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IUCAA

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School Students' Summer Programme 1999

Some of the participants of the School Students' Summer Programme 1999

This year's School Students' Summer Programme was held between April 12 and May 21, 1999. About 150 students from 75 schools (two students from each) in greater Pune participated in this programme. A batch of 26 students was invited to work at IUCAA from Monday to Friday each week. A sub-group of 4 to 6 students were allotted to work under the guidance of a member of IUCAA. No set syllabus or course guidelines was made for this programme. The students and the guide worked out the schedule themselves.

New Honorary Fellows of IUCAA

The Governing Board has elected Geoffrey Burbidge and Allan Sandage as Honorary Fellows of IUCAA. We are very happy to welcome them to the IUCAA Family.

Contents...

During the week, the students went through other activities too, in addition to the normal instructions from the guides. They were shown scientific films, a common lecture was arranged and they were taken to the Science Park. The students had a free access to the IUCAA library. A question and answer session was also conducted for the students. J.V. Narlikar answered their questions.

This year we added one more dimension to the programme, which has been running for the last six years. On Fridays, the students were asked to give an oral presentation of their work, in addition to submitting a report of their work. This presentation was followed by a tea party and a group photograph. We observed that the students responded exceedingly well to the instructions given to them. During the presentation by the first batch, we found that students had a strong inclination to use flowery language. Since then, instructions were given on how to present their work. Barring one or two instances, all presentations were in true scientific spirit.

Young Ph.D. students of IUCAA made a significant contribution to this programme. In particular, Sunu Engineer, K. Harikrishna and Tarun Saini, were guides, in addition to friends and philosophers. Niranjan Sambhus and Yogesh Wadadekar took Marathi/Hindi speaking students. The other guides were Kanti Jotania and Subhash Karbelkar (IUCAA Associates); Boud Roukema, Firoza Sutaria, Sushan Konar (Post-Docs) Jyotsna Vijapurkar (Visiting Fellow); S.N. Tandon, R. Gupta, Somak Raychaudhury, Jayant Narlikar (IUCAA Faculty), Dhananjay V. Gadre and H. K. Das (Eectronics/ Optical Engineers, Instrumentation Laboratory) and Vinaya Kulkarni (Assistant in Science Popularisation Laboratory). Asha Kembhavi gave a talk on uses and abuses of antibiotics.

Some of the projects done by the students, in random order, were Rotation of the Earth : Foucault's pendulum, Measuring time : Samrat Yantra, the Sun dial, Symmetries in nature : Topologically symmetric objects, Optics : lenses, reflecting surfaces, prisms, telescopes and microscopes, Solar system, astronomy and astrophysics: Kepler's laws, calculating masses of planets, law of gravitation, scale model of the Solar system, Doppler's effect, luminosity and temperatures, Hubble's law, understanding paradoxes : Olber's, Achilles and a tortoise, Mathematics : Non - Euclidean geometry, combinatornics, works of Fermat, Pascal, Gauss, Riemann, discovery of calculus - Newton and Leibnitz, Computer programming: understanding and writing computer programme, Evolution of life: Darwin's theory, etc.

Most of the students made use of the IUCAA Library and read introductory books in Astronomy. Outside this, some of the books appreciated by the students were : Surely you are jocking Mr. Feynmann, Feynmann's last lectures, How things work? Indian wildlife, etc.

The friendly atmosphere at IUCAA made students bold enough to make constructive suggestions. Most students voiced criticism on the lack of books in Marathi or Hindi languages and the short duration of the programme. On the last day of the programme, the station director of All India Radio, Pune, personally visited with her crew and covered the final proceedings of the event and interviewed some of the participants of the programme. It was a thrill to see young students respond to the occasion.

1500th Year of Aryabhatiya

To commemorate the 1500th year of the composition of the influential astro-mathematical text, ***ARYABHATIYA***, a workshop will be held at IUCAA during October 7-8, 1999. The workshop would seek to discuss the work of Aryabhata I, with a view to placing it in a wider perspective.

Most of this work deals with astornomy and spherical trignometry. Aryabhata - I also taught that the apparent rotation of the heavens was attributable to the rotation of the Earth on its axis and gave an accurate approximation for π. He was one of the first known to use algebra.

Invited speakers include J.V. Narlikar, J. C. Bhattacharyya, Rajesh Kochhar and other eminent scholars of History of Astronomy.

Interested persons who wish to attend this workshop may apply in plain paper, to the **Coordinator, Core Programmes, IUCAA, before August 10, 1999**, with a brief bio-data. Those interested in presenting their work may send an abstract of their talk.

Welcome to the IUCAA family

IUCAA is happy to announce the selection of the tenth batch of its Associates and Senior Associates, who are selected for a tenure of three years, beginning July 1, 1999.

Extension of the seventh batch of Associates/Senior Associates

Zafar Ahsan (SA)
Aligarh Muslim University

M.N. Anandaram (SA)
Bangalore University

Asit Banerjee (SA)
Jadavpur University (SA)

S.P. Bhatnagar (*)
Bhavnagar University

Somenath Chakrabarty (A)
Kalyani University

D.K. Chakraborty (SA)
Pt. Ravishankar S. University, Raipur

Suresh Chandra (SA)
S.R.T.M. University, Nanded

Sujit Chatterjee (SA)
New Alipore College

M.K. Das (SA)
Sri Venkateswara College, New Delhi

A.D. Gangal (SA)
University of Pune

B.A. Kagali (SA)
Bangalore University

Pushpa Khare (SA)
Utkal University, Bhubaneswar

V.C. Kuriakose (SA)
Cochin University of Science and Technology

Daksh Lohiya (SA)
Delhi University

S. Mukherjee (SA)
North Bengal University, Darjeeling

S.K. Pandey (SA)
Pt. Ravishankar S. University, Raipur

L.M. Saha (SA)
Zakir Husain College, New Delhi

L.P. Singh (SA)
Utkal University, Bhubaneswar

Ramesh Tikekar (SA)
Sardar Patel University, Vallabh Vidyanagar

The (*) indicates that they were previously Associates (A) and have now been made Senior Associates (SA).

New Associates/Senior Associates

Associates

Deepak Chandra
S.G.T.B. Khalsa College, Delhi

P.S. Goraya
Punjabi University, Patiala

S.N. Hasan
Osmania University, Hyderabad

K. Indulekha
Mahatma Gandhi University, Kottayam

Lalan Kumar Jha
L.N.T. College, Muzaffarpur

A.C. Kumbharkhane
S.R.T.M. University, Nanded

S.K. Pathak
Christ Church College, Kanpur

Lalan Prasad
Government P.G. College, Chamoli

Amitava Sil
St. Joseph's College, Darjeeling

V.O. Thomas
M.S. University of Baroda

Senior Associates

Bindu A. Bambah
Panjab University, Chandigarh

Arnab Rai Choudhuri
Indian Institute of Science, Bangalore

Jishnu Dey
Maulana Azad College, Calcutta

Mira Dey
Presidency College, Calcutta

P.P. Hallan
Zakir Husain College, New Delhi

M.L. Kurtadikar
J.E.S. College, Jalna

Usha Malik
Miranda House, Delhi University

P. Vivekananda Rao
Osmania University, Hyderabad

Molecules in Space

In 1944 van de Hulst had derived the important result that the atom of neutral hydrogen has two states for its electron, an upper energy state when it is spinning parallel to the proton and a lower energy state when it is spinning anti-parallel to it, and a transition from the former to the latter gives rise to a wave of 21 cm wavelength. In the early days of radio astronomy, this wavelength played a major role in identifying the presence of neutral hydrogen as the predominant component of the interstellar medium.

Nevertheless, astronomers by and large were not prepared to accept the presence of molecules distributed in giant clouds in the interstellar space, as proposed, for example by Fred Hoyle with R.A. Lyttleton in 1940. Although, Andrew McKeller discovered CH and CN by using optical methods, the real burst of activities began when in 1963, OH was discovered by S. Weinrab, A.H. Barrett, M.L. Meeks and J.C. Henry at the radio wavelength of 18 cm.

Because molecular transitions occur at such energies that the resulting photons are by and large emitted in the millimetre wavelengths (rather than at the radio wavelengths), antennas suitably designed for receiving radiation at such wavelengths began to be set up. The lead was taken by the NRAO at Green Bank in the USA and by the CSIRO in Australia. Thus in 1968, H_2O and NH_3 were discovered at wavelengths of 1.35 cm and 1.26 cm respectively as predicted by Charles Towns in 1955.

The sixties and the seventies saw molecular astronomy come into its own, with the realization that there are giant clouds with molecules filling the interstellar space. A typical molecular cloud is around a light year across, whereas, there may be hundreds of such regions in a giant molecular cloud extending to 100 light years.The process of star formation takes place in the relatively denser molecular clouds.

But what has been impressive is the wealth of molecules found, organic as well as inorganic. The latter are naturally larger. For example, HC_9N (cyano-octa-tetrayn), is an example of a molecule with 11 atoms. Other more familiar molecules include, methanol, acetaldehyde, dimethyl ether, etc. The origin of these molecules and their interaction in space form topics for the newly emerging branch of 'astrochemistry'.

The presence of organic molecules in space has also strengthened the speculation that extraterrestrial habitats for life may exist in the Galaxy.

IUCAA Telescope Update

Since October last year, there has been good progress on several fronts. The primary mirror has been received by Telescope Technologies Ltd., Liverpool; the telescope is being fabricated by this company through an arrangement with the Particle Physics and Astronomy Research Council of UK, who have the responsibility to supply the telescope. The fabrication of primary mirror supports is partly complete and several other mechanical parts are under fabrication. The mechanical construction of the faint object imager spectrograph has been completed at the Copenhagen University Observatory, and the full instrument is expected to be assembled in early part of the next year.

Work on developing the Observatory Control System, through which an observer would give commands to the telescope and the focal plane instruments for obtaining desired exposures and recording the data, has been started in our instrumentation laboratory. The land for the site has been acquired from the forest department, and construction of the road would be starting soon.

Seminars

5.5.99 George Efstathiou *on* The heating of IGM and Ly α forest; 6.5.99 George Efstathiou *on* Formation of disk galaxies; 14.5.99 Mahendra K. Verma *on* Energy spectra and cascades in MHD turbulence; 27.5.99 Sujan K. Sengupta *on* General relativisitc effects *on* the magnetic field and thermal evolution of neutron stars; 11.6.99 A. Gopakumar *on* Constructing search templates for LIGO/ VIRGO gravitational wave detectors

Artificial Neural Networks - An Application to Stellar Spectroscopy

Artificial Neural Networks (ANNs)

An ANN is an information processing system that has certain performance characteristics in common with biological neural networks. ANNs have been developed as generalizations of mathematical models of human cognition or neural biolog based on the following assumptions :

1. Information processing occurs at many simple elements called *neurons or nodes*.

2. Signals are passed between nodes over connection links.

3. Each connection link has an associated weight, which, in a typical neural net multiplies the signal transmitted.

4. Each node applies an *activation function* to its net input (sum of weighted input signals) to determine its output signal. Each node has an internal state, called its *activation* or *activity level*, which is a function of the inputs it has received. Typically, a node sends its activation to several other nodes.

NOTE : a node can send only one signal at a time, although that signal is broadcast to several other nodes.

A neural network is characterized by (1) its pattern of connections between the nodes (called its *architecture*), (2) its method of determining the weights on the connection (called its *training* or learning or algorithm) and, (3) its *activation function*.

ANNs employing various architectures and learning algorithms are finding uses in both academic research and industrial applications. Research in this area has been active since 1940's but underwent a decline in late 1960's since the network designs available at that time were unable to solve relatively trivial problems, partly due to the limitations imposed by the computational power of the computers at that time. However, recently the ANNs have received a fresh impetus after Rumelhart et. al. (1986) introduced the *Multi Layered Back Propagation* (MBPN) algorithm. The field continues to attract newer applications (Widrow and Lehr, 1990) and basics are described in some introductory text books like Wasserman (1989) or Beale and Jackson (1990). A recent review on astronomical applications appears in Miller (1993).

ANNs can be divided into two main classes viz. *supervised* and *unsupervised* learning. Hybrid systems using both classes have also been developed (Hecht-Nielson, 1987). For a network to be trained using a *supervised* learning system, a *training* data set of example inputs and their corresponding desired outputs are required. In the *supervised back propagation* algorithm, the input example is presented to the network and the *activation* function (mostly a sigmoid function) performs a complex non-linear mapping between the input and the output layers using the set of existing network *weights* (or connectivities) which are initially set to random values. An error term, based on the differences between the calculated and the desired output is then propagated back through the network to calculate the changes of the interconnection *weights* between each layer. After several such iterations, the error term reduces and the network is considered to be trained to give the desired output for a given class of inputs. A plot of the error term versus the number of iterations is called a *learning curve* which ideally should converge to zero for increasing number of iterations.

The *unsupervised* ANN as employed by Kohonen (1990) does not require the set of desired outputs and the network learns by associating different input pattern types with different clusters of hidden nodes. This type of ANN is becoming more popular now and is believed to have better classification accuracy (for more details, see Lahav and Storrie-Lombardi (1994)).

Astronomical Applications

Since the introduction of the MBPN scheme by Rumelhart et. al. (1986), ANNs have been very widely used in astronomical applications such as classification of stellar spectra (which is the topic of this summary);

morphological classification of galaxies (Storrie-Lombardi et. al. 1992); star-galaxy separation (Odewahn et. al. 1991); faint object classification (Serra-Ricart et. al., 1993); classification of young stellar objects in the IRAS point source catalog (Adorf & Meurs, 1988); scheduling of telescope observing time (Johnston & Adorf, 1992); adaptive optics (Angel et. al. 1990) and many more.

Classification of Stellar Spectra

The classification of stellar spectra has historically been an exceedingly useful exercise since it provides the statistical information about astrophysical parameters such as the effective temperature of stars, their luminosity, mass, radius, etc., besides resulting in the demarcation of stars into meaningful and self-consistent groups. (For a general introduction to the classification of stars, see Jaschek & Jaschek (1990)). The distribution of stars in various groups can be later used for studies of stellar populations in stellar systems; such studies are based on the observational determination of the physical properties of individual stars. Clearly, it follows that any method of classification used *must* be efficient (due to the vast amounts of data available on individual objects), objective and repeatable. Spectral classification was originally carried out by (human) experts via a visual inspection of the spectra of individual objects. This approach led to the development of many non-unique databases, since the classification schemes used were not universal and frequently reflected the inherent biases of the classifiers. Further, the above method is highly unsuitable for the analysis of voluminous quantities of data, since the analysis of each individual spectrum consumes a sizable amount of time. Thus, human classification clearly fails to meet the criteria of efficiency, objectivity and repeatability, which are essential for any good classification scheme. The recent availability of large archives of spectral data, coupled with the rapid advances in the efficiency achieved with modern instrumentation, have been a prime motivation for a large number of groups to investigate the possibility of the usage of automated techniques for the purpose of the above classification. Although these methods are presently still in an exploratory phase, their aims are clear: to devise an objective, repeatable and robust classification scheme and, crucially, one which provides a good estimation of the systematic and random errors which arise as a result of the above procedure.

Two approaches are commonly used in automated classification schemes : these are the methods of criteria evaluation and pattern recognition. In the first case, a set of specified criteria, such as the width or the strength of specified spectral lines, are automatically measured and then calibrated in terms of the desired quantities. On the other hand, in pattern recognition, an observed spectrum is compared with a library of reference spectra, with the usage of statistical methods for the analysis. Most of these techniques are, however, based on linear operations, whereas, the complicated inter-relation between the parameters affecting stellar spectra are usually strongly non-linear; one, hence, requires a technique which is capable of handling such non-linear relationships. Artificial Neural Networks (ANN) schemes are non-linear extensions of statistical methods; such techniques have been found to be highly efficient for the job of classifying stellar spectra and are, hence, widely used for this purpose.

Some of the advantages of ANN technique over the others are speed of classification, robustness, unbiased and most importantly attaches a probability factor to each classified output.

MBPN Algorithm and Application to Stellar Spectra

In general, each spectral class is characterized by absorption features at a few selected wavelengths which are *diagnostics* of spectral classes. These features change in strength, position, and width with change in spectral class. Therefore, certain characteristic fluxes at selected wavelengths that distinguished a certain class were selected as input parameters per spectrum. Thus, for each database, the input parameters vary according to the spectra and the number of input nodes and hidden layers have to be decided according to the database.

The MBPN algorithm consists of two stages of operation, namely: the training session and the testing session. The weights w_{ji} over the inter-layer connections are generated randomly at the start of the training session. Input x_j, to each node j, is computed by the weighted sum of the output from all nodes from the previous layer while the output y_j, of the node j, is computed using a sigmoid transfer function of the form :

$$y_j = (1) / (1 + e^{-x_j}) \quad (1)$$

The output y_j at the output layer is compared with the desired output d_j using an error function of the form :

$$\delta_j = y_j (1 - y_j)(d_j - y_j). \quad (2)$$

The error is then propagated backward from output to input layer to update the weight of each connection as follows :

$$w_{ji}^{n+1} = w_{ji}^{n} + \eta \delta_j y_j + \alpha (w_{ji}^{n} - w_{ji}^{n-1}), \quad (3)$$

where w_{ji} is the weight at iteration n, η and α are the gain and momentum factors respectively which control the rate of convergence. The process is repeated for each input pattern from all the classes till the error in the network output is reduced to a preassigned threshold value. The final frozen weights are used during the testing session to classify the large database.

Automatic classification of the optical stellar spectral library, available from the database Silva and Cornell (1992) and Jacoby et. al. (1984), was done by the group at IUCAA (see Gulati et. al. 1994a). This work essentially involved classifying automatically the stars ranging from O to M spectral types of the Jacoby et. al. (1984) spectral library into the corresponding trained spectral types of the Silva and Cornell (1992) spectral library. The results showed that the classification accuracy achieved by ANN technique was comparable to the 2-sub-spectral type accuracy of earlier techniques, i.e., human classification or χ^2 minimization techniques but incorporated the major advantages of ANN. Further, the classification was 2-dimensional, i.e., spectral type and luminosity class. Similar application was also made to automatically classify spectra from high dispersion objective prism plates by Hippel et. al. (1994), but with 1-dimensional classification, i.e., only spectral type.

The use of ANNs for classifying spectra in the near IR region has been reported by Weaver and Torres-Dodgen (1995). However, in the UV region, the IUCAA group was the first to apply this new technique (Gulati et. al. 1994b) for classifying the stars ranging from O to F spectral types from the IUE low-resolution atlas of Heck et. al. (1984). The classification accuracies now achieved were of the order of 1-sub-spectral type which was an improvement over the previous 2 sub-spectral type accuracy in the optical domain, primarily due to an improved network architecture (Gulati et. al., 1996; Mukherjee et. al. 1996).

Other related applications in stellar spectroscopy

More recently, the use of ANNs has been extended to newer areas of stellar spectroscopy:

1. Determination of fundamental stellar atmospheric parameters on the basis of comparison between the model generated synthetic spectra and the observed stellar spectra (Gulati et. al. 1997a).

2. Determination of a third dimension of classification viz. the color excess E(B-V) from the O and B stars in the IUE-UV data base (Gulati et. al. 1997b).

3. A refinement of the first optical region ANN classification by introducing a Principal Component Analysis (PCA) module as a pre-processor prior to applying ANN to the optical spectra and thereby considerably reducing the computational dimension of the data base (Singh et. al. 1998).

This resource summary is not exhaustive and is intended to give the reader ample material for pursuing further research in this area, which is fast becoming a possibility due to the upcoming large spectral libraries.

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IUCAA Preprints

Listed below are the IUCAA preprints released during April - June 1999. These can be obtained from the Librarian, IUCAA (library@iucaa.ernet.in)

B.F. Roukema and J.P. Luminet, *Constraining curvature parameters via topology,* IUCAA-15/99; **Sukanta Bose and Thant Zin Naing** *Quasilocal energy for rotating charged black hole solutions in general relativity and string theory,* IUCAA-16/99; **Sukanta Bose and Naresh Dadhich,** *On the electrogravity-dual solution to stringy charged black holes, IUCAA-17/99*; **Somnath Bharadwaj, Varun Sahni, B.S. Sathyaprakash, Sergei F. Shandarin and Capp Yess,** *Evidence for filamentarity in the Las Campanas Redshift Survey,* IUCAA-18/99; **D.B.Vaidya and Ranjan Gupta,** *Interstellar extinction by porous grains,* IUCAA-19/99; **Avijit K Ganguly, Sushan Konar, Palash B. Pal,** *Faraday effect: a field theoretical point of view,* IUCAA-20/99; **Padmakar and S.K. Pandey,** *New BVR photometry of six prominent RS CVn binaries,* IUCAA-21/99; **Niranjan Sambhus and S. Sridhar,** *Stellar orbits in triaxial clusters around black holes in galactic nuclei,* IUCAA-22/99; A. Mangalam, *Formation of a proto-quasar from magnetized accretion flows,* IUCAA-23/99; **Ali Nayeri, Sunu Engineer, J.V. Narlikar and F. Hoyle,** *Structure formation in the quasi-seady sate cosmology: A toy model,* IUCAA-24/99; **Sukanta Bose, Sanjeev V. Dhurandhar and Archana Pai,** *Detection of gravitational waves using a network of detectors,* IUCAA-25/99; **Yogesh Wadadekar and Ajit Kembhavi,** *A study of quasar radio emission from the VLA FIRST survey,* IUCAA-26/99; **Anirudh Pradhan and Anil Kumar Vishwakarma**, *A new class of LRS Bianchi type-I cosmological models in Lyra geometry,* IUCAA-27/99 and **J.D. Anand, N. Chandrika Devi, V.K. Gupta and S. Singh,** *Bulk viscosity of strange quark matter in density dependent quark mass model,* IUCAA-28/99

Total Solar Eclipse

This millennium's last total solar eclipse will take place on August 11, 1999 and will be seen in parts of India. There will be fair amount of publicity in the media before the event takes place. One particular aspect, we should be concerned about is the negative publicity of dangers of looking at the eclipses. We request you to join hands with us in fighting this fear by helping students and the people on the street in watching this event safely.

One must remember that the total solar eclipse is one of nature's most beautiful spectacles, leaving a lasting impact on the minds of those who are fortunate enough to witness it. Many have travelled long distances to see the only total solar eclipse that has occurred in their lives. It is hard to erase from the mind what one sees during such an event.

We bring you some excerpts on watching the eclipse safely, from the booklet "A Night Too Soon", which is jointly published by IUCAA and Jyotirvidya Parisanstha (an association of amateur astronomers in Pune).

Normally, we cannot look at the Sun for more than a couple of seconds at a time. At the time of the eclipse, however, there is a strong urge to do so as the Sun does appear to be "cut off ". One should know that there is every possibility of the retina being damaged when one looks at the Sun directly - eclipse or no eclipse. This is due to the fact that the solar radiation is too strong for the retina of the human eye to tolerate when it is directly looked at.

Normally, when a part of our body is exposed to excessive heat or radiation we feel the sensation of burning (conveyed to our brain by pain receptors) and the natural reaction is to immediately withdraw from such exposure. In the case of the human eye, there are no pain receptors in the retina. The person whose retina is burnt does not feel the pain immediately. He or she comes to know of the burn only at a later stage when the situation leads to partial or full blindness. It is, therefore, prudent to play it safe and avoid the light from being incident directly on the retina.

There are three basic methods for observing the progress of the eclipse safely: by applying the principle of pin hole imaging, by projecting the image of the Sun using an optical instrument, or by looking directly at the Sun through a safe filter. Let us examine these methods.

Pin hole imaging : A small hole in the roof acts like a pinhole camera and gives a reasonably sharp image of the Sun on the floor or a wall. You only have to look for such a place in your house. You can also make such a projection set up by taking a cardboard or plastic tube of approximately 5 cm.in diameter and 1 to 1.5 metres long to make a pinhole camera. Close one end of the tube with a thick sheet of paper/card and pierce a 3 mm hole in the centre. On the other end put a sheet of tracing paper or oiled paper. Point the end with the pinhole towards the Sun. Shade the tube from the Sun on all the sides. A clear and safe image is formed in this way.

Imaging with mirrors : A small pocket-sized mirror or table mirror (*Plane mirror*) can be used to project an image of the sun by reflection, on a plain wall 10 to 30 metres away. A large image of the sun is formed. The farther the wall, the sharper will be the image. This is a convenient method for showing the eclipse to a large group of people.

Alternatively, a screen can be mounted on a telescope / binocular about half a metre away from the eyepiece. A sharp and large image formed which may be viewed by many people at the same time. While doing this, make sure that nobody looks through the binocular / telescope towards the Sun. This is even more dangerous than looking at the Sun with the naked eye.

Looking directly : The simplest way of observing the eclipse is to use specially prepared and certified solar eclipse goggles. You are advised not to observe the eclipse even through the normal sunglasses.

There are solar filters specially designed to protect the eyes. Most of them have a thin layer of chromium alloy or aluminium deposited on their surface so as to reduce the radiation passing through. A safe solar filter transmits less than 0.003% of visible light and less than 0.5% of near-infrared radiation.

One can also use a welding glass (of shade no. 14) to observe the Sun without the help of any instrument. Glasses of lighter tint or shade may not be completely safe.

Sometimes exposed films are used as filters, but they are safe only if they are fully exposed to light and developed to maximum density. It is the metallic silver on the film which is the protective layer. Some of the new films have dyes instead of silver and are unsafe. So, as a general rule, exposed photo-films are unsafe. Colour films, black & white films without silver, photographic or X ray images, smoked glass, sunglasses, both single and multiple, neutral density filters used in photography, polarising filters, floppy disks, CDs and CD-ROMs are also unsafe. Many of these are transparent to infrared radiation, which can cause retinal burn.

While observing through a telescope, it is better to use filters that cut the light before it enters the objective rather than having filters on the eyepiece. This is because, the filter before the objective allows only a limited amount of light to enter the telescope.

If the sunlight is allowed to enter the objective without being cut down, all the light that enters the telescope gets concentrated at the focus and can damage the eyepiece and/or filter. This is very dangerous. Damage will most certainly be caused to the eye or any instrument that is kept behind and there is no corrective measure then. Therefore, if you are not experienced in using this kind of setup then you should completely avoid this method.

It is unsafe to see a partial or annular eclipse with naked eyes even if 99% of the surface of the Sun is covered by the moon.

While looking directly at the Sun, it is a must that one should take the necessary precautions. There are other phenomena related to eclipse which do not require one to wear these protecting glasses.

Let us see what these are : When we are under a tree we see the images of the sun on the ground. These images are due to the fact that the gaps between the leaves act like pinholes and a number of images of the Sun are formed on the ground. While the eclipse is in the partial phase, these images are in the form of crescents and gives a very interesting effect. This effect is seen best under trees having large leaves.

Selecting the placc from where you observe the eclipse is important for observing the approaching shadow. Select a high place, like a hillock, etc. with a clear view in the north-east direction, preferably till the horizon. Just before the totality, the giant shadow of the moon is seen rushing towards us from this direction. This is an overwhelming experience.

Spread out a large white sheet of cloth on the open ground and just before the shadow of the moon reaches you, shadow bands can be seen on the sheet. These are alternate bands of light and shade, with a shimmering dynamism about them, like thousands of snakes slithering on the ground. This phenomenon is due to refraction in the atmosphere.

Myths and Facts

Myth No. 1: There are dangerous types of radiation (like cosmic rays, etc.) associated with a solar eclipse and so it is better to avoid viewing the eclipse and stay indoors.

Fact : The radiation that is present during the eclipse of the Sun is the normal light in which we move around every day, i.e., the sunlight. There is no such thing as a special eclipse radiation and there are no special germs, bacteria, viruses or pathogens that affect us only at the time of the eclipse.

Myth No. 2 : If you have to see the eclipse with the naked eye, it is better to observe it reflected in water that is kept in a shallow basin. The justification is that the image is sufficiently cooled in the water so that it does not harm the eye.

Fact : This is not safe. The image of the sun is reflected from the upper surface of the water, which has quite a high reflectivity. The amount of absorption of the radiation is not sufficient to make it safe for observation without a proper filter.

Myth No. 3 : The radiation of the eclipse is especially harmful to pregnant women and they should avoid the use of any equipments or appliance; otherwise the foetus may be deformed at birth.

Fact: There is no harm whatsoever to a pregnant woman or to the foetus, due to the eclipse. There are many examples of pregnant women who have enjoyed the sight of the eclipse or used various equipment to view it without any harm being caused to them or their foetuses.

Myth No. 4: You can use a lamp blackened glass plate, to observe the partial phase.

Fact : Please do not do that The human eye is not sensitive to the infrared radiation which penetrates through the lamp black. Therefore, the normal precaution that the eye takes of reducing the iris does not work and you let more IR radiation fall on the retina.

Refresher Course in Astronomy and Astrophysics for College/University Teachers

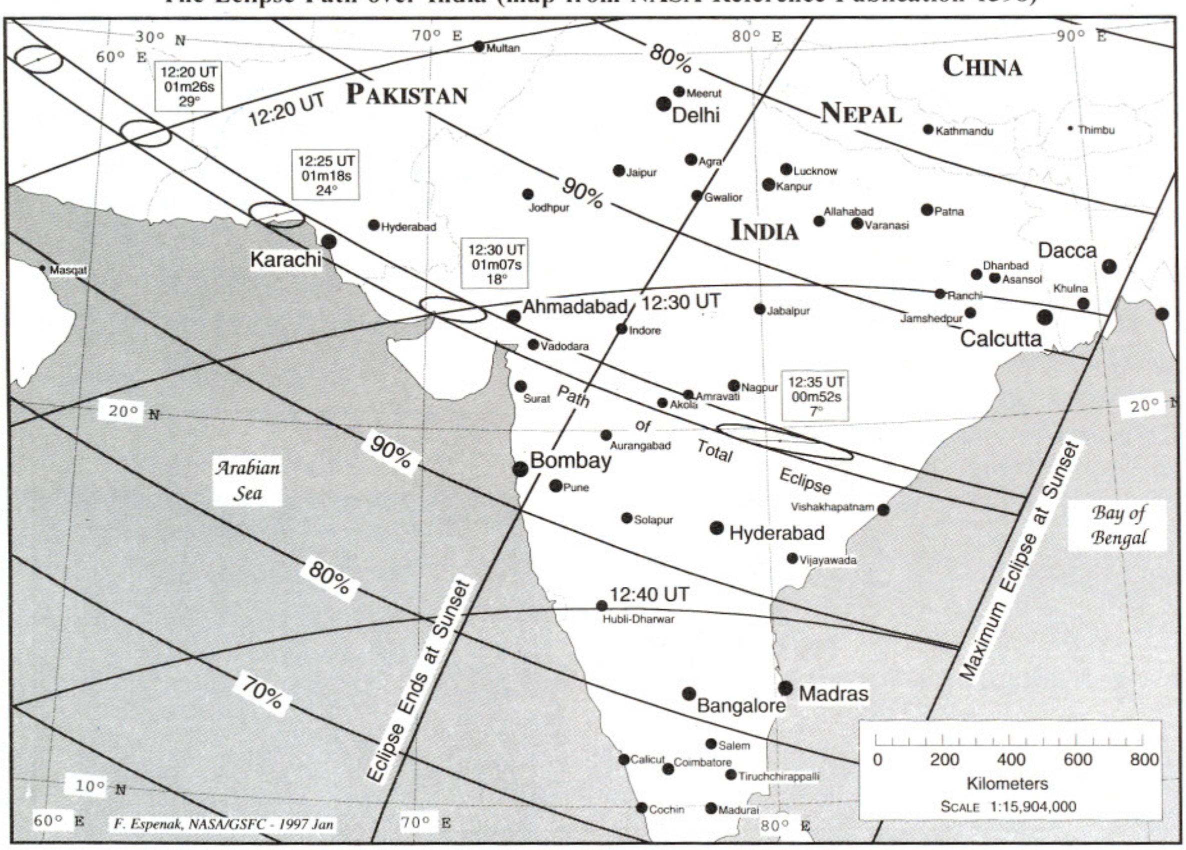
The Refresher Course in Astronomy and Astrophysics for College/University Teachers was held during May 17 - June 18, 1999. Fourteen teachers from colleges and universities from different parts of the country paricipated in the course.

The course consisted of two series of lectures on basic Astronomy and Astrophysics, Observational Techniques, and on various topics of Galactic and Extragalactic astronomy. An important feature of the course was that assignments and problem solving sessions made up a substantial part of the course. A brief introduction to acessing data on the Internet was provided.

Lectures were given by the faculty members of IUCAA as well as NCRA. S. Sridhar was the faculty coordinator

Total Solar Eclipse of 1999 August 11

The Eclipse Path over India (map from NASA Reference Publication 1398)



Eclipse map; courtesy , Fred Espenak, NASA / Goddard Space Flight Center. For more information on solar and lunar eclipses, see Fred Espenak's Eclipse Home page: Sunearth.gsfc.nasa.gov/eclipse/eclipse.html

Visitors
during April - June 1999

D. Thatte, Vinod Krishan, S.M. Chitre, A. Mahabal, D.B. Vaidya, Surendra Pal, I.K. Mukherjee, G.S. Rautels, M. Parvathinathan, S.K.Ray, Ram Sarma, I. Sanyal, K. Madan Gopal, S. Das, P. Roy, S.N. Karbelkar, K. Desikan, A.N. Ramaprakash, J.C. Bhattacharyya, R. Tikekar, K. Jotania, A.S. Reddy, L.P. Singh, D. Bhattacharya, Ram Sagar, G. Efstathiou, G.C. Kilambi, S.P. Bhatnagar, N.K. Jadeja, N.H. Patel, M.K. Patil, P. Mahajani, L. Resmi, M. Joy, V. Varghese, T. Subba Rao, Shwetabh Singh, S. Vasudevan, P. Bhagwat, L.K. Patel, M.K. Verma, S.V. Vaishampayan, S.S. Naik, S.N. Paul, S. Chaudhuri, D. Parasher, R.S. Kaushal, K.N. Joshipura, G.P. Singh, Suchita Ghosh, P.C. Vinodkumar, Sujan Sengupta, Jagdish Singh, S.B. Roy, Chandan Ghosh, S. Banerji, B. Ishwar, R.N. Ghosh, P. Khare, A. Pradhan, V.H. Kulkarni, S. Singh, M. Kumar, M. Sami, Sushil Kumar, V.K. Gupta, R. Datta, A. Mukherjee, R. Bali, A. Gopakumar, S. Rastogi, J.D. Anand, P. Dasgupta, A. Thampan, A.K. Sen, S..P. Khare, S.K. Sahoo, K.Y. Singh, U.V. Dodia, A. Sagar, M. Bora, B.B. Walwadkar, P.K. Srivastava, S. Mandal, S. Tomar, N. Bhattacharya, G. Ahmed and B.P. Sarma

Apart from this, about 13 persons attended the Refresher Course for College / University Teachers and about 17 students attended the Vacation Students Programme (VSP) and the Vacation Programme for University Students (VPUS).

Visitors Expected

July: K.P. Madhusoodan Nair, N.S.S. College, Chertalla; B. Basu, Calcutta University; Sayan Kar, IIT, Kharagpur, Somnath Bharadwj, IIT, Kharagpur; N. Banerjee, Jadavpur University; Moncy John, St. Thomas College; N.C. Wickramasinghe, University of Wales, Cardiff, P.M. Bhargava, Anveshna Consultancy Services, Hyderabad; Shyam Lal, Physical Research Laboratory, Ahmedabad; S. Ramadurai, Tata Institute of Fundamental Research, Mumbai; S. Shivaji, Centre for Cellular & Molecular Biology, Hyderabad; K. Kasturirangan, ISRO, Bangalore, Suman Datta, Indian Statistical Institute, Calcutta; P.N. Pandita, NEHU; S.R. Valluri, University of Western Ontario; Suketu Bhavsar, University of Kentucky; A. Zdziarski, N. Copernicus Astronomical Centre, Warsaw, et. al.

August: S.P. Khare, Ch.Charan Singh University, Meerut; I. Bardoloi, Handique Girls' College, Guwahati; S.R. Kulkarni, Caltech; Reem Sari, Caltech; Fiona Harrison, Caltech; Dipankar Bhattacharya, RRI; Ram Sagar, UPSO; U.C. Joshi, PRL; Andy Newsam; Vladimir Sokolov; et. al.

Einstein's Blunder

No, this is not about the much publicised 'blunder' by Einstein, viz the addition of a cosmological term to his famous equations of relativity. This concerns his technical invention relating to such a down-to-Earth item as a household refrigerator.

In 1926 Einstein put all his genius behind reinventing the refrigerator. He felt that having moving parts in a machine requires lubrication and other maintenance, and so he wanted to build a fridge without such parts. He worked out a system on which he took out some 45 patents in six countries, with his associate the atomic physicist Leo Szilard. He hoped to sell millions of these fridges, and Mrs Einstein confided to a friend, (the aerodynamics expert Theodor van Karman), that at last her husband had done something that would fetch money.

Unfortunately, Einstein's invention turned out to be a 'technoturkey', that is, a tchnological idea that did not become a market success. Perhaps, because the Einstein model (of the refirgerator, not of the universe) was considered too complicated to translate to a practical form. In fact, von Karman later wrote that refrigerators with moving parts have worked for years without lubrication: so why reinvent them?

Which is why, like the static universe, Einstein's static refrigerator also did not catch on.

[Based on the article *Bold and Costly Blunders* by Lee Edison, from *Across the Board* reprinted in *Span*, Jan-Feb 1999]

Khagol (the Celestial Sphere) is the quarterly bulletin of IUCAA. We welcome your responses at the following address:

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