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. 25 January 1996

The Seventh Foundation Day Lecture

R.A. Mashelkar delivering the 7th IUCAA Foundation Day Lecture

A highlight of our Foundation Day is the lecture delivered by a distinguished personality. This year we had the pleasure of having an old friend back amongst us: **Ramesh A. Mashelkar**, former Director, National Chemical Laboratory, Pune, and now Director General, Council of Scientific and Industrial Research, New Delhi. The topic of his lecture was *Making Economic Sense of Science: The Emerging Indian Challenge.*

Since taking up the apex position at the CSIR, Mashelkar has been trying to bring new enthusiasm and new concepts of operation into the largest network of scientific laboratories. These were much needed, especially in the present times when applied scientists have been encouraged to generate their resources through patents and aggressive marketing of new ideas. His lecture was an exercise in positive and practical thinking to address these issues. The full text of the lecture will be published in the next Annual Report.

The IUCAA Telescope

We are happy to announce that the University Grants Commission has approved, in principle, an optical telescope in the 1.5 m class under IUCAA's management. The telescope is expected to provide boost to observational astronomy in the university sector. Further details of the new project will be given in later issues of *Khagol*.

Workshop on Space Dynamics and Celestial Mechanics

A workshop on Space Dynamics and Celestial Mechanics, sponsored by IUCAA, was held at University Department of Mathematics, B.R. Ambedkar Bihar University, Muzaffarpur during September 18-22, 1995. The workshop reviewed the current state-of-the-art in space dynamics and celestial mechanics. There were 35 participants, consisting of university/college teachers and research workers from Bihar and the rest of India. The academic programme included 14 lectures by invited speakers, 13 papers were presented by young teachers and research workers. In addition Andre Deprit (U.S.A) delivered two lectures. A highlight of the meeting was a discussion on symbolic analysis of problems in Celestial Mechanics.

Participants of the workshop on Space Dynamics and Celestial Mechanics

Indo-US Workshop on Elliptical Galaxies : Structure and Dynamics

The Indo-US workshop on *Elliptical Galaxies: Structure and Dynamics* was held at IUCAA during November 23 - December 7, 1995. This was the third in the series of workshops planned under the Indo-US Exchange Programme in Astronomy and Astrophysics. The workshop consisted of a series of talks as well as seminars, by astronomers from the US and India. A variety of observational and theoretical aspects of elliptical galaxies were covered in the talks. There were about 60 participants in all and there was much discussion and exchange of ideas. Plans for collaborative research projects between US and Indian astronomers have been set up and it is hoped that these will be as scientifically fruitful as the projects which emerged from the earlier workshops of the series.

Workshop on Gravitational Waves

A workshop on Gravitational Waves was held during December 9 -12, 1995 at IUCAA. There were about forty-five participants with a break-up of about thirty from India and fifteen from abroad. The workshop consisted of lectures, seminars and discussion sessions. The discussions sometimes extended over dinner. An introductory talk to student participants was also given after dinner. The speakers were representatives of a wide area from experimentalists working on bar detectors and interferometers to theorists who were interested in intricate waveform calculations and data analysis. The wide coverage was useful for obtaining a perspective of the current status of the field. All the participants found the workshop highly stimulating.

Workshop on Gravitational Collapse

A workshop on Gravitational Collapse was held during December 20-23, 1995 at IUCAA. The workshop was inaugurated by P.C. Vaidya and the speakers included D. Brill, M. Bruni, C. Clarke, N. Dadhich, T. Dray, I.H. Dwivedi, J. Friedman, S. Hayward, S. Jhingan, P. Joshi, G. Kang, J. Moffat, K. Newman, A. Ori, J. Pullin, K. Rama, E. Seidel, T.P. Singh, P. Szekeres, C.S. Unnikrishnan and C. Vaz. There were in all about 50 participants.

Catching Glimpses of the Extragalactic World

While the overall picture of our Galaxy was taking shape (see Parsecstone 12), the astronomers were also becoming aware of what lies beyond. As early as 1755, in his book *Universal Natural History and Theory of the Heavens*, Immanuel Kant laid down what has become known as the "Island Universe" hypothesis. According to this hypothesis, the Galaxy is a stellar system floating like an island in space along with innumerable other such systems separated by enormous distances.

This idea was slow to catch on despite evidence coming through observations. For example, in the beginning of this century spiral nebulae were known as individual entities. But how large and how distant were they? As late as 1920, many astronomers believed that the Galaxy is larger than any other system and that the spiral nebulae were part of it or its satellites. A minority, however, believed like Kant that these nebulae were distant and were galaxies in their own right.

Harlow Shapley who had been correct in the controversy regarding the Galactic Centre (see Parsecstone 12) was on the wrong side in this argument. In 1919, for example, there was a debate between Shapley and Curtis with the latter maintaining the Kantian view. A major factor in these arguments was the claim by Van Maanen at the Mount Wilson Observatory that spiral nebulae like M 33, M 81, etc. (M denoting the Messier Catalogue) possessed proper motions, i.e., they moved perpendicular to the line of sight. If this claim was correct then they could not be very far as their transverse speeds would have to be impossibly high.

However, thanks to the work of Edwin Hubble who measured the distances of such nebulae by the more reliable method of Cepheid Variables (to be described in the next Parsecstone), the Curtis claim gradually prevailed. Moreover, by the mid-1930s Van Maanen's claim lost credibility as it could not be substantiated by others and the doors to the vast extragalactic universe were thrown open.

International Conference on Gravitation and Cosmology (ICGC-95)

The ICGC-95 was held during December 13 - 19, 1995 at IUCAA, Pune. The key themes for this meeting were: (a) Cosmology and Structure Formation (b) Quantum Gravity (c) Gravitational Radiation and (d) Classical General Relativity. This is the 3rd meeting in the series of ICGC meetings hosted in India. The first one was in Goa in 1987 and the second one was at PRL, Ahmedabad in 1991.

ICGC-95 had 16 plenary lectures and 4 workshops dealing with the 4 themes mentioned above. The plenary lectures reviewed the current status of different topics in gravitation and cosmology and the workshops were devoted to more specialised and intensive discussions. In addition to these, there was a special workshop on Alternative Cosmologies on one afternoon which generated lively debate on current status of cosmological models.

The following persons gave plenary lectures: L. Blanchet, G.F.R. Ellis, R. Ellis, S. Finn, J. Friedman, J.J. Halliwell, J. Katz, M. Longair, T. Padmanabhan. J. Peebles, J. Pullin, E. Seidel, D. Shoemaker, C. Torre, M. Varadarajan and J.-Y. Vinet.

Workshops were coordinated by N. Dadhich, G.F.R. Ellis, J.J. Halliwell, B.R. Iyer, K. Kokkotas, M.A.H. MacCallum, Varun Sahni, T.P. Singh and K.C. Wali.

Another feature of ICGC-95 was a special session devoted to the Raychaudhuri equation. Following the remarks by J.V. Narlikar and A.K. Raychaudhuri, there were four lectures by D. Brill, C. Clarke, P. Joshi and P. Szekeres discussing the applications of Raychaudhuri equation in various areas of gravitation and cosmology.

The conference summary was given by M.A.H. MacCallum.

More than 170 participants from India and abroad attended the ICGC-95.

Measuring the Solar Spin

Just as the earth spins, the sun also spins at a rate about once per 27 days. In fact, spin is a very common phenomenon in heavenly bodies, some of these spin fast and the others slowly. Interestingly, the words fast and slow can be quantified in this context. If a spherically symmetric body has a mass M, a radius R, and a spin rate f, the ratio of the centrifugal to the gravitation acceleration on its surface would be $\propto f^2 R^3/M$, and this ratio can be taken as a measure of fastness of the spin. Thus, one could say that the sun is spinning much slower as compared to the earth; this is not the same as saying that 27 days is much longer than 1 day.

We can measure the earth's spin by observing the apparent motion of the heavenly bodies; what can we do to measure spin of the sun? In this project, we will describe a simple method to do this.

Before proceeding further, please note that it is very dangerous to look at the sun either directly or through a telescope. One should either look at a projection of the solar image on a screen, or use special dark glasses designed for viewing the sun.

Using sunspots to measure solar spin

Solar surface is not exactly uniform but has some irregularities. In particular, during certain periods the surface shows dark spots, called sunspots. Although these spots are not permanent features, one can assume these to be fixed on the surface for periods of a few weeks. Thus, as the sun spins one might find a spot emerging from one edge, moving on the disk, and eventually disappearing on the opposite edge. In case the solar axis of spin is at right angle to our sight (the sun-earth line), the spots would take one half the period of spin to move from edge to edge and their tracks would appear as straight lines. These tracks can be used to measure the period and direction of the solar spin.

In order to observe the spots, the solar image should be projected on a white paper, and the solar disk and the spots should be marked on this, along with a line indicating the N-S direction. [Image of the sun is to be projected on a sheet of paper, kept normal to the axis of eye piece of a telescope. You may have to make a proper projection screen and attach it to the eye piece mount. The sun's image can be focused on this screen by turning (or push-pulling) the eye piece. Adjust the distance of the screen to get an image of

Reducing the data

1. Make a diagram, as shown on the right, for the daily positions of a spot on the solar disk.
2. Draw the best straight line fit to the positions of the spot. This line meets the image of the limb of the sun at A & A'.
3. Line PP', orthagonal to AA' and bisecting it, is the axis of the sun.
4. Calculate angle θ_1 and θ_2 as follows:

$$\theta_1 = \sin^{-}(X_1 / \sqrt{R^2 - Y^2})$$
$$\theta_2 = \sin^{-}(X_2 / \sqrt{R^2 - Y^2})$$

Choose positions X_1 and X_2 well away from the limb.

5. Calculate $\Delta\theta$ as

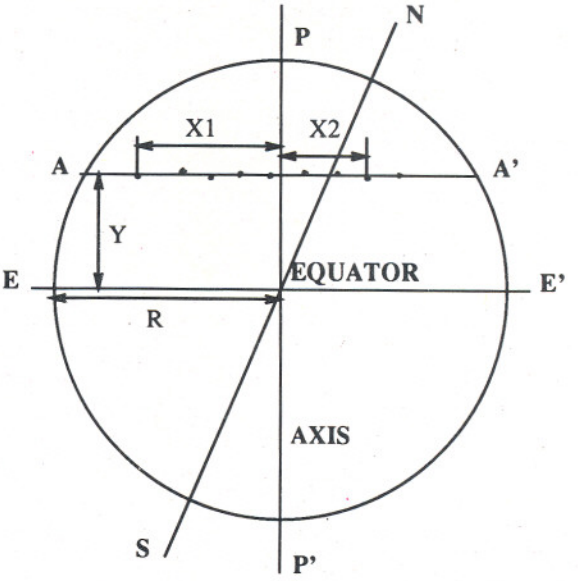
(i) $\Delta\theta = |\theta_1 - \theta_2|$ if the spots are on the same side of PP'
(ii) $\Delta\theta = \theta_1 + \theta_2$ if the spots are on different sides of PP'

6. Determine the period of rotation of the sun as:

$$P\ (\text{days}) = 360 / [\Delta t\ (\text{days}) \ / \Delta\theta\ (\text{deg})],$$

Δt being the gap between the observations for the positions X_1 and X_2.

7. Repeat the calculation for different pairs.
8. Repeat for the trajectories of the other spots.



- A. Paranjpye

10 cm diameter. Put a sunshield to avoid direct sunlight on the screen.] The observations should be made daily for atleast a week; in order to simplify the analysis, one should make observations at the same time of the day while keeping the same setting of the telescope and projection.

After the observations are collected, the track of each sunspot should be drawn on a separate sheet of paper; these tracks are used to measure the spin (see the box by A. Paranjpye).

Complications

This simple experiment has a few complications. Firstly, the sunspots are only prominent near the maximum of the solar activity; prominent spots are only expected after 2-3 years from now. Secondly, due to the earth's revolution around the sun, the observation does not give the true spin-period and a correction needs to be applied. Lastly, the solar axis is not always perpendicular to the earth-sun line, but it is so only in the first halves of June and December.

IUCAA Preprints

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

B. Nath and **S.K. Sethi** *On the interpretation of the He II absorption in the line of sight of Q0302-003,* IUCAA-31/95; **A.N. Petrov** *On the weakest falloff conditions in the metric for an isolated system,* IUCAA-32/95; **T. Padmanabhan** *Gravitational dynamics in an expanding universe,* IUCA-33/95; **N. Dadhich** and **L.K. Patel** *String-dust perfect fluid in singularity-free models,* IUCAA-34/95; **L.K. Patel** and **N. Dadhich** *Cylindrically symmetric cosmological models in the Kaluza-Klein spacetime,* IUCAA-35/95; **N. Dadhich** and **L.K. Patel** *The role of shear in expanding cylindrical perfect fluid models,* IUCAA-36/95; **L.K. Patel** and **N. Dadhich** *String-dust in Einstein and Godel universes,* IUCAA-37/95; U.S. Pandey and **S.S. Prasad** *On the evolution of magnetic moment of pulsars,* IUCAA-38/95; **S.S. Prasad** *A class of solutions for a rotating perfect fluid in general relativity,* IUCAA-39/95; **S.S. Prasad** and U.S. Pandey *Plane symmetric perfect fluid distribution admitting a one-parameter-group of conformal motions,* IUCAA-40/95; **S.S. Prasad** and U.S. Pandey *A spherically symmetric higher dimensional perfect fluid spacetime admitting a one-parameter-group of conformal motions,* IUCAA-41/95; **S. Chakraborty** *String cosmology in a stationary cylindrically symmetric spacetime,* IUCAA-42/95; **S. Chakraborty** *Motion of test particles around monopoles,* IUCAA-43/95; **D.K. Ojha,** O. Bienayme, A.C. Robin, M. Creze and V. Mohan *Structure and kinematical properties of the galaxy at intermediate galactic latitudes,* IUCAA-44/95; S. Mukherjee, U. Bhattacharya, S.K. Parui, **R. Gupta** and **R. Gulati** *Comparative performance of artificial neural networks for UV spectral classification,* IUCAA-45/95; **V. Sahni** and S. Shandarin *Behaviour of Lagrangian approximations in spherical voids,* IUCAA-46/95; **N. Dadhich** *How empty must empty space be?,* IUCAA-47/95; **L.K. Patel, R. Tikekar** and **N. Dadhich** *Inhomogeneous cosmological models with heat flux,* IUCAA-48/95; **J.S. Bagla, T. Padmanabhan** and **J.V. Narlikar** *Crisis in cosmology - Observational constraints on Ω and Ho,* IUCAA-49/95; **R. Srianand** and **P. Khare** *Analysis of Ly α absorption lines in the vicinity of QSOs,* IUCAA-50/95; **S.V. Dhurandhar,** P. Hello, **B.S. Sathyaprakash** and J.Y. Vinet *The thermo-optical coupling in optical resonators,* IUCAA-51/95; **R. Srianand** *Analysis of low z absorbers in the QSO spectra,* IUCAA-52/95 and **R. Srianand** *Dynamical history of Ly α clouds,* IUCAA-53/95.

Seminars

held during October - December 1995

22.9.95 **A. Krolak** on *On Estimation of Parameters of the Gravitational Wave Signal from a Coalescing Binary by a Network of Detectors*, 26.9.95 **W. Rudnicki** on *Blackhole Interiors Cannot be Totally Vicious*, 12.10.95 **A. Bandyopadhyay** on *Quantum Interferometry with Squeezed Radiation*, 17.10.95 **H.C. Spruit** on *Magnetically Accelerated Winds and Jets from Accretion Disks*, 18.10.95 **M. Chiba** on *The Origin and Evolution of Galactic Magnetic Fields*, 19.10.95 **A. Petrov** on *The Field Approach and Isolated Systems in General Relativity*, 9.11.95 **P.M. Gondhalekar** on *Soft X-Rays in AGNs and Quasars: Unification Schemes & Accretion Discs*, 14.11.95 **R. Sommerville** on *The Small Scale Velocity Dispersion of Galaxies: A Comparison of Cosmological Simulations*, 27.11.95 **F. Cooperstock** on *A New Look at Gravitational Energy and Gravity Waves*, 27.12.95 **Bill Saslaw** on *the Distribution Function Approach to Galaxy Clustering*, 28.12.95 **S. Raychaudhury** on *Velocity Distributions*, 28.12.95 **F. Ahmed** on *the Basis of the Thermodynamic Approach to Galaxy Clustering* and 28.12.95 **S.Kumar** on *Magnetic Fields in Accretion Discs.*

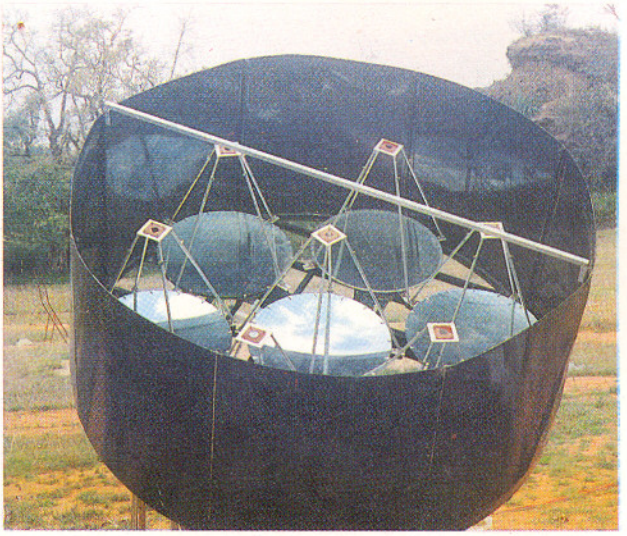
Colloquia

held at IUCAA...

16.10.95 **O. Gingerich** on *A Report on the Progress in Stellar Evolution to 1953*; 1.11.95 **Sharmishtha Roy** on *Hands-On Astrophysics: Discovering the Changing Nature of Variable Stars*; 13.11.95 **Mustansir Barma** on *Time-Dependent Properties of Interacting Stochastic Systems* and 4.12.95 **M.N. Kulkarni** on *The Global Positioning System: An Overview.*

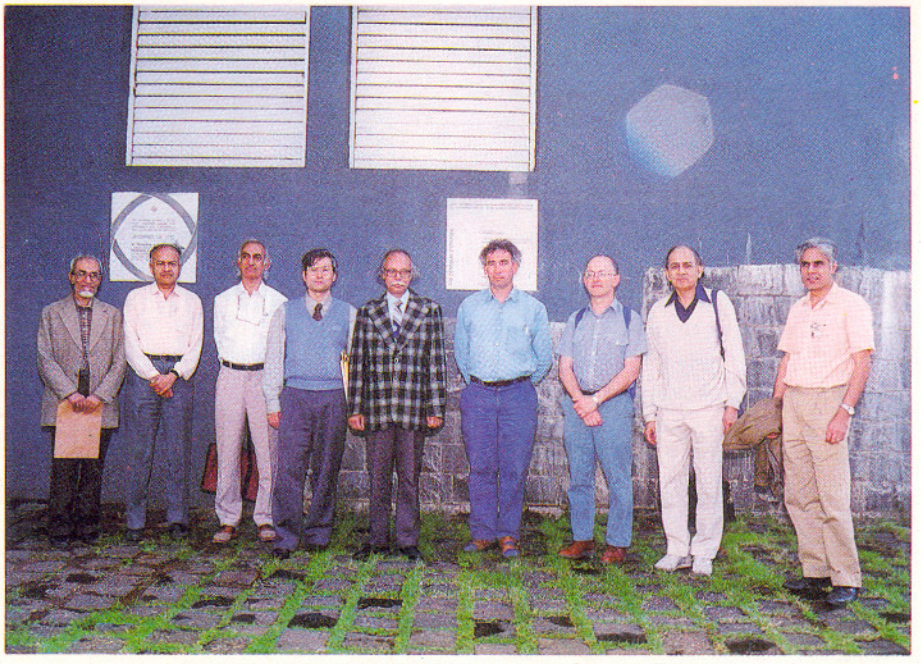
Gamma Ray Astronomy

An atmospheric Cerenkov experiment is being conducted at Pachmarhi in central India. This is a ground based observatory to detect gamma rays in the energy range 500 GeV to 5 TeV from celestial sources. The set-up consists of an array of 25 telescopes each made up of 7 parabolic mirrors of diameter 0.9 m (see picture), arranged in a 5 x 5 matrix over an area of 80m x 100m. The gamma rays incident on the top of the earth's atmosphere give rise to millions of electrons in the atmosphere which travel faster than the speed of light at that point. As a result, these electrons emit a radiation called the Cerenkov radiation which is in the visible range. This faint (10^{-4} times the brightness of the dark moonless night) light is detected through the parabolic mirrors at the foci of which are the sensitive photo-detectors. These mirrors are mounted on computer controlled equatorial mounts and are capable of tracking a source for several hours. The set up is used to study the lateral distribution of the Cerenkov light to distinguish between the gamma ray initiated and more abundant proton initiated showers. The sources of interest are Pulsars, short period X-ray binaries, AGN and some millisecond pulsars.



One of the 25 telescopes at Panchmarhi

So far positive signals of TeV gamma rays from several sources have been detected. The facility belongs to the Tata Institute of Fundamental Research, Bombay. Students and faculty members from universities and colleges who are interested in participating in observations using this facility may contact P.N. Bhat, Tata Institute of Fundamental Research, Homi Bhabha Road, Bombay 400 005 and Ajit Kembhavi at IUCAA.



SAC Members with the Director and Shyam Tandon

Visits Abroad

Biplab Bhawal and **S.D. Mohanty** attended the Les Houches school on *Astrophysical Sources of Gravitational Radiation* during September 26 - October 6, 1995. Biplab gave a seminar on *The coincidence detection of broadband signals by networks of the planned laser interferometric gravitational wave detectors* in the school.

R. Balasubramanian attended the school on Numerical Relativity during Septmber 18 - 22, 1995. He gave a seminar on *Estimation of parameters of the coalescing binary system* at Observatorie d Paris, Meudon, Paris. He also attended the Les Houches school on *Astrophysical Sources of Gravitational Radiation* during September 26 - October 6 and visited Linear Accelerator Laboratory, Orsay, Paris as part of the Indo-French Project during October 7 - 29. He then visited SISSA, Trieste during October 31 - November 8. He gave a seminar on the *Issues in the detection of gravitational waves from coalescing binaries* during his visit to SISSA.

N. Dadhich visited the University of Natal during August 20 - October 20, 1995 and gave a course of lectures on *Black holes* to the Honours students of the Department of Mathematics.

B.S. Sathyaprakash visited the Los Alamos National Laboratory, University of Kansas, University of Penn State, California Institute of Technology, University of Washington (all in USA), Les Houches, and Linear Accelerator Laboratory (France), during August 13 - November 6, 1995. During the visit he delivered seminars on *Gravitational waves from compact binaries as a tool to test general relativity, Geometrical and morphological properties of large scale structure in the universe, Morphology of large scale structure in the universe, Gravitational radiation as a tool to weigh an inspiralling binary*, and *How accurately can we estimate the parameters of an inspiralling binary signal?* He also gave an invited talk on *Signal procesing* at Les Houches School on Astrophysical sources of gravitational radiation. He also attended the GR-14 Conference at Florence, Italy, during August 6-12, 1995 and presented a paper entitled *Filtering post-Newtonian gravitational waves from coalescing binaries and estimation of parameters*. At the University of Kansas, he gave a colloquium entitled *Ripples of curvature: Are we ready to observe them?* on September 11, 1995.

Visitors

October - December 1995

H.P. Singh, M.K. Das, Suresh Chandra, V.M. Nandakumaran, T.C. Phukon, Ashvin Mehta, D.K. Chakraborty, A.C. Balachandra Swamy, A. Bandyopadhyay, O. Gingerich, H. Spruit, R. Tikekar, S. Chakraborty, M. Chiba, D.B. Vaidya, D. Sahu, S. Roy, P.S. Wamane, G.P. Pimpale, B.R. Iyer, A. Omont, M. Le Duc, F. Cooperstock, Java-Lo-Yes, J. Maslin, P.G.S. Mony, M.N. Kulkarni, A. Chamorro, K. Freeman, J. Vinet, C. Mukku, L.K. Patel, G. Srinivasan, S.S. Prasad, S. Mukherjee, K. Sato, S.M. Chitre, B.A. Kagali, R. Ellis, W. Saslaw, Sanjiv Kumar, P.S. Naik, T. Oka, R.A. Mashelkar, Udit Narain, V.H. Kulkarni, F. Ahmed.

Apart from the above visitors, about 250 visitors came to IUCAA to participate in the Indo-US Workshop on Elliptical Galaxies : Structure and Dynamics, Workshop on Gravitational Waves, ICGC-95 and the Workshop on Gravitational Collapse and Cosmic Censorship.

Visitors

Expected

January : S.G. Tagare, Hyderabad University; A. Khare, Institute of Physics; P. Khare, Utkal University; F. Verheest, University of Gent; J. Perry, University of Cambridge; C. Clarke, Queen Mary and Westfield College; S. Lamb, University of Illinois; B. Murphy, Butler University; I. Wanders, Ohio State University; A. Robinson, University of Hertfordshire; C. Vanderriest, Meudon Observatory.

February : Hermann Bondi, Churchill College, Cambridge.

March : Sven Sattler, Germany.

Welcome...

to **S. Sridhar,** who has joined as a core faculty member. His research interests are galactic dynamics and interstellar turbulence,

and... Farewell

to **Biplab Bhawal,** who has joined the VIRGO groupe, Laboratoire de l'Accelerateur Lineaire, Orsay, France, **Christian Boily,** who has joined the Astronomy Unit of the Queen Mary and Westfield College, London, **Tarun Ghosh,** who has joined the Canadian Institute for Theoretical Astrophysics, Toronto, and **Sucheta Koshti**.

Eclipse, Relativity and Rubaiyat

Since we just had a total solar eclipse on 24 October 1995, it is worth recalling another, on 29 May 1919 which became famous for Eddington's expedition to measure the bending of light by the gravity of the Sun in order to test a prediction by Einstein's general theory of relativity. We reproduce below Eddington's parody of the Rubaiyat describing the expedition that turned out to be a great success.

Ah Moon of my Delight far on the wane,
The Moon of Heaven has reached the Node again
But clouds are massing in the gloomy sky
O'er this same Island, where we laboured long — in vain?

And this I know; whether EINSTEIN is right
Or all his Theories are exploded quite,
One glimpse of stars amid the Darkness caught
Better than hours of toil by Candle-light

Ah Friend! could thou and I with LLOYDS insure
For God this sorry Coelostat so poor,
Would we not shatter it to bits — and for
The next Eclipse a trustier Clock procure

The Clock no question makes of Fasts or Slows,
But steadily and with a constant Rate it goes.
And Lo! the clouds are parting and the Sun
A crescent glimmering on the screen — It shows! — It shows!!

Five Minutes, not a moment left to waste,
Five Minutes, for the picture to be traced —
The Stars are shining, and coronal light
Streams from the Orb of Darkness — Oh make haste!

For in and out, above, about, below
'Tis nothing but a magic Shadow show
Played in a Box, whose Candle is the Sun
Round which we phantom figures come and go

Oh leave the Wise our measures to collate
One thing at least is certain, LIGHT has WEIGHT
One thing is certain, and the rest debate —
Light-rays, when near the Sun, DO NOT GO STRAIGHT.

IUCAA lost the B(ashes)

The seventh IUCAA-NCRA Bashes Cricket Match was won by NCRA, thus putting it one game ahead (4 against 3). IUCAA won the toss and put NCRA in to bat. Faced with the task of scoring 104 runs in 20 overs IUCAA could manage only 88, thanks to some excellent fielding by NCRA. By hindsight it seems that the IUCAA batsmen woke up too late, having managed only 32 runs in the first 12 overs.

PEP talks

held during October - December 1995

3.11.95 **J.V. Narlikar** on *Luck in astronomy*, 10.11.95 **P.M. Gondhalekar** on *Magic, mythology and theology in astronomy*, 22.12.95 **T. Dray** on *Rotating observers in relativity.*

Corpus Fund

IUCAA has set up a corpus fund to generate resources for covering its activities that are not otherwise funded by its regular grants. We invite you to contribute to the Corpus Fund: cheques, etc. may be made in favour of IUCAA. Donations to IUCAA qualify for 100 % deduction from the taxable income of the Donor under the Income Tax Section 35 (1) (ii).

Vacation Students Programme 1996

IUCAA invites applications for the sixth Vacation Students Programme (VSP). Students selected under the VSP will spend six weeks at IUCAA to work on specific research projects under the supervision of the IUCAA faculty. The programme will conclude with seminar presentations of the projects by the participants, a written test and an interview. Those who perform well will be preselected to join IUCAA as research scholars after the completion of their degree.

Students who will enter the final year of the M.Sc. (physics/applied mathematics, astronomy, electronics)/ B.Tech./B.E. courses in the academic year 1996-97 are eligible to apply. Application, in plain paper, giving the academic record of the applicant as well as two letters of recommendations from teachers, mailed directly, should reach the **Coordinator, Core Programmes, IUCAA**, by **March 1, 1996**. The selected candidates will be informed by April 1, 1996 for the programme to be held during June 3 - July 12, 1996.

Donation from L & T

Larsen & Toubro Ltd. have generously donated Rs.5 lakhs towards improvement of IUCAA's facilities for visiting scientists. We thank them for this kind gesture.

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

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