KHAGOL खगोल

IUCAA

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Contents

Refresher Course in Astronomy and Astrophysics for College/University Teachers

A refresher course in Astronomy and Astrophysics for college/university teachers was held at IUCAA during May14 - June 3, 1997. This course was meant for the teachers from colleges and universities. There were about 30 participants from all over India. An attempt was made to cover basic astrophysical processes, stellar structure and evolution, interstellar medium, properties of galaxies, intergalactic medium, general relativity, cosmology and structure formation in the universe. In addition to the regular course work, observational sessions and informal discussions were also arranged as a part of the course. The lectures and seminars were given by members of IUCAA and NCRA.

Participants of the Refresher Course in Astronomy and Astrophysics for College/University Teachers

IUCAA
ACADEMIC CALENDAR
(August 1997 - July 1998)

1997

AUGUST

18 — **IUCAA-NCRA Graduate School**
First Semester begins

SEPTEMBER

12-13 — **Mini School on Introductory Astronomy and Use of Computers**
at St. Thomas College, Kozencheri

Sept. 29 - Oct. 3 — **Workshop on Modern Trends in Gravitation and Cosmology**
at Cochin University of Science and Technology

Sept. 29 - Oct. 3 — **Level 1 Workshop on Astronomical Photometry**
at IUCAA

* — **Workshop on Introductory Astronomy and Astrophysics**
at Pondicherry University

OCTOBER

* — **Workshop on Astronomy and Astronomical Instrumentation**
at Kakatiya University, Warangal

NOVEMBER

4-8 — **Workshop on Introductory Astronomy and Astrophysics**
at Alipurduar College, Alipurduar Court , West Bengal

3-14 — **TIFR-IUCAA School on Cosmic Ray Astronomy**
at Ootacamund

9-23 — **School on Basic General Relativity and Cosmology**
at Mangalore University

DECEMBER

16-21 — **15th Meeting of the International Society on General Relativity and Gravitation (GR 15)**
at IUCAA

21 — **XIX Meeting of the Indian Association for General Relativity and Gravitation (IAGRG)**
at IUCAA

27 — **IUCAA-NCRA Graduate School**
First Semester ends

29 — **Foundation Day**

1998

JANUARY

12-26 — **Workshop on High Energy Particle Physics - 5 (WHEPP-5)**
at IUCAA

12 — **IUCAA-NCRA Graduate School**
Second Semester begins

* — **Workshop on Extragalactic Astronomy**
at University of Tezpur

FEBRUARY

2-6 — **Workshop on Stellar Structure and Evolution**
at IUCAA

28 — **National Science Day**

APRIL

April 13 - May 22 — **School Students' Summer Programme**

MAY

16 — **IUCAA-NCRA Graduate School**
Second Semester ends

May 18 - June 5 — **Introductory Summer School on Astronomy and Astrophysics**
at IUCAA

JUNE

June 1 - July 10 — **Vacation Students' Programme**

JULY

* — **Selection of Research Scholars**

** Dates to be finalised*

Welcome *to the* IUCAA *family*

IUCAA is happy to announce the selection of the **eighth** batch of its Associates and Senior Associates, who are selected for a tenure of *three years*, beginning July 1, 1997.

Associates

Moncy V. John
St. Thomas College, Kozencheri

G.P. Singh,
Visvesvaraya Regional College of Engineering, Nagpur

Santokh Singh
Deshbandhu College, University of Delhi

Senior Associates

Raj Bali
University of Rajasthan, Jaipur

Renuka Datta
Bethune College, Calcutta

* **Satya Sankar De**
University College of Science, Calcutta University

V.K. Gupta
University of Delhi

Ngangbam Ibohal
Manipur University, Imphal

Bhola Ishwar
B.R. Ambedkar Bihar University, Muzaffarpur

S.N. Karbelkar
College of Engineering and Technology, Akola

Manoranjan Khan
Jadavpur University

* **P.S. Naik**
Gulbarga University

* **V.M. Nandakumaran**
Cochin University of Science and Technology

* **Udit Narain**
Meerut College

* **Ramakrishna Reddy**
Sri Krishnadevaraya University, Anantapur

Asoke Kumar Sen
Assam University, Silchar

* **D.C. Srivastava**
University of Gorakhpur

* **S.K. Srivastava**
North Eastern Hill University, Shillong

* **P.C. Vinodkumar**
Sardar Patel University, Vallabh Vidyanagar

* *Appointments of these fifth batch of Associates and Senior Associates are extended for three years.*

Astronomical Telescopes

We have been remiss in missing out an important series of parsecstones on the observational front, namely the discovery and development of optical telescopes. The pioneer, of course, was Galileo Galilei who in 1609 first used a modified version of the telescope invented a few months earlier by Hans Lippershey in Holland. The potential of the telescope for astronomy was demonstrated by Galileo's discovery of the sunspots, lunar craters and the inner four satellites of Jupiter. After an initial mistrust of this new instrument (which was of a sociological origin), the telescopes gained in popularity amongst astronomers and instruments with bigger and better lenses came into operation. There was, however, the problem that because of dispersion of light through a glass lens there was chromatic aberration in the images produced, besides other problems like defects of focussing sharply.

For this reason, the refracting telescopes were gradually replaced by the reflecting types where a primary mirror, preferably paraboloidal in shape, performed a much better job than a lens. The prototype of the basic instrument was made by no less a person than Isaac Newton. This model was gradually improved upon and telescopes with bigger mirrors were made. The large telescope made by William Herschel in the late eighteenth century was of 48 inch diameter and had a forty foot long tube. In spite of this, the reflecting telescopes are more compact than the refracting ones and it is, of course, easier to prepare and maintain one surface (of a mirror) than two (of a lens). They come with various arrangements for focussing the images, such as Cassegrain, Coude, prime focus, etc.

By the second decade of the twentieth century, a large telescope with 100-inch diameter was constructed on Mount Wilson in Southern California. This telescope played a leading role in opening out the extragalactic world to the astronomers and in establishing the phenomenon of the expanding universe [see Parsecstone 14].

An even bigger telescope was in operation by 1949. It was the biggest working telescope in the world for nearly half a century, and it was located on Mount Palomar further south in California. Its primary mirror has a diameter of 200 inches (5 metres). Naturally this telescope played a major role in the studies of the large scale structure of the universe. The last three decades have seen the building of several telescopes in the 4-metre class.

We will return to the telescopes for a modern update in a later parsecstone.

Cosmology

1. HISTORICAL BACKGROUND

When did modern cosmology begin? Depending on the age of the person, the answer will be one of the following: 1917, 1929, 1965 or 1981. While these dates represent landmarks in the development of cosmology, the subject itself is much older. Indeed, one should go back to Isaac Newton, and his correspondence with Richard Bentley from December 10, 1692, to January 17, 1693 [See Whiteside, (1976)]. It is interesting to read Newton's attempts to construct the model of a homogeneous and isotropic but static universe and his realization that it is unstable. Later attempts before relativity came on the horizon were by Neumann (1896) and Seeliger (1895, 1896).

The advent of general relativity offered a possible resolution of the conflicts which were beginning to surface between the Newtonian law of gravitation and special relativity. For example, how can one have an instantaneous propagation of gravitational effects when special relativity required all physical interactions to follow the light speed limit? How can one arrive at an inertial frame so basic to special relativity when the universality of gravitational force did not allow a force-free environment. The classic Einstein paper (1917) has to be read with this background in mind.

Like Newton, Einstein also found that a static model was not permitted by his 1915 equations of relativity and introduced the so-called cosmological constant which implied (in the Newtonian approximation) a repulsive force that varied directly with distance. The static model that emerged required the universe to be closed. Einstein felt that the emergence of such a model was a demonstration of a unique and consistent relationship between spacetime geometry and the matter contents of the universe.

However, the paper by W. de Sitter (1917) which followed shortly, demonstrated that the model was not unique. De Sitter found a model universe which was empty but expanding. As we shall see later, this model has played a key role in cosmology on a number of later occasions.

In the second decade of this century, there was no systematic study of galaxies (see the Resource Summary-1 by S. Sridhar, Khagol, No. 30, 1997, pp-5), although observers like V.M. Slipher (1914) had reported nebular shifts, mostly redshifts, that indicated a radial motion of these nebulae. Thus, belief in a static universe was quite strong and de Sitter's solution was treated more as a curiosity. Indeed, a few years later the Russian physicist, A. Friedmann (1922, 1924), obtained models of the expanding universe for which the cosmological constant was not necessary; but these were also ignored by Einstein and others. Later Abbe Lemaitre (1927) and H.P.Robertson (1928) also obtained similar models independently.

It was the announcement of the velocity distance relation by E.P. Hubble (1929) that turned the tide in favour of these models. For, after a careful analysis of data on nebular redshifts Hubble arrived at what is today known as "Hubble's Law", namely that the radial velocity of a typical galaxy away from us is proportional to its distance from us. More exactly, the data show that the redshift of a galaxy increases with its faintness. If the redshift is interpreted as Doppler shift and faintness as due to distance, then Hubble's law follows. Although there might be other interpretations of the data, all cosmological models had to take cognizance of this basic fact about the universe.

Thus, soon after Hubble's law got accepted, Einstein and de Sitter (1932) jointly wrote a paper proposing what was really the simplest of the Friedmann models. Here one specifies the scale of the universe as a time dependent factor to be multiplied to the distance between any two galaxies. The Einstein- de Sitter model had the universe expanding with no cosmological constant and just enough energy to expand out to a state of infinite scale factor. In fact, at this stage Einstein abandoned the cosmological constant as the "greatest blunder" in his life. There were others, however, who thought otherwise and as we shall see, this constant continues to feature in cosmological literature even today.

In the 1930s, Milne and McCrea (1934) demonstrated how Newtonian ideas of gravitation and cosmology can be suitably adapted to give the standard models of relativity. For a discussion of Newtonian cosmology from a modern standpoint see Narlikar (1996).

We will conclude our historical narrative here and refer the reader, interested in knowing who did what and when in those early days, to the excellent source book by J.D. North (1965).

2. THE BIG BANG MODELS

The assumption of homogeneity and isotropy allows the cosmologist to define a "cosmic time". The spatial sections at a given cosmic time are supposed to be homogeneous and isotropic. The Friedmann models fall in three classes, depending on whether the spatial sections have zero, positive or negative curvature. Theorists use these models to work out the physical evolution of the universe and observers use them to test the theoretical predictions.

With the realization that the basic Friedmann models give an adequate description of the expanding universe, there have been many developments in cosmology in the last five decades, that are based on these models. These developments may broadly be divided into investigations of

(a) The large scale structure, through discrete sources,
(b) The history of the universe, through relics,
(c) The evolution of the universe from particles to galaxies,
(d) The basic physical laws operating in the extreme conditions a few moments after the big bang, and
(e) Alternative cosmologies.

We will briefly outline the developments in these fields. Whatever their differences, all the standard models share one common feature, viz., that they had an epoch in the past when the scale factor was zero. At this epoch, no normal description of the spacetime geometry and the operation of physical laws was possible as quantities specifying them either became zero or infinite. Such an epoch is called a singular epoch or the epoch of "big bang". We will return to this aspect of these models later.

3. OBSERVATIONS OF DISCRETE SOURCES

A relativistic cosmological model uses curved spacetime and as such there are effects of non-Euclidean geometries that may, in principle, be observable. This was the expectation which prompted optical and radio astronomers of the 1950s and 1960s to push their observing capabilities to the limit. By observing the distributions of discrete source populations (galaxies, quasars, radio sources, X-ray sources, etc.) the cosmologist hoped to find which of the various theoretical models came closest to reality.

The benefit of this attitude was that observing techniques improved considerably and today the most challenging areas of observation are in extragalactic astronomy. The disappointment was that the early expectations of distinguishing between different world models based on their different geometries, were not realized. This was because the inherent uncertainties of observations themselves, and the possible evolutionary changes in the sources mask any geometrical differences in the models.

The observations include (i) the measurement of Hubble's constant, (ii) the extension of Hubble's law to galaxies of large redshifts, (iii) the counts of galaxies and radio sources out to larger and larger distances, (iv) the angular diameter redshift relation, and (v) the relationship of surface brightness of a galaxy to its redshift. For details of these cosmological tests see recent textbooks and review articles, e.g. Sandage (1988), Hartwick and Schade (1990), Branch and Tammann (1992), Narlikar (1993).

As mentioned before, the trend of such studies has shifted from determining the geometry of the universe to determining how the discrete sources evolve. These studies are expected to tell us about the evolution of the physical environment of the universe, but so far no clear picture has emerged amidst a series of parameter fitting exercises. The reader may catch a flavour of this field from the IAU Symposium in cosmology of 1986 [see Hewitt, et al, 1987].

A key measurement that continues to be controversial is that of Hubble's constant. Hubble originally obtained the value of 530 km/sec/Mpc, but in retrospect, we find that there were several systematic errors in his measurements. Even today there are calibration problems related to the extragalactic distance scale, as well as the mixing of random motion with the motion of expansion for the typical galaxy. So both the velocity and distance measurements involve corrections whose nature and extent remain controversial. Although the gap has narrowed, the present value of Hubble's constant is about 55-75 km/s/Mpc. For a recent review of measurements, including those by the Hubble Space Telescope see Kennicutt Jr (1996) and Hoyle, et al (1997).

4. RELICS OF THE EARLY UNIVERSE

The big bang concept hinges on the fact that at a time $t = 0$, the universe came into existence and physical theories can examine its subsequent behaviour. One of the early attempts to go close to the big bang epoch was made in the late 1940s by George Gamow, who showed that the early universe was "radiation dominated", that is, its contents were made up of photons and other particles which were mostly relativistic in their energies. Thus, one could approximate the equation of state by pressure = 1/3 energy density, both being dependant on temperature as its fourth power, as for a gas in a thermal equilibrium. Gamow and his collaborators [see, for example,Gamow (1946), Alpher and Hermann (1948) and Alpher, Bethe and Gamow (1948), the last work being called the "alpha-beta-gamma" theory!] worked out the physics of the universe when it was around 1-200 seconds old.

Gamow had hoped to demonstrate that in the high temperatures prevailing in this era, particles like neutron and proton would be synthesized into heavier nuclei, thereby determining the chemical composition of the universe. In the end, this work was partly successful in that light nuclei like deuterium, helium, etc. could be made in the primordial soup, but not the heavier ones like carbon, oxygen and metals. Later it became clear from the important work of Burbidge, Burbidge, Fowler and Hoyle [referred to as the "B-square-F-H" work] that these nuclei are made in stars. Nevertheless, the abundances of light nuclei worked out according to the modern version of Gamow's pioneering attempt, show a broad agreement with the observed ones. For a pedagogical account of this work see Wagoner (1979).

A further check on the early hot universe scenario was the discovery of the cosmic microwave background by Penzias and Wilson (1965). Although the discoverers had been unaware of these results, Gamow and his colleagues had predicted such a background as the relic of the early era. (See, for example the paper by Alpher and Hermann (1948), cited above.) A modern textbook in cosmology describes the current status of these observations, in particular the spectacular achievements of the COBE satellite in measuring the spectrum and small scale anisotropy of the microwave background [see for example, Narlikar (1993)].

The microwave background, its spectrum and anisotropy have provided strong prima facie support as well as strong constraints on theories of structure formation in the universe. These issues are extensively debated these days: see, for example, a review by White, Scott and Silk (1994) and in a book by Padmanabhan (1993).

5. THE EVOLUTION OF THE UNIVERSE

As indicated above, there is a major industry in cosmology today whose aim is to demonstrate that in the standard big bang model, nucleons and leptons evolved out of more primordial particles and from them eventually the large scale structures in the universe formed. The former process involves the frontier of particle physics and cosmology and will be discussed in the next section. The latter idea is based on evolving tiny fluctuations in the spacetime metric and density in the expanding universe to match the observed large scale structure. Of particular interest in this work is the role of the inflationary phase first discussed by A. Guth (1981), K. Sato (1981) and D.Kazanas(1980). The basic idea is that, at the early epoch when the universe was hot and energetic enough to have the grand unification of basic interaction, the matter in it passed through a phase transition and the resulting switchover from the original vacuum to a new vacuum generated a cosmological constant that in turn made the universe expand in the de Sitter mode. Here was the old cosmological constant of Einstein resurfacing in a stronger form, stronger by some 108 orders of magnitude!

Apart from the original papers, there is extensive literature on inflation. For astronomers, the article by Narlikar and Padmanabhan (1991) will be particularly useful as it stresses the astronomical rather than the particle physics aspects.

The structure formation relies on initial fluctuations as they evolve through inflation and then as they grow further, their gravitational interaction becomes important not only with the visible matter but also with dark matter. In particular, the results are sensitive to the type of dark matter, cold or hot or a mixture of both. A review of structure formation is found in books by Padmanabhan (1993) and Peebles (1993), while for dark matter see a review by Trimble (1987).

6. ASTROPARTICLE PHYSICS

The big bang cosmology came into prominence at a time when the particle physicists were exploring the possibilities of attaining their holy grail of unification. The particle theories suggest that the energy needed for a grand unification of all physical interactions except gravity, would be in the range of ten million billion GeV. No man made accelerator could be expected to energize particles to that kind of energy and so these theories would have remained mere speculations but for the hot big bang.

The big bang cosmologists also need new ideas from particle physics, such as inflation, non-baryonic dark matter, strings, etc. to provide insights into the formation of large scale structures. For this reason, the field of "astroparticle physics" is gaining prominence amongst theorists. Although conferences in this area are many, the reader may find the proceedings of the Vatican Conference (Bruch, et al., 1982) particularly illuminating. Also worth reading is Weinberg's (1989) review of the status of the cosmological constant.

A conventional physicist may object to astroparticle physics in the big bang model on the grounds that (a) it describes operation of physics that occured only once, i.e., its repeatability has not been tested, (b) there are no directly observable consequences of the GUT epoch, and (c) the theoretical extrapolation of observable physics to GUT energies is by over 12 orders of magnitudes, which is unprecedented. The sole justification for this subject is in predicting relics that clearly indicate its stamp.

Somewhat apart from these discussions, there is a select band of people working in quantum gravity and cosmology which relates to an even earlier era of the universe, when the particle energies were three to four orders of magnitude above the GUT energy. One possible outcome of this work could decide whether the spacetime singularity is avoided in quantum cosmology. For references see Isham, et al. (1981) and Narlikar and Padmanabhan (1983).

7. ALTERNATIVE COSMOLOGIES

From time to time there have been alternatives proposed to the big bang cosmology, although the majority has always believed in the validity of the latter. In 1948, the steady state theory of H. Bondi, T. Gold and F. Hoyle livened up the cosmological scenario by offering a clearly testable alternative. This cosmology had the spacetime geometry described by the model proposed by de Sitter in 1917, although the physical rationale was different.The discovery of the microwave background in 1965 robbed the theory of much of its credibility. Other major initiatives in the field were the Brans-Dicke cosmology proposed by C. Brans and R.H. Dicke in 1961 as a theory with its origins in the Mach's principle and the cosmology proposed by P.A.M. Dirac in 1973 based on attempts to explain the very large dimensionless numbers that appear in cosmology and microphysics. For details of several alternative cosmologies see Narlikar (1993).

Lately, the steady state theory is attempting to stage a comeback in the modified form called the Quasi-Steady State Cosmology (QSSC), proposed in 1993 by Hoyle, Burbidge and Narlikar. For a review of this theory see Hoyle, et al. (1996).

As the observational details about the universe become more and more focussed, the big bang cosmology gets more and more constrained. As discussed by Bagla, et al. (1996) the room for maneuver for the standard model has disappeared and for survival it may be necessary to reinvoke the cosmological constant at this epoch. If the origin of this constant is in the very early universe, then we face the problem of understanding why only a very tiny fraction of the original cosmological constant (smaller by about 108 orders of magnitude) survived (Weinberg, 1989).

Such a cosmological constant can prolong the age of the universe and make it large enough to accommodate the globular clusters which are at least 15 billion years old. The age problem can be solved in the QSSC which has the universe without a beginning.

8. CONCLUSION

In the last analysis, what cosmological theory survives would depend on how the observational challenges are met. Unlike the situation at the start of this century, when there were hardly any cosmological parameters to constrain the theory, we now suffer from the embarrassment of riches. Let the fittest theory survive.

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Level 1 Workshop on

Astronomical Photometry

at IUCAA, Pune (September 29 - October 3, 1997)

A workshop on **Astronomical Photometry** will be held at IUCAA during September 29 - October 3, 1997. The workshop will focus on the light pollution of the night sky and elementary astronomical photometry. The participants of the workshop will make a photometer to observe the brightness of the night sky and stars using small telescopes developed in IUCAA's Instrumentation Laboratory.

Participation to this workshop is limited to 18. Limited funding for travel is available and local hospitality will be provided to all the participants. The participants should be prepared to work for extra hours in the Electronics Laboratory to build their own photometers and to take observations in the night.

Interested persons may apply to the **Coordinator, Core Programmes** (e-mail: vch@iucaa.ernet.in) at IUCAA **before August 8, 1997**, and preferably provide a breif bio-data and a note (not exceeding 500 words) about what they understand by light pollution, astronomical photometry and how they wish to use the photometer.

School on

Basic General Relativity and Cosmology

at Mangalore University (November 9-23, 1997)

A school on **Basic General Relativity and Cosmology** will be held at the Department of Physics, Mangalore University during November 9-23, 1997. The broad topics to be covered are: *Manifolds and Differential Geometry, Basic General Relativity and Cosmology, and Black Holes*. This school is open to the first/second year students of Ph.D. programme of universities and research institutes, who are pursuing research in General Relativity, Cosmology and Astroparticle Physics. Those intending to participate in the school may send in their application giving their complete bio-data and a small write-up on what they are presently doing, along with two letters of recommendations from their professors, one being from their research supervisor. The application should be addressed to the **Director of the School: A.R. Prasanna,** Chairman, Theory Division, Physical Research Laboratory, Ahmedabad 380 009, Gujarat (e-mail: prasanna@prl.ernet.in) and a copy to **P. Karat,** Department of Physics, Mangalore University, Mangalagangotri, Mangalore 574 199, Karnataka.

The last date to receive the application is **August 31, 1997.** The selected candidates will be informed by **October 1, 1997**.

Workshopl on

Introductory Astronomy and Astrophysics

at Alipurduar College, Alipurduar Court, West Bengal (November 4-8, 1997)

A workshop on **Introductory Astronomy and Astrophysics** will be held at Alipurduar College, during **November 4-8, 1997**. Interested persons may contact the Principal, Alipurduar College, Alipurduar Court 736 122, Jalpaiguri, West Bengal (Phone : 03564 - 55045).

IUCAA Preprints

Listed below are the IUCAA preprints released during April - June 1997. These can be obtained from the Librarian, IUCAA (**library@iucaa.ernet.in**).

Somak Raychaudhary, Kaspar von Braun, Gary M. Bernstein and P. Guhathakurta, *Tests of the Tully-Fisher relation II: Scatter using optical rotation curves*, IUCAA-23/97; **Shiv K. Sethi** and **Biman B. Nath**, *On the source of ionization of the intergalactic medium at z ~ 2.4*, IUCAA-24/97; **A. Mahabal, A.K. Kembhavi** and P. McCarthy, *Hosts of low redshift southern radio galaxies from the MRC*, IUCAA-25/97; **Sukanta Bose**, *Solving the graceful exit problem in superstring theory*, IUCAA-26/97; **S.K. Banerjee** and **J.V. Narlikar**, *Quasi-steady state cosmology: A problem of stability*, IUCAA-27/97; **S. Sridhar** and J. Touma, *Three dimensional, axisymmetric cusps without chaos*, IUCAA-28/97; S. Chakraborty and N. Chakravarty, *Study of Kantowski-Sachs model in Ashtekar variables*, IUCAA-29/97; **T. Padmanabhan** and **Sunu Engineer**, *Nonlinear gravitational clustering: Dreams of a paradigm*, IUCAA-30/97; **N. Dadhich** and K. Narayan, *On the third law of blackhole dynamics*, IUCAA-31/97; **N. Dadhich** and K. Narayan, *An ansatz for spacetimes of zero gravitational mass: Global monopoles and textures*, IUCAA-32/97; **N. Dadhich**, *On the Schwarzschild field*, IUCAA-33/97; **Ranjeev Misra** and **A.K. Kembhavi,** *Broadening of the iron emission line in MCG-6-30-15 by comptonization*, IUCAA-34/97; **Sayan Kar** and **Sukanta Bose,** *Exact solutions in two-dimensional string cosmology with back-reaction*, IUCAA-35/97; **Sayan Kar,** *A note on the Einstein equation in string theory*, IUCAA-36/97; **N. Dadhich,** *On "minimally curved spacetimes" in general relativity*, IUCAA-37/97; Yu. V. Shtanov, *Origin of quantum randomness in the pilot wave quantum mechanics*, IUCAA-38/97; **N. Dadhich,** *Black hole : Equipartition of matter and potential energy*, IUCAA-39/95; **N. Dadhich,** *Inhomogeneous imperfect fluid spherical models without Big-Bang singularity*, IUCAA-40/97; A. Banerjee, *Domain walls in Brans-Dicke theory*, IUCAA-41/97; Udit Narain and R.K. Sharma, *Nonlinear viscous damping of surface Alfven waves in polar coronal holes*, IUCAA-42/97; Yu. V. Shtanov, *Spacetime description of neutrino flavour oscillations*, IUCAA-43/97; **Sukanta Bose** and Daksh Lohiya, *Behaviour of quasilocal mass under conformal transformations*, IUCAA-44/97; **Ranjeev Misra**, V.R. Chitnis and Fulvio Melia, *A fit to the simultaneous broad band spectrum of Cygnus X-1 using the transition disk model*, IUCAA-45/97; and Asim K. Ray and Saswati Sarkar, *Almost degenerate neutrinos in a left-right symmetric model with discrete symmetries*, IUCAA-46/97.

PEP Talks

17.4.97 K. Bhaskar *on* Discovering strange attractors using experimental data; 23.4.97 P. Saha *on* Frobnication, universal grammars, and the "Pela Bilong Missus Kwin": A review of "The Language Instinct" by Pinkar; and 2.5.97 S. Sridhar *on* Flow through pipe.

Seminars

3.4.97 R.G. Vishwakarma *on* Some Robertson-Walker models with constant active gravitational mass; 4.4.97 Bruno Guiderdoni *on* The cosmic infrared background and ISO deep counts; 22.4.97 Prasenjit Saha *on* Can lensed QSOs really tell us Ho?; 18.6.97 Debojyoti Dutta *on* Think parallel, think now; 20.6.97 Niranjan Sambhus *on* Optical morphology of radio galaxies; 25.6.97 R.P. Saxena *on* Duality and cosmological compactification of superstring; and 26.6.97 Yuri Shtanov *on* Preheating after inflation.

Extramural Talk

18.6.97 Anupam Mishra *on* Traditional water sources and their relevance today.

Talks during Visits Abroad

Ranjan Gupta: *Artificial neural networks as a pattern recognition tool in astronomy,* Institute of Physics and Mathematics, Tehran, Iran, April 23.

T. Padmanabhan: *Nonlinear gravitational clustering*, Caltech, USA, April 16 and *Inflation and the generation of density perturbations*, Caltech, USA, May 28.

School Students' Summer Programme

Like previous years, the School Students' Summer Programme was very successful with an unprecedented response from local schools. About 140 students completed their week-long project at IUCAA under the guidance of the academic members. The students were from about 70 local schools in Pune. Each school had nominated two students of eight/ninth standard. The programme was spread over six consecutive weeks starting from April 14, 1997. Students performed experiments/observations, made astronomical models, attended informal lectures and discussions and were given reading assignments in the library. Some of the projects undertaken by these students were on the Foucault's pendulum, the Sun dial, Sun spots and the determination of the rotation period of sun, the solar system, construction of the periscope and kaleidoscope, etc. Instructions were given in Marathi and Hindi as well as in English.

Workshop on Astrophysical Spectroscopy

An IUCAA-sponsored workshop on Astrophysical Spectroscopy was held at Sri Krishnadevaraya University, Anantapur during February 12-14, 1997. P.R. Naidu, Vice-Chancellor, Sri Krishnadevaraya University inaugurated the workshop and N. Kameswara Rao, IIA gave the key note address. Some of the other main lecturers were Sunetra Giridhar, K.R. Subramanian, S.P. Bagare (all from IIA), S.N. Tandon and Ranjan Gupta (IUCAA), J.N. Desai (PRL), D.B. Vaidya (Gujarat College). A sky-watch programme was arranged in the night on February 13. T.V. Ramakrishna Rao and R. Ramakrishna Reddy from Sri Krishnadevaraya University were the conveners and Ranjan Gupta was the coordinator from IUCAA.

Minischool on

Introductory Astronomy and Use of Computers

at St. Thomas College, Kozencheri, Kerala
(September 12-13, 1997)

A minischool on **Introductory Astronomy and Use of Computers** will be held at St. Thomas College, Kozencheri during September 12-13, 1997. Interested persons should contact **Sajith Philip / Moncy John**, St. Thomas College, Kozencheri 689 641, Kerala .

Workshop on

Modern Trends in Gravitation and Cosmology

at Cochin University of Science and Technology
(September 29 - October 3, 1997)

A workshop on **Modern Trends in Gravitation and Cosmology** will be held at Cochin University of Science and Technology during September 29 - October 3, 1997. Interested persons should contact **V.C. Kuriakose,** Physics Department, Cochin University of Science and Technology, Cochin 682 022, Kerala.

TIFR-IUCAA School on

Cosmic Ray Astronomy

at Ootacamund
(November 3-14, 1997)

A TIFR-IUCAA school on **Cosmic Ray Astronomy** will be held at Ootacamund during November 3-14, 1997. Interested persons should contact **P.N. Bhat**, Tata Institute of Fundamental Research, Homi Bhabha Road, Mumbai 400 005.

UPDATE

The IUCAA Telescope Project

The work on the detailed designing of the telescope is progressing at the RGO (UK) and it is expected to be completed soon. The mirrors of the Cassegrain optics have been ordered by them, and the mechanical interfaces which are necessary for the design of the building and the focal plane instruments have been specified.

Proposals have been submitted, in collaboration with CSIO, Chandigarh, to the CSIR and DST requesting funding for the Imager Spectrograph. Another proposal has been submitted to the DST requesting funding for the Near IR Imager.

Visitors

April - June 1997

B. Guiderdoni, V. Chitnis, P.S. Wamane, G.P. Pimpale, P.S. Naik, B. Sannakki, Prasenjit Saha, S.B. Roy, R. Nityananda, G. Yellaiah, J.N. Islam, D. Dutta, S.S. Aundhkar, D. Duari, T. Subba Rao, A. Mahabal, S. Vaishampayan, A.K. Rath, A.K. Ray, R. Jotania, C.A. Safeeque, V. Krishnakumar, S.K. Natarajan, M.S. Desai, H.C. Chandola, G. Varghese, Nagalakshmi Rao, M.P. Mahabole, B. Lakshmiprabha, S.J. Devasagayam, R.S. Singh, P. Subramanian, R.P. Bhatt, R.J. Topare, K. Revathy, Sajith Philip, Moncy John, K. Yugindro Singh, A. Balasubramanian, R.M. More, S.G. Ghosh, G.P. Singh, A.N. Jadhav,, N.M. Badiger, L. Yadav, S.N. Desai, R.P. Singh, M.K. Gokhroo, L.K. Patel, Hemant Patel, A. Banerji, S.N. Paul, B. Chakraborty, R. Bhattacharya, D. Lohiya, R. Tikekar, M. Sethi, S. Gahlaut, S.R. Prabhakaran Nayar, Snigdha Das, C. Sur, P. Khare, R.P. Deo, D. Thatte, A. Deshpande, S.K. Shukla, D. Dhaygude, I. Chakraborty, U. Narain, P. Agrawal, Rakesh Kumar Sharma, Sushil Kumar, J. Touma, A. Borkakati, E. Barua, M.R. Sukumaran Nair, Aiyappan Pillai, S. Sathyadas, V. Sreekumar, S. Nadkarni, S.R. Ramasubramaniyan, K. Narayan, P.C. Vinodkumar, N. Gaur, M.K. Patil, G.K. Goswami, R.P. Saxena, M.R.H. Khajehpour, P. Dasgupta, N. Banerjee, S. Mukherjee, T.P. Prabhu, P.C. Agrawal, Anupam Mishra.

Visitors

Expected

K. Freeman, R. Ellis, K. Sato, D.P. Datta, G. Ambika, D.B. Vaidya, P. Khare, R. Cowsik, S.K. Pandey, G. Srinivasan, S.M. Alladin, K.S.V.S. Narasimhan, K. Jotania, Y. Sobouti, P. Warlow, A. Khopkar, S. Bradini, A. Chitre, B.S. Agrawal, V.H. Doddamani, R. Nityananda, S. Ganesh, R.S. Singh, D. Syer, P. Thakur and S.M. Wagh.

On Tigers and Theoreticians

Chip Arp, a distinguished observer was describing at a meeting of astronomers, his data on quasars, found in proximity to galaxies. As the data did not conform with the conventional picture of an expanding universe, theoreticians produced calculations to show that what he was finding were not cases of real proximity but mere chance projection effects. Exasperated by their failure to see what was obvious to him, Chip told the following story:

Two astronomers one, an observer and the other a theorist, were going through a jungle when the observer suddenly shouted: *"Run for cover! There is a sabre-toothed tiger over there."* He pointed in the relevant direction and climbed a tree.

The theorist was unmoved. He said: *"Oh, what you see is a chance fluctuation of light and shadows: there is no real tiger out there."*

Seconds later he was eaten up.

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

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