Teaching of Astronomy in Asian-Pacific Region

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Preface

At first, I apology my long delay of publication of this volume originally scheduled in October, 1995. At that moment, I had only three papers which were not enough to make one volume. I waited several monthes to have enough pages of papers. When I got all the papers included in this volume, it was at the end of our fisical year and I had no budget remained to print this volume under our feasible way. Therefore, I had to wait till the time when our new fisical year budget can be used.

Our Bulletin started at 1990 February 26 and was only one journal of teaching of astronomy published regularly. I have still an intension to publish it continuously with our cost. However, I can not certainly publish if any papers would not be submitted. To keep this Bulletin, I strongly request your contribution for papers in this Bulletin.

Thank you for your coolaboration.

May 20, 1996

Syuzo Isobe,
Chairman of Committee
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A SIMPLE MODEL FOR THE FOUCAULT PENDULUM

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The Foucault pendulum in an astronomical institute is the prime attraction for visitors of all ages. But the present author has noticed that even students of junior colleges have some difficulties in understanding how it proves that the earth is rotating. There are two main reasons for this: i) the Foucault pendulum is not included in the junior college physics. ii) Secondly, the plane of oscillation of pendulum completes one rotation every day, if it is located on the pole. But at other places it requires more time. For example, the plane of pendulum in the IUCAA, Pune (latitude 18.5°N) takes about three days for one rotation. This fact conflicts with our common knowledge that the earth completes one rotation in one day. Therefore a simple model was conceived by the present author recently and used in some summer vacation programmes in Pune. The purpose of this note is to share it with the readers of this journal.

We need following things for making the model, which are easily available at home. A metallic disc with small holes all over the surface. Such discs are used for covering milk, curd etc in the kitchen. Two knitting-needles, a string, a massive lock and a small ring. With these things, the model can be set up as follows.

First tie the lock at one end of the string and insert the other end of it through the central hole, F, in the disc - see the dark hole, F, in Fig. 1. Secure the other end of string on the other side of disc with a small ring. Insert two long knitting-needles in two diametrically opposite holes near the boundary of disc, see dark holes A and B in Fig. 1. Hold the disc horizontally with hands, like the steering-wheel of an automobile. Suggest the viewers to imagine that they are on the North pole, the disc represents the dome from which the pendulum is hanging and needles stand for pillars supporting the dome. Set the pendulum oscillating, keeping the plane of oscillation fixed w.r.t. walls of the room. Let the plane be parallel to two opposite walls, for other two walls it would be perpendicular. Let the viewers observe carefully the plane of oscillation in relation with the plane formed by needles also.

Then start rotating the disc carefully in the anticlockwise manner, without disturbing the plane of oscillation w.r.t. walls, see Fig. 2.1 and 2.2. Lead the viewers to appreciate this fact. But the plane of oscillation appears rotating clockwise w.r.t. plane of needles because, actually, they are rotating anticlockwise along with the dome. Repeat the demonstration if it is necessary.

It is necessary to put emphasis on the point that the effect seen in this demonstration is under the control of the demonstrator, as the disc is rotated by hands. On the contrary, in case of real Foucault pendulum the rotation of plane is due to the rotation of earth. In this respect, the model given above can be described as a pseudo-Foucault pendulum because it simply dramatizes the required effect. However, it has been observed that this model can facilitate the understanding of real Foucault pendulum, if it is shown prior to the visit to an astronomical institute.

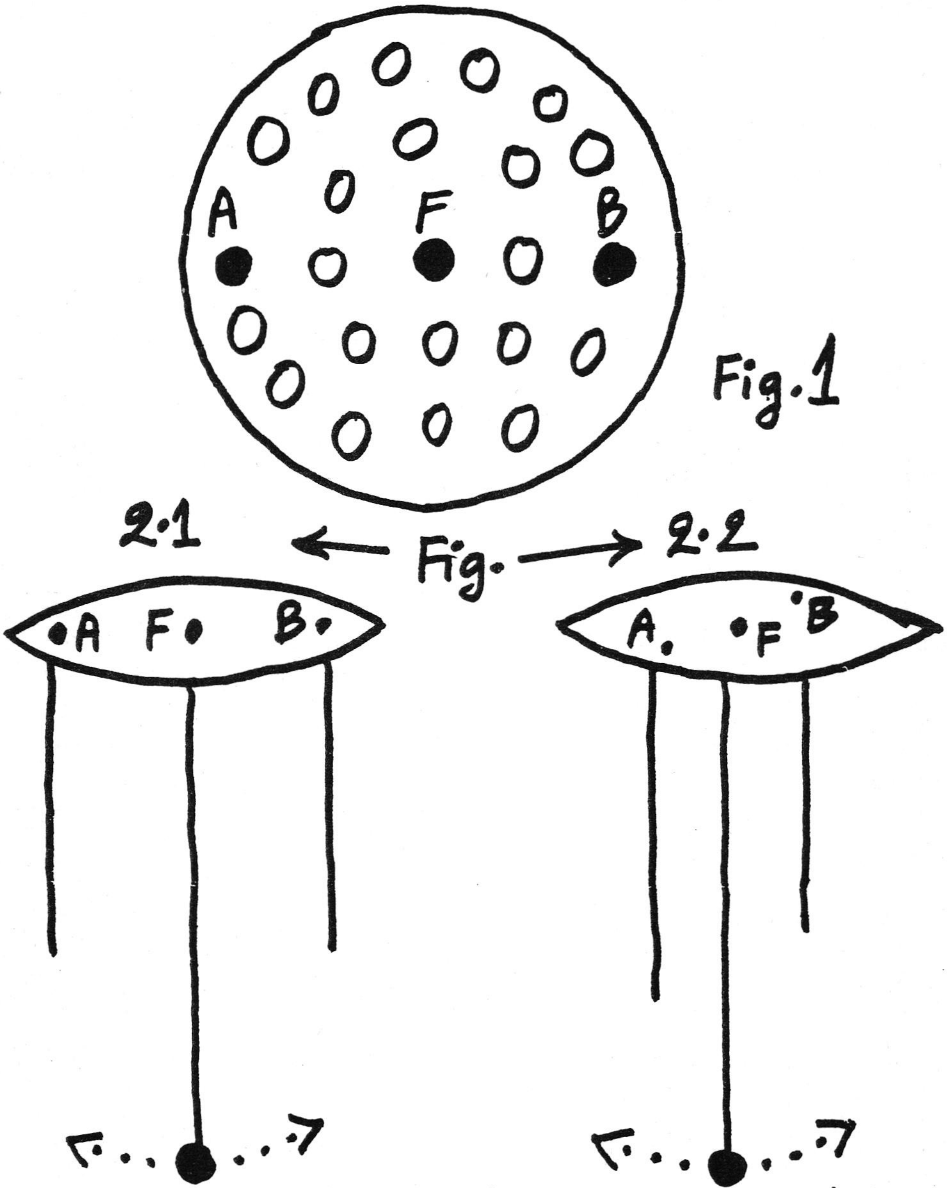

Fig.1

2.1 ← Fig. → 2.2

Pendulum oscillates along the dotted lines.

DARKNESS ON A SUNNY MORNING

SASTI BRATA KABIRAJ.

On Oct. 24th, 1995, hundreds of millions of people will have the chance to observe a total solar eclipse (T.S.E.)which incidently happens to be Diwali-the festival of lights. The path of totality of the eclipse passes over thickly populated regions of northern India, providing a rare opportunity to view and study the eclipsed sun-one of the natures super spectaculars. So this T.S.E. has paramount interest to specially Indian astronomers as well as general public as the path will cross over India. The last T.S.E. was seen from Indian soil on 16th Feb 1980, when a large number of our countrymen were fortunate enough to witness this unique rare astronomical phenomenon. The path of totality was passed over Orissa,Andra Pradesh and Karnataka. Before the year 2000 A.D. there will be another T.S.E. on 11th Aug. 1999. Which will be visible from India. No T.S.E. would be visible over India in the entire 21st century. In fact on average the path of totality crosses over a given place on the earth just one in every 360 years or so. Even when it does the moon's shadow has a most perverse habit of passing over relatively remote and inaccessible regions. Few total solar eclipses occur in areas where well equiped astronomical observatories are located. Generally astronomers,solar scientists have to travel to far off places to be in the shadow of the moon.

It is estimated that only one in hundred of us ever has a chance to be in the shadow of moon. Surprisingly many of us have been partial solar eclipse so do not understand that the difference between a total and a partial eclipse in the difference between night and day.

A solar eclipse occurs if the moon happens to come exactly between the earth and the sun as it does once in every 18 months or so and on a new moon day. It happens due to a remarkable coincidence of size and distance not found on any other planets. By a quirk of nature our moon is 400 times smaller in diameter than the sun and at the sametime it is also 400 times closer to earth. Because of this, the sun and moon subtend almost exactly the same angle. In the sky and it is about $1/2^{\circ}$. This makes both appear almost of the same size from the earth.

A lunar eclipse can be visible from any part of the globe where moon is up but a T.S.E. can be seen only along a narrow path where the shadow of the moon sweeps over the face of the earth. The shadow consists of two parts one is umbra where no direct sunlight enter and the other is penumbra where sunlight ponetrates from only a part of the sun's disc. To an observer who is within the peneumbra will see the partial solar eclipse.

There are many factors that will determine the kind of eclipse i.e. total, partial or annular and also duration of the totality. These are depend on the relative position of the sun, the moon and the earth. We know that the orbit of the earth, around the sun and the orbit of the moon around the earth are not perfectly circular but elliptical. As a result distance between the earth and the sun, varies by as much as 5 million kms between perihelion and aphelion. Similarly our moon's distance from earth also changes by 50,000 kms between perihelion and aphelion. Because of these variation in distance the apparent size of the sun and the moon sometimes larger when they are closer to earth and sometimes smaller when they are farthest from the earth. Now if the condition are other wise suitable for a solar eclipse than three things can happens. Firstly if the apparent size of the moon exactly matches with that of the sun then the eclipse will be total and duration of the totality may be as short as fraction of second.

The second possibility is if this is observed at a situation near the equator under the most favourable condition possible viz. the sun at its farthest position from the earth and the moon closest to the earth then, the apparent diameter of the moon would be larger than that of the sun. In this situation duration of the totality would be the largest upto 7 minutes 31 seconds. Such an eclipse will be visible in India on July 52168 A.D. the largest eclipse in human history.

Now the 3rd possibility arises if the sun is nearest and the moon is near to its farthest distance from the earth. In this case sun appears larger than the moon and the moon will appears too smaller to completely cover the sun's surface. The result is that the narrow rim of the sun remains visible around the black disc of the moon and the viewers see an annular eclipse. This is due to the fact that the moon's shadow i.e. umbra will be too short to reach the earth surface. On average the solar eclipses are more numbrous than the lunar eclipses and nearly in the ratio of 3:2.

The experience of a total solar eclipse is dramatic. If you are fortunate enough to be in the shadow of moon you will find excitement. About an hour or an hour and half before the totality begins,partial phase of the eclipse starts. Nothing of special interest is visible to the naked eye immediately. But if you look at the sun through a special filter you will see that the dark moon stedialy creeps up the solar disc. However as totality approaches, there is a sizeable decrease in the intensity of light. It will continue to decrease untill about 15 minutes before the totality. The sky grows strangely dark. The animals are per-plexed and birds go to nest. Temperature falls and sometimes dew appears.. [During the minute or two before the totality begins, partial phase of the eclipse starts. Nothing of special interest is visible to the naked eye immediately. But if you look at the sun through a special filter you will see that the dark moon stedialy creeps up the solardisc. However as totality approaches, there is a sizeable decrease in the intensity of light. It will continue to decrease untill about 15 minutes before the totality. The sky grows strangely dark. The animals are perplexed and birds go to nest. Temperature falls and sometimes dew appears.] During the minute or two before the totality begins if the observer is situated in such a place where his view command the distant horizon he will begin to notice a shadow approaching from the western horizon like a heavy thunderstorm advancing almost terrifying swiftness at a speed of 1700 km per hour. Just before the shadow reaches the observer, bands of shadow race across the ground. They are called 'Shadow Band' and it happens one minute before the totality. This is caused due to the refraction of sunlight in earth's atmosphere. Then the limb of the sun appears like circular bright thread which is the thin sliver of the photosphere. Then the sliver breaks into a chain of beads along the rim of the moon. These are called 'Baily's Beads'. This is due to irregularities on the moon's surface. The deeper valleys that happens to be located at the edge of the moon allowing the last rays from the photosphere just before the commencement of the totality. This can be seen for several seconds, to the observers situated near the edge of the totality path. It gilistens and dazzles for a few sconds sparkling like a diamond. This is known as 'Diamond Ring Effect'.

With the passage of the diamond ring effect total phase of the eclipse commence. For a few seconds, a raddish glow is visible in a narrow band arround the leading edge of the moon giving viewers a momentary glimpse of the solar chromosphere and perhaps one or more prominences. Chromosphere is a layer of gas at a temperature of $7000^{\circ}K$ - $15000^{\circ}K$. Scientists studying the chromosphere have to work fast and have their photographic devices operating at a rapid pace in order to make their observation successful in a few seconds. Moments later the most spectacular sight of the total solar eclipse flashes into view is the faintly glowing corona that bursts forth as a halo around a dark sun right at the moment of totality. [This corona is the outmost part of the solar eclipse flashes into view is the faintly glowing corona that bursts forth as a halo around a dark sun right at the moment of tatality.] This corona is the outmost part of the solar atmosphere and the link between the sun and the interplanetary space. Made up of hot gas at a temperature of about $2000000^{\circ}K$. The brightness of the Corona extend upto several millions of kms. The corona serves as a unique and valuable laboratory in which scientists can study gaseous plasmas in a near vacuum. It is proved that the brightness of the corona depends on the sunspots present at that moment. The corona becomes bright and round at the time of high sunspots activity and on the other hand at the time of low sunspot activity the corona becomes thinner and more irregular in shape. The detail study of the Corona provides wealth of information that goes on inside the sun. At this moment the sky overhead darkness and suddenly bright stars and planets can be seen through. The coming solar eclipse will provide us an opportunity to see the mercury and the venus.

As the photosphere is totally hidden at the time of totality so it is perfectly safe to look at the corona with naked eye and without any filter. Its brightness is comparable with that of the fullmoon and is equally safe to look at. Unfortunately many of us are not adequately informed about this most important phase of the total solar eclipse and miss the sight of a pearly white unearthly light enveloping the sun. At the end of the totality the diamond ring reappears on the other side of the sun then the 'Baily's Beads' and then the partial phase. With this the totality ends and the moon rapidly uncover the Western limb of the sun. It is the patron of life in earth, the primary source of energy in our solar system, grows full to reign in the sky again.

The coming 24th Oct. 1995 total solar eclipse is the shortest of this decade begins at 7.22 IST and ends at 12.43 IST. The fleeting shadow of the moon would make its first landfall at a place south of Tehran at 8.23 IST. At this place duration of the totality about 25 secs and width of totality path will be 19kms. Travelling south east, the umbra, after crossing Iran quickly reach Afganistan-Pakistan border near Chaman at 8.27 IST. At this point duration of the totality about 39 secs and width of totality 40kms Some places in Rajasthan which lie in the path of totality are Ratangarh, Nim Ka Thana, Alwar, Bharatpur, Fatepur Sikri etc. Then the moon's shadow will enter U.P. at about 8.35 IST. Here duration of totality about 63 seconds and width of totality increase to 50kms. Some important places in U.P. lie in the path of totality are Kalpi, Hamirpur, Allahabad, Ghazipur, Karari, Rajapur, Lalganj, Jalan (Orai) etc. It is worth mentioning that only Bhind in M.P. lies in the path of totality. After crossing U.P. the shadow will enter Bihar at 8.42 IST. Some of the easily accessible places which lie in the path of totality are Daltanganj, Robertsgonj, Muhammadganj,Panki,Ramgarh,Jhalida,Patratu etc. After Bihar the shadow will enter West Bengal(W.B.)at about 8.35 IST. Some places in W.B. which lie in the path of totality are, in Purulia district : Purulia,Hura, Puncha,Manbazar,Bandoan,Jhalda,Balarampur,Barabhum etc. In Bankura district : Mukutmanipur,Malian,Hirbandh,Simlapal,Taldangra,Khatra, etc. In Midnapur district : Midnapur,Tamluk,Ghatal,Chandrokona etc. In 24 Pgs. district : Falta, Diamond Harbour,etc. Duration and width of totality path goes on increasing from 48 seconds in Rajasthan to 82 seconds in W.B. and 46 kms to 55km respectively. Diamond Harbour will have the maximum duration of 80 seconds. The umbra cross India-Bangladesh border at 8.50 IST and passes through Burma,Thailand,South China sea, Combodia,Vietnam,Borneo and Pacific ocean. Partial phase can be seen from north east Africa,Central-South-Eastern Asia,Indian Ocean,Northern half of Australia and Western pacific Ocean. Finally the eclipse ends at 11.42 IST with sun set at Pacific Ocean.

Looking directly at the sun with naked eye or through incorrect or inadequate filters even if the sun is partially eclipsed by the moon can cause permanent eye damage. Because of its high brightness and the ultraviolet and infrared radiation that it emits all the time. Remembers that the 24th Oct,1995,eclipse in total. Therefore at every moment during the eclipse you must practice safe observing techniques.

<u>How can you safely watch the Sun</u> ?

The following techniques can be used for direct viewing the solar eclipse.

1. One can use the arc welding filter shade No.14 available in any arc welding shop. Less dense welding filter with lower shade number are not suitable for direct viewing the Sun.

2. Specially designed metal coated piece of plastic typically Aluminized Mylar filter can be used for direct viewing the

Sun.

The safest way to observe the Sun and watch the progress of the eclipse is not to look directly at the sun at all. The following ways can be practiced to project the Sun's image.

1. The simplest technique of obtaining a solar image requires a plane mirror. A pinhole of 1-2cm in diameter may be cut on a black paper and then taped to front of the flat mirror. Position the mirror in the Sunlight to reflect the Sun image into any convenient direction. The Sunlight reflects from this arrangement may be thrown on to a shaded wall indoors to give an image of partially eclipsed Sun. By reducing the diameter of the hole in the paper increase sharpness of the image.

2. Make a pinhole about 1 mm. in diameter in a piece of aluminium foil or a piece of cardboard so that light can get through the pinhole. Stand with your back to the sun and project the Sun's image through the pinhole into a second piece of white paper kept at a distance of two to four feet away.

<u>What are the unsafe direct viewing</u> ?

The following are the unsafe ways through which to view the Sun.

1. Smoked glass or sunglass of any type.

2. Colour slide film no matter how many thickness are used.

3. X-ray films.

4. Black & White photographic films. There are some photographic films which can be safely used in multiple thickness (those that are silver bearing after development)but unless you are sure what you are doing,why take the chance ?

5. An Aluminized Mylar or welding filter that has been damaged.

6. Reflection of Sun's image in water.

When using filters to view the Sun directly be sure to inspect both side of the filter before each use to ensure that mishandling or accidents have not put holes or deep scratches in the material or otherwise damage it.

Those who will use the optical diveces like telescope,binocular,camera etc. for viewing the solar eclipse remember that the filter must be used in between the Sun and the objective lens. Be sure that the filter attach with the opening of the telescope in such a way that do not fall off or blow off on a sudden gust of wind.

What are the four contacts ?

Total solar eclipse provide the astronomers an opportunity to determine the precise moment of each of the so-called 'Contacts'. The first contact takes place when the moon's leading edge first become visible on the Solar disc or touches the edge of the Sun. The second contact is when the eclipse is become total or annular. At this moment the sun totally disappear behind the moon and the solar corona becomes visible. The third contact takes place with the reappearance of the solar rim and the fourth contact is takes place when the moon finally leaves the Sun's disc. From the first contact to the fourth contact the time can be a little over four hours. If the time of the contact are determined more accurately at various points along the path of totality it will help to determine the distance between the earth and the moon with more precisely. This has also been utilised to determine the shape of the earth and the exact position of the moon in the sky for comparision with the theoretical prediction.

The upcoming total Solar eclipse offer a special chance to hundreads of millions of people to see at least partial phase of the Sun.

Let us do not miss the grand opportunity. Of course not all of us, in the country would be able to witness the totality but a partial phase of the eclipse. This event would no doubt help to inculcate scientific outlook among the people and thereby help our country to become a nation of scientifically thinking people in the coming days.

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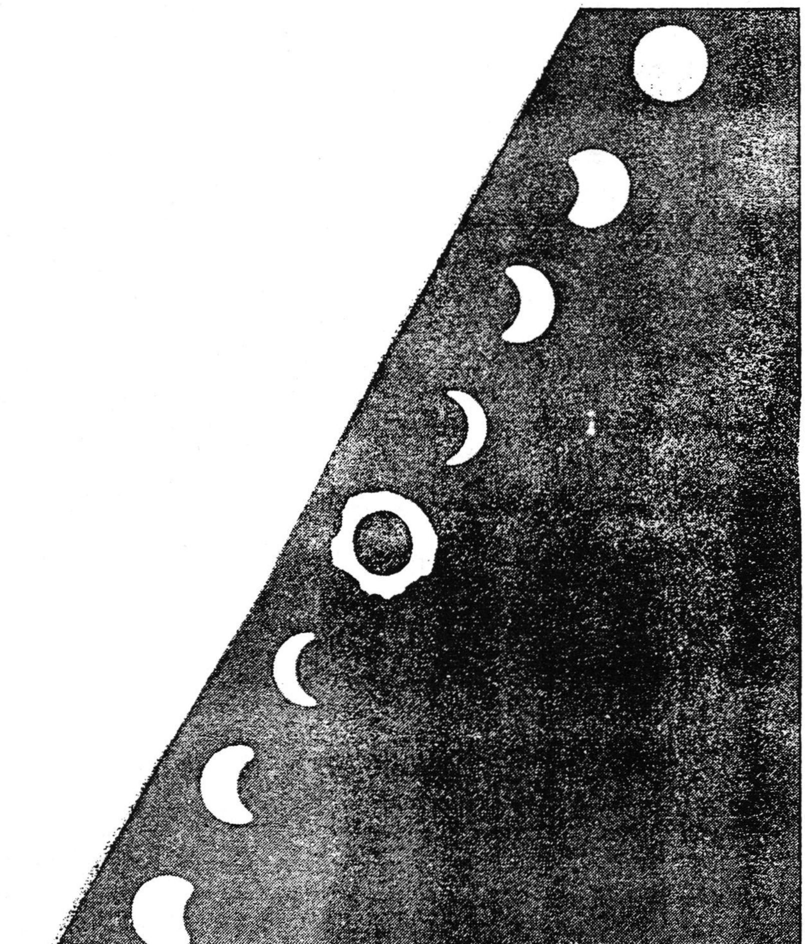
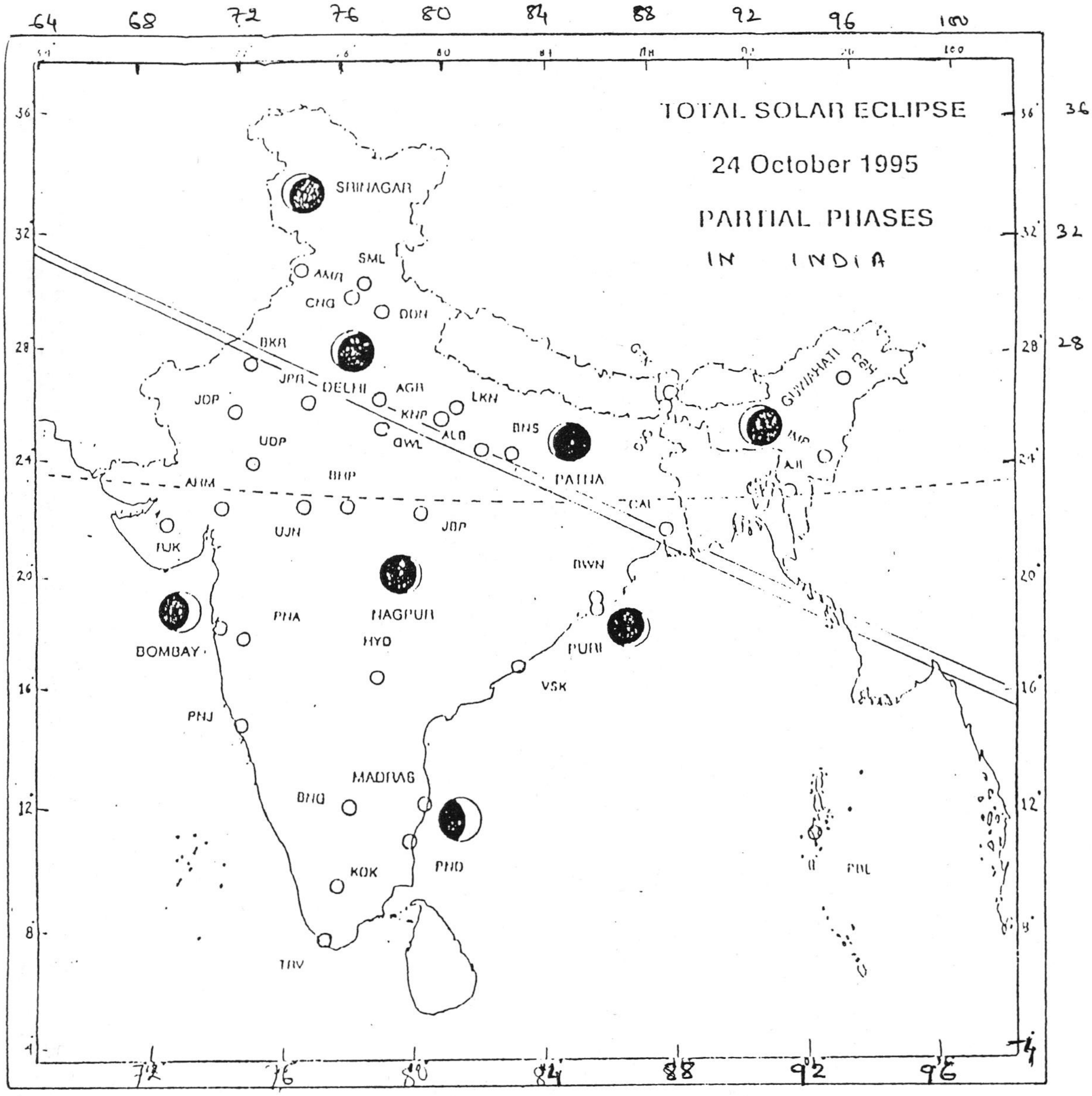


The Total Solar Eclipse of 16th Feb 1980


TOTAL SOLAR ECLIPSE
24 October 1995
PARTIAL PHASES
IN INDIA
SRINAGAR
SML
CHG
DDN
DKR
JPR
DELHI
AGR
KNP
LKN
ALD
DNS
PATNA
GUWAHATI
JDP
UDP
AHM
BHP
UJN
JBP
CAL
TUK
NAGPUR
BWN
BOMBAY
PNA
HYD
PURI
VSK
PNJ
MADRAS
BNG
PND
KOK
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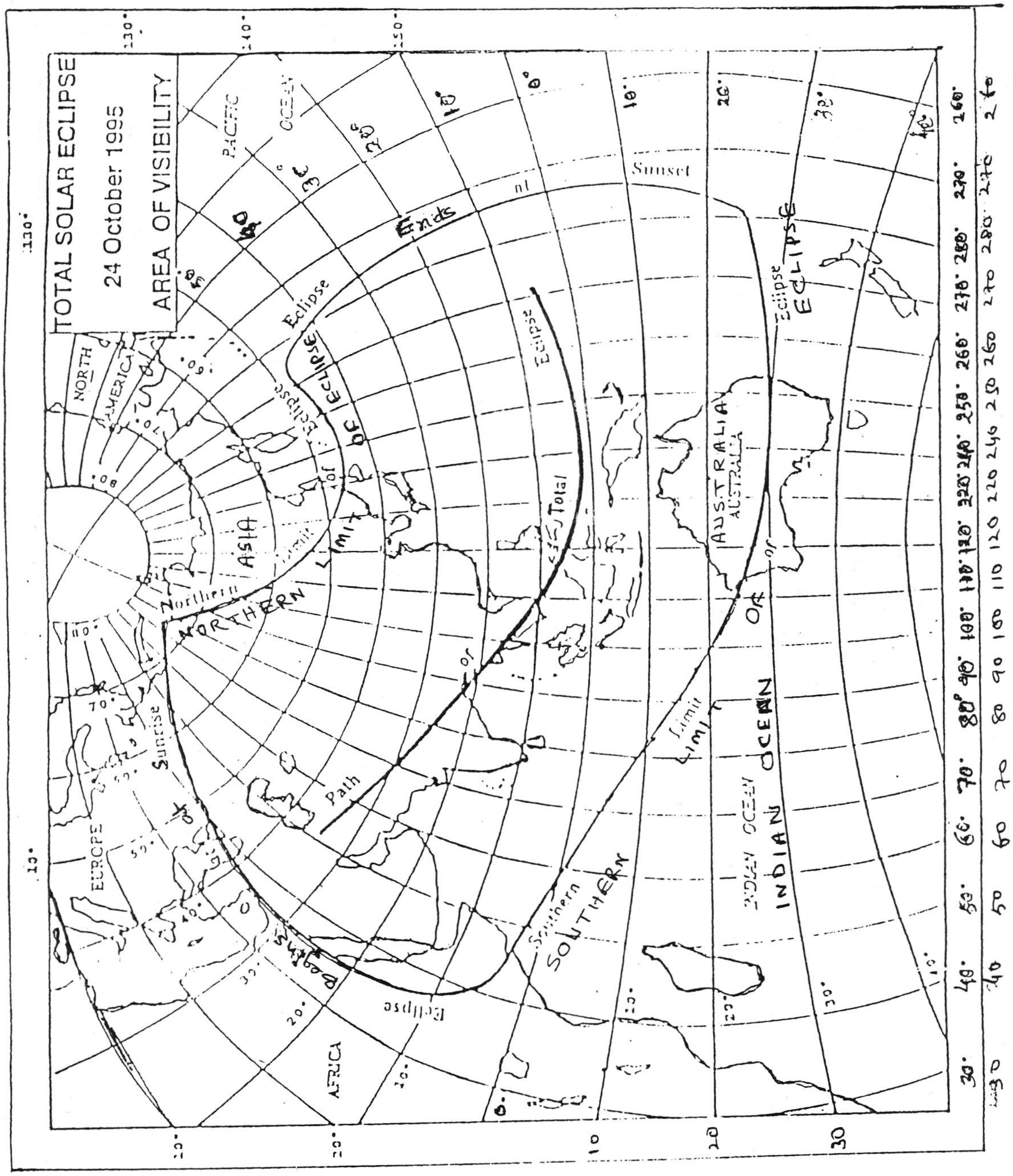
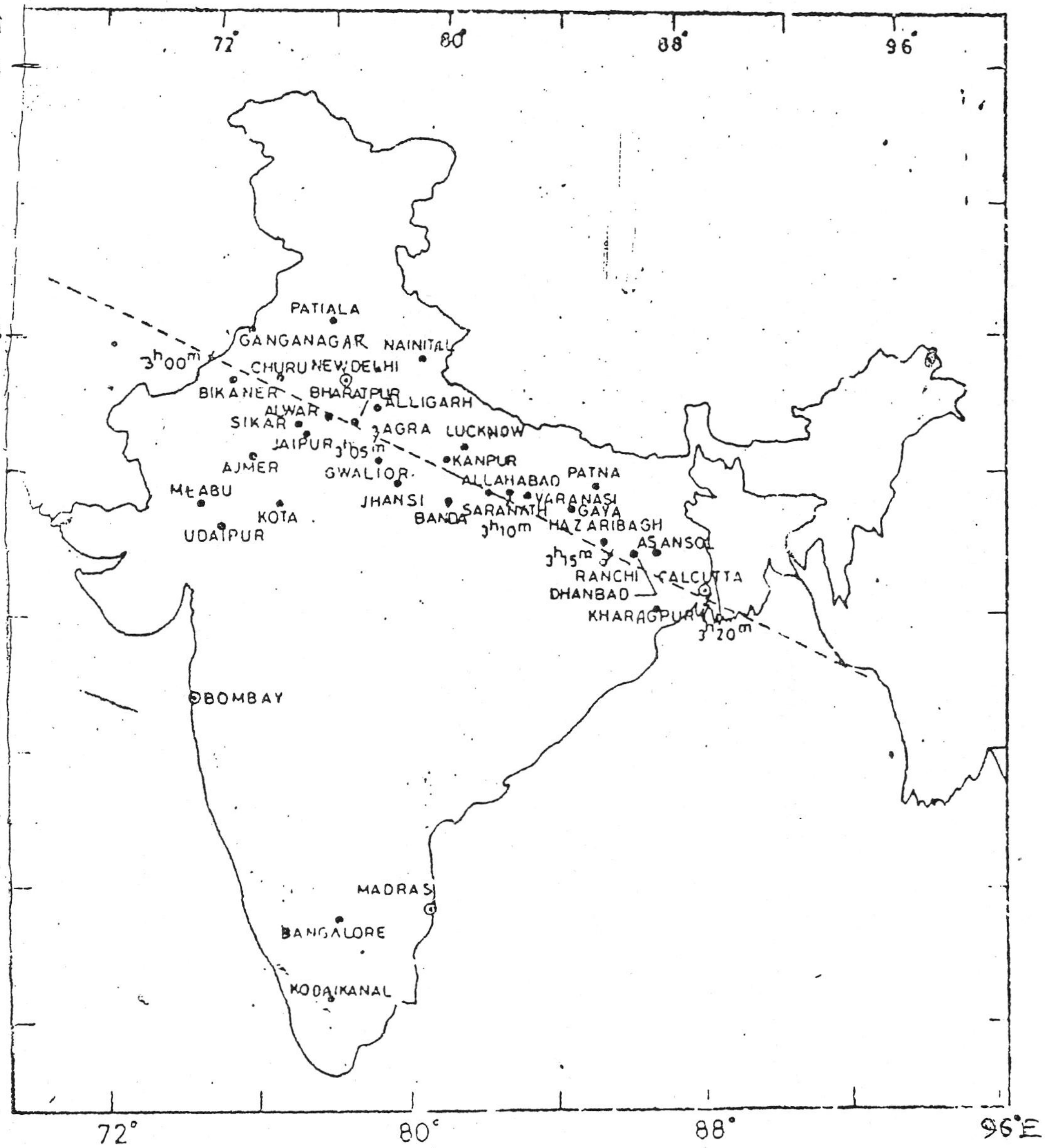
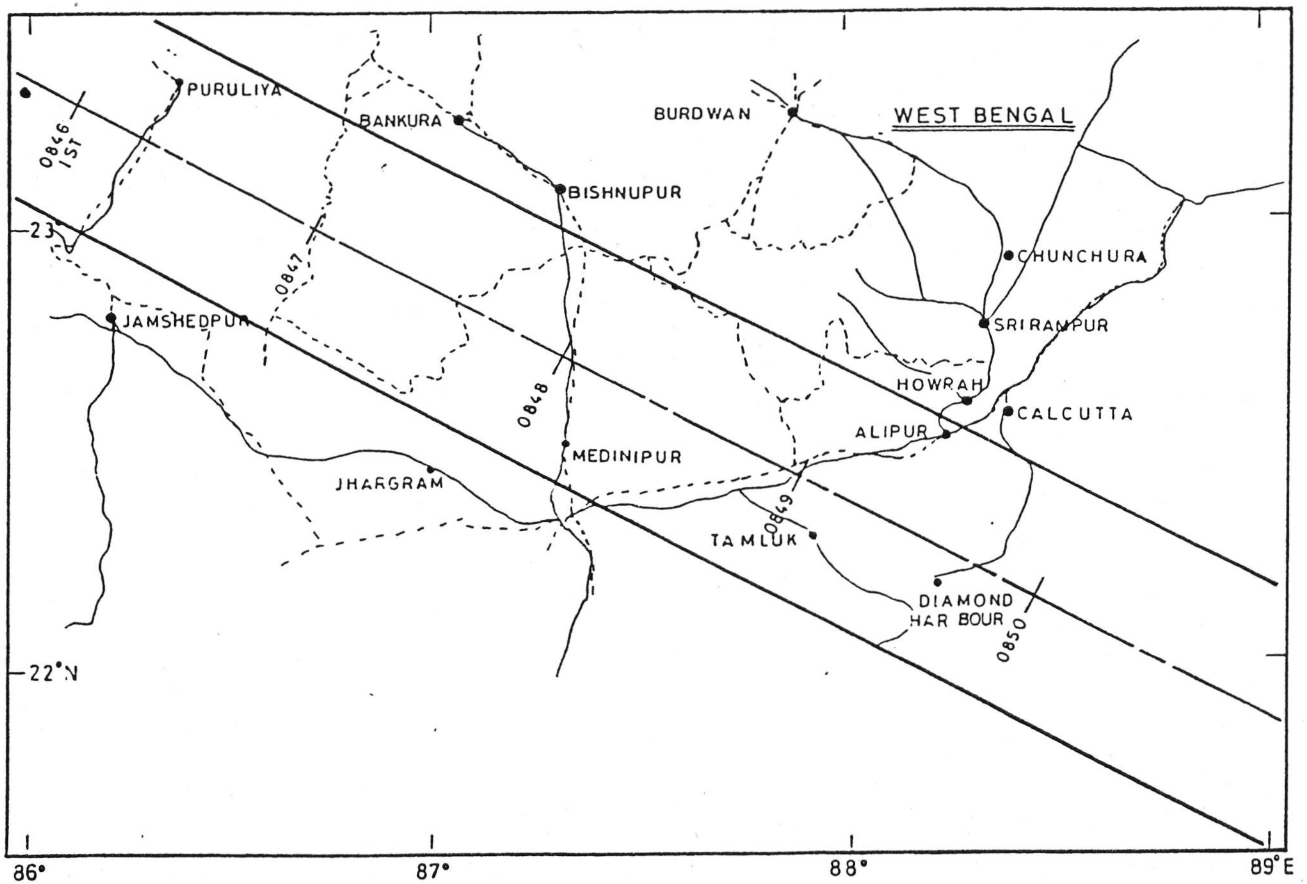

TOTAL SOLAR ECLIPSE
24 October 1995
AREA OF VISIBILITY
NORTH AMERICA
PACIFIC OCEAN
ASIA
EUROPE
AFRICA
AUSTRALIA
INDIAN OCEAN
Sunrise
Sunset
Northern Limit of Eclipse
NORTHERN LIMIT OF ECLIPSE
Southern Limit of Eclipse
SOUTHERN LIMIT OF ECLIPSE
Path of Total Eclipse
Eclipse Begins
Eclipse Ends



Path of totality of the coming 24th Oct 1995 Total Solar Eclipse in India

6



Path Of Totality in - West Bengal, INDIA

Cyclic Molecules in Cosmic Objects

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Abstract. Radioastronomical observations of emission spectra from cosmic objects (astronomical objects) led to the discovery of a number of molecules in the sources. By now about one hundred molecules (including molecular ions and radicals), ranging in size of two to thirteen atoms, have been detected in a large number of astronomical objects. These objects are generally interstellar molecular clouds, associated with the regions of star-formation, or circumstellar envelopes of evolved (late-type) stars. Hence, the study of molecules in astronomical objects is of great importance, as it provides information about the stars, from the stage of their birth to the stage of their death. The molecules observed in the cosmic objects are not only the simple (or polyatomic) ones, but there are some cyclic molecules also. This article is devoted to provide information about the cyclic molecules, namely, SiC_2, C_3H_2 and C_3H, detected in cosmic objects.

1. Introduction

Because of the assumed harshness of the interstellar environment, scientists had no feelig about the existence of molecules in interstellar regions. In 1931, a radio engineer, named Karl G. Jansky of Bell Telephone Laboratories, New Jersey, U.S.A. accidentally discovered a radio-window, which opened up an entirely new astronomical world. This window, extending from a few millimetres to about 15 metres in wavelengths, provided astronomers, for the first time, a means to study molecules in astronomical objects. The first molecule detected in 1963, after more than three decades of the discovery of the radio-window, in the interstellar space by S. Weinreb and coworkers was the OH radical, whcih was later on, in 1965, found as the first masing molecule. With the detection of the molecule in interstellar medium, scientists were astonished as their assumption of the harshness of the interstellar medium shattered down.

After that, scientists started searching for the molecular species, which were familiar through laboratory measurements, in the astronomical objects, and they succeeded, too, in finding the familiar and stable molecules, such as, water, ammonia, carbon monoxide. A number of simple organic molecules, such as alcohols, aldehydes, amines and substituted acetylenes were also found.

In spite of their surprise by finding the well known stable molecules in interstellar space, scientists did not think that the interstellar space could be more rich in molecules than their terrestrial laboratories. Therefore, they did not make any efforts from their own to search for the molecules other than those were known from the laboratory-measurements. But, nature did not let them to remain ignorant of the invaluable information regarding a large number of unusual molecules available in the cosmic objects.

A new radiation at 89.190 GHz was observed at the National Radio Astronomy Observatory in Tucson, Arizona, U.S.A. in 1970. It was later on identified as a radiation produced by the molecular ion HCO^+ (not known earlier). Subsequently, other observed radiations from cosmic objects were identified as produced by the unusual molecules, namely, HNC, C_2H, N_2H^+, SiC_2, C_3H_2, C_3H, C_4H etc. However, these molecules were later on produced and studied in the terrestrial laboratories, too, for their confirmations. By now about one hundred molecules have been detected in the cosmic objects (Table 1).

Since the detection of polyatomic molecules, searches for cyclic species in cosmic objects have been carried out, and pursued more vigourously following the discovery of increasingly complex carbon-chain molecules. So far, three cyclic molecules, SiC_2, C_3H_2 and C_3H, have been found in cosmic objects. Interest in the cyclic molecules followed from the suggestion that their presence might be an indication for the formation of ring molecules on the surface of the interstellar dust grains.

2. Cyclic molecules

(i) c-SiC_2

The spectral lines from astronomical objects at 95.579 GHz, 115.383 GHz, and 140.918 GHz, could not be assigned to any of the known molecular species for several years. Besides these lines, some more spectral lines at 93.065 GHz, 94.245 GHz, 170.742 GHz, 137.180 GHz, 141.751 GHz and 141.755 GHz, from cosmic objects, were identified as generated due to the transitions between the rotational levels in the cyclic molecule SiC_2 (abbreviated as c-SiC_2, where the letter c stands for the word "cyclic") by P. Thaddeus and coworkers in 1984. The structure of the molecule is in the form of a ring and is shown in Figure 1. Thus, it was the first cyclic molecule (ring molecule) found in the cosmic object, IRC +10216.

(ii) c-C_3H_2

The spectral lines from cosmic objects at 85.338 GHz, 46.756 GHz and 18.343 GHz, remained unassigned for quite some time. The transition at 18.343 GHz was found to be easily detectable in a wide range of the cosmic objects throughout the galaxy. The properties of the emission and absorption profiles of the spectral line indicated clearly

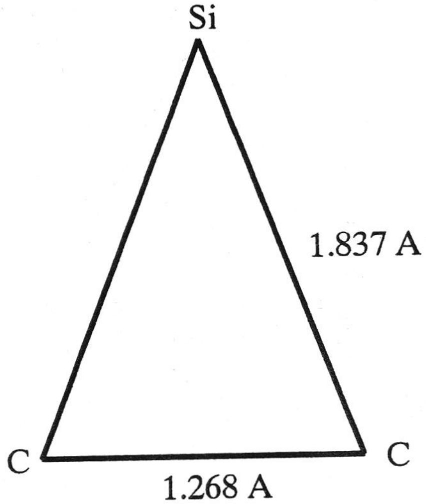

Figure 1: Structure of the cyclic SiC_2 molecule

that the radiation was due to the transition between two low lying energy levels of a strong polar specie. These lines were identified by P. Thaddeus and coworkers in 1985 as due to the transitions between the rotational levels of the cyclic molecule C_3H_2. The structure of the molecule is shown in Figure 2.

It is generated via dissociative recombination

$$C_3H_3^+ + e \rightarrow c\text{-}C_3H_2 + H$$

(This reaction has some more channels which would be given in the next section.) The $C_3H_3^+$ is a very stable ion and can be produced from acetylene in only two steps:

$$C_2H_2 + C^+ \rightarrow C_3H^+ + H \qquad \text{(fast ion-molecule reaction)}$$

$$C_3H^+ + H_2 \rightarrow C_3H_3^+ \qquad \text{(slow radiative association)}$$

(iii) c-C_3H

Since the discoveries of the linear radicals, C_2H in 1974 and C_4H in 1978, the detection of the linear radical C_3H (abbreviated as l-C_3H, where the letter l stands for the word "linear") in cosmic objects was a prime goal before the astronomers, until it was detected in 1985 by P. Thaddeus and coworkers in the cosmic objects IRC +10216 and TMC-1. During the survey of the vibrational satellites of l-C_3H (obtained in the laboratory by discharging the mixture of C_2H_2, CO and He), several lines, which

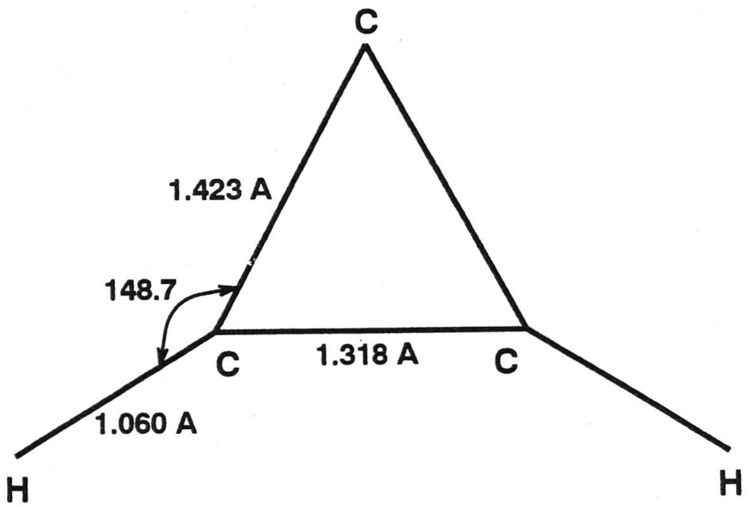

Figure 2: Structure of the cyclic C_3H_2 molecule

could not be assigend to l-C_3H, were observed in 1987. On the basis of the rotational constants derived from these frequencies, the carrier of the lines was concluded to be the cyclic molecule c-C_3H. Later on this molecule was discovered in the astronomical object TMC-1, in 1987, by S. Yamamoto and coworkers. The structure of c-C_3H is shwon in Figure 3.

The most plausible process for the formation of c-C_3H is one of the competing reaction channels of the dissociative recombination reaction of $C_3H_3^+$

$$
\begin{aligned}
C_3H_3^+ + e \quad & \rightarrow \text{c-}C_3H_2 + H \\
& \rightarrow \text{c-}C_3H + H + H \quad \text{or} \quad \text{c-}C_3H + H_2 \\
& \rightarrow \text{l-}C_3H + H + H \quad \text{or} \quad \text{l-}C_3H + H_2
\end{aligned}
\tag{1}
$$

3. Discussion

It is undisputable that the hydrogen molecules in the interstellar space are formed on the surface of the dust grains, as no other compatible mechanisms have been found so far. Graphite particles and silicates are considered to be a likely significant components of the interstellar dust and there has been much speculation concerning their possible role in molecular formation in interstellar space. If, on the otehr hand, interstellar molecules are formed primarily in gas phase ion-molecule reactions rather than on the grain-surfaces, the ring-molecules would not be expected to form in appreciable

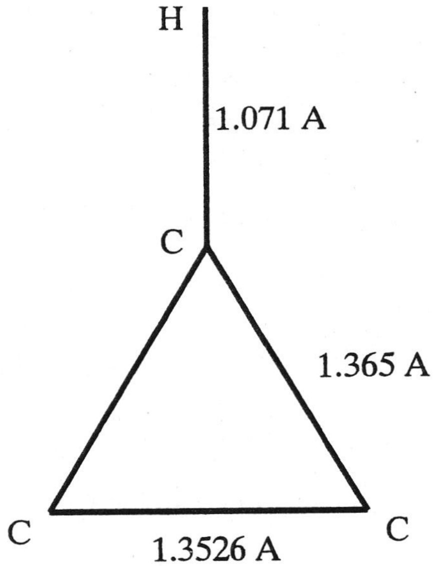

Figure 3: Structure of the cyclic C_3H molecule

quantity. However, the molecules with long carbon chains are to be formed. At low temperatures, in the gas phase reactions, the unsaturated carbon chains will not be able to close on themselves to form rings. However, on the surface of the dust grains several unsaturated chains may join together to form rings. Since no ring-molecule in the cosmic objects was discovered by 1975, it was concluded that the interstellar molecules (with exception of hydrogen molecules) were formed in the gas phase rather than on the dust grains. Whether other molecules are formed on the grains is still conjectural. A major theoretical problem is regarding their removal from the cold grains, once they have been formed. The detection of ring molecules in cosmic objects may play an important role to decide about the mechanisms for the formation of molecules in cosmic objects.

Acknowledgements

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Table 1. List of the molecules observed in cosmic objects*

Molecules of two atoms

AlCl, CO, CP, CS, H_2, HD, HCl, N_2, NH, AlF, C_2, CH, CH^+, CN, KCl, NO, NaCl, PN, SO^+, SiN, NS, OH, SO, SiC, SiO, SiS

Molecules of three atoms

C_2H, C_2S, H_3^+, HCN, HNC, HCO, HCO^+, HNO, H_2O, N_2H^+, OCS, SO_2, HCS^+, H_2S, c-SiC_2, H_2D^+, NaCN, NaOH, HDO, C_3

Molecules of four atoms

C_2H_2, l-C_3H, c-C_3H, C_3O, $HCNH^+$, H_2CO, C_3N, C_3S, H_2CS, HNCS, $HOCO^+$, H_3O^+, NH_3, HNCO, D_2CO, HC_2N

Molecules of five atoms

C_4Si, CH_2CN, HCOOH, HC_3N, H_2CCO, H_2NCN, CH_4, c-C_3H_2, C_4H, H_2CHN, SiH_4, C_3HD, C_4D, H_2C_2S, C_5

Molecules of six atoms

C_2H_4, C_5H, CH_3NC, C_5O, C_5S, CH_3CN, CH_3OH, CH_3SH, CH_2C_3, $HCONH_2$, HC_2CHO, HC_2COH, H_2C_4

Molecules of seven atoms

CH_3CCH, HC_5N, C_6H, CH_3NH_2, CH_2CHCN, $HCOCH_3$, CH_2CHON, CH_2CHOH

Molecules of eight atoms

CH_3C_3N, $HCOOCH_3$, CH_2CHCHO, CH_3COOH, $(NH_2)_2CO$

Molecules of nine atoms

CH_3C_4H, C_2H_5CN, $(CH_3)_2O$, HC_7N, C_2H_5OH, CH_3C_4N

Molecules of ten atoms

C_6H_3N, H_3CCOCH_3

Molecules of more than ten atoms

HC_9N, $HC_{11}N$

*Here, we did not include the isotopes of these molecules, and the molecules observed in comets. In order to distinguish between cyclic and linear isomers, the prefices c and l, respectively, are used. Only three molecules c-SiC_2, c-C_3H and c-C_3H_2 are cyclic.

DOWNTOWN EXHIBIT ON THE SUN AND MOON

Julieta Fierro
Instituto de Astronomía, UNAM

Downtown Mexico City has gone through a process of restoration. Many of its colonial homes have been remodeled and adapted to suit the needs of shops and restaurants. As part of the governments efforts to preserve the historical city it has organized a festival whose leitmotif are the Sun and Moon. Mainly people from the arts, painters, poets, writers and musicians have displayed there work at several of the museums, art galleries and concert halls.

Universum, the main mexican science center, was invited to display an exhibit on the Sun and the Moon. It was to be installed in a mezzanine at one of the Palacio de Minería, an imposing neoclassic XVIII'th century building, that originally housed the school of mining. Such a projects was welcomed by *Universum* staff, since we feel science is part of culture and its artificial separation is only a matter of tradition that we feel must be modified.

The entrance proper to the exhibit is flanked by models of the pyramids of the Sun and Moon at Teotihuacan. Even though we have no idea if they were dedicated to these celestial bodies, they are easily recognizable by general population, and they are a link between art, which is what the rest of the exhibits in downtown Mexico City are about, and astronomy.

We decided the main attraction of the exhibit were to be three great models of the Earth, Moon and Sun, that would show their internal structure. The physical conditions of these bodies were described by labels and illustrations placed on side panels. Since this is a historical building we were not allowed to hang anything on nor against the walls.

One of the innovative apparatuses on display was meant to explain seasonal changes. Statistics carried out in many countries to heterogeneous groups have shown that it is a difficult concept to understand. The approach we gave the problem was to show the way insolation falls on planets like Jupiter, that has no seasonal changes whatsoever, Uranus where they are extreme. We figured out once limiting cases were understood intermediate cases like the Earth and Mars would be easier to grasp.

One of the items we built to make the exhibit attractive was a model of the rocked used by the characters of Jules Verne's book, A Trip to the Moon. It was built of wood and covered by aluminum panels, inside a multimedia explains some of the Moon's features.

We had other multimedia displays, one on Earth tectonics and the other on physical characteristics of the Sun. We felt the one on Earth tectonics was specially important since Mexico City is due to have several earthquakes per year.

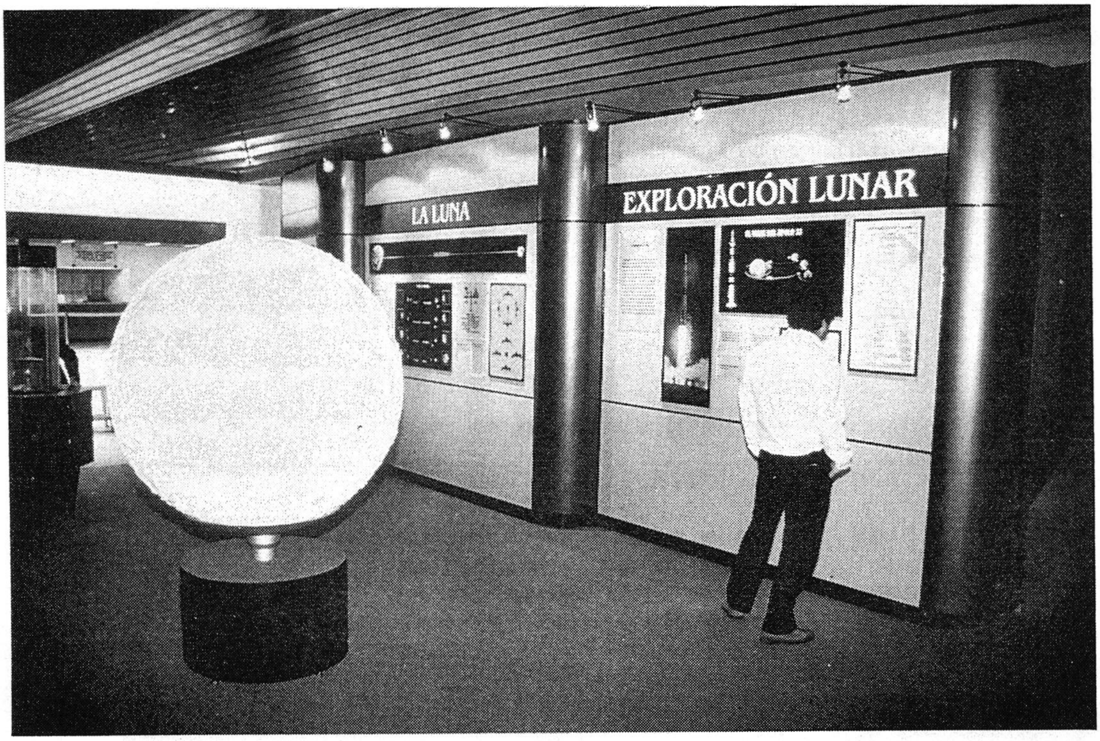
An other feature worth mentioning is that me built a small projection room where 12 different films on the Sun and Moon were continuously projected, scientific and not.

We had a shop selling items sold at *Universum*, a peek-through astronaut suit with a built in camera to take one's picture, floating in space.

Something we feel worth mentioning is that we produced a one page pamphlet, where *all* labels in the exhibit were printed out.

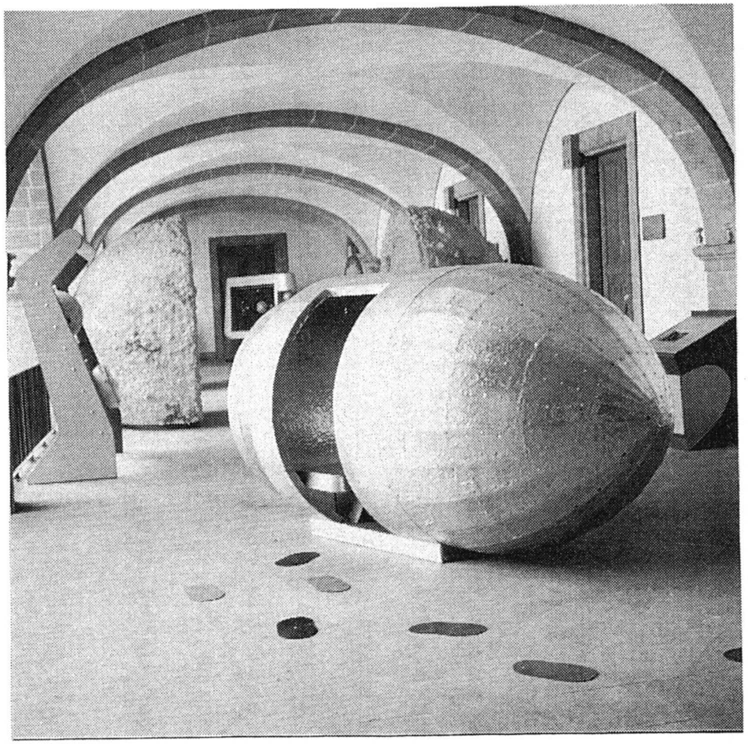
Unfortunately in mexican museums one often sees students copying labels for homework purposes. We feel we should continue printing this sort of pamphlets for all our displays.

Mezzanine of the *Palacio de Minería* where the astronomical exhibit was placed.



Moon model.


Season's display.



Jules Vernes´ rocket model.

Moon's model label.

A MOON TOUCHSTONE FOR UNIVERSUM

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Instituto de Astronomía, UNAM

One of the greatest accomplishments of mankind has been the Moons exploration. As years go by it seems more outstanding for those who witnessed it and more remote for those who were born after the event. Moon's exploration is not only and extraordinary technological achievement, it involved organizing hundreds of people in a single project and encouraged lunar geological studies which were not very prolific before our satellites direct exploration.

Universum, the main science museum in Mexico, was granted the custody of two Moon Rocks. One is a touchstone and the other is placed in an acrylic cube for its display.

Universum's staff decided to place the Moon rocks in a 4 by 6 meter exhibit area facing the main entrance, so as soon as visitors access the Museum they will be immediately encouraged to visit the display.

Although the main attraction of this exhibit is the touch-stone, we though people standing in line would be willing to find out more about the Moon, so we designed several displays on its principle features and the importance of its exploration. Visitors must stand in line, look at the first Rock, collected by Apollo 11, go up a ramp, touch the second sample, from Apollo 17 mission, and exit the exhibit area. And as we mentioned earlier, in the meantime, they will be able to ponder about some of the properties of our satellite.

When visitors enter the exhibit area they will have the Moon Rock, collected by Apollo 11 astronauts, placed in a safely guarded pedestal to the right; and on the left a TV screen showing some of the highlights of the Saturn rocket voyage to the Moon. After that a panel explaining the main physical characteristics of our satellite and the Saturn trajectory to Moon are shown, using labels and pictures to describe different features of the subjects at hand.

Even though we know people do not tend to read labels as much as museum people would like, we feel standing in line will encourage the visitors to take a look at what is shown.

To the right there are three tables where the visitor can manipulate panels in several ways and find out the landing spots of the lunar missions, the Apollo 17 journey on the Moon's surface and a "push button" display on its general properties (temperature, density, sky color, chemical composition, surface gravity, etc.).

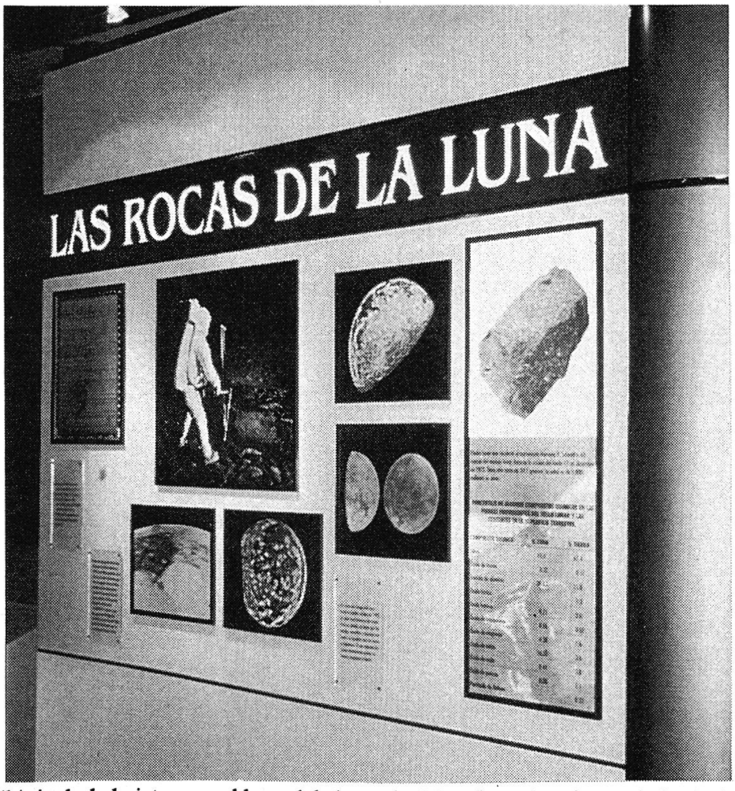
Finally the visitor reaches the main attraction, the Touch-stone. It is placed in a complicated pedestal that had to meet the safety regulations that NASA requires for such an item. In the background the visitors can see a blowup picture of the Earth seen from the Moon.

After descending the ramp visitors can watch panels showing the importance of the Moon's exploration and what particular characteristics rocks from our satellite have. Visitors con watch a 3D "artistic" depiction of the Moon, they can manipulate an interactive display explaining electrical properties of the Moon studied by a Mexican geophysicist, and finally watch a video about how the Rocks, came to Earth, the NASA Headquarters and at last to *Universum*.

It is a custom in Mexico for teachers to send middle school pupils to museums to do their homework. We have printouts on the Moon so that students will not have to copy labels. *Universum* has a large library and bookstore where they can find more information if it is required by their teachers.

We feel this exhibit on the Moon had specially good timing since it was dedicated on the 25 th anniversary of the lunar exploration and at the time when Clementine probe was making a new geological survey of our satellite.

General view of the exhibit on lunar rocks placed at *Universum*.



This small exhibit included pictures and large labels on the Moon's exploration and physical conditions.