofs the great superiority of the spectroscopic method over all others, in determining the real time of contact, to a small fraction of a second, with ease and certainty. The main object of this mission is therefore accomplished."

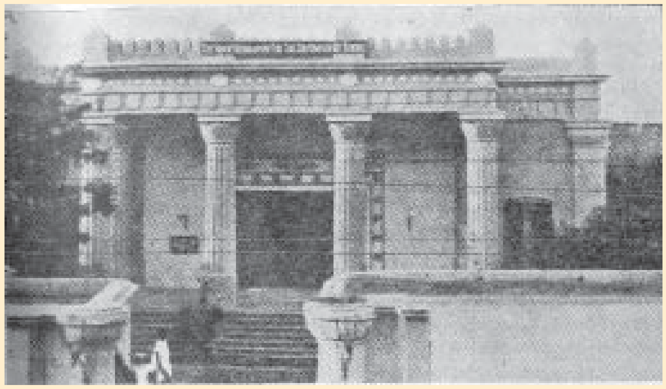
Tacchini did not leave India immediately after the observation of the transit of Venus. This is because he had been invited by the Royal Astronomical Society of London to join the planned expedition for the observation of the total solar eclipse to be visible from the Nicober Isles. During his stay in India, Tacchini decided to give shape to long thought out research project. Tacchini had founded the Italian Spectroscopists' Society (Societa degil Spettroscopisti Italiani) in 1871. This happened to be first scientific society specifically devoted to astronomical spectroscopy or physical astronomy. Other founding members of the society were Secchi, Giuseppe Lorenzoni, Lorenzo Respighi (1824-1889) and Arminio Nobile (1838-97). The first major aim of the society was to examine and study solar features in a continuous way. For this they needed an observatory in another country. Tacchini realized that an observatory in India would serve their purpose very well. To quote Tacchini: "During our stay in Muddapur (…) we experienced the most favourable climatic conditions to carry out a series of spectroscopic observations of solar limb in a season in which we are seldom successful in Palermo and in other Italian towns. We recall, then, the necessity already expressed in preceding years by me and by Secchi, of having in another country an observatory which could be used to, complement the series of our observations, as during the winter season they are suspended in our observatories, especially from November to March."

Nineteenth century Observatory of St. Xavier's College

In July 1875 Lafont wrote To Tacchini: "I am pleased to announce to you that our observatory is almost completed (…). Mr. Merz had already written to me and he is busy building a 7-inch Equatorial with parallactic mounting for 12,500 francs. It will not be finished before eighteen months. I am going to receive a 10-prism spectroscopes which I will use with a small 3-inch telescope of Steinheil, while waiting for the installation of my grand instrument."

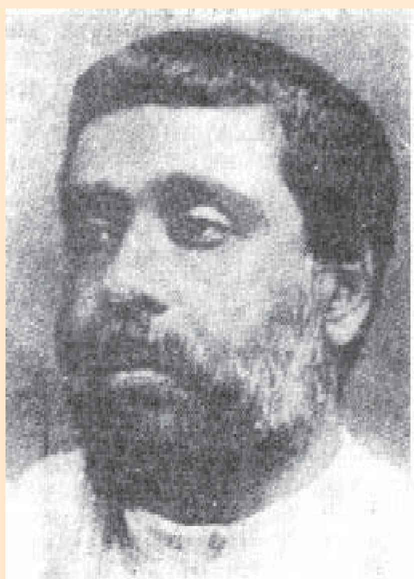
Tacchini announced the creation of the spectroscopic observatory in Kolkata to the scientific community: "The eminent father Lafont, Director of St. Xavier's College in Calcutta, after observing the chromosphere and the solar prominences with our instruments in Madhupur, and seeing the practical way to execute the spectroscopic observations of the Sun at our Station, has accepted the proposal to build an Observatory in Calcutta in his College with aim of carrying out there regular solar observations, which (…) could fill the inevitable gaps of our Observatories because of the too often overcast sky in (winter) months (…) The station is almost complete….the new Calcutta Observatory will be able to give the best results under the active direction of Lafont, to whom our colleagues will be very grateful for remedying, with his ability and commitment, a long complained snag."

To see wherefrom the money came from for building the observatory we quote from *The Xaverian:* "Professor Tacchini, the Italian astronomer, had been so impressed during his short visit (December 1874) to India by the value of solar observations in our cloudless sky that he persuaded Father Lafont to erect a spectro-telescope at St. Xavier's. An appeal was made for funds and Sir Richard Temple, the Lieutenant Governor, personally interested himself in the matter. He paid an afternoon visit to the college…By the end of the month, the Government of Bengal sanctioned a grant of Rs.5000 towards the erection of the observatory, on condition that a like sum be gathered by private subscription before the end of March. The money was soon forthcoming…Towards the end of June 1875, the Observatory was near completion, and the estimated cost was Rs. 9000. With the instruments ordered out from Munich and London, it was calculated that the total expenditure would come to Rs. 15,900. The Government increased the original grant by Rs.2000, and the commercial community of Calcutta generously made up the remainder. In all, Father Lafont collected Rs. 21000. Asiatic Society of Bengal had sanctioned a token grant towards this project." The famous international journal, Nature, also took note of the development. A report signed by the chemist Raphael Medola (1849-1915) observed: "Now that the subject of solar observation in India is likely to occupy the attention of the scientific public, the following details of the Solar Observatory now in progress of construction at Calcutta may be of interest to readers of NATURE. The suggestion emanated in the first plan from the well-known Italian astronomer and spectroscopist, Prof.Tacchini, who was sent by the Italian Government as director of the Transit of Venus' Expedition. The idea thus put forth was at once taken up by Pere Lafont, the Principal of St. Xavier's College…The Italian Transit of Venus' Expedition has thus been the means of sowing seeds which, finding themselves in a soil most favourable for development, are calculated but no very distant period to bear fruit of the greatest value to science (…) It is only by systematic observations of this kind carried on by public enterprise, that we can never hope to direct cyclical changes in the sun's composition and constitution…"



Indian Association for the Cultivation of Science at 210. Bowbazar Street Kolkata

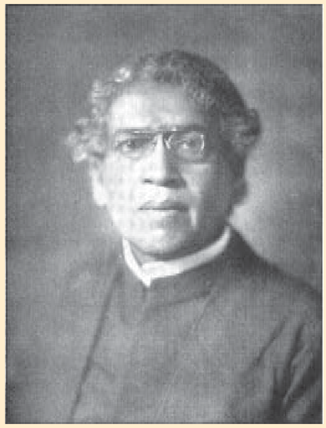
The Indian Association for the Cultivation of Science was established in 1876 with the object "to enable the Natives of India to cultivate Science in all its departments with a view to its advancement by original research, and (as it will necessarily follow) with a view to its varied applications to the arts and comforts of life." It was Mahendra Lal Sircar who first proposed the creation of such an institution for the creation of mass interest in science and for the training of scientists for undertaking original research. It was working in this institution that C. V. Raman brought the Nobel Prize in science to India. Father Lafont not only lent his wholehearted support to Sircar's scheme but also helped the Association in its development in many ways. The provisional committee appointed for drawing up a plan for the organization of the Association was chaired by Father Lafont. The Association was finally established on January15, 1876. The teaching work of the Association started shortly after its inception with the appointment of Father Lafont and Dr. Sircar as honorary lectures in Physics and of Dr. Kanai Lal Dey as an honorary lecturer in chemistry. It was Father Lafont who started his course on August 24, 1876. He lectured on light, General Physics and Sound. On an average he gave 20 to 30 lectures per year. He continued to give regular lecture at the Association till 1893. However, he continued to give popular science lecture at the Association off and on and he he also continued to participate in its annual meetings. His last lecture at the Association was on November 21, 1907. The occasion was the 30th Annual General Body meeting of the Association. In his lecture he supported the idea that the Association should move away from teaching and concentrate on original research. He urged the students 'to develop all their faculties in a complete and harmonious manner.' Father Lafont said:



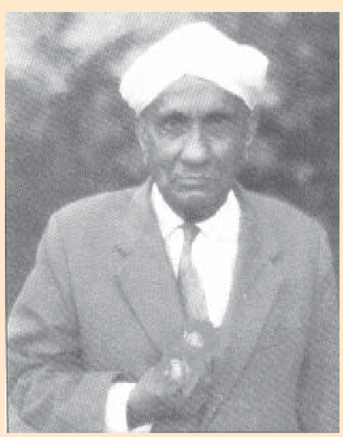
Dr. Amritalal Sircar, who became the Secretary of the Indian Association for the Cultivation of Science after the death of Mahendra Lal Sircar

"Let us beware of accepting all theories and mere working hypotheses, as absolute truths. Even our cherished Atomic Theory, so fruitful in excellent results, might have to give way for a new conception of Matter. The discoveries about Radium and other radiant substances must make us very cautious in assuming that we are already in possession of final certainty about the constitution of Matter, the Nature in general. It is a great thing to learn how to say: "I do not know", instead of pretending rashly that we know all about everything." In this meeting of the Association, the last one attended by Father Lafont, C. V. Raman was present. Dr. Amrit Lal Sircar while presenting the annual report of the association mentioned about Raman's commencement of research work at the association. Dr. Amrit Lal reported: "It is my greatest satisfaction to be able to announce before you that we have already got a young student with fine intellect who has been doing research work in our laboratory on physical optics and a side issue of his work has been published in the Nature of the 24th October 1907. The actual work will be laid bare before you in a meeting very soon. This young student, Mr. C. V. Raman, who has also become our member, is now in the Finance Department for his livelihood…." So Father Lafont had the opportunity to welcome and encourage the future Nobel Laureate of India. Regarding his role in creating the Association Father Lafont said: "…I consider that the privilege I have had of helping however humbly, towards the foundation of the Science Association was the best thing I had done in India."

Father Lafont's oratory skill was proverbial. His scientific lectures accompanied with experimental demonstrations. Professor Ruchi Ram Sahni , who played a pioneering role in popularizing science in Punjab wrote: "No less beneficial was my regular attendance at the lectures on popular science at Dr. Mahendra Lal Sircar's Institute. It was these lectures that led myself and Professor Oman to start the Punjab Science Institute at Lahore. I shall never forget the wonderful popular lectures of Father E. Lafont of St. Xavier's College. There were other lecturers also who appeared on the platform now and again, but in making a difficult point crystal clear and, especially, in creating popular interest in science, no one could approach the Jesuit Professor." Commenting on Father Lafont's lectue at St. Xavier's College *The Indo-European Correspondence* wrote (May 14, 1870): "In spite of the intense heat, and the distance of St. Xavier's College from the north part of the town, Fr. Lafont's opening lecture on Physical Science on Thursday, the 5th instant (5 May 1870), was well-attended, a fair number of the elite of the native savants being present. The lecturer's object being eminently practical, he wisely eschewed anything like showiness and unnecessary technicalities—in fact, as the *Hindoo Patriot* remarks, "there was not one technical word or phrase which an ordinary English student could not understand." This was the system pursued by Faraday and Brande in their lectures at the London Royal Institution, and as it proved not only useful but attractive in London, we see no reason why it should not do so in Calcutta." Similarly commenting on Father Lafont's popular scientific lecture delivered on August 23, 1887, *The Statesman* wrote on August 26, 1887: " The Rev. Father Lafont delivered a most interesting and instructive lecture on 'Colour: What it is', at the Dalhousie Institute on Tuesday night, before a fair attendance of ladies and gentlemen. The exposition although necessarily largely scientific, was made so clear to laymen, that any person of ordinary intelligence was easily able to follow the lecture. The instruction given was exemplified by experiments of various kinds, showing how all colours are contained in the rays of the sun, and can be distinctly seen, as in the rainbow, when reflected through a prism of glass, but which when striking the retina of the eye simultaneously produce the ordinary white light of the sun. The lecture also exemplified the cause of colour-blindness, and exhibited magnesium light, and the light produced from the metal known as sodium; the effect of the latter being to make all things of whatever colour, appear yellow. A most pleasant evening was passed."


Jagadis Chandra Bose

Father Lafont gave lectures on a variety of topics. Here we list some of the topics on which he gave lecture. Dalton's Atomic Theory (19 May 1870); Physical Basis of Spectrum Analysis (April 11, 1872); Electricity (April 10, 1876); The Truth about Galileo's Condemnation (June 23, 1881); The properties of Air We Breathe (January 19, 1882); Lenses (March 30, 1882); The Transformation of the Physical Forces (December 20, 1882); The Properties of Gases (November 12, 1885); The Barometer (November 19, 1885); Barometers and Barometrographs (November 26, 1885); Balloons (January 14, 1886); Introductory Acoustics (January 21, 1886); Three Qualities of Musical Sounds (February 11, 1886); The History and Capabilities of Edison's Speaking Phonograph with Illustration and Experiments (July 15, 1886); Velocity of Light and Means of Measuring It (August 26, 1886); Reflection of Light (September 8, 1886); Refraction of Light (November 17, 1886); Equilibrium of Fluids (September 6, 1887); Human Eye (September 25, 1888); Motion on Gyroscope (January 22, 1891); General Methods in Chemical Analysis (January 22, 1891); Effect of Rapidly Alternating Currents in the Induction Coil (September 6, 1893); X-ray or Rontgen Rays (December 6, 1896); Telegraphy Without Wires—assisted by Ex-student Jagadis Chandra Bose (September 16, 1897); The Evolution of Induced Electric Current: Demonstration with Latest Equipment from Paris (May 6, 1902); The Phenomenon of Radioactivity (November 1907). Lafont gave his last lecture on Demonstration of Gramophone four days before his death.


Chandrasekhara Venkata Raman

Father Lafont took keen interest in any kind of new machines or experiments. He brought a phonograph from the Paris Exhibition in December 1878 and he started experimenting upon it. He also gave a lecture on the phonograph on July 15, 1886. He had brought another phonograph from the Gramophone Company of USA. Father Lafont keenly observed the balloon ascent experiments in Kolkata during 1889-90 particularly those which were meant for scientific experiments.

Father Lafont was all for the development of science and technology for understanding the Nature and welfare of the humanity. At the annual meeting of the Indian Association for the Cultivation of Science on November 29, 1906 Father Lafont said: "We live in an age which has the full right of being proud of its achievements, there is no gainsaying it. The last century and few years of this one through which we have passed already, mark an epoch in the history of mankind, which is most extraordinarily of progress. No century has seen the progress which we have witnessed in the last century, and the powers of mankind over nature have increased in a most unaccountable manner by leaps and bounds, and what is remarkable, is that more discoveries we make, the more we expect.…Out of the knowledge of truth, we must secure facts—facts, not fancy, not imagination, not dreams but hard facts. Then having secured as many facts as we can, by observation and experiment, as the case may be, we have learnt to compare and analyse them in such way that we find out the law that binds that great chain of facts in a rational and reasonable manner." But then being a deeply religious man he was not satisfied by mere understanding of the material world. Thus he further continued: "We try to find out the laws of nature and we very often succeed. It is altogether false that those wonderful methods of scientific investigations and studies apply to matter and nothing else. Further, all the progress which the human mind has made during the nineteenth century, and of which we are justly proud, is confined to matter, remember. Now, who will say that there is nothing to be known in this world but matter? It is to be regretted that men who are proficient in the study of experimental science should become rank materialists and should come the conclusion that there is nothing but matter in this world."

Father Lafont tried to explain or rationalize the condemnation of Galileo by the Church by citing the existing circumstances and also Galileo's attitude. In his lecture titled "The Truth About Galileo's Condemnation" delivered on June 23, 1881 at the Indian Association for the Cultivation of Science, Father Lafont said: "Do not for a moment imagine that I intend denying the fact of the condemnation; on the contrary, I have here the very text of

The New Campus of the India Association for the Cultivation of Science

the sentence (here read) and I candidly admit the Congregation condemned the system of Copernicus about the earth's rotation in most emphatic terms. But what I do repudiate is that in so doing they acted cruelly towards the old Astronomer, that they evinced a secret hatred of scientific progress, or committed such an error against faith as to debar the Catholic Church from claiming infallibility…It is all very well for us in the nineteenth Century, surrounded by all the proofs of the system, to laugh at the simplicity and ignorance of the Inquisitors declaring that system false in philosophy and heretical, but to judge them fairly we must go back to their own times and see on what scanty evidence they were asked to sanction an hypothesis which ruined an interpretation of the Scriptures universally admitted. We can only repeat that if Galileo instead of intruding into the domain of theology had confined his genius and energy of the work of perfecting the knowledge of the laws of Dynamics he would have been unmolested and would have advanced the case of Science, which his imprudent impetuosity retarded considerably."

Father Lafont died on May 10, 1908 in Darjeeling in West Bengal. He preached science and religion till his last days with equal success.

For Further Reading

1. Biswas, Arun Kumar. *Father Lafont of St. Xaviers College and the Contemporary Science Movement*. Kolkata: The Asiatic Society, 2001. **This is the first-ever critical survey of Father Laont's life and contributions in science and religion.**
2. Geddes, Patrick. *An Indian Pioneer of Science: The Life and Work of Sir Jagadis C. Bose*. London: Longmans, Green, And Co., 1920 (Asian Educational Services, New Delhi has brought out a reprint in 2000).
3. Dsgupta, Subrata. *Jagadis Chandra Bose and the Indian Response to Western Science*. New Delhi: Oxford University Press, 1999.
4. Sehgal, Narender K and Subodh Mahanti (Eds.). *Memoirs of Ruchi Ram Sahni: Pioneer of Science Popularisation in Punjab*. New Delhi: Vigyan Prasar, 1994 (Distributed by New Age International Limited, New Delhi).
5. *A Century*. Kolkata: Indian Association for the Cultivation of Science, 1976.
6. Salwi, Dilip M. *Jagadish Chandra Bose: The First Modern Scientist*. New Delhi: Rupa & Co, 2002.
7. Chinnici, Ileana. An "Italian" Observatory in India: The History of the Calcutta Observatory" in *Studies in History of Medicine & Science*, Vol. XIV, No. 1-2, New Series (!995/96), pp. 91-115.
8. Scholberg, Henry (Ed.). *The Biographical Dictionary of Greater India*. New Delhi: Promilla & Co., Publishers, 1998.

◆◆◆

Form IV-B (see rule 8)

Details of the ownership and other facts relating to manthly newsletter 'DREAM 2047'.

Place of Publication	:	New Delhi
Periodicity of Publication	:	Monthly
Name of the Publisher&the Printer (on behalf of Vigyan Prasar)	:	Dr. Subodh Mahanti
Nationality	:	Indian
Address	:	Vigyan Prasar C-24, Qutab Institutional Area, New Delhi-110016
Name of the Editor	:	Dr. V.B. Kamble
Nationality	:	Indian
Address	:	Vigyan Prasar C-24, Qutab Institutional Area, New Delhi-110016
Name & Address of the owner	:	Vigyan Prasar C-24, Qutab Institutional Area, New Delhi-110016

I, Subodh Mahanti do hereby declare that to the best of my knowledge and belief, facts mentioned above are true.

(Sd) Subodh Mahanti
(Signature of the Publisher)

Letters to the Editor

Congratulations for bringing out an excellent issue of your DREAM 2047, the Monthly Newsletter of Vigyan Prasar. The thematic content of the issue viz. "50 years of DNA Double Helix and 25 years of IVF" was very appropriate and all the article were highly inspiring and brought out with missionary zeal by its respective authors.

Dr. P.K. Banerjee
Director, Govt. of India, Ministry of Defence,
DRDO, DIPAS, Lucknow Road, Timarpur, Delhi-110 054

Every issue of DREAM 2047 is an encyclopedia in itself giving the most useful and information in the field of science. We have been reading ROBERT HOOKE. You are born with your password and Double Helix of DNA. This magazine has been a good source of inspiration for science education to my self and my friends.

Braj Bihari Prasad
Adviser, Gyanoday Club
AT-Belhariya, P.O.-Tekari. Dist-Gaya, Bihar-824236

I have gone through the monthly newsletter of Vigyan Prasar. It is a very informative document to be useful for the schools.

Khem Singh
Chairman, Akal Academies, 119-D, Kitchlu Nagar, Ludhiana (Pb)

Nuclear Research Laboratory

An Interdisciplinary Center for Enhancing Agriculture Productivity

❑ Dilip M. Salwi
e-mail: dilipmsalwi@hotmail.com

"The main objective of our center, "said Dr P.S.Datta, Project Director, Nuclear Research Laboratory, New Delhi, "is to conduct studies related to agriculture using nuclear techniques, namely, plant physiology, water bodies' assessment, drought-combat strategies, post-harvest technologies, collect and collate the results obtained and provide them to users – from a farmer in the field to a hydraulic engineer and an agro-industrialist – for a higher qualitative and quantitative food production". This statement sums up what the NRL today stands up for. A `National Center' for application of nuclear techniques to agriculture, the studies done here are nowadays not only being utilized by organizations and universities all over India but all over the world, especially in neighbouring countries like Bangladesh, Mangolia, China, Sri Lanka, and the Middle East, Europe and the U.S.A. Besides, the NRL is a major center for teaching and training students, agriculture extension-workers, farmers, engineers, technicians and agro-industrial workers in various nuclear techniques related to crops, ground water and post-harvest preservation.

Nuclear Research Laboratory building in the I.A.R.I. campus, New Delhi

The Nuclear Research Laboratory is not easy to locate in the sprawling, huge and peaceful Pusa campus of the Indian Agricultural Research Institute because often people wonder what a nuclear laboratory has to do with agriculture. Even today people have that old image of farming where agriculture research is simply confined to developing high yielding hybrid crops, more effective fertilizers and pesticides. It has not yet sunk into people's mind that growing crops in an open field cannot be thought of in isolation. Soil conditions, weather, water availability, post-harvest preservation, etc, go a long way to improve crop yield quantitatively and qualitatively and its supply to the market without any loss. Nuclear techniques can assist a farmer in this endeavour. The NRL was set up in 1969 as a multi-disciplinary center with this purpose in mind jointly by the United Nations Development Programme, Food and Agricultural Organisation and International Atomic Energy Agency under the 'Peaceful Applications of Nuclear Research in Agriculture' Programme.

Preparation line at NRL for determining the oxygenating isotopic composition in water and plant tissues

Initially set up in a cowshed behind the Agronomy Department, Dr N.P.Datta, NRL's first Project Director, was the brain behind the establishment of the laboratory, even the design of its building. At that juncture, it was equipped with the most sophisticated equipment and instruments available anywhere in the world. For instance, it housed Isotope Ratio Mass Spectrometer, Nuclear Magnetic Resonance, Liquid Scintillation System, E-Emission Analyser, Gamma Irradiation Chamber, Ion Chromatograph, Multi-Channel Analyser, etc.

Today this multi-disciplinary center has scientists belonging to a diverse variety of disciplines, namely, physics, agricultural physics, hydrology, soil science, physical chemistry, biochemistry, plant physiology, plant breeding and genetics, including tissue culture, entomology and plant pathology. Today, the NRL scientists are consultants to various international programmes and are members of various national committees.

Every year India loses 20 to 30 per cent of her grown crops, cereals and pulses due to losses in post-harvest preservation. The NRL has been making efforts to reduce this loss by developing and refining gamma irradiation techniques for preservation of various agriculture produce, namely, pulses, soyabean, vegetables, fruits, wheat and rice. "To combat losses occurring due to drought conditions, we're addressing our research to help plant breeders identify those varieties or hybrids of crops which make best use of the available water using the non-invasive nuclear magnetic resonance techniques," said Dr Shantha Nagarajan, Scientist Incharge, demonstrating the equipment. Earlier, she and her co-workers had also used nuclear magnetic resonance for determining oil content in oil-seeds, a non-invasive quick technique now used by plant breeders for developing high yielding hybrids and in evaluating germplasm materials. The Rubber Research Institute, Kottayam, has adopted this technique for estimating dry rubber content.

Similarly, Dr Bhupendra Singh, a young plant physiologist and an award-winning scientist, is using nuclear techniques in identifying the specific variety of several crops, such as wheat, which is more efficient in absorbing nutrients or micro-nutrients from the soil, or is more resistant to various stresses such as drought, heat, water logging, soil acidity, etc., prevailing in open fields. "Our studies, for instance, help plant breeders in identifying that specific variety of crops," said Dr Singh, showing the laboratory," which can survive in zinc-deficient soils that prevail in the Gangetic belt".

Interview with Dr P.S.Datta, Director, NRL


Dr P.S.Datta

An I.I.T.-Kanpur post-graduate and doctorate, Dr Datta did his preliminary studies on groundwater in several river basins using nuclear techniques at I.I.T.-Kanpur and the Physical Research Laboratory, Ahmedabad. He is today an internationally recognized authority in groundwater storage and management. A winner of the International Zeyad Award for environmental studies, among other honours, he is today on various committees of national and international importance and is a consultant to various organizations related to water. In 2002, he took over the Directorship of the National Research Laboratory, New Delhi. What has he to say about the NRL and its role in present agricultural system in the country and the world?

Dilip M. Salwi : What is essentially the role of the NRL in agricultural research?

Director: Look, everybody says agriculture practices are fast being modernized. What does this mean? It means that agriculture is no more based on farmer's intelligence and limited experience, which has been practised by our forefathers since times immemorial. Today, every aspect of farming, whether it is seed, soil, fertilizer, pests, pesticide, weather, water availability, etc, is first properly studied so that when a crop is sown in the field it gives maximum yield. Even a plant breeder needs correct genetic information for the creation of the kind of hybrid species he desires to produce. Earlier, once harvesting was done, the farmer's job was over. It is no more so now. The harvest has to be properly stored, processed and preserved before sending it to the market lest it gets infested or eaten up by pests.

Over the last three decades, the NRL has been conducting studies using nuclear radiation and isotopes on these various aspects of modern farming – from genetics of hybrids to soil conditions, to the nutrient uptake by various crops, to the optimal use of water, groundwater storage and management, to post-harvest preservation practices. It has developed several nuclear techniques, methodologies and processes to conduct these studies which are of considerable use to farmers, agricultural scientists, hydrologists and agro-industrialists in India and all over the world.

Dilip M. Salwi : How does the NRL brings its studies and researches to the notice of the people who need them most?

Director: We use a variety of communication means. We present our findings in various conferences, seminars, workshops, etc., which the concerned scientists attend. We train people working in universities, research organizations and private laboratories; we even train entrepreneurs. We bring out pamphlets, technical, semi-technical and even popular publications on various aspects of our studies and findings. We participate in 'Krishi Vigyan Melas', and other private exhibitions organized for agro-industries. We put up exhibits for farmers and entrepreneurs. We also participate in 'Vichar Gosthi', discuss farmer's problems and provide them solutions.

Finally, our staff also writes popular articles on our studies in various magazines and newspapers aimed at farmers and the common man.

Dilip M. Salwi : Are you planning to set up some courses for training people besides agricultural scientists?

Director: Yes, we are planning 5 to 6 month long Diploma courses on some cutting edge scientific subjects, namely, food preservation, water conservation and assessment, environment-related issues in agriculture, and biofuel extraction. These courses would be aimed at a science graduate.

Dilip M. Salwi : What is the biggest problem hampering your studies and techniques from reaching a wider populace?

Director: Fear for anything nuclear! Obviously, nuclear explosions have created a scare in the minds of the common man about anything nuclear. Nowadays, people are watching television, working on computers, using mobile phones and microwave ovens, which also release radiations likely to cause harm to them, but nobody is concerned about their personal health. But as soon as they hear the word 'nuclear', they get scared and want to keep off us and our studies.

Dilip M. Salwi : What is the future planning for more useful and effective research at your laboratory?

Director: We are planning to re-organise our activities as a 'National Physical Instrumentation Facility for Agricultural Research' with three distinct programmes, namely, (a) Application of physical approaches for enhancing crop productivity and post-harvest storing ability; (b) Nutrient use efficiency in cropping system; and (c) Integrated catchment approaches for quantification of groundwater recharge towards enhancing water availability under changing land use.

Dilip M. Salwi : Thank you!

Interviewed by : Dilip M. Salwi

Over the last three decades, the NRL has been making efforts to meet priorities of national importance and developed environmentally sustainable newer techniques and methodologies. For instance, it has made important contributions to nutrient uptake and its efficient use in various plants; biophysical, biochemical and physiological basis of response of crop plants to various stresses, such as, drought, heat, water-logging, soil acidity, etc, prevailing in an environment; relationships between elements, carbon and nitrogen, in cereals and legumes; relationships between insects and pests; and has developed instrumental techniques for improvement of crop quality and production.

Under the aegis of the Indian Agricultural Research Institute, a Deemed University, the NRL today offers post-graduate and Ph.D. courses in plant physiology, plant biochemistry, plant biophysics, environmental sciences, soil science, entomology and agricultural meteorology. To date, about 250 students have done Ph.D.s and more than 200 persons have been trained in nuclear and allied techniques at the laboratory. " We provide a balanced diet to our students," said Dr A.V.Moharir, Head, Division of Agricultural Physics, " in the sense we have some core courses in which we taught all basics in agriculture. Then students themselves take up problems for study related to their specialized fields". An expert in the structural properties of India's one of the most important industrial crops, cotton, he said that the NRL has done pioneering studies in remote sensing. "We've identified the

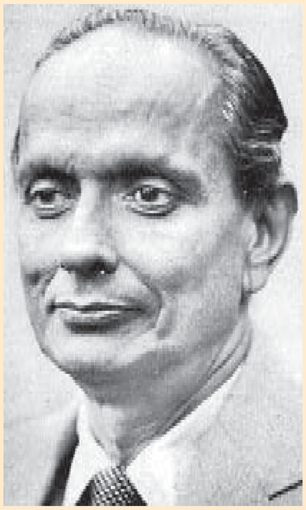
contd. on page...26

Sivaraj Ramaseshan

A Life Dedicated to Science

❑ Rintu Nath
e-mail: rnath@vigyanprasar.com

It was 29th December, 2003. It was a very sad day for the scientific community in India since on this very day we had to bid a tearful farewell to Professor Sivaraj Ramaseshan, one of the outstanding scientists that all Indians feel proud of. He had worked in many disciplines like optics, X-ray crystallography, condensed matter physics, materials science etc. in his professional career that spanned over five decades. Ramaseshan's research included wide areas ranging from designing and fabricating the first nutation damper for India's first satellite *Aryabhata*, the porous tubes for desalination, and materials and processes for India's first heart valve prosthesis. However, it would be wrong to identify Ramaseshan as only a scientist who was engrossed with all technicalities in his chosen areas. In fact, his contributions were not only significant in enriching scientific knowledge in many disciplines, but he had far more greater impact in spearheading the scientific movement in India. He cherished the vision to put Indian science in the world map. He was behind the foundations of some of our high profile scientific organizations, institutions and academics. He was also one of the most prominent persons to popularise science in the country.


Sivaraj Ramaseshan

Ramaseshan grew up in the shadow of his uncle Nobel laureate physicist C. V. Raman and drew inspiration from his life. He graduated from Science College, Nagpur in 1943. He carried his doctoral work at the Indian Institute of Science (IISc) and obtained his doctorate degree from Nagpur University in 1951. His real training in physics started in IISc under the guidance of his uncle. His early area of work was related with magnetism, paramagnetic resonance and optics. However, he decided to take up crystallography as his research interest in the beginning of his career in early 1950s and 1960s when he was the member of the faculty of the physics department of IISc. In 1954, he was invited as a distinguished visiting scientist to Brooklyn Polytechnic in New York, where he worked on low temperature crystallography. His contributions to crystallography have established novel methods, which are employed in the determination of the crystal structures of the complex molecules including biological molecules.

He left IISc in 1962 and joined Indian Institute of Technology (IIT) in Madras as Professor and Head of the physics department. He established the crystallography group in IIT, Madras. Though he stayed in IIT for a relatively short period of time, yet he had left lasting impressions to his students and colleagues there through his ideas, lectures and research works.

In 1964, he visited Nobel laureate Professor Dorothy Hodgkin's laboratory at the University of Oxford, where he worked on phase problem of large biological structures. In 1966, he returned to Bangalore and set-up the materials science division at the National Aeronautical Laboratory (NAL) (presently the National Aerospace Laboratories). The world-class materials program built by him at NAL has been a critical element in the development of indigenous capabilities in aerospace research. His notable contributions included his works on anomalous dispersion methods in crystallography and condensed matter physics and materials. At NAL, he also organised the fabrication of the dish and back-up structure of the 10.4M diameter millimetre wave telescope, which was originally designed by Robert Leighton of CalTech.

He was instrumental in carrying out multi-disciplinary areas of researches. He was invited as Visiting Professorship at Sree Chitra Tirunal Institute for Medical Sciences and Technology at Thiruvananthapuram. This enabled him to expand his interests in materials science to the fields of bio-materials and bio-medical devices. His collaborative work with scientists in the institute resulted into the development of the *Chitra* heart valve. Not only developing those useful devices, but he was also instrumental in the transfer of such technologies to industry. He initiated the process of setting up industries to manufacture those devices and led to the connection between laboratory research development and manufacture. He was closely involved in the successful transfer of technology for blood bag production, developed at this institute. These extended his capabilities in the field of applied science. He was also one of the founders of a research institute in biological and pharmaceutical chemistry named Astra Research Centre India, which he served as the first chairman of the Governing Board.

Ramaseshan's uncle C.V. Raman died in 21 November, 1970. Raman presided and nurtured three institutions: the Raman Research Institute (RRI), the Indian Academy of Sciences and the Current Science Association for long period of time. In his death, all these institutes needed attentions to carry on his ideologies ahead. Ramaseshan shouldered the responsibilities to keep the momentum of his uncle's keen ideas. According to Raman's last wishes, Raman Research Trust was formed and Ramaseshan was appointed as the secretary of the Trust, which he held almost throughout his life. He started rebuilding the RRI to make it as a 'great centre of learning, embracing many branches of science'. To fulfil his dreams, he defined the theme of the research of the institutes and attracted outstanding people across the country to join the institute. Now the RRI is one of the prominent institutes in India and world.

In 1971, Ramaseshan was elected as the vice president of the Indian Academy of Sciences. In order to restructure the Academy, he felt the need of scientific publications from the Indian Academy of Sciences. His constant efforts and motivating force led to the birth of the physics journal *Pramana* in 1973. It was published in collaboration with Indian National Science Academy and the Indian Physics Association. He was the founding editor of the journal. He introduced the peer review system in the journal. In its early years, *Pramana* attracted some of the best physics papers originating from India. Later the journal started covering different subject areas like astronomy, biology, genetics and material science. The Proceedings of the Academy also being recognised to cover different subject areas. Part A of the *Proceedings* was split into *Chemical Sciences, Mathematical Sciences* and *Earth and Planetary Sciences*. Part B was split into *Plant Sciences, Animal Sciences* and *Experimental Biology* (later to be renamed as *Biosciences*). In 1977, Ramaseshan was appointed as the first Editor of Publications of the Academy, an office that he held till 1982. Later, he also brought another journal *Current Science*, which was established in 1932, under the auspices of the Academy.

In 1979, he joined IISc as Joint Director, and then in 1981, he became the Director of the institute. During this period, he also served as President of the Indian Academy of Sciences for a three-year term from 1983 to 1985. In 1984, Ramaseshan retired from the directorship of the IISc. But it was just the beginning of a remarkable post-retirement phase to pursuit his dreams more vigorously. He played an important role in developing and disseminating technologies and advising industries and research and development institutions regarding technology alternatives. He was also involved with bodies responsible for science and technology policies and industrial development.

In 1989, Ramaseshan took over the editorship of *Current Science*. This journal was quite old and had an illustrious past as a widely read interdisciplinary science journal. As the editor of the journal, he took the charge of rejuvenating the journal. He was instrumental to make *Current Science* as one of the most outstanding journals from India as we see it today. He wrote at length in the 'In this issue' pages, which were intended to highlight the journal's contents. He organized special sections in the journals like 'Research News' about recent discoveries, 'Review Articles' on frontier topics of research, discussion and debates on important issues etc. He himself wrote memoirs of people and events. He was one of the most authoritative persons who had vast personal experiences of people and events during the five decades of the development of science research and education in India. This was reflected in some of his incisive portraits of country's most influential scientists - Raman, Chandrasekhar, Harish Chandra, Bhabha, Sarabhai, Mahalanobis among them.

He was the visiting faculty member and Distinguished Professor-Emeritus in Raman Research Institute (RRI), Bangalore. In spite of his old age, he constantly used the library facilities of RRI and attended the seminars and the Journal Club meetings like a young enthusiast. In his words, this kept his 'mind and brain comparatively active'. He continued in RRI till the end of his life.

He also co-authored an illustrated biography of C.V. Raman with Raman himself and C. Ramachandra Rao. He also edited two books on the 'Scientific papers of C.V. Raman'. In his long illustrious career, he was honoured with many awards and accolades, which included the S.S. Bhatnagar Award (1966), the Vasvik Award (1980), the INSA Aryabhata Medal (1985), and the Padma Bhushan.

Ramaseshan always strived for excellence and all his life was passionately dedicated in pursuit of the highest quality of science. He wished to see the Indian scientists to achieve the same quality so that they are recognised all over the world. He led and motivated all scientists in that direction. The perfect combination of excellence and simplicity of the life of Ramaseshan is beautifully sketched by one of his long time friends C. N. Rao through the following words: 'He stood for excellence without being arrogant. He carried his accomplishments and recognitions lightly. He was a good communicator without being pompous. He loved people because it was his nature. He loved life and laughed easily. Wherever he is, he is probably reading a book, with music in the background, and planning a new science journal'.

We will indeed miss the dedicated, enthusiastic and extraordinary scientist, teacher and leader very much.

Source

Indebted to articles of C.N. Rao and P. Balaram for their moving personal accounts of Sivaraj Ramaseshan. Those articles may accessed from the website of *Current Science* at: http://tejas.serc.iisc.ernet.in/~currsci/

Nuclear Research.... contd. from page...29

rootwilt disease in coconut using Infrared images from space, " said he, "and also identified its virus for the first time in the country".

Of course, most of the projects conducted at the NRL are interdisciplinary in nature. For various interdisciplinary studies, the center therefore collaborates not only with various divisions of the Indian Agricultural Research Institute located in the Pusa campus but also with various national and international organizations like International Atomic Energy Agency, Vienna; National Physical Laboratory, New Delhi; Physical Research Laboratory, Ahmedabad; Bhabha Atomic Research Center, Mumbai; Central Ground Water Board, New Delhi; National Capital Planning Board, New Delhi; National Remote Sensing Agency, Hyderabad ; Indian Meteorological Department, New Delhi; and several agricultural universities and organizations.

"The major portion of rainfall in Delhi and its neighbourhood comes from the Arabian sea, and not the Bay of Bengal," remarked Dr Datta, mentioning one of the interesting findings of his groundwater studies. An internationally recognized authority in groundwater management, he has conducted a wide range of studies using nuclear techniques related to ground water bodies in Delhi and its neighbourhood. Due to the dumping of industrial and other wastes indiscriminately, he says that the underground water situation is alarming in Delhi and its neighbourhood. "There is a need to integrate our findings with the on-the-site situation," he emphasized, " This is true not only of our underground water findings but all the agricultural-related studies that we do here at the NRL". Off and on, he does receive queries from individuals, organizations, universities, NGOs, extension workers, even politicians, to assist them in their endeavours related to farming and water management. But a concerted and sustained effort to improve the situation is lacking, he said.

◆◆◆

Recent Developments in Science and Technology

New form of matter created in lab

A long-sought new form of matter has been created for the first time – the matter, called a fermionic condensate. The creation of the new condensate is considered the crucial first step toward producing superconductors that work at room temperatures.

"This is a tremendous success," says Keith Burnett, a physicist at Oxford University, UK. The University of Colorado researchers who accomplished the feat are "fantastic experimentalists", he says, adding that scientists around the world have been racing to overcome the technical challenges of creating the matter.

Much of the difficulty centers on the nature of fermions. These are subatomic particles such as protons, neutrons, and electrons that have half-integer spins (1/2, 3/2, etc) and atoms comprised of odd numbers of the particles.

Unlike bosons, another form of elementary particles that have integer spins (1, 2, 3, etc), identical fermions are prevented by the laws of quantum physics from sharing the same state of being. For example, identical fermions cannot share the same location or momentum. But photons, which are bosons, can - which is why lasers work.

Two fermions that bind strongly into a molecule become a boson because their spins add to an integer value but, in the Colorado experiment, the fermions did not link that tightly. However, they behaved enough like bosons to allow them to share the same momentum for about one ten-thousandth of a second.

Source : New Scientist.com

New Light-emitting transistor

A light emitting transistor that could make the transistor the fundamental element in opto-electronics as well as in electronics has been uncovered by Professor Nick Holonyak Jr.and Milton Feng at the University of Illions at Urbana Champaign. The scientists' report their discovery in the journal Applied Physics Letters.

"We have demonstrated light emission from the basic layer of a hetero -junction bipolar transistor and shown that the light intensity can be controlled by varying the base current said Holonyak a John Bardeen professor of electrical and computer engineering and physics at Illinois. Holonyak invented the first practical light emitting diode and first semiconductor laser to operate in visible spectrum.

A transistor usually has two ports – one for input and one for output. Our new device has three ports – an input, an electrical output and optical output. This means that we can interconnect optical and electrical signal for display or communication purposes. The light emitting transistor unlike traditional transistors which are built from silicon and germanium are made from indium gallium phosphide and gallium arsenide".

Source :Applied physics Letter

When Solids Flow Like Liquids

Researchers in the United States believe that they have created a new phase of matter - a "supersolid" that flows like a liquid . Reporting their work in issue of *Nature,* Pennsylvia State University physicists Eun--Seong Kim and Moses Chan say they compressed liquid helium-4 into a sponge-like glass disc riddled with atom-sized pores, while chilling it to a fraction of a degree above almost absolute zero (-273 degrees Celsius, -459.67 degrees Fahrenheit).

The porous glass was held inside a leak-tight capsule, whose pressure was gradually increased. When it reached 40 times atmospheric pressure, the helium became a solid but appeared to move with the remarkable frictionless flow of the substances known as superfluids. In superfluids, all the atoms are in the same quantum state, which means that they all have the same momentum - if one moves, they all move.

That enables superfluids to crawl, friction -free, through tiny cracks. Indeed, superfluid helium will even flow up the sides of a jar and over its lip. Superfluidity occurs as a result of a. phenomenon called Bose-Einstein condensation, when all the panicles have been chilled to temperatures so extreme that they enter the same quantum-mechanical state. Gases, too, have also responded in this way Bose- Einstein condensate, but this is the first proof that solids, too – the third state of matter – can also enter a superstate, the authors maintain.

Source: PTI, News, February 2004

ISRO Starts satellite-based e-learning

The Indian Space Research Organisation (ISRO) has launched pilot programme of satellite-based distance e-learning initiative. An inaugural lecture delivered at a studio here will be beamed via the INSAT 3A satellite to 70 of the 113 engineering colleges in Karnatka state.

The pilot project was a precursor to the countrywide programme, which would be taken up after the launch of GSAT 3 (EDU-SAT) satellite in September. The technological university was one of the three universities in the country participating in the pilot programme, the other two being Yashwant Rao Chavan University in Maharashtra and the Rajiv Gandhi Techno-logical University in Madhya Pradesh.

GSAT 3 (EDUSAT) is one of the four ex-perimental payloads that ISRO planned to launch with its own launch vehicles, the GSLVs DI to D4. When launched, the GSAT 3 will be a dedicated educational service satellite, one of the first of its kind. The satellite will help broadcast programmes aimed at literacy, higher education, and training through five KU-band transponders. Two Ku-band and six Extended C--band transponders are included to provide India coverage for interactive education.

To develop "content" for e-learning pro-gramme, the VTU had identified "resource persons," mostly professors, at VTU colleges and from premier institutions such as the Indian Institute of Technology and the Indian Institute of Science.

Source: ISRO.org

Compiled by: Kapil Tripathi

◆◆◆

The Little Secrets of Puberty

When your little bodies blossom & become mature

❑ Dr. Yatish Agarwal
e-mail: dryatish@yahoo.com

Soon as you enter the plus10 age, you go through a big change. Your little body decides to blossom. You experience a sudden increase in height and weight and very soon, the sex organs mature, turning you physically into an adult. This is the period of puberty, the secrets of which all young boys and girls wish to know! Its timing is not fixed, but generally, girls begin around the age of 9-10 years, although some may start as early as 8, while others may begin at 13 years. Boys are just two or three years late, and begin anytime between 10 and 15 years. If you are at the doorstep of puberty, read on for the interesting changes that your body is soon going to experience…

Changes Girls Go Through

During this period of big change, you are going to experience many changes both within your internal body organs and your outer appearance. Let's take a look at these changes as they occur while you add to your years:

Breasts

The first change that marks the beginning of puberty in girls is the stage-by-stage development of breasts.

At first, the nipples and area around them change colour and begin to feel fuller. That's because there is an increase in the blood flow to this area.

Next, the breast tissue swells into a bud and the diameter of the coloured area around it, called areola, increases.

In the third stage, the breast and areola enlarge further.

As the breasts swell further, they become raised.

Finally, as the breasts mature fully, the nipples project while the areolae recede to conform to the general contour of the breast.

These changes begin around the age of 8 or 9 years and get completed anytime in the late teens. Often one breast grows faster than the other, and that should not have you worried. The growth varies between individuals and is dependant largely on your body constitution. There is nothing you can do to increase or check it.

Pubic hair

The pubic hair appear a little after the onset of breast development. At first, they appear along the outer lips of the vagina. These are followed by dark and coarser hair over the pubic bones. Then the area of pubic hair extends further and forms an inverted triangle. Some hair also appear on the inner surface of thighs.

External sex organs

There is a gradual enlargement of both outer and inner lips of vagina and clitoris. There may be a clear or whitish fluid secretion from the vagina. This is quite normal and is due to secretion from some glands that are located on its inner sides.

Skin

The oil glands increase their activity under the influence of sex hormones. This leads to excessive oil on the skin of the face and often results in quite bad outbreaks of acne or pimples. The sweat glands also become more active. Girls may develop a peculiar body odour.

Axillary hair

Just a few months before you have your first period, you would find that hair would begin to grow under the arm. If you so wish, you can shave the axillary hair.

Body shape

During puberty, your body would also take the classical feminine shape. The hips will get rounder, and your waist will get narrower.

Menstrual flow

Menses usually begin two years after the breasts begin to develop and about a year after the pubic hair appear. This usually means that you start by the age of 10-13 years. If the periods do not begin by the age of 15 years, a doctor must be consulted.

The first few menstrual cycles are often very irregular. The inner body clock takes time to find its rhythm and this should not worry you. The cycles usually settle into a sequence in 12 to 24 months.

Exercise excellent personal hygiene during the days of menstrual flow. Use sanitary napkins or tampons, but napkins are easier to use. Never think of the menstrual flow as any thing unhealthy or unclean; it is simply the discarded lining of the uterus that's no longer needed and must be shed so that the next cycle may begin.

A word of care and caution: With the onset of menstruation, your young body begins to release an egg every month and sex with a male can lead to pregnancy.

Changes in Boys

Boys also go through a number of striking physical changes during this phase. At the completion of puberty, they attain sexual maturity. The changes are as follows:

Testes

The sack below the penis contains the two testicles. At age 11 or 12, the testes begin to enlarge. They reach a diameter of 2 cm or more and become more pendulous. This is the first significant change of puberty in boys. Over the next four or five years, there is a further increase in size and by about 15 years the testes measure 4 cm in diameter.

Penis

The penis enlarges both in length and circumference. This enlargement begins around the age of 12 or 13 years and continues over the next three years or so, by which time it acquires its adult size.

Pubic hair

At the age of 13 or 14 years, a few, slightly pigmented, fine hair appear in the pubic area. Soon, they become dark and tend to curl. They become more abundant, coarse and curly and over time, take the adult configuration extending upwards to the tummy, side wards to the inner surface of thighs and backwards to the anal area.

Hair on the face and under the arms

A little after the pubic hair appear, boys develop hair under the arms and later on their faces. Incidentally, in some families, due to genetic reasons, bodily hair may be sparse or absent both in the pubic area and on the face. This does not mean that a person is not reproductively mature.

Change in voice

Boys experience a deepening of the voice which sometimes cracks as the larynx settles down. This change of voice usually takes place at 14 or 15 years.

Body shape

The proportions of the body also change in boys, with a widening of the shoulders. The hips however do not widen and round out like in girls.

Puberty is the age of change. It allows you to grow and develop into responsible young adults. By knowing about what changes to expect and when these changes occur, and to accept them with charm, is the best way to celebrate this change.

Vigyan Rail..... *contd. from page...44*

Vigyan Rail reached Kanpur on Jnauary 14, 2004 and was stationed there up to January 17, 2004. Shri Prashant Trivedi, DM, Kanpur and Prof. Sanjay Govind Dhande, Director, IIT, Kanpur, jointly inaugurated the exhibition. Over one lakh people visited the exhibition at Kanpur.

The next halt of Vigyan Rail was at Allahabad where it was stationed during the period 18-23 January 2004. Shri Ravindra Nath Tripathi, DM, Allahabad, Prof. K.B. Pandey, Chairman, Public Service Commission, UP and Prof. M.S. Kulkarni, Director, Harish Chandra Research Centre for Mathematics and Mathematical Physics, jointly inaugurated the exhibition. Among other dignitaries present during the inaugural function were Prof. A. K. Gupta, Dean, Faculty of Science, Allahabad University, Prof. Shivgopal Mishra, General Secretary, Vigyan Parishad Prayag, Shri B. K. Singh, ADRM, Allahabad, Dr. Abhiraj Singh, Ministry of Environment and Forest, and Dr. V. B. Kamble, Director, Vigyan Prasar.

Vigyan Rail was stationed at Varanasi during the period 24-28 January 2004. Prof. P. Ramachandra Rao, Vice Chancellor, Banaras Hindu University, Shri Dev Sharan Singh Yadav, Commissioner, Varanasi Region, and Shri R.K. Bansal, DRM, Railways inaugurated the exhibition. Over one lakh twenty five thousand people visited the Vigyan Rail in Varanasi.

Visitors flock Vigyan Rail at Lucknow

Visitors flock Vigyan Rail at Varanasi