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

No. 24 October 1995

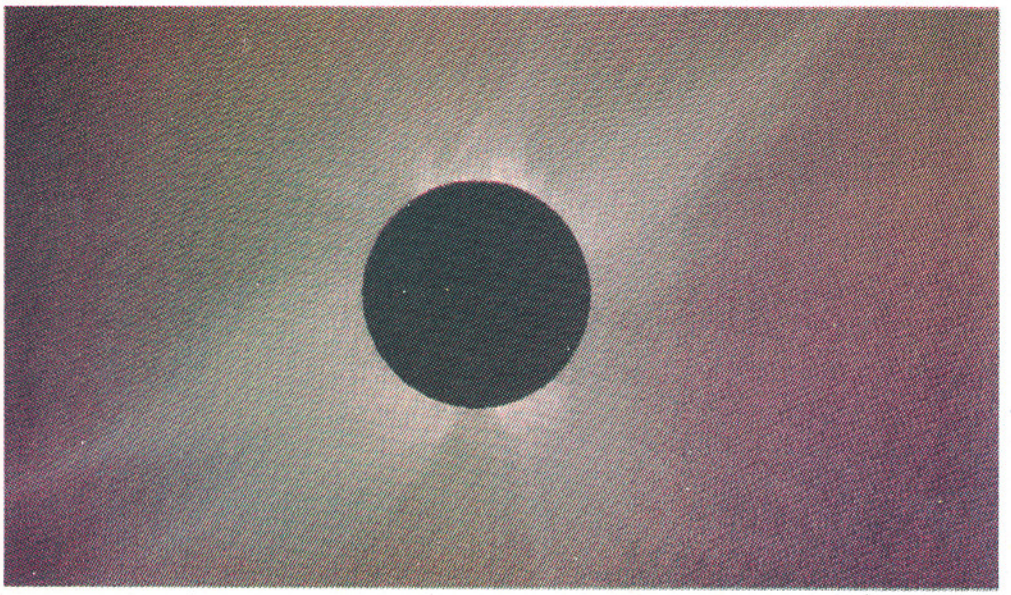
Scientific Programmes of IUCAA on Total Solar Eclipse of October 24, 1995

On October 24, 1995, a total solar eclipse will be visible from many parts of North India. The path of totality will pass through cities like Agra, Bharatpur, Allahabad and Purulia. The path will pass just south of the Taj Mahal in Agra. Visitors to the Taj Mahal on that day will see a spectacular near total solar eclipse. A total solar eclipse, like this one, presents astronomers (both professional and amateur) with an opportunity to study the Sun's tenuous corona, in addition to the chromosphere and prominences. Researchers from IUCAA intend to carry out the following research projects:

Determination of Umbral Boundaries and Solar Radius

The radius of the sun is still continued to be expressed as 953.63 arc second exact following Auwers (1891) and 69600 km. exact in the Astronomical Almanac, the former being two orders of magnitude higher in precision than the latter one. The predictions of the umbral boundaries for central eclipses still lack a precision of no better than 0.8 km. Using a pair of GPS units of the mapping grade and a reference datum in WGS84 system (accurate to 1 cm., thanks to The Survey of India) near Delhi, IUCAA has planned for erecting a linear array of 81 photodetectors at a separation of 25 m., each placed right across the two predicted fuzzy limits (namely, the northern and the southern ones) of the umbral path, that cut across the National Highway No. 8 connecting Jaipur and Delhi. Another pair of sites over a different longitude are tentatively chosen to be in the Allahabad-Jaunpur-Hamirpur region, provided the detectors can be made ready.

Each photodetector is sensitive to flux density levels between 0.04 and 1500 lux, with response being log-linear throughout the range and capable of discerning 0.178 db of signal into a bit leading to a byte size of signal, after due amplification and digital conversion. The sampling rate is chosen to be 500 times a second with adequate EPROM memory size to store the data



A digital mosaic of the Total Solar Eclipse of 1991

collected over four minutes around the totality. A single relay system would remotely initiate the process of data acquisition on site. NPL is helping us to obtain a millisecond accuracy of absolute timing in UTC. The local hardware and software specialists from Pune have rendered their professional service in the spirit of amateur astronomers. The market price of each such unit complete with sturdy tripod stand and directivity device on mount is at least about Rs. 5,200. The required total number of such units is 324 for the above project. Acquisition of raw materials would perhaps start from September 10th, and we hope to make the detectors ready latest by October 6th.

Fully Automated Recording of Shadow Bands

A cross-like array of 13+12 photodetectors at the central line at a separation of 3 cm. each with suitable multiplexing has been designed to study the intensity variations on a time scale of 1 ms. The observations would also help to study the atmospheric scintillation and seeing under a situation of one-minute nightfall.

Weather Monitor

IUCAA has acquired an automated weather monitor for pressure, temperature, humidity and rainfall record to be kept on line with a PC so that data acquisition would take place without manual intervention. Another set of hand-held display monitors are also acquired.

Eclipse Photography from Airplanes

The Indian Air Force (IAF) has agreed to take photographs of the ground from a height of 5 km. from above the 76 degree longitude line using two ordinary transport airplanes at a rate of 18 shots/sec. over the predicted north and south umbral boundaries, thanks to the efforts of National Council for Science and Technology Communications (NCSTC). IAF has also agreed to take a shot of the entire umbral boundary from a height of 21 km. above the ground using one of their MIG-25's.

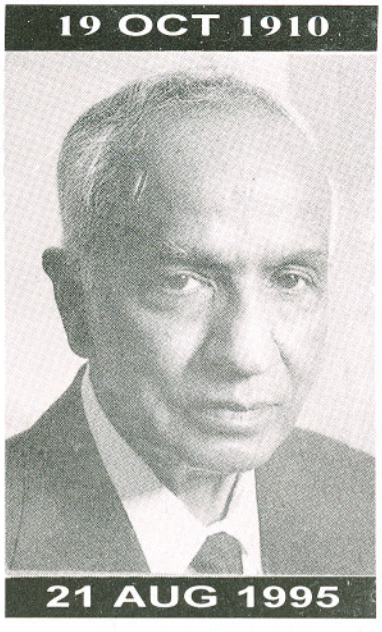
Radio Observation

A toy radio telescope has been built to detect coronal radio emission from the sun at 135 MHz taking the expert help from Shubhendu Joardar (NCRA).

Latest Designs for Projecting Solar Image In-house

Following the prescriptions laid out in one of the Applied Optics Journals (1985), we have developed two compact models of sun viewer, encased in light-weight thermocol chamber. The method utilises the multi-reflection technique in order to increase the effective distance between the pin-hole and the screen. The cost of one such device comes down to about Rs. 120, including the primary reflector with rotatable metal stand.

S. CHANDRASEKHAR



The staff of NCRA (TIFR) and IUCAA met to condole the death of Professor **Subrahmanyan Chandrasekhar**, an honorary fellow of TIFR and IUCAA. The following resolution was passed:

"The scientists at the National Centre for Radio Astrophysics of the Tata Institute of Fundamental Research and the Inter-University Centre for Astronomy and Astrophysics express their deep sorrow at the passing away of Professor Subrahmanyan Chandrasekhar on August 21, 1995 in Chicago. A doyen of astrophysicists the world over, Chandra was a special source of inspiration for the budding community of his native country not only through his pathbreaking research but also through his authoritative textbooks and monographs. Both IUCAA and TIFR were proud to have him as their Honorary Fellow.

On this sad occasion we convey our heartfelt condolences to Lalitha Chandrasekhar, who was Chandra's constant companion as well as a source of comfort and strength for over six decades, and pray that she is able to bear with fortitude this great personal loss."

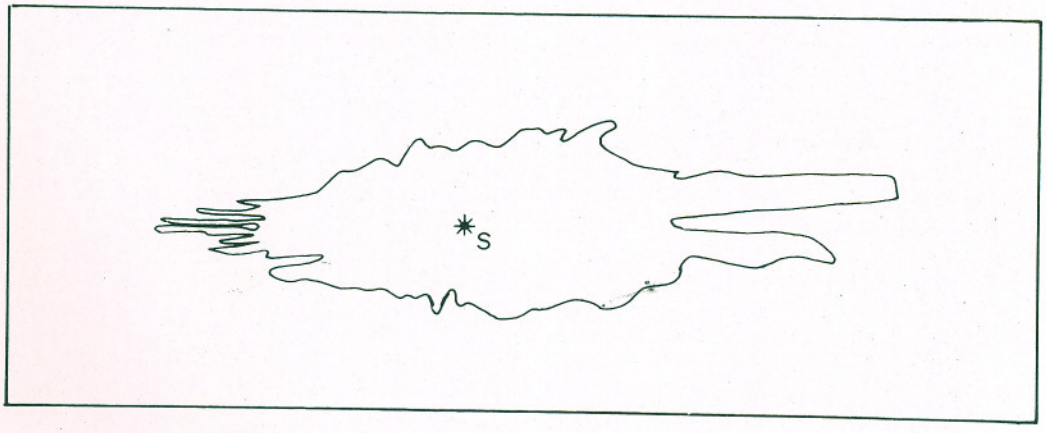
The Galactic Centre

Late in the eighteenth century, William Herschel had begun measurements of stellar distances, starting with the assumption that stars are basically similar to the Sun. Thus, the fainter the star the farther it would have to be. By counting stars to fainter and fainter magnitudes, Herschel was able to get a qualitative picture of their distribution in what became known as the Galaxy.

It was thus he found that stars are largely distributed within the plane of the Milky Way and that the Galaxy of stars extends farther in the plane than in the perpendicular (polar) direction. This disc-like distribution was reflected in the map of the Milky Way (see Figure) drawn by Herschel. In retrospect, it turned out not to give the entire picture, but given the limitations of observations two centuries ago, it was a step in the right direction.

As seen in the picture, the Sun is at the centre of the Milky Way. This belief survived throughout the nineteenth century and when towards its end, J.C. Kapteyn planned a large scale programme of spectroscopy and photometry of stars in the Milky Way so as to determine its structure, he was guided by the same belief. The outcome of this work led to the *Kapteyn Universe* in 1922, in which the entire system was believed to be 10,000 light years in diameter and centred on the Sun.

By 1918, however, thanks to the work of Harlow Shapley, picture of a different and larger system was emerging with the Sun well away from the centre. Shapley determined, with the help of measurements of angular sizes of globular clusters (these are spherical distributions of stars) that the true centre of the Galaxy lies in the direction of Sagittarius. His estimate of the diameter of the Galaxy at 300,000 light years, however, turned out to be too large by a factor three. This was because he had not taken into account the attenuation of starlight by interstellar dust... an effect that became known and established in the 1930s. After an initial period of controversy between the Kapteyn and Shapley schools of thought, the latter prevailed.



Herschel's map of the Milky Way with the Sun *S* at the centre

GR-15 in India in 1997

Naresh Dadhich and **B.S. Sathyaprakash** from IUCAA attended the 14th meeting of the International Society for General Relativity and Gravitation (GR-14) held at Florence, Italy in August 1995. Other participants from India included B.K. Datta, B.R. Iyer and C.V. Vishveshwara. It was heartening to note the good impression made by the work of the Indian gravity wave group at the conference. We are also happy to report that the next meeting in the series, GR-15 will be held at IUCAA, Pune, in December 1997. This will provide a boost to the Indian community of workers in general relativity and gravitation.

Dileep V. Sathe *

A Simple Model for the Foucault Pendulum

A Foucault pendulum in an astronomical institute is a prime attraction for visitors of all ages. But the author has noticed that even junior college students find it difficult to understand how it proves that the earth is rotating. The main reason is that the Foucault pendulum is not included in the junior college physics syllabus.

The plane of oscillation of the pendulum completes one rotation per day if it is located on the pole, but at other places, it requires more time. For example, the plane of the oscillation of the pendulum in 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 author recently, and used in some summer vacation programmes in Pune. The purpose of this communication is to share it with the readers of this bulletin.

We need the following material for making the model, which are easily available at home. A metallic disc with small holes all over the surface (such discs are used to cover milk, curd, etc. in the kitchen), two knitting-needles, a string, a suitable weight and a small ring. The model can be set up as follows:

First, tie the weight at one end of the string. Insert the other end of string through the central hole *F*, from one side and secure it on the other side by using a small ring or any other suitable object, see Fig. 1. 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 Foucault pendulum is hanging and the needles stand for the pillars supporting the dome. Set the pendulum oscillating, keeping the plane of oscillation fixed with respect to the walls of the room. Let the plane be parallel to two opposite walls, for the other two walls it would be perpendicular. Let the viewers observe carefully the plane of the oscillations in relation with the plane formed by the needles.

Then start rotating the disc carefully in the anti-clockwise direction, without disturbing the plane of oscillation with respect to the walls (see Fig. 2.1 and 2.2). Lead the viewers to appreciate this fact. But the plane of oscillation appears rotating clockwise with respect to the needles because they rotate anti-clockwise 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 a demonstrator, as the disc is rotated with hands. On the contrary, in case of the

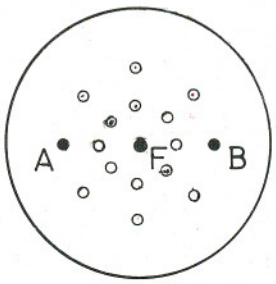


Fig.1

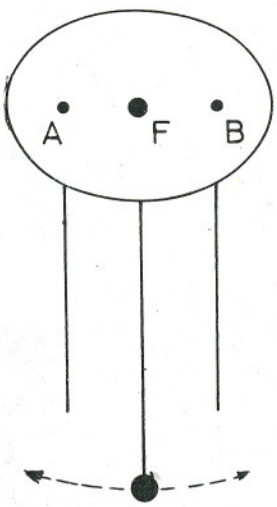


Fig. 2.1

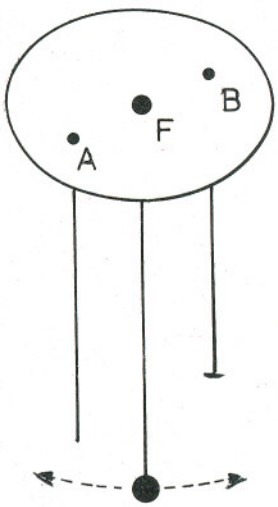


Fig. 2.2

real Foucault pendulum the rotation of plane is due to the rotation of the earth. In this respect, the model described 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.

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* *The author is a teacher in the Dadawala Jr. College, Pune.*

Why is it difficult to make a Foucault pendulum?

Readers might wonder as to why one should not make a real Foucault pendulum instead of the model described in this project. The real pendulum is in principle a simple device, but in practice it gets complicated by non-essential effects which could mask the effect of the Earth's rotation.

Firstly, in order to be able to see a significant rotation of the plane of oscillations, the pendulum should be kept operating for at least 15 minutes, and in order to ensure that there is not too much damping (of a pendulum without an electrical drive) during the period of observations one needs a long and heavy pendulum.

Secondly, in order to see the small rotation of the plane, the pendulum should have a circular symmetry of about one part in one lakh. Such a requirement could be understood as follows: the motion of the pendulum can be thought of as a combination of a clockwise and an anti-clockwise rotational oscillation (in each of these the pendulum's bob moves in a circle lying in the horizontal plane, instead of too and fro in a vertical plane). For an ideal pendulum, the periods for the clockwise and anti-clockwise rotational oscillations would be identical. But the rotation of the Earth in effect increases the period for one and decreases it for the other of the two rotational oscillations, and this leads to the rotation of the plane of oscillations. If the pendulum is not ideal and it has unequal periods for the clockwise and anticlockwise rotational oscillations, this difference in the periods would also lead to a rotation of the plane of oscillations and mask the effect of Earth's rotation. For example, if the period of the pendulum is 5 sec., and the periods of the two rotational oscillations differ by 1 part in 10^4, this difference in the two periods would lead to 1 rotation of the plane of oscillations per day and would completely mask the effect of Earth's rotation.

- S.N. Tandon

IUCAA Preprints

Listed below are the IUCAA preprints released during July - September 1995. These can be obtained from the Librarian, IUCAA.

D.P. Datta *On the cosmological constant problem,* IUCAA-19/95; **V. Chickarmane** and **S.V. Dhurandhar** *The performance of a dual recycled interferometer with squeezed light*, IUCAA-20/95; **R. Balasubramanian, B.S. Sathyaprakash** and **S.V. Dhurandhar** *Gravitational waves from the coalescing binaries : Detection strategies and Monte Carlo estimation of parameters*, IUCAA - 21/95; **T. Padmanabhan** *Structure formation : Models, dynamics and status*, IUCAA-22/95; **D. Ojha** *Faint star counts and the milky way structure*, IUCAA-23/95; A.C. Robin, C. Michel and **D. Ojha** *The thick disc of the galaxy : Sequel of a merging event*, IUCAA-24/95; **R. Balasubramanian, B.S. Sathyaprakash** and **S.V. Dhurandhar** *Estimation of parameters of gravitational waves from coalescing binaries*, IUCAA-25/95; **J.S. Bagla** *A new indicator of nonlinear gravitational clustering*, IUCAA-26/95; **T. Padmanabhan** *Modelling the nonlinear gravitational clustering in the expanding universe*, IUCAA-27/95; **R. Sachs** *Exact solutions of the field equations in the quasi-steady state model and relation to observations*, IUCAA-28/95; **B. Bhawal** amd **S.V. Dhurandhar** on *Coincidence detection of broadband signals by networks of the planned interferometric gravitational wave detectors*, IUCAA-29/95 and M. Gerbaldi, **R.K. Gulati**, R. Faraggiana and R.L. Kurucz on *UV Spectrum of λ Boo*, IUCAA-30/95.

Colloquia

held at IUCAA...

24.7.95 **S. Shandarin** on *Topology of Galaxy Distribution*, 28.8.95 **N.C. Wickramasinghe** on *Iron Whiskers in the Galaxy and Elsewhere*, 4.9.95 **G.C. Asnani** on *Some Challenging Problems in Tropical Meteorology*, 11.9.95 **K.S. Krishna Swamy** on *Infrared Emission from Comets* and 25.9.95 **M.N. Kulkarni** on *The Global Positioning System : An Overview.*

Admission to IUCAA-NCRA Graduate Course Lectures for University Students

Every year IUCAA and NCRA jointly run a Graduate School for the first year Research Scholars at these institutions. The School has 2 semesters and the following courses are offered:

(a) First Semester Courses (August - December)

1. Introductory Astronomy and Astrophysics
2. Mathematical Methods in Physics
3. Electrodynamics and Radiative Processes
4. Quantum and Statistical Mechanics

(b) Second Semester Courses (January - May)

5. Astronomical Techniques
6. Galaxy and Interstellar Medium
7. Extragalactic Astronomy and Cosmology

Starting from January 1996, it has been decided to admit a small number of students, working for Ph.D. in Physics, Astronomy or Astrophysics in Indian Universities, to attend these Graduate Course Lectures. The details of the scheme are as follows:

(1) Admission is on a semester basis. Right now applications are invited for the January - May, 1996 semester.

(2) Those students who have joined for their research programme in a University after July 94 are eligible to apply.

(3) The selected students will stay at IUCAA during the semester and should attend all the lectures and take at least 2 courses for credit. They are strongly encouraged to take all the courses which are offered during that semester for credit.

(4) The travel and lodging expenses for the students will be borne by IUCAA in accordance with the prevailing norms.

Students interested in making use of this scheme, should write on plain paper to the **Coordinator, Core Programmes, IUCAA**, giving the following details: (i) Name & full address,(ii) Male / Female, (iii) Date of birth, (iv) Major subject(s) and the year in which B.Sc. and M.Sc. degrees were obtained, (v) Marks / grades in B.Sc. and M.Sc., (vi) University / Institute from where B.Sc. & M.Sc. degrees were obtained,(vii) University / Institute in which currently registered for Ph.D., (viii) Current status and research interests, (ix) The name of the guide, (x) Do you have UGC/CSIR or university fellowships?, (xi) Any special awards / certificates (give details).

They should also arrange two letters of recommendation, one of which should be from their Ph.D. guide and at least one of the two should be from an Associate or Senior Associate of IUCAA, to be sent independently to the above address. The last date for receipt of applications is **November 15, 1995**.

Post-Doctoral Positions

Applications are invited for post-doctoral fellowships in astronomy and astrophysics. The duration of the fellowship is flexible within a range of one to five years with the possibility of conversion to a tenured position. *IUCAA offers challenging opportunities to young research workers in theory, observation and instrumentation in A & A and will be especially looking for observers and experimentalists.*

Facilities at the Centre

- State-of-the-art computer network, e-mail, tcp/ip, www
- Instrumentation laboratory
- Astronomical image processing and data centre
- Modern library

Other academic activities

- Schools and workshops
- Refresher courses
- Graduate and post-graduate courses
- Science popularisation

Research areas covered

- Cosmology and large scale structure
- Galactic and extra galactic astronomy
- High energy astrophysics
- Astrochemistry
- Nuclear astrophysics
- Quantum cosmology and quantum gravity
- General relativity
- Gravitational waves
- Observational astronomy
- Astronomical instrumentation

Candidates should apply to **The Coordinator, Core Programmes, IUCAA,** with curriculum vitae and list of publications and arrange for three confidential references to be sent independently. All the relevant material should reach IUCAA by **December 25, 1995.** Candidates will be informed of the result by **February 15, 1996**. The fellowship will normally commence **during 1996**.

Visits Abroad

A.N. Ramaprakash attended the *East-Asian Meeting on Astronomy* held at the National Olympic Memorial Youth Centre, Tokyo, Japan, during July 17-21, 1995 and gave a talk on *Imaging polarimeter.* He also visited the Nobeyama Radio Observatory of NAOJ.

R. Gulati visited the Institute de Astrophysique, Paris France, during June 22 - July 5, 1995, where he carried out collaborative research work with Michele Gerbaldi. He participated in the international workshop on *Model atmospheres and spectrum synthesis* held in Vienna, Austria during July 6-11, 1995, and presented a paper on *Spectrum Synthesis of the λ Boo.* On July 12, 1995, he visited the Observatoire de Merseille, Merseille, and gave a seminar on *Classification of stellar spectra using artificial neural networks.* From July 12-21, 1995, he had been to the Observatoire de Haute Provence, Saint Michele, France, where spectroscopic observations of MK standard stars were done using 120 cm. telescope attached with Marly Spectrograph.

Ajit Kembhavi visited the Astronomical Institute of the University of Amsterdam from May 10 to August 18, 1995. During this visit, he was collaborating with Professor E.P.J. van den Heuvel on mechanisms leading to the formation and evolution of low mass binary pulsars and related objects.

Deepak Munshi attended the 4th Summer School on *Non-accelerator particle physics,* organised by International Centre for Theoretical Astrophysics (ICTP), Trieste, during July 17-28, 1995. He also visited the Max Planck Institute for Astrophysics at Garching, Germany and SISSA, Trieste, where he presented seminars on *Approximations to gravitational clustering.* He visited Service de Physique Theorique de Saclay in France for discussing ongoing collaboration with Richard Schaeffer and Francis Bernerdeau. He also interacted with scientists working at Observatory of Paris at Meudon and Institute of Astrophysics, Paris. In addition, he also visited Peter Coles of Queen Mary and Westfield College at London and the Institute of Astronomy in Cambridge.

T. Padmanabhan visited Theoretical Astrophysics Center (TAC), Copenhagen from May 1 to May 7, 1995 and gave a seminar on *Quantum gravity - still at large.* He was at the Pennsylvania State University, USA from May 8 to June 30, 1995 and gave a course of 10 lectures on *Structure formation in the universe.* He also attended the IAU symposium 173 at University of Melbourne, Australia, on Gravitational Lensing during July 9-14, 1995 and gave an invited lecture on *Structure formation : Models, dynamics and status.* He was at the Institute of Astronomy, Cambridge, UK during August 7-11, 1995 to attend the conference on *Gravitational dynamics* and gave an invited talk on *Gravitational dynamics in an expanding universe.*

A. Paranjpye attended a two-day meeting of *Outdoor-lightning and Night-sky brightness* during July 15-16, 1995, at Tokyo, Japan. He presented a working on low cost photometer developed at the Instrumentation Laboratory of IUCAA. He also attended the *East-Asian Meeting on Astronomy* during July 17-21, 1995, and gave an oral presentation on *Estimation of sky brightness with a low cost photometer.* He also gave a public talk on *Sky watching in India.*

Vacation Students' Programme

The Vacation Students' Programme (VSP) was conducted at IUCAA during June 5 - July 14, 1995. Under this programme 15 students were selected on all India basis and only 11 joined. They spent 6 weeks at IUCAA and completed projects under the supervision of 8 of the IUCAA faculty members and post-docs. During the programme, about 20 lectures were delivered by the academic staff of IUCAA and National Centre for Radio Astrophysics (NCRA). B.S. Sathyaprakash was the coordinator of the programme.

Seminars

held during July - September 1995

14.7.95 **Marc Van Loo** on *Uniform Universal Expansion and a Variable Light Speed: The Predictions of a Bimetric Spacetime Proposal*, 27.7.95 **S. Kalyana Rama** on *Consequences of Nontrivial PPN Parameters in a Graviton-Dilaton Theory*, 1.8.95 **A. Gopakumar** on *Gravitational Radiation from Compact Binaries in Quasi-Elliptical Orbits*, 24.8.95 **Rainer Sachs** on *The Quasi-Steady State Cosmological Model - An Exact Solution* and 5.9.95 **N.C. Wickramasinghe** on *Microsoot: A New Model for Interstellar Dust.*

PEP talks

held during July - September 1995

21.7.95 **B. Bhawal** on *Rewinding Back to Michelson and Playing LIGO*, 27.7.95 **S. Kalyana Rama** on *Inconsistent Physics in the Presence of Wormholes*, 1.9.95 **N.C. Wickramasinghe** on *Life Outside the Earth : Scientific Facts and Sociological Attitudes*, 15.9.95 **K. Harikrishna** on *The Hitchhiker's Guide to the Euler Characteristic.*

Visitors
July - September 1995

M.N. Anandaram, A. Petrov, R. Somerville, T. Subbarao, B.A. Kagali, S. Chandra, Marc Van Loo, P.G.S. Mony, T. Majumdar, N.C. Nigam, K. Boruah, H.L. Duorah, S. Shandarin, A. Gopakumar, S. Kalyana Rama, G.P. Malik, M.N. Satish, S.M. Chitre, N. Kameswara Rao, U. Narain, Rakesh Kumar Sharma, S.K. Pandey, N.C. Wickramasinghe, T. Nagarajan, N.V. Madhusudana, A. Bhanumathi, O.N. Srivastava, Soma Mukherjee, A.P. Pathak, Satishkumar Umadi, N. Panchapakesan, K.S. Krishna Swamy, G.B. Mulay, Andrej Krolak,, Witold Kondracki, Ramakrishna Reddy, S.S. Prasad.

Visitors
Expected

October : Alok Gupta, Indian Institute of Astrophysics; M.K. Das, Sri Venkateswara College; H.P. Singh, Sri Venkateswara College; Somenath Chakrabarty, University of Kalyani; D. Chakraborty, Pt. Ravishankar Shukla University, O. Gingerich, Harvard University; M.N. Anandaram, Bangalore University; Henk Spruit, Max Planck Institute; S.S. De, Calcutta University; P. Gondhalekar, Rutherford Appleton Laboratory.

November : Sharmistha Roy; Alberto Chamorro, Universidad del Pais Vasco; G. Djorgovski, Caltech; M. Rich, Columbia Astrophysics Laboratory; W. Saslaw, University of Virginia, C. Sarazin, University of Virginia; H. Ferguson, Space Telescope Science Institute; I. Jorgensen, University of Texas at Austin; G. Fazio, Harvard Smithsonian Centre for Astrophysics; T. Statler, Ohio University.

December : K. Freeman, Mount Stromlo & Sliding Spring Observatories; R. Ellis, University of Cambridge; K. Sato, University of Tokyo.

Apart from this, about 150 visitors will be coming to IUCAA in December to attend the Workshop on Gravitational Waves during December 9-12, the ICGC-95 during December 13 - 19 and the Miniworkshop on Gravitational Collapse and Cosmic Censorship during December 20-24.

Welcome...

to **Somak Raychaudhury**, who has joined as a core faculty member. His research interests are *observational cosmology, dynamics of galaxies in clusters and superclusters, optical and X-ray observations of galaxy clusters, making maps of the distribution of galaxies,*

to **R. Srianand**, who has joined as a post-doctoral fellow. His research interest is *quasar astronomy*, and

to **K. Harikrishna**, who has joined as a research scholar.

and... Farewell

to **Rainer Sachs**, who has joined his parent institution.

Copernicus the Healer

In his *Fireside Astronomy,* Patric Moore describes a little known aspect of Nicolaus Copernicus, the astronomer who launched the heliocentric theory five centuries ago.

Before he embarked on his astronomical adventures, Copernicus was trained in the famous medical school of the University of Crakow followed by a three year medical course at Padua University. His notebooks contain medicinal recipes. Here is a universal remedy, which may be rather difficult to obtain in modern times:

"Take two ounces of Armenian clay, a half ounce of cinnamon, two drachms of tormentil root, dittany, red sandalwood, a drachm of ivory and iron shavings, two scruples of ash and rust, one drachm each of lemon peel and pearls; add one scruple each of emerald, red hyacinth and sapphire; one drachm of bone from a deer's heart; sea locusts, horn of a unicorn, red coral, gold and silver foil - all one scruple each; then add half a pound of sugar, or the quantity which one buys for one Hungarian ducat's worth."

Then he adds: *" God willing, it will help."*

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

IUCAA, Post Bag 4, Ganeshkhind,
Pune 411 007, India

Phone
(0212) 351414

e-mail
PUBL@iucaa.ernet.in

Fax
(0212) 350760

Telex
0145 7658 GMRT IN

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