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A Bulletin of the
Inter-University Centre for Astronomy and Astrophysics
(An Autonomous Institution of the University Grants Commission)

No. 18 **April 1994**

FRED HOYLE AT IUCAA

It was a pleasure to welcome Fred Hoyle, one of our Honorary Fellows, to IUCAA for a two week visit. He had last visited this location in January 1988 when IUCAA was a nebulous concept. On that occasion he had advised us : Keep as many of these big trees intact as you can while you build. He was happy to see the advice being followed, including transplantation of trees which would have come in the way of civil construction.

Hoyle delivered a public lecture,"On the origins of cultures and civilizations", at the Tilak Smarak Mandir in the town on February 8, 1994, in which he examined the hypothesis that the human societies went through phase transitions as a result of periodic visits of a comet whose debris might have hit the Earth to produce catastrophic effects. He estimated the period at around 1600 years.

The following Saturday (February 12) being the second Saturday, the school students coming to IUCAA for the monthly lecture-demonstration were in for a treat when they had Hoyle talking to them on how natural biological processes following a mathematical sequence can produce the various shapes of leaves and other living systems. Aptly billed, "An unusual scientific adventure", the lecture was a personalized account of how the speaker was led to the idea through correspondence with a person whom at first he was inclined to dismiss as a crank.

By a happy coincidence, Hoyle was participating in the Silver Jubilee Meeting of the Indian Association for General Relativity and Gravitation being held at IUCAA; he had been present when the association was initiated at Ahmedabad in February 1969 and had held its first meeting at the Physical Research Laboratory. He gave the opening address on his recent work on the quasi- steady state cosmology at the IAGRG meeting.

IUCAA Director with his Guru, Fred Hoyle

National Science Day

As in previous years, IUCAA celebrated the National Science Day on February 28, 1994, giving special emphasis to programmes involving school students. In the morning, a science test was held to select teams for the quiz contest. The first prize, the rolling trophy for the quiz contest, was won by Kendriya Vidyalaya, Range Hills Estate; the second prize, the rolling cup, by the Muktangan English School and the third prize by St. Vincents' School. Since the year 1994 marks the Silver Jubilee of Man's landing on the Moon, a competition for making models and drawings of Apollo Rocket, Command Module, Lunar Module and Man Walking on the Moon was organized for school students. The best three entries were given prizes donated by the Rotary Club of Pune, Hillside. The Jnana Prabodhini School, Modern High School and Muktangan English School won the first, second and third prizes respectively. The Sanjeewan Vidyalaya, Panchgani, presented an Astroballet on the origin of the universe which was very much appreciated by the audience. In the afternoon, IUCAA facilities were kept open for visitors from the public.

First prize winners of the quiz contest with the Director

Parsecstones in Astronomy - 6

J. V. Narlikar

The Universality of the Law of Gravitation

Folklore has it that the fall of an apple in his orchard at his residence, the Woolsthorpe Manor, inspired Isaac Newton to think of the law of gravitation. However, the real quantitative evidence for the inverse square law came from the data on the motions of the Moon and the planets [see Parsecstones in Astronomy- 5]. But the question still remained as to how wide in its ap plicability is the law of gravitation. Here too astronomy, rather than terrestrial laboratory experiments, provided further inputs.

Even during Newton's lifetime, his friend and scientific colleague Edmund Halley made the important prediction that the comets that had previously visited the Earth's neighbourhood in the years 1456,1531,1607 and 1682 were one and the same comet that was following a highly eccentric orbit under the Sun's gravitational field and that it would next visit in the year 1758. Halley calculated the comet's orbit using Newton's laws of motion and gravitation. The comet did visit exactly as predicted, although, Halley was not alive to witness this triumph. The comet itself has since been named after Halley.

There were other post-Newtonian triumphs of the law of gravitation. The discovery in 1845, of planet Neptune came out of the application of the law of gravitation to understand the small but unmistakable discrepancy in the orbit of planet Uranus: Uranus was not moving exactly along its Keplerian orbit. Adams in England and Le Verrier in France independently deduced the existence of a new planet from its possible effect on the orbit of Uranus. Galle of the Berlin Observatory was able to confirm the location of the planet as predicted.

However, the validity of the law of gravitation beyond the narrow confines of our solar system began to be evident in the 19th century with the observations of binary stars. In 1803, Sir William Herschel first recognized visual binaries and their orbital motions which appeared to follow Keplerian laws. Unlike the rather unequal combination of a massive Sun and a very low mass planet, the binary stars were of comparable masses but one could still study them as examples of Newtonian two-body gravitating systems.

Today the astronomer applies the phenomenon of gravitation to even larger systems like galaxies, quasars, clusters and superclusters of galaxies and even to the entire universe... but we will come to those applications in later parsecstones.

XVII Meeting of the IAGRG - Silver Jubilee Conference

The Indian Association for General Relativity and Gravitation celebrated its Silver Jubilee by holding its XVII meeting during February 14 - 18, 1994 at IUCAA, Pune. The meeting was funded by UGC and DST. Several eminent scientists around the world participated in the meeting and delivered plenary talks on cosmology, gravitational waves, classical general relativity and quantum cosmology. There were workshops on classical general relativity and gravitational wave detection and a symposium was held on 'Fifty years of the Vaidya metric'. The Vaidya-Raychaudhuri endowment lecture was delivered by N. Panchapakesan on February 18, 1994.

About 100 members attended the meeting from various institutions, universities and colleges in the country. Some of the participants presented their work during the course of the meeting.

An essay competition had been conducted by the IAGRG and the prize winners of the essay competition presented their essays in brief. C.S. Unnikrishnan, TIFR, Bombay, won the first prize, Anuradha Das Purkayastha, Cotton College, Guwahati, the second prize and Masafumi Seriu, IUCAA, the third prize.

A sight-seeing trip of Pune and a banquet followed by an 'After Dinner Talk' by C. V. Vishveshwara, were some of the additional activities arranged during the meeting.

Participants of the IAGRG meeting

Seminars held during January - March, 1994.

12.1.94 J.P. Ostriker on *Gravitational Lensing: The Clue to Understanding Large Scale Cosmic Structures*, 13.1.94 S. Koshti on *Classical and Quantum Dynamics of the Faraday Lines of Force*, 21.1.94 J. Balakrishnan on *Effective Action for Quantum Fields*, 27.1.94 D. Sugimoto on *Terraflops Project Dedicated to the Many Body Problems*, 4.2.94 P. Coles on *The Case for an Open Universe*, 10.2.94 S.V. Chervon on *Exact Solutions in Cosmological Inflation*, 1.3.94 N. Andersson on *Phase-Integral Approach to Quasi Normal Modes*, 3.3.94 B.C. Bhatt on *Studies in Galactic Star Clusters*, 4.3.94 S. Bhavsar on *Filaments, Sheets and Voids in the Universe - The Challenge and Quantifying Visual Structure*, 23.3.94 K. Rajendran on *Computer Simulation of Trajectory of a Charged Particle in Cusped Magnetic Fileds*, 24.3.94 V. Chickarmane on *Laser Interferometric Gravitational Wave Detector using Dual Recycling and Squeezed Light.*

Workshop on Astroparticle Physics

A workshop on Astroparticle Physics was organised at IUCAA, (*Co-sponsored by S.N. Bose Centre for Basic Sciences, Calcutta*), during February 21 - 26, 1994. The workshop consisted of series of invited review talks covering cosmology and particle physics, inflationary models, baryogenesis, detection of WIMPS in the laboratory, experiments on neutrino mass, supernovae, astroparticle physics, etc. In addition, there were a few seminars on selected topics related to the main theme.

Speakers included Pijush Bhattacharya, S.M. Chitre, Rohini Godbole, Kamales Kar, J.V. Narlikar, T. Padmanabhan, N. Panchapakesan, Varun Sahni and K. Subramanian. About 30 participants from various institutes and universities attended the workshop.

Welcome...

to Sukanya Sinha, who has joined as post-doctoral fellow.

OBSERVING POLARISATION OF MOON'S LIGHT

One of the basic properties of light is its polarisation, i.e., the directionality of the electric field with reference to the direction of propagation. Although most of the light emanating from stars and other luminous sources is not polarised, in very many situations the light reaching us has a significant amount of polarisation; one of the most common processes leading to polarized light is scattering by astronomical bodies. We know that the planets and the Moon scatter the solar light falling on them, and a study of the polarization of this light received by us can lead to a better understanding of the scattering on the surface of these bodies. In the following, we briefly discuss the relation between scattering and polarisation, and a simple method to observe polarisation of Moon's light.

The degree of polarisation can be defined operationally in terms of transmission through polaroids. The amount of plane polarisation is given by the equation:

$$P = \frac{I_m - I_t}{I_m + I_t},$$

where I_m is the maximum intensity observed through a polaroid (while the polaroid is rotated on

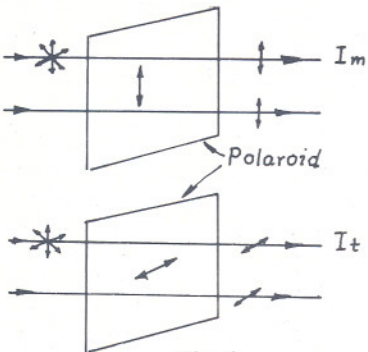


Fig. 1

an axis along the direction of the light beam) and I_t is the intensity observed when the polaroid is rotated by 90^0 with reference to the position for I_m (see Fig. 1).

Thus if $I_t = 0$, we get $P = 1$, i.e., the light is fully polarised, and if $I_m = I_t$ we get $P = 0$, i.e., the light is unpolarised. Most of the ordinary light is unpolarised; however, the solar light scattered from the atmosphere is highly polarised if seen in a direction about 90^0 away from the Sun's direction.

Before looking at the Moon, we can observe polarisation of solar light scattered from sand, dust, etc. For such observations, two polaroids which are orthogonal to each other should be placed side by side on a rotating mount (see the box in page 5). If you keep this Polaroid Mount about 20 cm away from your eye and rotate it slowly while looking at the scattered light from a surface, which is uniformly illuminated by solar light or light from a lamp, you would notice that the parts seen through the two polaroids do not always appear to be equally bright. In particular, if you look at a rough surface, e.g., a heap of sand or clay, then for a particular position of the Polaroid Mount, the two parts would look quite different when the scattered light is at an angle around 90^0 with respect to the incident light (see Fig. 2). This difference shows that the scattered light is polarised. By making observations under different conditions of illumination, you would also notice that the extent of polarisation

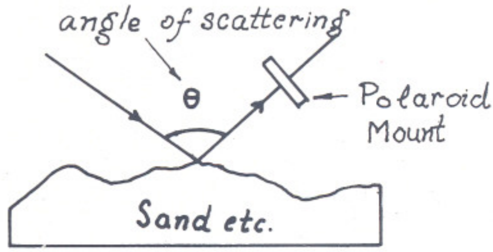


Fig 2.

does not depend much on the angle of the surface of the heap.

Moon's surface is made of sand like particles and the above observation is a good guide to the properties of moonlight. Thus, if you observe the Moon through the Polaroid Mount, the polarisation would be found to vary with the phase of the Moon; angle between the light incident on the Moon from the Sun and the light scattered to us, which is nearly equal to the angle between the directions of the Sun and the Moon as seen by us, changes with the phase causing a variation in the amount of polarisation. For the observation, Mount is aligned such that axis of one of the polaroids is parallel to the line which divides the Moon symmetrically into two halves (this line is normal to the straight edge of half-moon), and then the Mount is moved such that the Moon is seen alternately through each of the polaroids. The difference in the brightness of the Moon as seen through the two polaroids is a measure of the polarisation. Similar observations can be made on planets like Venus and Mars, but are much more difficult to carry out.

Making of the Polaroid Mount

We need to mount two sheets of polaroids side by side in such a way that their axes of polarisation are perpendicular to each other. To find the axis of polarisation, look at the reflection of a bulb through a sheet of polaroid at grazing incidence from a surface such as a table or paper etc., and rotate the polaroid. At the minimum intensity of the reflected light, axis of the polaroid will be normal to the reflecting surface.

Cut two square sheets of polaroid which are 25 mm x 25 mm. As shown in Fig.3, cut two square pieces of 65 mm x 65 mm from a thick cardboard (A) sheet. Also cut two strips from the same cardboard, of size 15 mm x 65 mm (B) and two more pieces of size 5 mm x 25 mm (C).

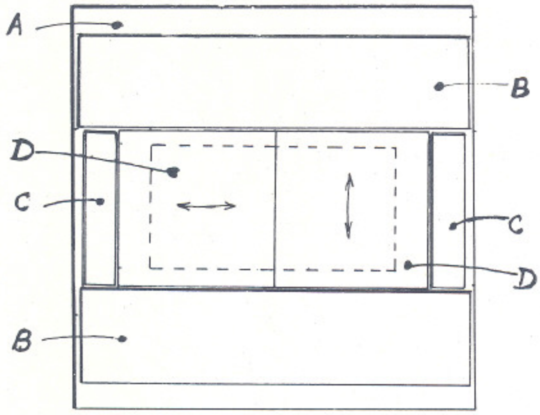
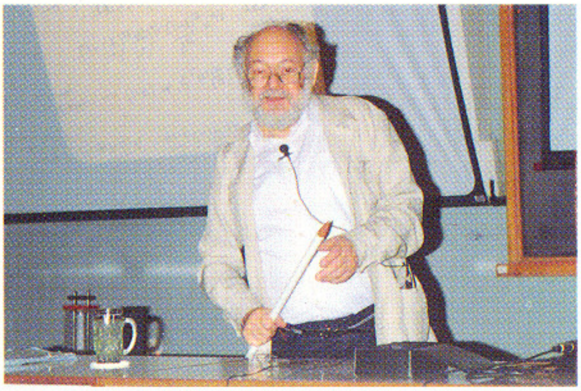


Fig. 3

In the centre of both the square cardboard sheets (A), cut a rectangular aperture of 20 mm x 40 mm (shown by dashed lines in the figure).

Now place the polaroids on apperture of one of the cardboards and stick the cardboard strips (B's & C's) around it, so that the polaroids are held tightly on the apperture. We are now ready to mount the polaroids.

Place the two squares of polaroids side by side on the cardboard so that their axes of polarisation are perpendicular to each other. Just to check that the axes of polarisation are indeed perpendicular to each other, slide one square over the other and look at some source of light. When axes are perpendicular to each other, the transmission through the pair will be the least, if not zero. Glue the other cardboard on the top of this.



Leon Mestel

Colloquium held during January - March, 1994

10.3.94 Leon Mestel on *Tom Cowling and the Early Days of Stellar Structure.*

Visits Abroad

Anita M. Kane visited the International Centre for Theoretical Physics, Trieste, during September 26 - October 23, 1994 as an instructor for the workshop on Telematics.

T. Sahay visited IOA, Cambridge and ICTP, Trieste, in January, 1994. His trip was mainly to get first hand experience of the working of these institutes since they are the role models on which IUCAA is set up. He also visited the Isaac Newton Institute of Mathematical Sciences.

T. Padmanabhan attended IAU Colloquium 148: Future Utilisation of Schmidt Telescopes, Bandung, Indonesia during March 7 - 11, 1994. He delivered an invited talk on "Observational Constraints on Cosmological Models".

Ashok K. Sen attended the International Symposium of Astronomical Telescope and Instrumentation for 21st Century and presented a paper on the 'Imaging Polarimeter' under construction at IUCAA. The symposium was organised by International Society for Optical Engineering (SPIE), at Kona, Hawaii, USA, during March 13-18, 1994. He also visited the National Astronomical Observatory, Tokyo, Nagoya University and Kobe University to discuss collaborative programmes with the astronomers working there.

XX-IAU International School for Young Astronomers (ISYA)

In January 1994, IUCAA hosted the XX International School for Young Astronomers of the IAU. 35 students from 12 countries including Russia, Iran, Vietnam, Turkey, South Korea, Bulgaria, Argentina, Ukraine, Ireland, Nepal and the USA attended. The teaching faculty included, apart from the ISYA Secretary, Donat Wentzel and the IAU representative M. Gerbaldi, S. Isobe from the National Astronomical Observatory, Japan, Peter Eggleton from the Institute of Astronomy, University of Cambridge and six Indian scientists. The school covered a wide ranging syllabus in astronomy and astrophysics and included observing with the IUCAA's 8 and 14 inch telescopes.

Workshop on Large-Scale Structure Beyond N-Body Simulations

(Dedicated to the memory of Ya. B. Zeldovich)

A workshop on 'Large-Scale Structure Beyond N-body Simulations' will be organised at IUCAA during July 18 -27, 1994. The workshop will be dedicated to the memory of Ya. B. Zeldovich, who during his lifetime, succeeded in providing a unique physical insight into the problem of structure formation in the Universe. In the same spirit, the aim of this workshop would be to highlight the underlying physics behind the phenomenon of non-linear gravitational clustering. The workshop will focus on recent developments in the area of non-linear gravitational instability, with particular emphasis on analytical and semi-analytical techniques for understanding structure formation in the Universe. A preliminary list of topics includes: Review of non-linear gravitational clustering; The Zeldovich approximation and its extensions; Comparison of non-linear approximation methods with N-body simulations; Statistical measures of large scale structure; Void evolution and void statistics. Participation is limited to about 25 persons. Limited funding for travel will be available and local hospitality will be provided to all selected participants. Those who are interested in attending the workshop should write to **the Coordinator, Core Programmes,** IUCAA, giving their bio-data and research interest. Applications should reach IUCAA **by May 10, 1994.**

IUCAA preprints

IUCAA preprints released during January to March, 1994 are listed below. These can be obtained from the Librarian, IUCAA.

Tikekar R., Patel L.K. and Dadhich N., *A Class of Cylindrically Symmetric Models in String Cosmology*, IUCAA-1/94; Blanchet L. and Sathyaprakash B.S., *Detecting the Tail Effect in Gravitational Wave Experiment*, IUCAA-2/94; Blanchet L. and Sathyaprakash B.S., *Signal Analysis of Gravitational Wave Tails*, IUCAA-3/94; Bhawal B. and Chickarmane V., *Squeezing and Recycling in Laser Interferometric Gravity Wave Detectors*, IUCAA-4/94; Subramanian K. and Padmanabhan T., *Constraints on the Models for Structure Formation from the Abundance of Damped Lyman Alpha Systems*, IUCAA-5/94; Munshi D., Sahni V. and Starobinsky A., *Non-linear Approximations to Gravitational Instability: A Comparison in the Quasi-linear Region*, IUCAA-6/94; Dhurandhar S.V. and Schutz B.F. , *Filtering Coalescing Binary Signals: Issues Concerning Narrow Banding, Thresholds and Optimal Sampling*, IUCAA-7/94; Hoyle F., Burbidge G. and Narlikar J.V., *Further Astrophysical Quantities Expected in a Quasi-Steady State Universe*, IUCAA-8/94 and Dadhich N. and Patel L.K. , *Inhomogeneity can Remove the Big Bang Singularity*, IUCAA-9/94.

Pep Talk By Locals....

21.1.94 Ramana Athreya (NCRA) on *Extragalactic Radio Sources*, S.D. Mohanty on *Supersymmetric Quantum Mechanics*

and by Visitors.....

12.2.94 G. Burbidge on *Quasar Redshifts : Some Idle Thoughts*, 13.2.94 P. Coles on *Probability in Cosmology*, 24.2.94 U. Yajnik on *Solitons in Physics*, 4.3.94 S. Bhavsar on *Surprising Uses of Statistics*.

Astroballet on the National Science Day

Arvind Paranjpye

GEMINI, THE TWINS

Gemini is one of the ancient zodiacal constellations. It is known as twins in different cultures, as two infants, twin brothers or a boy and a girl as Mithuna in India, etc. The ecliptic, the apparent path of the Sun on the celestial sphere, passes through this northern most zodiacal constellation. As the planets and the Moon do not travel very far from the ecliptic, these bodies are most favourably placed for observation from the northern latitudes when they are in this constellation. The Sun itself is in this constellation between the last week of June and last week of July.

Castor, or α Gem (Alpha Geminorum), is a pair of brilliant white stars. Visual magnitudes of the two stars are 1.9 and 2.9. This was the first pair to be recognized as true physical binary. The stars rotate around each other in about 400 years. Presently their separation is increasing. The pair has another companion, which is rather faint (9.1 mag.). In fact, Castor is a system of six stars, each of the three visible stars is a spectroscopic binary.

Pollux , or β Gem (Beta Geminorum), is brighter than Castor. It is possible that one of the stars has changed in luminosity. Pollux, which is about 4.5 degrees from Castor, makes a lovely pair with a contrast in colour. Pollux is yellowish and Castor is white in colour. Together they make 7th *Nakshatra* Punarvasu of our Indian system of Nakshatras.

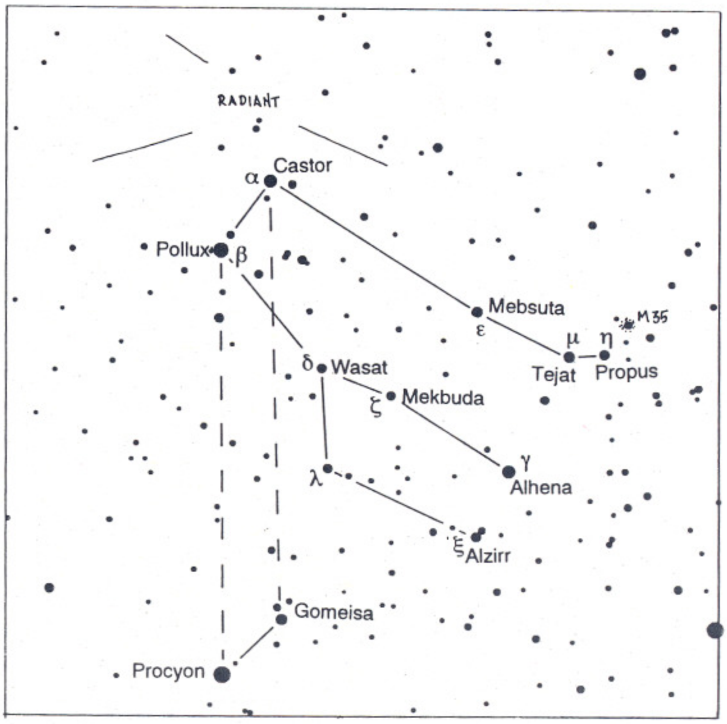
In some textbooks, Alhena, or γ Gem (Gamma Geminorum), is referred to as the 6th *Nakshatra* Ardra, the Wet One, whereas in the literatures, Betelgeuse in Orion is referred to Ardra. Around 600 AD, the Sun was rising with this star in the first week of June, the starting of monsoon in India, announcing the coming of the wet season. Betelgeuse is quite too far from ecliptic than Alhena. Its name in Sanskrit is Kakshi, which is "masculine gender" or "name (also title or epithet) of a man" seems more appropriate for Betelgeuse (it is also called Bahu, the Arm) in Orion, which is personified as "Prajapati" under the form of a Stag, Mruga.

Uranus and Pluto were discovered while they were in Gemini. William Herschel discovered Uranus, near η Gem, by chance, on March 13, 1781. Pluto was discovered, after a systematic search by Clyde W. Tombough, on February 18, 1930, near δ Gem. This discovery was announced on March 13, 1930, on the 149th anniversary of the discovery of Uranus.

M35 is a beautiful open cluster for binoculars. It can be seen by naked eyes as a fuzzy patch of light under dark clear sky. It is very close to the ecliptic. Planets and the Moon pass very close to it. Venus and Mercury will pass the cluster from the north, respectively on May 22 and 30 of this year.

This constellation has one of the major meteor showers, called Geminids. Geminids are at peak around December 13/14, every year. This is one of the finest meteor showers. At peak, as many as 90 meteors per hour can be seen coming from the direction as shown on the map below. This year, the peak activity is expected to take place around 16:30 IST on December 14 .

Castor and Pollux with Procyon and Gomeisa in Canis Minor make a parallelogram, which is called the Gateway of Heaven as all the planets, the Moon and the Sun pass through it. Watch for the Venus in this group in the first week of June this year. Crescent Moon appears beautiful while in the Gateway.



Funding Agencies

It is found that the Indian University researchers often do not know where to approach for research grants. The Department of Science and Technology, New Delhi, has brought out a booklet namely 'General Information on Research and Development Funding Schemes of Central Government Departments /Agencies', giving all the details of the various agencies, which give research grants. Interested researchers may write to the following address and get the booklet:

The Adviser,
National Science and Technology
Management Information System (NSTMIS),
Department of Science and Technology,
Technology Bhavan,
New Mehrauli Road,
New Delhi 110 016.

Further clarifications may be obtained from the **Coordinator, Core Programmes, IUCAA.**

Safe Science... Dull Science

Funding agencies opting for caution and conservatism may heed the dedication of the Journal Icarus written by Sir Arthur Eddington: which is printed in each issue:

In ancient days two aviators procured to themselves wings. Daedalus flew safely through the middle air and was duly honoured on his landing. Icarus soared upwards to the Sun till the wax melted which bound his wings and his flight ended in fiasco.... The classical authorities tell us, of course, that he was only "doing a stunt"; but I prefer to think of him as the man who brought to light a serious constructional defect in the flying-machines of his day.

So, too, in science, cautious Daedalus will apply his theories where he feels confident they will safely go; but by his excess of caution their hidden weaknesses remain undiscovered. Icarus will strain his theories to the breaking-point till the weak joints gape. For the mere adventure? Perhaps partly, that is human nature. But if he is destined not yet to reach the Sun and solve finally the riddle of its construction, we may at least hope to learn from his journey some hints to build a better machine.

Visitors during January - March 1994

January: F. Ahmad, P. Coles, P. Eggleton, M. Gerbaldi, S. Isobe, J.P. Ostriker, B.K. Pal, D. Sugimoto, R.S.Tikekar and D. Wentzel,

February: N. Andersson, S. Banerji, B.C. Bhatt, P. Bhattacharya, N. Bishop, D.G. Blair, L. Brink, E. Butler, F. Hoyle, K. Kar, G. Burbidge, S.M. Chitre, R. Cowsik, D.P. Datta, R. Godbole, P. Joshi, R.K. Kochar, S. Maharaj, T.K. Menon, S. Mukherjee, V.M. Nandakumaran, N. Panchapakesan, L.K. Patel, S. Ramani, A.K. Raychaudhuri, S.Ramakrishnan, L. Radhakrishna, S.K. Srivastava, C.S. Unnikrishnan, P.C. Vaidya, C.V. Vishveshwara, Ashoke Sen.

March: S.P. Bhatnagar, S. Bhavsar, G.K. Johri, T.K. Marar, L. Mestel, Soma Mukherjee, T.P. Prabhu, S. Selladurai, M.R. Srinivasan.

Visitors Expected

April: S.R. Kulkarni,Caltech; S.K. Parui, ISI; A.K. Sapre, Ravishankar University; A. Banerjee, Jadavpur University; S.D. Verma, Gujarat University; A.C. Balachandra Swamy, Saradavilas College; R. Ramakrishna Reddy, Srikrishnadevaraya University; U.S. Pandey, University of Gorakhpur; S.H.Behere, Marathwada University; D.B. Vaidya, Gujarat College; K. Sankara Sastry, Osmania University; P. Dasgupta, Delhi University.

May: M.N. Anandaram, Bangalore University; L.K. Patel, Gujarat University; S.S. Prasad, UNPG College; S.K. Pandey, Ravishankar University; H.L. Duorah, Gauhati University; P.P. Saxena, Lucknow University; L. Radhakrishna, Shivaji University; S.Chakrabarty, University of Kalyani; L.M. Saha, Zakir Hussain College; M.K. Das, Sri-Venkateshwara College; S.M. Alladin, Osmania University; R.S. Tikekar, Sardar Patel Universtiy; S. Chandra, Universtiy of Gorakhpur; B. Ishwar, University of Bihar; S. Mukherjee, North Bengal University .

June: D.K. Chakraborty, Ravishankar University; P. Khare, Utkal Universtiy; T. Singh, Banaras Hindu University.

Khagol **(the Celestial Sphere) is the Quarterly Bulletin of IUCAA.We welcome your responses at the following address:**

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