KHAGOL खगोल

IUCAA

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Contents

National Science Day

28 February 1997

A Science Festival for high school students in the morning. An Open House for the general public with an exhibition, along with lectures, screening of documentaries on video and skywatching in the afternoon and evening. This is how the National Science Day was celebrated at IUCAA on February 28, 1997.

The Science Festival for Schools

Over five hundred students and science teachers attended the Science Festival. There were three competitive events for the students: one for artists, one for writing essays, and another, a team event, for scientific proficiency and knowledge. Prizes were given in each category (books for individual students, rolling trophies for their schools). The school with the best overall performance was awarded the N.C. Rana Memorial Trophy, which was introduced this year, in memory of our deceased colleague who was indeed sorely missed on this day.

In the first round of the Science Quiz Contest, seventy teams (each comprising of four students representing their school) attempted to answer questions in physics, astronomy, mathematics, chemistry and biology.

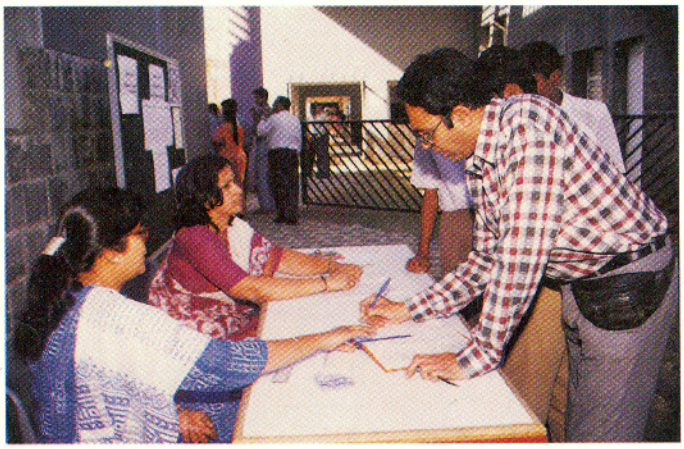
During the day, visitors observed the Sun using telescopes. (Note that the Sun should never be looked at through a telescope). After sundown, our members and volunteers helped hundreds of visitors look at the night sky.

Students got the opportunity to talk to the scientists who were present, including Professor Yashpal.

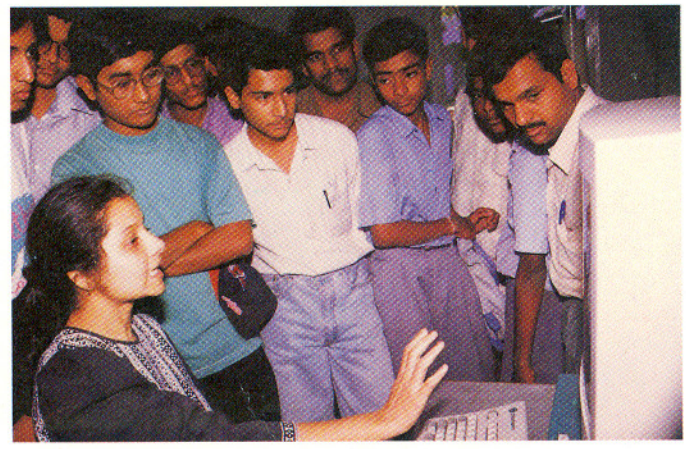
Academic members of IUCAA presented exciting new results in Physics and Astrophysics to visitors as part of the Open Day activities.

One representative from each school competed for the Drawing prize. They were invited to draw in pencil either how they imagined *A View from a spaceship* would be, or their impressions of *Violent phenomena in the universe*. First and second prizes were awarded to Abhishek Kulkarni (Sardar Dastur Boys High School) and Shahid Shaikh (S.V. Union High School). Another student from each school participated in the Science Essay competition. They had to write, either in English or in Marathi, about either the *Scientist who inspires them most*, or on whether *Science should remain a compulsory subject in High School*. They were also given the choice to fantasise about what it would be like if Gravity did not exist, or if Dinosaurs were alive today. First and second prizes were awarded to Manasi Kakatkar (Muktangan English School) and Ameya S. Gujar (Loyola High School) in the English Essay category and to Hemangi S. Modak (N.M.V. Girls' High School) and Amit V. Thombare (Sheth Jyotiprasad Vidyalaya, Daund) in the Marathi Essay Category.

Seventy schools participated in the first round of the Science Quiz Contest, each school being represented by a team of four students. In the first round, they were given 40 minutes to attempt to answer 25 multiple-choice questions in physics, astronomy, mathematics, chemistry and biology. Of these, seven teams were selected for the final stage, which was conducted in a full Chandrasekhar Auditorium. The finals were convincingly won by M.E.S. Bal Shikshan Mandir, who also won the N.C. Rana Memorial Trophy for the best overall performance in all the events of the day. Prizes were also awarded



Over two thousand visitors attended the Open Day activities at IUCAA in four hours.



Visitors took an active interest in the Internet and the Worldwide Web, and were treated to stunning images from our Astronomical Data Centre.

to Vidya Bhavan High School and St. Vincent High School for ranking second and third respectively. J.V. Narlikar gave away the prizes.

A principal attraction among the day's activities was an hour-long presentation by the *Andhasradhdha Nirmoolan Samiti* (an organisation dedicated to eradicating superstition), who showed simple chemical ways of performing many apparent miracles that some so-called godmen perform.

The Open Day

IUCAA was open to members of the general public for four hours on the afternoon of the 28th. The open day activities, in addition to a general tour of the Centre buildings, consisted of an exhibition to highlight the interests of the academic members of the Centre, demonstration of the instrumentation and computing facilities, slide shows and lectures, video screenings, and the viewing of the Sun and of the night sky using telescopes.

The exhibition consisted mostly of posters prepared by the academic staff and students presenting different aspects of research in IUCAA. In addition, there were posters representing recent important research in other areas of physics. Also shown (courtesy of the library staff) were some aspects of C.V. Raman's research, which forms the basis of the National Science Day celebrations. Visitors could address their queries to the authors of the posters, many of whom were present in the exhibition area.

Exhibits set up by the Instrumentation Laboratory included a CCD camera, a seeing monitor and a demonstration of networking. Staff of the Computer Centre demonstrated the capabilities of the Internet, and the facilities of the Astronomical Data Centre. Image processing and results of astrophysical simulations were also demonstrated on screen.

Short half-hour lectures on various astronomical topics, accompanied by slides, were given by various academic members and visitors. These were very well attended and discussions with the lecturers often went on for hours outside the lecture hall.

Assisted by volunteers of the local amateur astronomers' association (*Jyotirvidya Parisanstha*), skywatching with telescopes was arranged. During the afternoon, visitors could view sunspots with the help of several telescopes varying in aperture between 7 and 20 cm. After dark, a queue of visitors waited in patience to get the opportunity of viewing nebulae and clusters through several telescopes placed in the Aditi complex of IUCAA.

More than two thousand visitors attended various activities during this period.

Dear Reader,

Sometime back we conducted a reader response survey regarding the features in Khagol. We received several suggestions regarding possible new features in Khagol and we have decided to incorporate some of the suggestions starting from this issue.

In this issue, you will find a **Resource Summary** on **Galaxies: their Structure and Dynamics** by *S. Sridhar* which we hope will be useful. We plan to run Resource Summary in other topics in Astronomy and Astrophysics in the coming issues. We welcome your suggestions on all aspects of this new feature and especially, suggestions for possible topics in which Resource Summary may be useful.

- Editor

The Steady State Theory

While the newly born science of cosmology was enjoying a fairly quiet progress in the aftermath of Hubble's discovery and the theoretical models of the expanding universe, the situation was enlivened in 1948, by the appearance of a radical new theory of the universe. Known as the steady state cosmology (SSC) the theory was proposed by three British astrophysicists, Hermann Bondi, Thomas Gold and Fred Hoyle.

The approach to the theory was from two different angles, however. Bondi & Gold argued that for testing a model universe on a large scale, one is necessarily assuming that the laws of physics used in the interpretation of observations must be the same at all points in spacetime. As the universe, encompasses everything, it also includes the laws of physics. As such, in an evolving universe, like the big bang models, one cannot guarantee that the basic physics has all along remained the same. Hence, such models are basically untestable and therefore not scientific. A testable cosmology that guarantees that the laws of physics here and now are the same as in a distant galaxy observed at earlier epoch is one in which the universe does not change in time as well as space. That is, the universe must be in a steady state. This principle they named, the perfect cosmological principle.

Hoyle's approach, was more physical than philosophical and it concentrated on the most obvious observable feature of the universe, namely the existence of matter in it. How did it come about? In the big bang cosmology, it arises in a singular event and as such lies beyond the scope of physics. Hoyle looked for a field theory, involving a scalar field which not only produced matter, but also led to the expansion of the universe. The simplest solutions of his equations, which were the same as those of relativity but with the addition of the scalar field, produced the same steady state model that Bondi and Gold obtained from their perfect cosmological principle.

Has the universe always remained more or less in the same state, or has it evolved through a series of very different states? The opposite conclusions of the steady state theory and the big bang theory prompted astronomers to make observations of the distant parts of the universe as carefully as possible. The 1950s and the 1960s therefore saw a lively debate between the two theories with the healthy fallout that the knowledge of the extragalactic universe improved considerably. We will encounter examples of this in later parsecstones.

M.P. BIRLA MEMORIAL AWARD 1997

The Birla Institute of Astronomy and Planetarium Sciences, 96, Jawaharlal Nehru Road, Calcutta 700071, invites NOMINATIONS from Vice-Chancellors / Deans / Directors of universities, institutes of technology, national laboratories, observatories, other scientific institutions, distinguished astronomers and scientists for the above Award. The Nominee should be Indian national having eminent record of research in Astronomy, Astrophysics, Space Science or a related area. The nomination should be accompanied by a summary of the qualifications and research achievements of the individual. The Award comprises a citation and Rs.1 lakh in cash. Nominations should be sent to the above address by May 31, 1997.

Galaxies: their Structure and Dynamics

1. INTRODUCTION

"What are galaxies? No one knew before 1900. Very few people knew in 1920. All astronomers knew after 1924...", so begins *The Hubble Atlas of Galaxies* (Sandage 1961) which illustrates Hubble's (1926) pioneering classification of galaxies, based on the *structural forms of nebulae*, and subsequent revisions, through photographs of 176 galaxies. Sandage further observes that galaxies are to astronomy what atoms are to physics. Before we get to the photographs, we are given a brief lesson in the history, as well as the classification scheme devised by Hubble. This, and the much larger, two volume *The Carnegie Atlas of Galaxies* (Sandage and Bedke 1994) is well worth at least a browse, to acquaint ourselves with the diversity of forms the beasts can assume, at least in the optical bands.

Most galaxies are either ellipticals, or discs. The former are round, apparently featureless objects, and get their names from the shapes of their isophotes. Most disc galaxies, on the other hand, have spectacular spiral features, and some of them have bars. And there are galaxies so ungainly that they can only be called irregular, or even peculiar. The amount of gas and dust varies, with little in ellipticals, to substantial amounts in irregulars. Above all, galaxies are the largest single aggregates of stars in the universe, and our Galaxy (the Milky Way) is an average spiral galaxy.

2. SOME BASIC PHYSICS OF STELLAR SYSTEMS

Almost all that one needs to acquire a broad perspective of the structure and dynamics of galaxies is available in the textbook, *Galactic Dynamics* by Binney and Tremaine (1987); hereafter referred to as BT. I will try to provide a sketch, taking the opportunity to refer to other sources as well. Galaxies are stellar systems with more than 10^{10} stars, whose motions are influenced by their mutual gravitational attraction (galactic dynamicists quickly get used to including *dark matter*, just like prospective real-estate investors in our country adjust to the concept of black money). For many purposes, gas and dust may be ignored, or included as a perturbation. It is useful to approximate a galaxy as a large N system of point particles interacting via Newtonian gravity. Where the physics differs from most situations is in the long-range nature of gravity; quantities like energy are no longer extensive, so the usual routes via thermodynamics, or statistical mechanics are of limited use. In the mean field limit, an isothermal system is a configuration of infinite mass and energy. Bounding it by a spherical box does not really help: Antonov (1962a) showed that the entropy does not even have a local maximum, if the radius of the box is sufficiently large. See also Lynden-Bell and Wood (1968) and Padmanabhan (1990) for more on isothermal spheres, and the gravitational catastrophe that drives the unstable isothermal sphere to a *core-halo* configuration. In fact, this is generic to any stellar system: given sufficient time for deviations from the mean field (*two-body collisions*, or gravitational encounters between stars) to be effective, the system evolves to a core-halo state, where the central core progressively shrinks, transfering energy to an ever expanding halo of stars that escape to infinity; a nice argument, given in § 4.7.1 of BT shows why the entropy increases without bound. Thus there is no true thermal equilibrium for stellar systems! The escape from this situation is that, for a large N stellar system, the fluctuating deviations from the mean field, take a very long time (more than the age of the universe!) to be effective. Chandrasekhar (1943a) is a classic review of his work on the nature of collisions in stellar systems, set in the context of fluctuations in other areas of physics. One of his most famous contributions to stellar dynamics is the *dynamical friction* (c.f. Chandrasekhar 1943b and chapter 7 of BT), that is felt by a massive object, as it moves through a stellar system; the friction coefficient he derived remains a useful approximation, even when applied to the decay of globular cluster orbits, or the orbits of galaxies themselves inside clusters of galaxies.

Fluctuations, and dissipation (i.e. dynamical friction) are two sides of a coin, a fact that is encoded in the "collision terms" of the Fokker-Planck equation describing both stellar systems and high temperature plasmas. This equation describes the time evolution of a distribution function (DF) in a six dimensional phase space. Indeed the most elegant derivation of the collision term is that due to Landau, given in Lifshitz and Pitaevski (1981; see also Padmanabhan 1990). The two fields, galactic dynamics and plasma physics, share a great deal in basic formulation, and technique. But there is a fundamental physical difference: the electrostatic interactions in plasmas are both attractive as well as replusive, so a charge is effectively dressed in a cloud of opposite charges, which curtails the range of its force to about a Debye length. Gravitational interactions are always attractive, and there is no shielding. Plasmas of sizes larger than the Debye radius are effectively homogeneous, whereas stellar systems are inside their "Debye radius". Globular clusters, with about 10^6 stars evolve slowly due to gravitational collisions, so the Fokker-Planck description of their secular evolution is particularly appropriate (c.f. chapter 8 of BT). Spitzer (1987) is a slim, self contained book devoted to the dynamical evolution of globular clusters, and IAU Symposium No. 113 (Goodman and Hut 1985), as well as the recent review by Meylan and Heggie (1997) are also recommended.

Galaxies are almost completely collisionless systems. The orbits of stars in the self-consistent, mean gravitational field assume a fundamental role as building blocks of stellar systems. Being collisionless frees us from demanding a unique steady

state. Indeed, there is an infinity of steady states, spherical, axisymmetric, even triaxial, all described by DFs which are functions of the six phase space coordinates (BT, chapter 4). Their stability, however, is a very difficult problem, with general results available for only the simplest DFs (BT, chapter 5) — those which are functions only of single particle energies. Again the first results are due to Antonov (1960, 1962b), later sharpened into the Doremus—Feix—Baumann theorem, which can be stated simply: any spherical stellar system with a DF that depends only on single particle energy is stable if it is a decreasing function of this energy. IAU Symposium No. 100 (Athanassoula 1983) gives a broad view of the dynamics of galaxies; of course, it is somewhat dated now, but remains a good marker.

3. DISC GALAXIES

Our address in the universe was arrived at only this century, when Shapely located the geometric centre of the globular cluster system of our Galaxy. Lindblad and Oort discovered the differential rotation of the Galaxy, and slowly the Milky Way acquired a bulge, stellar halo, a dark halo and, recently, firm evidence for a bar. Galactic Structure (ed. Blaauw and Schmidt 1965) is a classic collection of articles by the pioneers themselves. IAU Symposium Nos. 106 (van Woerden et. al. 1985) and 169 (Blitz and Teuben 1996) are very good indicators of our appreciation of our Galaxy, in the early 80s and 90s, respectively. There is a strong correlation between the ages, metallicities (in astronomy, "metal" refers to any element heavier than helium) and kinematics of stars in the Milky Way; younger stars, with more metals are confined to near-circular orbits in the disc, whereas older stars, with lower metallicities, are found on orbits with great eccentricities and vertical motion. Based on this segregation, Eggen, Lynden-Bell and Sandage (1962) theorised that the Galaxy formed from a rapid, dissipational collapse of an extended, protogalactic gas cloud. More recent theories suggest that the collapse could have been stochastic (Searle and Zinn 1978), but the broad picture holds.

Lindblad's idea that the spiral structure of discs could be density waves (rather like sound waves, only with differential rotation and gravity thrown in), and major developments since the mid 1960s are reviewed by Toomre (1977), an article that is remarkable for both its depth and style. Disc galaxies sometimes possess central bars, that are rotating, highly non-axisymmetric structures. Sellwood and Wilkinson (1993) is a good review of the dynamics of bars, their instability to buckling out of the plane to form bulges, and other structures like rings and lenses. The proceedings of the Goteborg conference (Sundelius 1991) is also a good source, and Binney (1992) reviews warped dics. Toomre (1964) proved a basic result on stability of discs to axisymmetric modes, a result that has proved to be fundamental in understanding discs (c.f. Kennicut 1989, for the connection with star formation rates). Understanding modes of oscillations and instabilities of discs, and the role of resonant orbits is basic to disc dynamics. Chapter 6 of BT is a good place to begin, and the reviews and conference proceedings listed here will, hopefully, open the gates for a romp through the extensive literature.

It is about half a century since the 21 cm transition of neutral hydrogen was discovered, and it has truly revolutionised our knowledge of the universe. The interpretation of the Doppler shift of 21 cm emission lines from neutral hydrogen clouds provided evidence for the differential rotation of our Galaxy. Other disc galaxies also rotate, and it came as a surprise when it was established in the 1970s that the rotation speeds of many disc galaxies are "flat", instead of the Keplerian decay, $v \propto r^{-1/2}$, expected for galaxies whose masses are centrally concentrated (c.f. Rubin 1983). Freeman suggested that this could be interpreted as evidence for substantial amounts of dark matter and, indeed, the flat rotation curves of disc galaxies are even today the best evidence for dark matter on galactic scales.

4. ELLIPTICAL GALAXIES

Elliptical galaxies looked so smooth, featureless, and dead, that a theory was needed to explain their blandness: a theory of their formation by dissipationless collapse was proposed by Lynden-Bell (1967). It is a brilliant creation, full of insights on the *violent relaxation* (which physically, is phase mixing in a time dependent, self-consistent, mean gravitational field) of stellar systems to a steady state, from initial states that are, presumably, far from equilibrium. Tremaine, Henon and Lynden-Bell (1986) is an interesting discussion of some useful characterisation of the mixing that occurs during violent relaxation. Yet, after three decades, violent relaxation remains an idea in search of a theory.

In the mid seventies, careful photometry and spectroscopy revealed giant ellipticals to be very slowly rotating, contrary to what most dynamicists had assumed based on their flattened shapes. Theoretical modelling suggested that these galaxies could well be triaxial. Schwarzschild (1979) constructed numerical models of triaxial galaxies, introducing a new technique of orbit-based model building that is both powerful and refreshing in its directness. Binney (1982) is a good review, written at a time when there was much ferment in the field regarding the shapes and kinematics of these erstwhile dull relatives of the spirals. The discovery of triaxial, fully integrable mass models by de Zeeuw and Lynden-Bell (1985)—models that had been discovered by Kuzmin (1973), and reported in a conference—ushered in a new era, whose excitement is captured in the papers presented at IAU Symposium No. 127 (de Zeeuw 1987).

Most, if not all, elliptical galaxies have densities that seem to rise in a power law cusp toward their centres (c.f. Lauer et. al. 1995), and they probably host supermassive black holes (*dead quasars*—see Rees 1990a,b) at their centres (see Kormendy and Richstrone 1995 for a review). There appears to be some evidence for a dichotomy among ellipticals (c.f. Lauer et. al. 1995): fainter ellipticals have steeper cusps and more rotational motions than bright ellipticals. Are these smaller ellipticals similar to the bulges of disc galaxies? Attempts at building self-consistent models have resulted in models (of the fainter ellipticals—the ones with steep cusps) that are axisymmetric, rather than triaxial. At any rate, the models of ellipticals built in the 1980s cannot accommodate either density cusps, or

central black holes without a fundamental breakdown of their regular orbital structure. de Zeeuw (1994) is a fairly recent review of crossroads we are at. More recent work, reported in Buzzoni et. al. (1995) and Arnaboldi et. al. (1997), provide a flavour of the revolution that we are witnessing.

5. EVOLUTION OF GALAXIES

Atlas of Peculiar Galaxies, published by Arp (1966) has more than 300 photographs of galaxies caught in various compromising positions; names such as Antennae and Mice cannot be passed by without at least a glance! Holmberg's proposal that galaxies could collide, experience friction, and eventually merge with each other was probably too revolutionary for the 1940's. In the 1950's, Zwicky speculated that the tails and bridges he had photographed might arise from gravitational tides between galaxies, but even this was not taken seriously. Only after the Toomres (see Toomre and Toomre 1972, 1973) demonstrated that the bridges and tails could be reproduced by simple, numerical models of colliding galaxies, did the idea that galaxies interact acquire legitimacy.

Galaxies can evolve by interacting with their environment, and with each other. Collisions between galaxies are highly inelastic; as much as half the orbital energy can be converted to internal energy. Moreover, angular momentum can be soaked up by stars that escape, allowing the colliding galaxies to settle toward their common centre of mass, and eventually merge. Thus a galaxy's place in Hubble's classification is not an indelible brand; indeed, the Toomres suggested that ellipticals could have been made from the mergers of discs. The Toomres also noted that close encounters can lead to bursts of star formation. The ultraviolet and visible light emitted by the newly-born stars is absorbed and reemitted in the infrared by the surrounding dust clouds; IRAS observations later revealed that colliding galaxies emit almost all their light in the infrared. There is also some evidence that tidal interactions can fuel the central engines of quasars. Ostriker and Tremaine (1975) proposed that cD galaxies (large, bright galaxies that are found near the centres of some clusters) grow by consuming other cluster members as they sink toward the centre of the cluster.

The observational evidence for interactions is now extensive: tails and bridges around interacting disc galaxies, polar rings around S0 galaxies, shells, ripples and counter-rotating cores in ellipticals. Schweizer (1986) is a good review of the observations, and the dynamics is reviewed in Barnes and Hernquist (1992). Chapter 7 of BT is recommended, as is the conference proceedings edited by Wielen (1990).

Isolated galaxies can also evolve more gently, chemically and photometrically, through the evolution of their stars. The mixing of interstellar gas with the ejected products of stellar nucleosynthesis enriches the gas with heavy elements. These "metals" are carried from one part of a galaxy to another by large-scale gas flows. Within a galaxy, the metallicities of both stars and gas decrease outward from the centre. Also, more luminous galaxies tend to have higher metallicities. Information about galaxy formation is encoded in the composition differences among old stars, whereas the abundances in young stars indicate the nature of progressive enrichment. We have already referred to the seminal work of Eggen, Lynden-Bell and Sandage in correlating metallicities with age and kinematics, and thereby inferring the nature of the formation of the Milky Way. As Tinsley notes in her review, "Theories of galaxy formation, and of star formation within galaxies, are challenged to explain this close correlation between the forms of galaxies and their histories of star formation." Chapter 9 of BT provides an introduction to the field, and Tinsley (1980) is a good reference.

6. SOME COMMENTS

The review by Freeman (1975) is a very good account of stellar dynamics in just 100 pages. *Galactic Astronomy*, by Mihalas and Routly (1968) is a quite good, concise account of the kinematic and dynamics of our Galaxy; differential rotation, and random motions of stars in the solar neighbourhood are treated in some detail. Within two decades, this text was to fission into two, setting standards for a relatively modern account of the structure and dynamics of galaxies. The first, *Galactic Astronomy* (Mihalas and Binney 1981) limits its ambit to structure and kinematics, but has extensive additions, incorporating new data on external galaxies as well. Furthermore, the first 200 pages are a self-contained introduction to astronomy itself! The second part, *Galactic Dynamics* (BT) has been referred to extensively in this article.

Workshop on

Dynamics at the Centres of Galaxies

at IUCAA, Pune (July 3-5, 1997)

The workshop will focus on dynamics near the centres of elliptical galaxies and the bulges of disc galaxies. Of particular interest will be the environment around supermassive black holes. Participation is by invitation only. Interested persons should contact **S. Sridhar** (e-mail: sridhar@iucaa.ernet.in) at IUCAA **before May 15, 1997**, and preferably provide a brief description of their background/research interests.

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COMET GALLERY

Photo 1

Photo 2

Photo 3

Jayant Tulpule from Pune used the hand operated drive described in Astroproject-15 to capture Comet Hale-Bopp. His mount cost him Rs.50/-. He used 400 ASA Kodak Gold Film. Photo 1 was taken on February 12, 1997 using 50mm lens and Photo 2 was taken on February 19, 1997 using 200mm telephoto. His mount is shown in Photo 3. Jayant Tulpule may be contacted by mail at c/o Mr. B.D. Limaye, 1133, Sadashiv Peth, Pune 411 030.

IUCAA Preprints

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

P. Goldreich, and **S. Sridhar**, *MDH turbulence revisited*, IUCAA-1/97; V.B. Johri, *Cosmogenesis without big bang: A new model of the early universe*, IUCAA-2/97; **A.N. Ramaprakash, R. Gupta**, A.K. Sen and **S.N. Tandon**, *An imaging polarimeter (IMPOL) for multi-wavelength observations*, IUCAA-3/97; **B.B. Nath**, *Lyman Alpha absorption lines from mini pancakes*, IUCAA-4/97; R. Tomaschitz, *Ether in a cosmic world view*, IUCAA-5/97; R. Tomaschitz, *Extended Robertson-Walker cosmology*, IUCAA-6/97; **S. Bose**, L. Parker and Y. Peleg, *Lorentzian approach to black hole thermodynamics in the Hamiltonian formulation*, IUCAA-7/97; **S. Kar**, and S. Mahapatra, *Planetoid strings : Solutions and perturbations*, IUCAA-8/97; H. Singh, **R.K. Gulati** and **R. Gupta**, *Stellar spectral classification using principle component analysis and artificial neural networks*, IUCAA-9/97; **J.V. Narlikar**, N.C. Wickramasinghe, R. Sachs and F. Hoyle, *Cosmic iron whiskers: Their origin, length distribution and astrophysical consequences*, IUCAA-10/97; U. Narain, R.K. Sharma and G. Vekstein, *On alfven wave damping in polar coronal holes*, IUCAA-11/97; **R. Balasubramanian** and **S.V. Dhurandhar**, *Gravitational waves from coalescing binaries: Estimation of parameters*, IUCAA-12/97; M. Chiba, and **B.B. Nath**, *On the origin of metallicity in lyman-alpha forest systems*, IUCAA-13/97; **R. Misra**, V.R. Chitnis, F. Melia and A.R. Rao, *A transition disk model fit for the broad band x-ray spectrum of cygnus x-1*, IUCAA-14/97; **S.D. Mohanty**, *Hierarchical search strategy for the detection of gravitational waves from coalescing binaries: Extention to post Newtonian wave forms*, IUCAA-15/97; **V. Chickarmane, S.V. Dhurandhar**, R. Barillet, P. Hello, and Jean-Yves Vinet, *Radiation pressure and stability of interferometric gravitational wave detectors*, IUCAA-16/97; **V. Chickarmane, S.V. Dhurandhar,** T.C. Ralph, H.-A. Bachor and D.E. McCelland, *Squeezed light in a frontal phase modulated signal recycled interferometer,* IUCAA-17/97; **Varun Sahni**, *Growth of non-Gaussianity during cosmological gravitational clustering,* IUCAA-18/97; S. Mukherjee, B.C. Paul and **N. Dadhich**, *General solution for a relativistic star,* IUCAA-19/97; **N. Dadhich,** K. Narayan and U.A. Yanjik, *Schwarzschild black hole with global monopole charge,* IUCAA-20/97; K.S.V.S. Narasimhan, K.S. Sastry and S.M. Alladin, *Gravitational potential energy of interpenetrating spherical galaxies in Hernquist's model,* IUCAA-21/97; **T. Padmanabhan,** *Quantum gravitational corrections to propagator in arbitrary spacetimes,* IUCAA-22/97; **Somak Raychaudhary,** Kaspar von Braun, Gary M. Bernstein and Puragra 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 $z \sim 2.4$,* IUCAA-24/97; **Ashish Mahabal, Ajit Kembhavi** and Patrick McCarthy, *Hosts of low redshift southern radio galaxies from the MRC,* IUCAA-25/97; **Sukanta Bose,** *Solving the graceful exit problem in superstring cosmology,* IUCAA-26/97; **S.K. Banerjee** and **J.V. Narlikar**, *The quasi-steady state cosmology: A problem of stability*, IUCAA-27/97; and **S. Sridhar** and J. Touma, *Three dimensional, axisymmetric cusps without chaos,* IUCAA-28/97 .

Seminars

held during January - March 1997

2.1.97 Jean-Claude Pecker on The roughening effect and the determination of abundances of elements in sun and stars; 3.1.97 R.P. Malik on Integrability in nonlinear realization scheme; 7.1.97 Andrezej A. Zdziarski on X-rays/Gamma-rays from black holes; 11.1.97 G. Burbidge on An outsider's view of scientific controversies in Cambridge; 15.1.97 H.C. Arp on Creation and evolution in the local supercluster; 16.1.97 John A. Klobuchar on Real time radio science - The new reality; 24.1.97 C. Murali on Globular cluster evolution in M87 and the specific frequency problem; 28.1.97 Grigory Vekstein on Solar coronal heating: MHD models and possible observational signatures; 29.1.97 P. Biermann on Gamma rays and neutrinos from AGN; 30.1.97 Grigory Vekstein on Collisionless magnetic reconnection and acceleration of charged particles; 6.2.97 Kim Griest on Results from microlensing search for dark matter; 13.2.97 H. Schnopper on What have we learnt about the X-ray sky?; 25.2.97 Francoise Genova on CDS as an astronomical information hub; and 27.2.97 Mark Whittle on Ionized gas kinematics in galactic nuclei.

Discussion Meeting on

Big Bang Cosmology and Alternatives: A Critical Appraisal

at JNCASR, Bangalore
in collaboration with JNCASR,
MRI (Allahabad) and IIT (Kanpur)

An informal and lively discussion meeting on the above topic took place at the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore from January 8 to 10, 1997. It was sponsored by the JNCASR, IUCAA, the Mehta Research Institute, Allahabad and IIT, Kanpur.

There were about 40 participants at the meeting from the leading astronomy and physics institutions and universities in India. Participants from abroad included Tarun Souradeep (CITA, Canada), Gustav Tammann (Basel, Switzerland), Geoffrey Burbidge (UCSD, La Jolla), Chip Arp (MPI, Munich), J.-C. Pecker (College de France, Paris), David Roscoe (Sheffield University).

The meeting was conducted with short talks followed by discussions. The "spectrum" of the meeting had, however, been structured to begin conservatively with talks on microwave background, evolutionary evidence from galaxies and quasars, synthesis of light nuclei, the measurements of Hubble's constant, etc. on the first day. From then on the shade began to change to discussions of problems with the big bang paradigm, e.g., ages of globular clusters, constraints of dark matter and structure formation, and the possibilities offered by alternative cosmologies like the Brans Dicke class of models, string cosmologies, the quasi-steady state cosmology, and so on.

On the final day, there were discussions of data that apparently cannot be accommodated within the standard expanding universe hypothesis. Anomalous redshifts, quantized redshifts, alternative explanation of flat rotation curves, etc. were presented. Although the meeting allowed ample time for interventions and impromptu remarks, the panel discussion at the end was perhaps the liveliest of them all.

Is the big bang still flourishing? Or is it down and out? The meeting hardly changed the beliefs of the participants; but it surely made them more aware of the other point of view. It is hoped that the meeting will be a trend-setter for others to follow. Professor C.N.R. Rao, the President of JNCASR had, in his inaugural talk, expressed the Centre's desire to host such meetings annually.

Workshop on Introductory General Relativity and Applications

at Tezpur University, Assam

A workshop on Introductory General Relativity and Applications was held at the newly founded Tezpur University during January 27-29, 1997. There were about 25 participants from colleges and universities in the North East region. The main aim of the workshop was to give an expose to some aspects of general relativity and relativistic astrophysics. All the lecturers were unanimous that it was perhaps the keenest lot, and was a pleasure to lecture to them.

Mini-School on Cosmology

at Lucknow University, Lucknow

A mini-school on Cosmology was held at Lucknow University during February 3-12, 1997. The school was organised by Sunil Datta and P.P Saxena of the Mathematics Department, Lucknow University, and was aimed at advanced graduate students, post-docs and other researchers. An attempt was made to cover all the basic aspects of Cosmology - both theoretical and observational. Lectures were given on General relativity, The early universe: (Nucleosynthesis, Baryogenesis, Inflation), Structure formation in the universe, Cosmic microwave background, The high redshift universe, Clusters and superclusters of galaxies, Gravitational lensing, etc. Lecturers at the school included members of the IUCAA faculty (N. Dadhich, S. Raychaudhury, V. Sahni, R. Srianand) as well as physicists from other parts of the country (S. Bhardwaj, P. Das Gupta, V.B.Johri, N. Panchapakesan, D.D. Sahdev, R.P. Saxena).

Computer Training

for Administration & Support Staff of IUCAA

A special six-week course on the use of computer softwares is being conducted at IUCAA for the benefit of the Administration and Support Staff. The course is being given to those who are already familiar with routine computer usage. The course is being conducted by expert teachers from outside IUCAA and involves lectures as well as practical sessions.

UPDATE

The IUCAA Telescope Project

As reported in the January'97 issue of Khagol, two prospective sites have been monitored for the observatory. It has been found that the two sites, which are separated by about 26 km along a north-west (or south-east) line, have very similar conditions concerning the seeing and sky-brightness. The site near the village Giravali, in tahasil Junnar of Pune district, is more convenient from logistics angle and it has been chosen for the observatory; the site is at a height of about 1000 metres, and it is at a distance of about 80 km by road from IUCAA (Latitude ~ 19 deg 4.4 arcmin North, and Longitude ~ 73 deg 50.8 arcmin East). A summary of the site parameters measured during Nov. 96 to Feb. 97 is given below:

MEDIAN SEEING ~ 1.4", SKY- BRIGHTNESS 21.2 mag. to 20.7 mag. in the V band, EXTINCTION in the V band ~ 0.15 mag in good conditions, and in these months ~ 90% of the nights are spectroscopic and about 60% nights are photometric.

The work towards acquiring the land for the observatory and design of the buildings have started.

Differing Standards

Once upon a time an astronomer, a statistician and a mathematician went to Scotland on a hiking tour. As they entered the Scottish border, they saw a sheep grazing in a farm. "So all sheep in Scotland are black", exclaimed the astronomer.

"You astronomers are notorious for drawing sweeping conclusions from scanty data", chided his statistician friend. "Before you draw any such conclusion, you need to collect samples from different parts of Scotland and do a proper statistical analysis. All you can say now is that black sheep may be found in Scotland." He turned to the mathematician who had been a silent listener, for support.

"I am afraid, I disagree with both of you" remarked that worthy. "On the basis of what you see, all you can say is that the animal over there is black on the side facing you."

PEP Talks

held during January - March 1997

20.2.97 R. Balasubramanian on *Geometry in Statistics;* and 27.2.97 Yuri Shtanov on *Pilot wave quantum cosmology.*

Visitors

January - March 1997

J.C Pecker, A. Zdziarski, R.P. Malik, G.P. Pimpale, H. Arp, D. Roscoe, Soma Mukherjee, R. Ramakrishna Reddy, J. Klobuchar, S.K. Pandey, R. Ramachandran, U. Narain, G. Vekstein, C. Murali, S.P. Khare, D.M. Whittle, V. Chitnis, Y. Shtanov, N. Kameswara Rao, S. Banerji, S.P. Chadha, T.N. Rengarajan, U.C. Joshi, R.S. Khairnar, A.L. Choudhuri, Bharat Kumar Reddy, K. Griest, P. Hello, K.P. Singh, H. Schnopper, E. Silver, K.S.V.S. Narasimhan, F. Genova, I.K. Mukherjee, V.N.R. Pillai, Pramod Kumar, V.M. Choudhuri, G.K. Mehta, N. Raghavan, Yash Pal, N.C. Mathur, H.L. Duorah, R.P. Gangurde, Y. Narasimhulu, S.S. Jha, S.N. Karbelkar, R.G. Vishwakarma, Ashok Kumar Sharma, S. Mukherji, S.R. Prabhakaran Nayar, A.K. Borkakati, S. Philip, S.P. Bhatnagar, Gopi Garge, Anurag Kumar, S. Ramakrishna, V.H. Kulkarni, S. Ramani, S.M. Pathak, L.N. Katkar, P.S. Wamane, R. Adhikari, Subenoy Chakraborty, E. Vinodkumar, Indira Sreedevi, Durga Prasad, Amitabha Roy, Neeru Chhabra, S.V.R. Anand, Dipak Singh, S.A. Kumar, C.S. Kumar, Anita Mehta, Malati Hegde, S.S. Naqvi, Surendra Pal, Bruno Guiderdoni.

Visitors

Expected

April: Mukund Unavane, Institute of Astronomy, Cambridge; P.S. Naik, Gulbarga University; Prasenjit Saha, Oxford University; G. Yellaiah, Kakatiya University; Rajaram Nityananda, RRI; S.S. De, Calcutta University

May: T. Subba Rao, Sri Venkateswara University; S.S. Aundhkar, Nanded; A.K. Ray, Visva Bharati University; Sarita Vaishampayan, North Maharashtra University; V.H. Kulkarni, Bombay University; M.K. Gokhroo, Govt. College, Ajmer; V.B. Johri, Lucknow University; P. Khare, Utkal University; B. Chakraborty, Jadavpur University; D.B. Vaidya, Gujarat College; K.N. Joshipura, Sardar Patel University; L.K. Patel, Gujarat University

June: A.K. Borkakati, Tezpur University; S.S. Prasad, UNPG College, Deoria; Indira Bardoloi, Handique Girls College, Guwahati; T. Singh, Banaras Hindu University; R.P. Saxena, Delhi University; Kanti Jotania, RRI; Udit Narain, Meerut College; S. Chatterjee, New Alipore College; N. Banerjee, Jadavpur University; S.R. Prabhakaran Nayar, Kerala University

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