Teaching of Astronomy in Asian-Pacific Region

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Some Lessons from Astronomy

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I am often asked this question by members of the general public, and, since I am known to most people who meet me as an enthusiast for space exploration and colonization as well, the question is put to me even more forcefully. In the light of Japan's lunar ambitions, let us face this question head on.

Firstly, there are several lessons to be learned from astronomy and space science for our life on Earth. In science, learning from extreme cases usually gives one insights into the ordinary situation; in medicine, we often learn about diseases and treatments from studying other species. So, in the case of Earth's climate and history, we can learn from other planets.

The danger of all-out nuclear war, mercifully now receding after the end of the Cold War, was unique in that, alone of all the perils we face, it endangered not just civilization, but even our biological existence. Other threats, like Ebola virus plagues, global warming, or even a new Ice-Age, may destroy civilization, perhaps irreversibly, but would not wipe out the whole race. The reason given in the mid 1980's was the phenomenon of nuclear winter. In this picture, the exchange of more than a certain number of bombs (thought to be 100-200 by many authorities), would cause so much dust and smoke to enter the stratosphere that 99% of sunlight would be blocked from the Earth's surface for 6-12 months. Average temperatures would fall 20-25 degrees Celsius, and all agriculture would cease. It is apparent that most creatures larger than an insect would perish, and that humanity would die of cold, hunger, disease, insanity and mass suicide. Not surprisingly, even the superpowers flinched from this prospect of desolation, and Messrs. Gorbachev and Reagan began to talk their way out of it. The result is that, although the world still has many problems, nuclear annihilation is much less likely.

Where did this idea of Nuclear Winter come from ? The answer, surprisingly enough, was the planet Mars. In 1971, the American space probe Mariner 9 went into orbit around Mars, only to be totally by a planet--wide dust storm. This took weeks to settle, during which time it was learned that the surface was much colder than usual -- 30degs C -- and was slowly warmed when the dust settled. Some scientists, particularly planetary scientist Carl Sagan of Cornell University, were so impressed by this story that they looked at Earth with the question -- Could it happen here? Extensive studies showed that there are three possibilities on Earth .

The first, and most relevant, was the threat of global nuclear war. The second, and much more remote, is the possibility of multiple volcanic eruptions. Sometimes, we have periods of intense volcanism, when the continental plates are more than usually mobile, and there is extensive mountain building. Some have thought that this extinguished the dinosaurs, but Dr David Brez Carlisle of Ontario has shown that volcanic dust deposition at that time was extensive -- nearly as extensive as during our own million year history! We face many problems, but global volcanic cooling is not one of them.

The third and most alarming discovery is believed by an increasing number of scientists to have been the true killer of the dinosaurs, and comes straight from astronomy and space science. As we shall see, so does its solution.

By the year 1800, astronomers had reached an understanding of Newton's new cosmos, and were looking for underlying laws explaining the positions and birth of the planets. The mathematicians Titius and Bode related all the planets then known in a simple formula; using 1 Astronomical Unit AU = 150 million kilometres, or Earth's distance from the Sun, the planets Mercury to Saturn stood at 0.4, 0.7, 1, 1.6, 5.2, 10.0, and 19.6 units from the Sun. Apart form Mercury, which is very eccentric, the distance between the planets doubles as you move outwards. This agrees well with the reality, except for the gap where 2.8 should be. We now know that this "Law" is not true, and that Neptune and Pluto break it completely -- but in the 1780's the discovery of Uranus at just the right distance gave it support. The gap between Mars and Jupiter led to a search for the "missing planet", and, on New Year's Day

1801, it was found. However, it was very small, and did not show a disc in the telescopes of the day. Because it looked like a star -- a point of light -- but moved slowly like a planet, it was called an "asteroid", or star--like object. The name has stuck, and the first was called Ceres. Pallas, Juno, and Vesta were found in the next few years, and , by 1980 several thousand were known. Ceres, the biggest, is 1000 kilometres in size, Vesta is 538 kilometres, while the smallest are little bigger than a truck! It is likely that there are hundreds of thousands, in orbits ranging from between Saturn and Uranus -- Chiron -- and between Earth and the Sun, for example, Aten, Hathor, and Ra-Shalom. Vesta is the only one visible with the naked eye, at magnitude5.7. Good eyesight reach down to mag. 6.0. Asteroids are given numbers corresponding to their order of discovery -- for example, 1 Ceres, 4 Vesta, 1566 Icarus and so on. More recently, with the avalanche of small objects, initial naming uses the year, followed by a letter code, like 1993FW. Sometimes asteroids are found in pairs or groups, and sometimes they collide and break up, leaving dust clouds which generate meteor showers if we cross them . They come in three main types -- nickel/iron, stony, and carbonaceous. The first two are easy to understand; the third carbonaceous group contains up to 10% sooty or tarry material made up of organic compounds better known to petroleum chemists. These are frequently the burnt out remains of comets, as the European Giotto probe showed at Halley's Comet in 1986.

Asteroids, considered by some astronomers as of little interest, have been of vital relevance to Earth since the beginning, and will be even more so in the future. Some small carbonaceous Near Earth asteroids are believed to be the remains of comets which have blown off their gases and water after several trips around the sun, so this discussion is equally relevant to comets.

In early days, some scientists believe, much of the water of the oceans, and the complex chemicals from which life originated, were delivered here free of charge by incoming planets and asteroids. The evidence is firstly, the detection of chemicals in comets by observation and spacecraft, and secondly, study of small fragments which reach the ground (meteorites). Secondly, we know that life began 3.6 to 3.8 billion years ago, but that the bombardment of the young hot earth by mini-planets which formed the earth only slowed down some 3.9 billion years ago; so that life got started very quickly. It is easier to believe that life received an input from the heavens, or, to put it more poetically, that Mother Earth was fertilized by sperm-like comets. What could be more natural?

In earliest times Nature gave humans access to meteoric iron and nickel, thus probably giving ancient Egyptians the idea that their Duat or Heaven was a real place, and that the Milky Way was a heavenly Nile. They believed that Osiris and Isis had "bones of iron" , the heavenly material of great strength which they did not as yet understand how to mine on Earth. We have utilised the resources of space since our earliest days!

However, the givers of life can also be killers. In 1979, Dr Walter Alvarez found that , all over the world, at levels dating 65 million years ago, there was a thin layer of clay heavily enriched with Iridium, at a level which spoke clearly of a gigantic asteroid collision with the Earth, wiping out the great dinosaurs. Since then over 150 sites on Earth have shown this boundary layer (now known as the K-T boundary). For 10, 000 years after this event, there are no fossils at all, and then a slow regeneration of vegetation and new animals -- an explosion of mammals, leading, in time, to us. Visits to the Moon, and pictures of Mercury, Mars, and Jupiter's moons, all show the same evidence of multiple bombardments, while the space shuttle crews have located 130 probable impact formations on Earth over the last 2 billion years, of 100-200 kilometres in diameter. Allowing twice that number under the sea , and a loss of many more by erosion, we can see that Earth is an island in a stormy sea, lashed with rain made

The discovery of a 150 kilometre crater at Chixculub, Mexico, dated to 65 million years ago, now shows that Alvarez was right, and that Earth's most successful and well-loved creatures were indeed destroyed from space.

What of the future? Recent astronomical studies show that asteroids bigger than one to two kilometres have the capacity to extinguish humankind, and that the 100 now known is probably 5% of the total awaiting discovery. In 1989, and in May 1996, 300 metre asteroids - enough to destroy us as a civilization, if not as a species, passed by us at lunar distance, with less than two weeks' warning, while Shoemaker-Levy 9 showed what can happen. The nuclear detection satellites of the Cold War, it is now revealed , showed that, every month, an asteroid capable of inflicting damage equal to a Hiroshima bomb, passes through our upper atmosphere, and sails out into space again .

The US House of Representatives set up a committee in 1992 to look at ways of detecting more of these earth crossing asteroids, in a programme called Space Watch; over the next 20 years, some 75% of the one kilometre sized objects are expected to be found. However, long period comets will be unpredictable, while chaos theory shows that, even if an orbit is determined, the object can drift in as little as ten years, owing to its small size. The Space probe NEAR (Near Earth Asteroid Rendezvous) will take our first look at 433 Eros -- a large Earth crossing asteroid -- in 1999.

So, astronomy and space science has given us an enormous warning, and the tools to investigate it properly. The question remains-- what can we do about it? The first is to do nothing. Since we are Homo Sapiens, and *can* do something, this alternative is suicide by negligence, unethical, and unworthy of further discussion.

The second is to deflect likely impactors at an early time by launching nuclear tipped missiles at them in an attempt to deflect them -- only one or two centimetres per second velocity change would be needed if we had 50 years' warning. This would work in some cases, but risks breaking up the asteroid instead of moving it; we would then face multiple impacts instead! Also, asteroids coming from the sunward direction, like the Aten class members, or new comets, would not give us time. Finally, do we really want, having painfully negotiated our way out of the threat of nuclear winter, to re-introduce it by the back door, and tear up all our test ban treaties. What a dilemma!

There is a third, and much more positive, way out. Remembering that Near Earth asteroids are small, we could use them for mining purposes, place newly developed electromagnetic propulsion systems on them, and build an extraterrestrial civilization from their raw materials. In terms of rocketry, they are easier to reach than the Moon. Studies show that, in 1,000 years' time, the solar system could be supporting a trillion people in good life styles, in island space colonies, for thousands of years. It seems that humanity will migrate out into space, just as the amphibians crawled onto a hostile and virgin land, out of necessity. There are many reasons for astronomy and astronautics -- adventure, science, biomedicine, new materials, tourism and new sources of energy -- to name a few. A trillion tons of rock travelling towards us at 60 kilometres per second is, however, unanswerable.

As Arthur C. Clarke has said -- "The dinosaurs became extinct because they did not have a space programme". We do not have to follow them!

ENDS

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THE TRAINING OF TEACHERS OF ASTRONOMY

COURSES FOR IMPROVING THE TEACHING OF SCIENCE
for secondary school teachers---University of Rome I La Sapienza
AA 1993 and 1994 Astronomy/Geology
Directors: Nicoletta Lanciano, Roberto Nesci

GENERAL CONSIDERATIONS

These courses are designed for the mode of learning particular to adults, rather than to that of younger students or to that of particular pedagogical methods; in this sense, we concentrate our attention on showing the following:

--that adults, too, can engage in discussion of their own understanding,
--that there are points of difficulty (historical, epistemological, and psychological) which we cannot continue to pretend have trivial effects on students,
--that topics from a traditional textbook can be approached from different perspectives.

CONSIDERATIONS OF THE TIMING FOR THIS TRAINING

The attention focused on the conceptualizations particular to adults has stimulated our students

--to turn their own attentions onto themselves,
--to permit us to put them ìon the spotî without offending them.

We have focused on adultsí frequent, sometimes ìbizarreî questions

--not to show how ignorant they can be or to judge them or to marvel at their errors
--but to create a common ground for research arising from their as yet unresolved questions, and to use this to reflect on the very acquisition of scholarly information and on the characteristics of the initial conception which leads to it.

THE CENTRAL QUESTIONS

Questions which seem very simple on the surface, because all the attendees know the theoretical elements necessary for the answer, are often, in reality, very difficult and technically complex because they simultaneously bring into play various spatial-temporal elements and ideas which generally remain isolated from each other. Such questions have brought our students to the points of

--revisiting their textbooks,
--revisiting their own training as scholars and teachers.

--searching for diverse perspectives on a problem and not just for a single one which provides an answer.

Let us give an example of these types of questions: In the first meeting of one group, Nicoletta Lanciano posed a question, one which she had already tried out several times with adults and high school students, which probed her studentsí perceptions of our position here on Earth:

They were asked to respond with a gesture, a drawing, or a verbal explanation to the question, ìWhere is the Sun at midnight?î The second question she posed asked for an explanation of the difference in that position between winter and summer. (In this way, a time variable is easily introduced.) The complete solution, referred to or ìseenî only by some, is not usually achieved by every student at the end of the first meeting and so opens a research activity which determines the groupís direction during successive meeting. As everyone leaves, Professor Lanciano posed yet another question on spatial perception: ìWhere is Norway?î Toward the end of the course, the questions emerging from the discussions have achieved a level of sophistication where they sound more or less Ptolomeic or Copernican in substance.

THE COURSE CONTENT

Several objective have guided our choice of content. We have aimed

--to break an attachment to textbooks as the unique source for learning,

--to face students directly with the difficulty of visualizing space in the large,

--to create a base of observations on which to reflect and to direct inquiry,

--to propose unanticipated pedagogical methods.

We have chosen for each branch of Astronomy contents which are important (but not those which hold as fundamental and irrefutable) and which can serve as a means of communicating some aspect of our method:

1. Certain critical conceptual moments which challenged our vision of the world and our models for interpreting it. (Ptolomy and Copernicus; the vast emptiness and enormous space of the cosmos, spatial-temporal reasoning and models for that)

2. The Astronomy of position.

3. An exercise on the study of the planets: Study the direction of the tail of a comet by working on professional photographic plates.

4. An exercise in astrophysics: Measure the dimensions of a global mass and describe the use of masses as indicators of distance, again working on photographic plates.

5. History of astronomy: The history of astronomy before and through Galileo can be found, for better or worse, in the literature. For the astronomy of the last two centureies, it becomes important to understand connections among technological development, scientific hypothesis, and developments in physics. In particular, it is important to ìrevealî that Astronomy is not just an optical science. (For example, what phenomena are ìobservedî today, from the Earth or from some other position in the universe, with what instruments of perception. . .)

THE 36-HOUR RETREAT AT ORIOLO

One aspect of our method peculiar to the standard teaching of astronomy is our revisiting of the places and times of our schooling, of our initial training as adults, and of our retraining. Therefore, it is of crucial importance for us to get away from others for an entire day and night and to pass that time together as a group.

As classroom preparation for our retreat, we ask each attendee to describe his or her predictions of the observations we would make: Where must the full Moon rise? Which planets would be visible given that the Sun...? The predictions often turn out to be quite far from what we actually find.

Observations to be made by day and night, with bare eyes and with instruments:

--the astronomy of the horizon - the setting of the Sun and the rising of the Moon

--the night and the shadow of the Earth - constellations, planets, and myths

--light and shadow: the Moon, Sun, and Earth - initial concepts and plans for bserving the setting of the Moon - the position of the "parallel world-map".

The observations made help students to construct a mental model which serves to answer fully, with regard to time and three-dimensional space, the central questions of the course. Our method of guiding these observations, beyond the objects themselves which we have proposed for observation, is itself an object for reflection. Through this examination, we hope to communicate a means of being in relation among the persons who wish to understand something together and between the observers and the objects to be understood. This is a lesson which cannot be taught through words in a classroom; it can be transmitted only through direct experience.

TIME AND SPACE
FOR THE BODY AND FOR THE COSMOS
Residential courses for adult training in Astronomy
Near the Casa-Laboratorio di Cenci (Amelia), and near the Masseria Malvezzi di Matera: Introductory Course and 2nd-Level Course

These courses, where we hope adults will re-establish confidence in their own abilities to understand scientific facts and ideas, are aimed at schoolteachers of any level as well as at adults who are not teachers. In fact, in the past we have seen the fruitfulness of such meetings of different levels of competence and diverse professional backgrounds.

In the courses our work is centered on the skies and their relationships to

--the geometry of space, with the great circles of the skies and the Earth: the Equator, the horizon, the meridian, the Ecliptic.., angles of altitude...

--music, with research into the connections between the observation and study of the heavens and those of music, sound, rhythm, song, and the construction of musical instruments.

In an evocation of an ancient tradition, our research into the realm of the geometric-astronomic is accompanied by research into rhythm, into song, and into the characteristics of sound: the four cardinal directions are united in a large square percussion instrument with its sides oriented toward the songs and rhythms of the four continents.

--myth and the meeting of diverse cultures (myths of the constellations and of the planets)

--the design and manual construction of instruments which make possible

- the observation and registering of celestial phenomena
- a reliable and accurate memory of complex phenomena tied to clear and precise images, which will supplement oral explanantions for references and written texts with two-dimensional figures, both of which can seem difficult and little tied

to our intuitions
to emotions
to a personal effort.

--movement which enriches the perception of self, of oneís own body, and of the space around us.

In our pedagogical hypotheses, we take in account the fact that the skies are everywhere, regardless of economic realities, and available to any school, rich or poor, well-supplied with equipment or not. Therefore, everyone can study Astronomy, as long as we use the sky as the laboratory to which we are privileged for observation. Furthermore, the study of the heavens represents an ecological gesture in its illustration of a rapport between nature and science, rather than a relationship of manipulation, exploitation, and overuse.

In addition, Astronomy can be viewed as a union, instead of a separation, of various disciplines, vocabularies, and techniques. In a world which divides, parcels, creates hierarchies, and sets differences into competition against each other, this seems to us to be an important attribute.

The heavens are beautiful, and Astronomy both pleases and fascinates: within our present context of reality, it seems to us of fundamental importance to offer our youth--deluded and bored as they might be--something of beauty with which they engage, to give them the possibility of discovering a potential activity for study and research, to stimulate an internal passion.

Among the our methodological elements it is worth the effort to underline

- the possibilities inherent in the recounting of myth,
- the validity of direct observation done in the open,
- the critical importance of extensive and continuous time for observation,

  Moments of quiet individual work in which one begins to solidify an intimate and personal contact with the stars (perhaps deciding which star to study), with the sky, with the darkness and the night (through an hour of solitary vigil at night), with the Sun
- the confluence of diverse vocabularies through research into themes usually confined within the boundaries of a single scientific language,
- the attention to the preconceptions of the participants: difficulties emerge once again in seeing the reciprocal movements of the Earth-Sun system, or in conceptualizing movement in a not completely observable mega-space,
- the utility of constructing together
- the usefulness of actual construction with the mind and hands to build models and instruments for recording three-dimensional events and objects in confomity with the astronomical phenomena observed.

In the introductory-level course is designed around the observation of the night sky and of the path of the Sun over an entire day, through the construction of instruments/monuments. It also focuses on the observation of the true local horizonand on modelling it on plywood, on plexiglass, with clay and with a wire mobile in which we take into account the depth of the horizon in varying directions.

The 2nd-level course is built around observing and recording the movements of the planets, their risings and settings over the eastern and western horizons, then on the great circle of the Ecliptic. The particular difficulties presented by the varying positions eventually occupied during the night by this circle, maximal with respect to the circle of the celestial Equator and of the local horizon, are faced through the construction of a large observatory containing two instruments, one for the east and one for the west, to record the risings and settings of the stars and planets, in an angle of 60° around the Eastern and Western cardinal points, and of a plane "basculante". The instrument is always in the process of being perfected.

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THE OBSERVATION ON TOTAL SOLAR ECLIPSE OF 24 OCTOBER, 1995

Sri Sudhindra Nath Biswas

There may be as many as five and as few as two Solar Eclipses in a year visible from somewhere on the Earth's globe. Out of these eclipses the Total Solar Eclipse (TSE) is a rare celestial phenomenon for an observer of a particular place on the Earth. The phenomenon is rare mainly because of the measures in angular diameters of the solar and lunar discs vary due to the periodic variations in radial distances of the Earth from the Sun and that of the Moon from the Earth. It is also due to variation in the inclination of orbital plane of Moon to the ecliptic from 4°59'43" to 5°17'43" in a period of 173 years. That is why, such an occurance draws curious attention of large section of people who not only live within the surface area of the Earth under the probable cover by the shadow of TSE, but far beyond.

The author of this report had the opportunity to organise a project for observation of such a rare celestial phenomenon as the TSE on the 24th October, 1995. The site of observation was the roof-top of three storey building of Budge Budge College located at (88°10' E, 22°27' N) in a rain prone zone of Eastern India (Figure 1.). From this site, the circular horizon could be seen all around to terminate hardly beyond 5km, overthe near.by buildings invaded with tall coconut trees. On the north-west direction, a part of the vast and mighty Ganges was in view. There was a big tank full of water on the south-eastern side of the College building. Several chimneys of the local factories were profusely ejecting smoke into the air.

The author and his colleagues arrived at the site of observation on the previous night of 23-24 October, 1995. It was programmed to observe the following phenomena during the TSE of next day :

1. The Mannual Recording of Contact Timings,
2. The Animal Behaviours,
3. The Observation of Celestial Objects,
4. The Recording of Temperature Variations, and
5. The Waning and Waxing of solar disc.

On the night of 23-24 October, 1995, the sky from the site of observation was cloudless ; yet, the atmosphere was hazy due to the presence of water droplets and smoke. The droplets were the residue of recent rain, whereas the smoke was the discharge from the nearby chimneys of the local factories. Due to the presence of haze the visibility of night sky was poor, so poor that only the third magnitude stars could

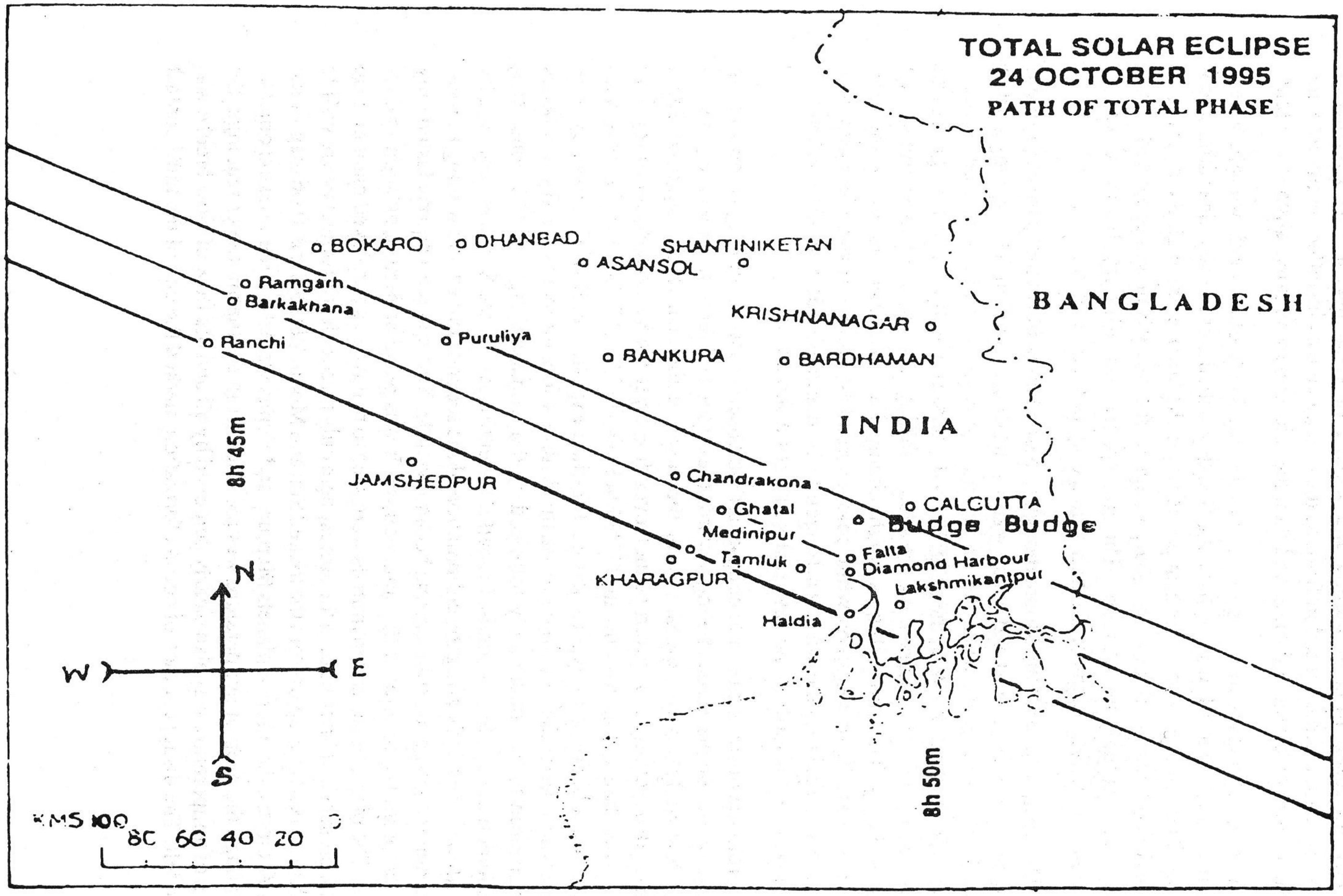

Figure 1. The site of our observation, Budge Budge College is situated at some 20 km. away from Calcutta in the south-western direction.

hardly be seen with naked eye.

For the observation of waning and waxing of solar disc, a 3-inch refracting telescope with a screen fitted in front of the eye-piece was installed on the roof-top of three storey College building, and then the telescope was polar aligned at night.

The sky during the morning twilight of the day 24 October, 1995, was absolutely free from any clouds. It was perhaps the first day with the entire sky clear after a few weeks. The crimson disc of the Sun peeped over the horizon through the opening of the leaves of coconut threes. The sharp image of the rising Sun was projected on the said screen through the telescope. The atmosphere was still hazy, but there was no hindrance in taking snaps of the Sun's image by ordinary cameras.

The opaque body of the Moon, though remained invisible in the glare of sunlight, traversed towards the east and began waning the disc of the Sun. The waning started at $07^h32^m33^s$ a.m. (IST) when the first contact took place, and it was continuously under our observation. With the progress in the phases of eclipse, the daylight began to decrease, the temperature started gradually falling, and the wind also commenced to flow slowly. The diminishing sunlight changed to variegated colour. At the time close to TSE, there was silver white colour spread all over the surface on Earth. The horizontal circular plane was clearly seen to be marked by dark shadow extending from west-west-north to the east-east-south for a short while.

From the onset of the solar eclipse, all the observers were looking at the waning image of Sun on the Screen facing towards the opposite direction of the Sun. As soon as, a few Baily's beads appeared near the cusps of the near totally eclipsed Sun's image, all observers at once turned their eyes directly to the Sun in the eastern sky. The Sun was then at the co-ordinate ($13^h12^m43^s.84$,-11°34'15".75). All the observers burst into jubilation for experiencing a life-time experience. It was a heavenly look everywhere from the sky down to Earth. Within a few moments the Baily's beads disappeared to be immediately followed by the wonderful sight of Diamond Ring phenomenon for a few seconds. Finnally, the entire disc of the Sun was obscured by the Moon's disc indicating the culmination of the second contact and waning as well, and then the gorgeous solar corona became visible. This splendid corona lasted only for the period of totality of the solar eclipse. It was peculiar feeling of night in day-time. The birds, fishes and mammals were seen to behave in a perplexed manner. Due to the presence of thick haze in the atmosphere only three celestial objects were visible with the naked eye, apart from the locked Sun and Moon. Besides the -0.06 magnitude star Arcturus, the inferior planets Mercury and Venus were the three celestial objects. Although the drop of temperature was recorded from the thermometer readings, the drop of temperature was also clearly perceved by all and the flow of slow breeze was also felt. The disappearance of corona formation marked the end of the third contact and begining of waxing. In the process, reappearance of the Diamond Ring and Baily's bead formation were seen. After these phenomena, the waxing process of the Sun's disc observed again from the image of the eclipsed Sun, on the screen fitted with the telescope and it was terminated by the fourth contact at 10^h17^m a.m.IST when the entire process of eclipse ended.

Five groups of observers accompanied by the author recorded the respective datafrom various observations during the period covering the entire solar eclipse from 7^h00^m to 10^h20^m a.m. (IST), on the 24th October, 1995, as programmed earlier. A team of photographers from the Central Workshop Photographic Division, Department of Physics, Andhra University, also took position on the same roof-top of College building for taking photograph of solar eclipse. This team was led by Prof. D. V. Krishna Rao and Sri Jakka Ramoo. The results of the observations are listed below :

1. The Mannual Recording of Contact Timing.

Contact	Time in IST*		Phenomena Observed	Waning and Waxing
	Observed a.m.	Predicted a.m.		
	h m s	h m s		
First	07 32 30	07 32 03	At the end of first contact Baily's beads and Diamond Ring appeared successively.	Waning began
Second	08 48 35	08 48 50	Baily's bead and Dimond Ring vanished and Corona formation appeared.	Waning ended
Third	08 49 45	08 49 59	Corona formation disappeared and Diamond Ring & Baily' beads appeared	Waxing began
Fourth	10 17 10	10 17 32	At the begining of fourth contact Diamond Ring & Baily's beads disappeared.	Waxing ended

* Indian Standard Time, IST + 5^h30^m = U. T.

2. The Animal Behaviours.

(i) The Behaviour of Birds.

From the day-break, the different species of birds were excuting their usual business. The species of birds came under observation are doves, crows, pigeons hawks and titmouses, if they are to be considered as birds. The larger species, such as, doves and hawks were flying at different heights, even sometimes after the first contact.Some of the hawks spiralled up at such a height that they appeared very small. Other species like crows and pigeons were seen to fly at lower heights, casually stopping over the building tops and trees.

With the gradual progress of eclipse towards second contact and fading of daylight followed by appearance of peculiar silverish colour everywhere, all these birds under observation started to behave in a strange manner. The species like crows and pigeons settled on the building and tree tops, while the hawks and doves swiftly came down for the preparation of taking rest apprehending the fall of night to be imminent. In between the second and third contact, that is, during the totality of the eclipse, the only species dared to fly overhead was the titmouses. With the gradual disappearance of darkness and reappearance of daylight, the birds began to behave in a manner they usually do in the morning twilight.

(ii) The Behaviour of Fishes.

From the top floor of the three storey College building, the behaviour of fishes in the adjoining tank was observed. They were very rarely seen to raise their heads above water surface before the totality. During the total solar eclipse, these fishes began to swim over the water surface hastily in shoals. Usually fishes diaplay such behaviour during the twilight hours of the day.

(iii) The Behaviour of Mammals.

From the site of observation, there was ample scope to keep watch on a few dogs and hogs. Before the TSE started, these animal were involved in the activity of searching their food. But at the onset of TSE, while the hogs proceeded towards their den in queue, the dogs assembled to rest on the Earth. These are exatly the practice what they are used to perform after sunset.

3. The Observation of Celestial Objects.

During the period of interval between the second and third contacts, the nature all around presented a look resembling a night of full-moon. Apart from the eclipsed Sun decorated with its majestic corona, the sky was depicted with only three eclestial objects which were not visible earlier in the glare of sunlight. The eclipsed Sun was preceded by the planet Mercury at (12^h54^m,-3°34') about 15° on the Western side, whereas it was followed by the planet Venus at (15^h05^m,-17°09') about 17° on Eastern side along the ecliptic. It was a lifetime experience to observe two inferior planets on either sides of the Sun at a time. The only other object appeared in view was the-0.06th magnitude star Arcturus which is the brightest star in the constellation of Bootes. The predicted sky and observed sky have been shown in Figures 2.1 and 2.2 respectively. As there was dense haze causing the visibility poor, no other object was observable

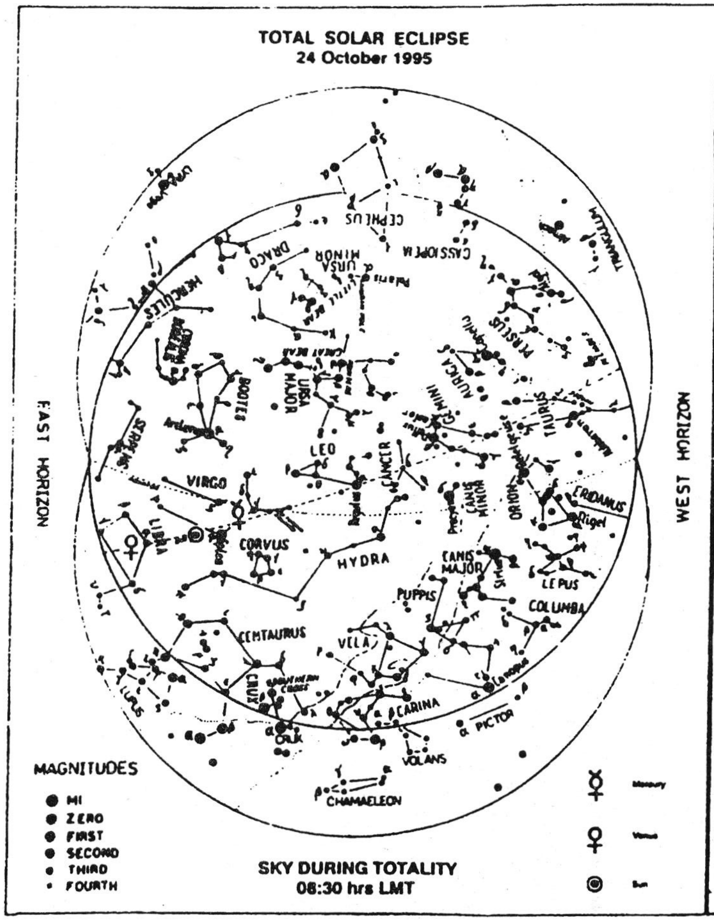

Fig. 2.1

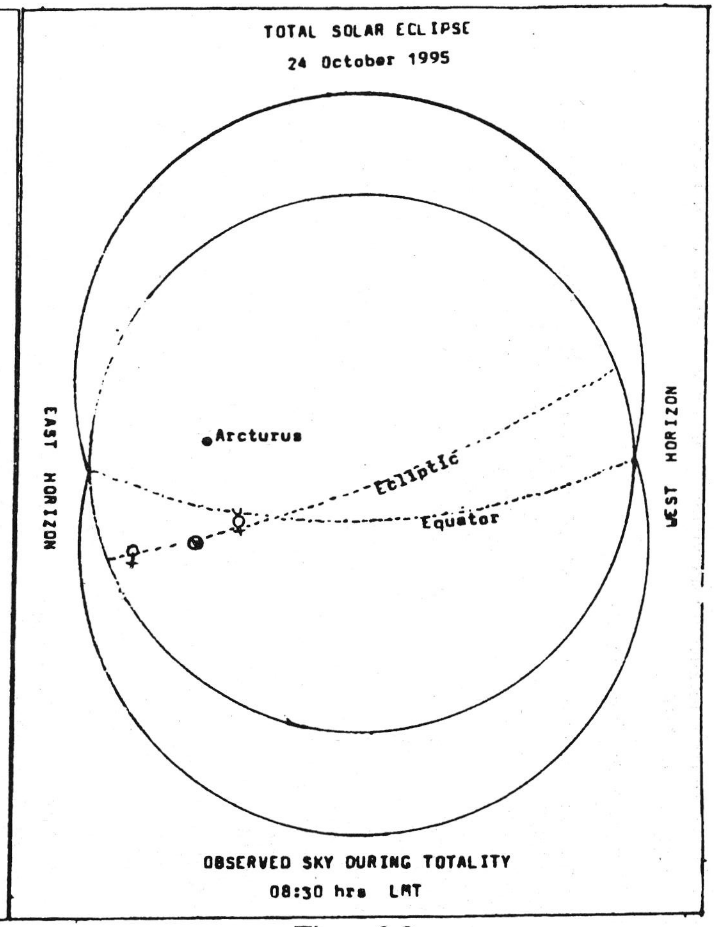

Fig. 2.2

Figure 2. The map 2.1 is the predicted sky map and the map 2.2 is the observed sky map from 22°N latitude at 08 : 30 am. LMT on 24th October, 1995, from India.

in the sky with naked eyes. The site of our observation, Budge Budge College, was situated almost near the North border of totality path of about 55 km. in width. This situation added another hindrance for the visibility of celestial objects in the localised dark sky caused by the TSE.

4. The Temperature Variations.

Observations on the variations in temperature during the period of eclipse from 07^h00^m to 10^h20^m a.m. IST, were recorded from the readings of the thermometer one in sunlight and the other in shadow. The continuous line drawn with the help of readings obtained from the thermometer in sunlight and the dotted line drawn with those from the thermometer in shadow (Figure 3). The remarkable features of these two lines are given below :

One, the fluctuations in temperature readings are mainly before the TSE,

Two, the temperature of sunlight remained higher even some time after the waning phase is half, and then the temperature of shadow surpassed the former till the end of TSE, and

Three, the range of variation in temperature of sunlight is from 22°.8 C at 08^h47^m a.m. IST to 27°.2C at 07^h35^m a.m. IST ; whereas the same of shadow is from 24°C at different times including the period of totality to 27°C at 09^h55^m a.m. IST towards the end of eclipse.

Both the thermometers showed the prolonged reading of same temperature of 24°.5 C prior to 07^h00^m a.m. IST, thereafter, they displayed different readings until 09^h55^m a.m. IST when they recorded the same temperature of 27°C once again.

5. The Waning and Waxing of the Solar Disc.

We took photographs of the images of eclipsed Sun by ordinary cameras from the screen fitted in front of eye-piece of our telescope. But the auother received a set of photographs of phases of Solar Eclipses from Sri Jakka Ramoo of the Dept. of Physics, Andhra University. The changes of these phases with change of time have been shown in Figure 3 along with the temperature variation curves. These photographs were taken by Prof. D. V. Krishna Rao and others, directly with the help of more sophisticated cameras from the same roof top of the College building.

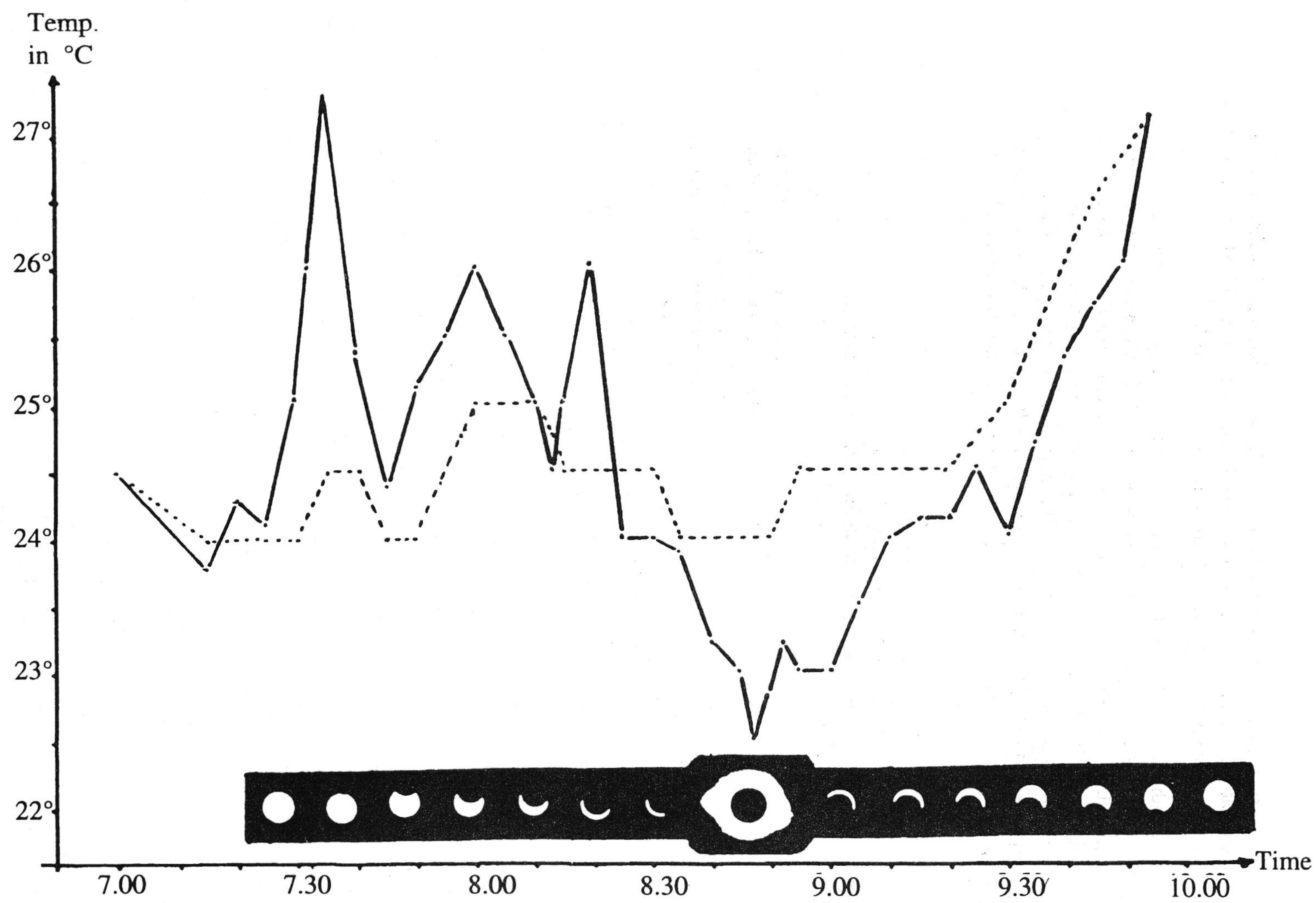

Figure 3. The variations in sunlight temperature by continuous line, shadow temperature by dotted line and the phases of eclipse with the change of time during the eclipse are shown.

Acknowledgement.

This project was organised by Shri S. N. Biswas, National Teacher, Barasat Satyabharati Vidyapith and Prof. B. Basu, Ex-Head, Dept. of Appld. Math. Calcutta University, on behalf of the Indian Astronomical Society, IAS.

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Reference.

Total solar Eclipse of 24 October, 1995
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Spectra and Spectroscopes

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1 Introduction

Light for us is a source of information about the stars. The distribution of the luminosity depending on the wavelength gives rise to the spectrum. The presence of several absorption lines or emission lines informs us about the presence of different neutral or ionized atoms and molecules. Through the study of the spectrum of a star, we can know the physical conditions of its surface: temperature, density, chemical composition, etc. Some experiments on this are possible to do at school if we have a spectroscope. We only have to direct it at the Sun to be able to observe the spectrum. Or if we direct this at a fluorescent tube, it is very easy to observe the emission spectrum line of mercury. The luminosity of a light bulb through a KM_nO_4 solution offers us an absorption spectrum in the green zone. The absorption depends on the number of molecules that the light finds on crossing the liquid.

In the next sections we present two constructions of spectroscopes, which can be done at school, and made by the students, in order to use them for the activities mentioned before and for others.

2 Spectroscope in a match-box

At first, we present the construction of a spectroscope with a big match-box for the kitchen. It is necessary to paint the inside of the box in black. Inside the match-box we put $\frac{1}{8}$ of a CD, which constitutes the diffraction network, and we cut an opening in the box in order to be able to see inside (fig. 1). We open the sliding part of the match-box a little to allow the sunlight to

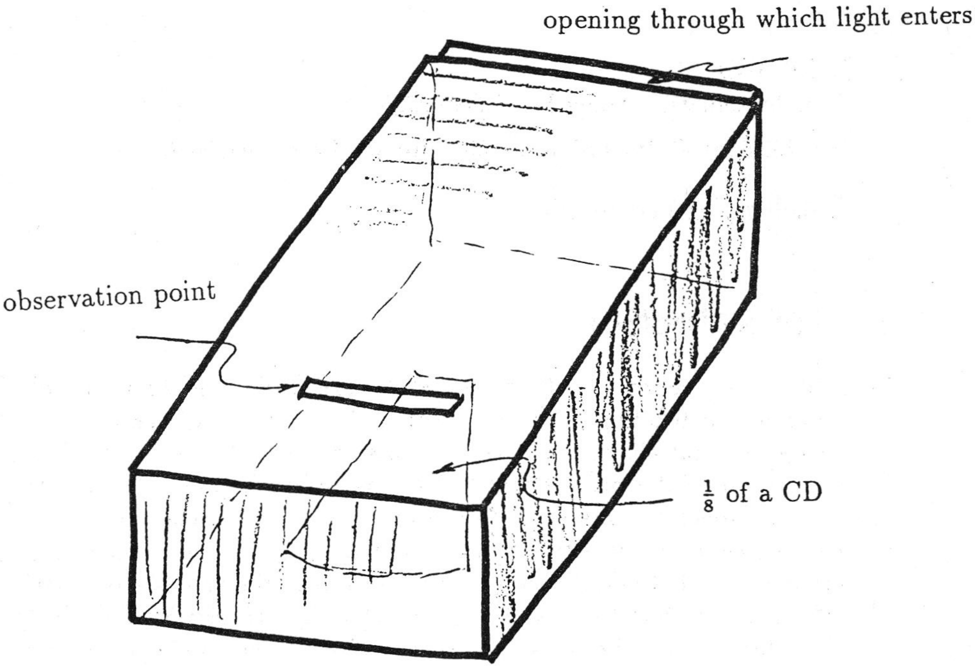

Fig. 1: Spectroscope in a match-box.

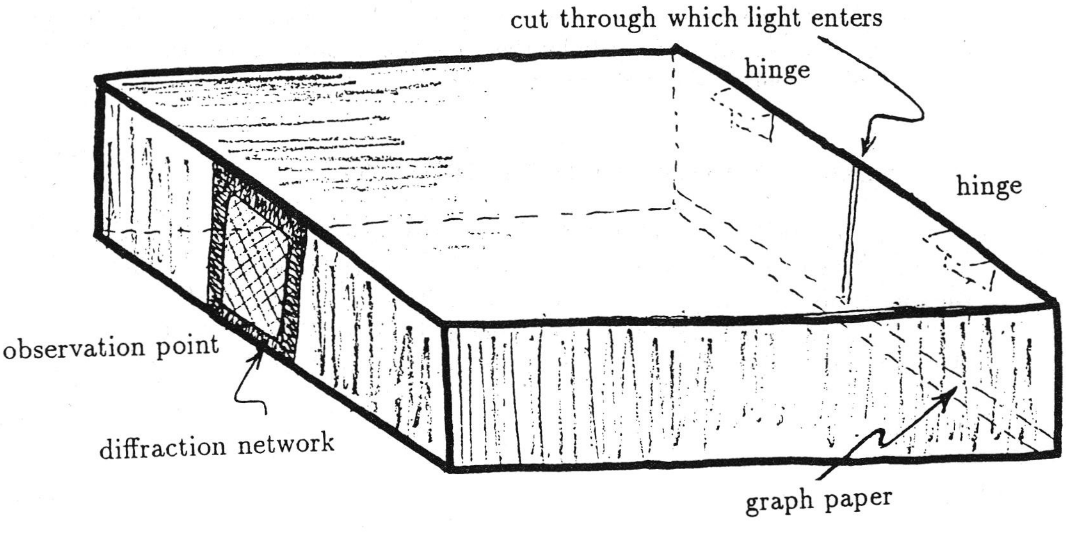

Fig. 2: Spectroscope with wavelength measurer.

enter and for us to look through the opening. It is possible to observe the sunlight by putting a camera at the opening and taking a photograph of the continous spectrum.

3 Spectroscope with wavelength measurer

To construct this spectroscope, it is necessary to have a diffraction network, which can be obtained from a shop specializing in material for physics laboratories. Normally they supply a large piece which can be divided into 12 or more smaller pieces, similar in size to a slide and which can be framed in a slide mount. When we buy this material we can find out what the constant of this network is. For example, if we construct one with network 525 $lines/mm$, then the constant of the diffraction network d is:

$$d = \frac{1}{525} = 1.90 \times 10^{-6} \quad m$$

Through this network we observe the inside of the spectroscope. Next, we construct a box which agrees with figure 2. In one side of this box, we make a very thin cut to allow light (sunlight, the light of a fluorescent tube, etc.) to enter so that we can observe it. In the opposite side, we put the slide which contains the diffraction network. It is very important to centre a piece of graph paper (fig. 3) at the bottom of the cut inside the box (see fig. 2). Then it is possible to calculate the wavelength of the spectrum line of a chemical element of our choice.

If the wavelength of a colour is λ and has a angular deviation θ, the beam of this colour (fig. 4) verifies:

$$n\lambda = d \sin\theta$$

then, we can write

$$\sin\theta = \frac{n\lambda}{d}$$

and using the geometry of figure 4,

$$\sin\theta = \frac{x}{\sqrt{x^2 + D^2}}$$

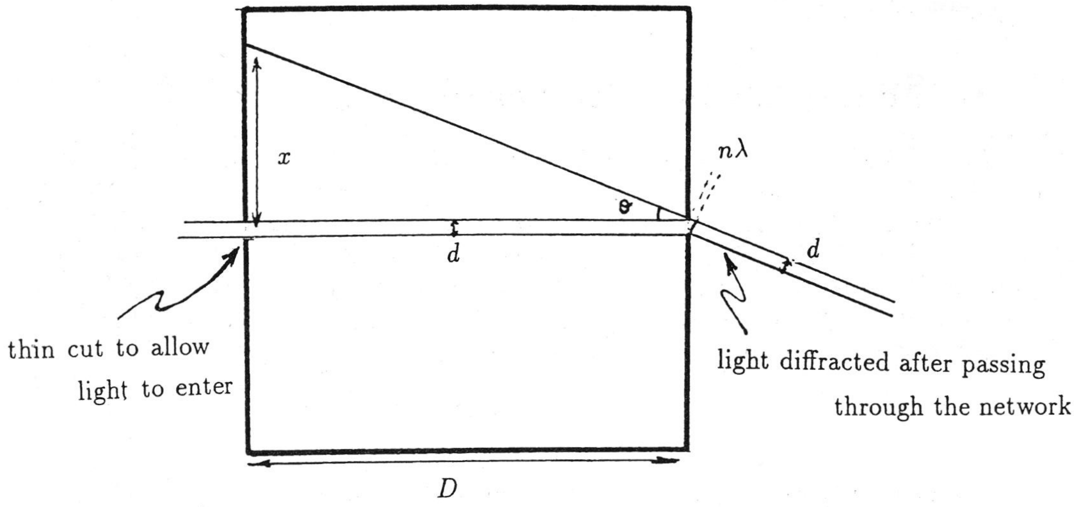

Fig. 4: Sketch of the spectrocope with wavelength mesurer.

If we equalise both sines,

$$\frac{n\lambda}{d} = \frac{1}{\sqrt{1+(\frac{D}{x})^2}}$$

then, we obtain:

$$n\lambda = \frac{d}{\sqrt{1+(\frac{D}{x})^2}}$$

where, λ is the wavelength that we want calculate.
x is the value read in the spectroscope.
D is the size of the spectroscope.
d is the constant of the diffraction network used.
$n\lambda$ is a multiple of λ.
(for $n = 1$ we have the first spectrum,
for $n = 2$ the second spectrum which is weaker, etc.)

For example, if we observe the continuous spectrum we see figure 5, then

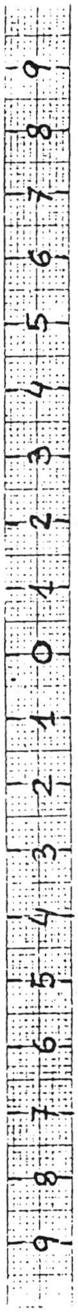

Fig. 3: Graph paper.

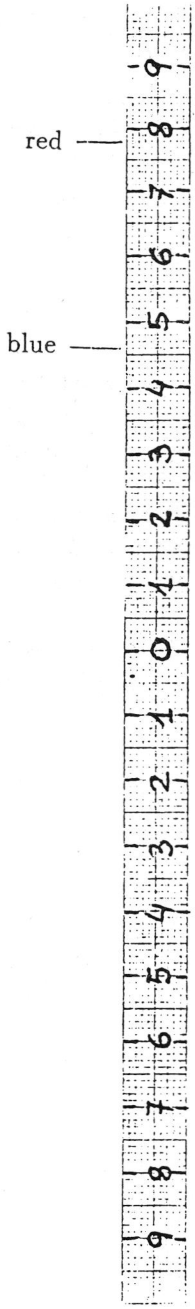

Fig. 5: Example of observation.

we can obtain the λ wavelength of the deviation of blue and red colors.

$$\lambda_{blue} = \frac{1.9 \times 10^{-6}}{\sqrt{1 + (\frac{20}{4.6})^2}} = 0.4259 \times 10^{-6}\ m = 425.9\ nm = 4260 \mathring{A}$$

$$\lambda_{red} = \frac{1.9 \times 10^{-6}}{\sqrt{1 + (\frac{20}{7.8})^2}} = 0.6904 \times 10^{-6}\ m = 690\ nm = 6900 \mathring{A}$$

These results are in line with accepted values.

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Teaching Rahu and Ketu with a bucket handle

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Moon's orbit intersects the ecliptic at two points, called the ascending node and the descending node. These nodes have to be considered while predicting eclipses because they are not stationary points but are moving through the zodical constellations in the retrograde manner. As eclipses arouse interest in the public always, these nodes are famous. In India, the ascending node is popularly called Rahu and the descending node is called Ketu. The same terms are used in Thailand, according to a programme on B.B.C. which was telecast a few days before the eclipse of 24th October 1995. Therefore I prefer using these famous terms, Rahu and Ketu, over the lengthy scientific terms while enlightening the public on eclipses.

There are some misconceptions and fear associated with Rahu and Ketu because of which many people avoid seeing the eclipse. Therefore in 1995 I made a simple model by using the handle of a bucket and found it useful in dispersing that fear and convincing people to see the solar eclipse of 24th October 1995. It can be made as described below.

Take a semicircular handle of a bucket, with ends of it about 30 cm away. Take a hollow, spherical bead or ball of about 1 inch diameter and pass the handle through it. Then take a wire pass it through a ball of about 2-3 inch diameter. Secure the ball at a particular position on the wire. This can be done by using a suitable glue, but there are other ways also. Lastly, attach the ends of wire to two ends of handle in such a way that the ball on the wire appears at the centre of line joining the ends of handle. The semicircular handle represents half, is to be considered as the moon and the big ball on the wire as the earth. Fig, 1 shows the model. It can be used in the lecture as outlined below.

of moon's orbit around the earth. The small bead, movable on the handle, Put the handle on the top of a table and hold it in the inclined position. Suggest the viewers to consider the table-top as the ecliptic. Half of moon's orbit is represented by the handle above the table-top. The other half, which has to be below the table-top in reality, can be left to the imagination of viewers.

Initially keep the bead, standing for moon, at one end of handle suggest the audience to consider that point as Rahu, supposing that the moon has just come up from the lower side of table-top. Then move the bead with hand along the handle and take it to the end slowly. The other end becomes Ketu, where from the bead should go bellow the table-top. Time required for going from Rahu to Ketu to Rahu in the region below the ecliptic moon takes two weeks. Let viewers realize this before going to discuss eclipses.

in the region above the ecliptic is two weeks and for going from Ketu

Keep a lamp on the table-top, as the sun, about 2 m away from the present model. Rotate the handle by hand to show various orientations of nodal line in relation to the sun. With this model viewers can immediately appreciate the fact that an eclipse can happen only if i) The nodal line is directed towards the sun and, ii) The moon happens to be on the Rahu or Ketu. The nature eclipse, that is solar or lunar, can be easily decided by considering positions of the sun, earth and moon. Thus, Rahu and Ketu are only imaginary points and not material bodies, one can easily emphasize, and they are needed only for determining the orientation of nodal line. But one should not be afraid of them. I received good response to it from the public, readers are requested to try it in their countries and let me know the response of the people.

Figure: 1

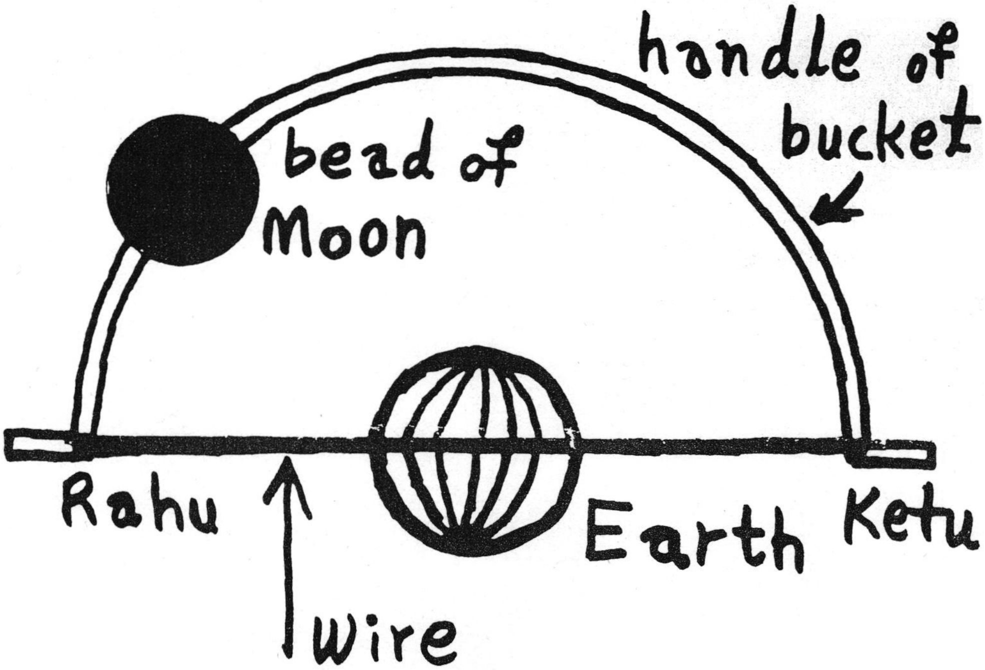

Figure: 1