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Mini-workshop on Gamma Ray Bursts : Status and Future

Participants of the mini-workshop on Gamma Ray Bursts : Status and Future

This mini-workshop was organised by T. Padmanabhan and S. N. Tandon at IUCAA during August 26-28, 1999. Out of about thirty participants, six were from outside India, and five of the participants were from Indian universities.

The value of coordinated observations in different wave-bands and from many observatories (for a good temporal coverage) was specially emphasized during the talks and discussions. Shri Kulkarni (Caltech, USA) reviewed history of gamma ray bursts observations, and discussed results obtained with optical observations on properties of the afterglows and host galaxies; Dipankar Bhattacharya (RRI, Bangalore) discussed the fireball physics, and spectral and temporal properties of the afterglow; Fiona Harrison (Caltech, USA) discussed high energy properties of the bursts, and talked about future space missions on gamma ray bursts; Dale Frail (NRAO, USA) discussed radio observations of the afterglows;

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Ram Sagar (UPSO, Nainital) presented results showing the usefulness of small (1-2 metre) telescopes in observations of afterglows and S. N. Tandon (IUCAA) discussed the possibility of using imaging polarimeter on small telescopes to study the polarisation of afterglows in optical band. During last session of the workshop, importance of REACT Network was discussed; REACT Network is a proposal from the Caltech group in which several observatories would participate to get well-calibrated temporal coverage of the light curves, with similar multiband optical cameras.

Mini-school on Computer Astronomy

Ajit Kembhavi

Kozhencherry is a small town in Kerala, located about an hour's drive from Alleppey (Allepuzha). It has a lush, green ambience, has the river Pampa flowing through it, and is home to one of the famous snake boat races. Amidst all this splendour is located the St. Thomas College, which has drawn several people from IUCAA over the last few years for workshops and lectures. Moncy John of St. Thomas is an associate of IUCAA, and another lecturer from there, Ninan Sajith Philip, is a regular visitor and collaborator.

A mini-school on *Computer Astronomy* was jointly organized by IUCAA and St. Thomas College from August 30 to September 3, 1999 at Charal Mount, which is a retreat on a hill top, a short distance away from Kozhencherry. Surrounded on all sides by an ocean of greenery, the retreat has simple but comfortable accommodation for more than 50 persons and offers excellent dining facilities. It has a large and airy hall for lectures, along with a few small ones for related activities. Everything works well and on time. The retreat is altogether a wonderful place for academic meetings.

The workshop dealt with image processing, with particular emphasis on applications to astronomy. Photometry of stars and galaxies was discussed, following lectures on image processing techniques. The lecturers included Yogesh Wadadekar and myself from IUCAA, S. K. Pandey from Pt. Ravishankar Shukla University, Raipur and G.C. Anupama and Annapurni Subramanian from the Indian Institute of Astrophysics, Bangalore. Sarah Ponarathnam of IUCAA provided able and much needed support with the hardware and software. Lectures were also given by local resource persons.

The participants included lecturers, post graduate students and a sprinkling of undergraduates from various places in Kerala. The area around Kozhencherry is rich in fine colleges, many of which have postgraduate classes, with excellent students and teachers. The aim of the schools organized with St. Thomas College has been to encourage this population to take actively to the joys of astronomy and information technology, and it appears that these expectations may be amply fulfilled.

An outstanding feature of the mini-school was the set of demonstrations of computer techniques, and most importantly, practical training in the installation and use of *Linux* and image processing software, particularly *IRAF*. Some participants brought their own computers to the event, and with the help of local and visiting experts, loaded them with useful softwares. The current fall in the price of computers means that adequate hardware, even for rather ambitious projects like the processing of voluminous astronomical data, is available everywhere. What is required to get the machines going is the transfer of software and experience, and this can be most efficiently achieved in the manner followed on Charal Mount. The Principal of St. Thomas College, P.J. Philip, who is an economist, and the Head of the Physics Department, Abraham Kuruvilla Kunnilethu provided much active support. The Manager of the college, the Rt. Rev. Euakim Mar Kurilos Episcopa provided the infrastructure and encouragement. But the person who has been most important in initiating and sustaining the activity has been the Most Rev. Philipose Mar Chrysostam, who will be the next Metropolitan of the Marthoma Church. He understood how information technology could be harnessed even in a remote place, and made it possible for us to have an ERNET node of sorts at St. Thomas College, much before many of the larger institutions in the region began to appreciate the importance of having access to e-mail and related facilities.

IUCAA will continue to have further activity in the region, and it is to be hoped that much research work will emerge from there in the years to come.

Subrahmanyan Chandrasekhar Memorial Fellowship

The University of Chicago, USA has established Subrahmanyan Chandrasekhar Memorial Fellowship for outstanding incoming graduate students in the Ph.D programmes of the Department of Physics and the Department of Astronomy and Astrophysics. The term of the fellowship will be two years. During this period, the Fellowship will cover tuition expenses in full, and will pay a stipend above the rate normally paid to teaching assistants and research assistants. Chandrasekhar Fellows will be required to serve as teaching assistants for a total of two quarters during the two-year term, but otherwise will have no teaching or research duties associated with the Fellowship. The Chandrasekhar Fellows will be selected from the applicants to the Ph.D. programmes of the Departments of Physics and Astronomy and Astrophysics; no separate application procedure is required. It is expected that approximately one Fellowship will be awarded each year, with the first Fellow to be chosen from the applicants entering for the class of the academic year 2000-2001. Preferential consideration will be given to applicants from India.

Post -Doctoral Positions

Applications are invited for post-doctoral fellowships in astronomy and astrophysics. The duration of the fellowship is flexible within a range of one to five years., with the possibility of conversion to a tenured position. IUCAA offers challenging opportunities to young research workers in theory, observation and instrumentation in Astronomy and Astrophysics. IUCAA plans to have a 2m optical telescope operational during 2000 and there will be special opportunities of optical astronomy and related instrumentation. Candidates should apply to The Coordinator, Core Programmes, IUCAA, Post Bag 4, Ganeshkhind, Pune - 411 007, India, with curriculum vitae and list of publications and arrange for three confidential references to be sent independently. All the relevant material should reach IUCAA by November 25, 1999. Candidates will be informed of the result by January 15, 2000. The fellowship will normally commence during 2000. Accommodation on the campus will be offered to all post-doctoral fellows. For further details, please contact the Coordinator, Core Programmes, IUCAA.

Welcome to . . .

Arun V. Thampan, who has joined as a post-doctoral fellow. His research interests are Neutron Stars and Accretion Astrophysics.

Peyman Ahmadi, **R. Guruprasad**, **Pradeep Koshti**, **Anand Sankar Sengupta** and **Parampreet Singh**, who have joined as Research Scholars.

. . . Farewell to

Shymal K. Banerjee, who has joined the Mody College of Engineering and Technology, Lakshmangarh, Rajasthan.

Sukanta Bose, who has joined the University of Wales, College of Cardiff, UK.

K. Harikrishna

Arun Mangalam, who has joined the Indian Institute of Astrophysics,Bangalore.

Ranjeev Misra, who has joined the North Western University, Evanston, USA.

Ali Nayeri, who has joined the Massachusetts Institute of Technology, Cambridge, USA, and

Mohammad Nouri Zonoz, who has joined the Institute for Studies in Theoretical Physics and Mathematics, Tehran, Iran.

Seminars

26.7.99 Sushan Konar *on* Highlights of NATO / ASI meeting on neutron star - black hole connection; 4.8.99 Tirthankar R. Choudhury *on* Quantum cosmology of Bianchi type I models; 4.8.99 Jatush V. Sheth *on* Particle production in the inflationary universe; 9.8.99 Arun Mangalam *on* Violent relaxation to a spherical halo; 10.9.99; Boud Roukema *on* High z clustering conference, Marseille and 27.9.99 Andrzej Zdziarski *on* Spectral states of black hole binaries.

Colloquium

21.9.99 Yashodhan Haltwalne on Abrikosov phases of soft matter.

Contributions of Space Astronomy

When the Sputnik was launched in 1957, the reactions from the astronomical community were mixed. Although space technology opened out new windows of observations of the universe by providing access to parts of the electromagnetic spectrum that normally got absorbed by the Earth's atmosphere, the doubt was whether the powers that could be convinced sufficiently to invest in esoteric astronomical observations in an environment dominated by defence and commerce. In the end, the result was not too bad, considering the inputs space astronomy has provided. A very partial listing of highlights is given below:

The pioneering work in telling us about the galactic and extragalactic X-ray sources was carried out by the UHURU satellite launched in 1972. Later, the Einstein X-ray Observatory launched in 1978 (so named to commemorate the Einstein centenary in 1979), revealed further details including the information that quasars are strong emitters of X-rays. The ROSAT launched in 1990 provided an all sky survey of X-ray sources. The ASCA satellite launched in 1993 provided information on X-ray spectra. In 1999, Chandra (commemorating the Indian-born astrophysicist Subrahmanyan Chandrasekhar) has been launched as an advanced space facility with great expectations in X-ray astronomy.

In the ultra-violet (UV) region, the Copernicus satellite launched in 1973, the 5th birth centenary of Copernicus, gave information about cosmic deuterium. This was followed by the longest lasting satellite (1978-96), the IUE (International Ultaviolet Explorer), which yielded UV-spectra in the 1200-3200 Angstrom range from a variety of astronomical objects both galactic and extragalactic. Although the ROSAT provided some information in the extreme-UV range, a dedicated extreme ultraviolet Explorer (EUVE) was launched in 1992. This bridges the gap between the X-ray and the UV.

Perhaps the most productive satellite with a short lifetime was the Infrared Astronomy Satellite (IRAS), which during its 10 month tenure in 1983, enriched astronomy from evidence of new planetary systems in making, to discovery of remote galaxies emitting far more in infrared than they do in the optical band. Now a more advanced IR facility is expected to give more details of the infrared universe.

The HIPPORCOS satellite was launched basically to study stars and measure stellar distances. Its acronym was brought close enough to Hipparchus, the name of the Greek astronomer, who more than 2000 years ago carried out such detailed observations of the heavens.

As if to underscore the advantage of space technology even for optical astronomy, the Hubble Space Telescope, launched in 1990, has been producing excellent pictures of the heavens, some of them hardly (or not at all) visible to ground-based telescopes. One of its major projects is to narrow down the uncertainty in the measurement of the Hubble constant.

Perhaps competing with the HST in glamour was the COBE (Cosmic Background Explorer) satellite, which measured the spectrum of the microwave background in 1990 so very accurately (-to show that it is closer to the classic Planckian black body spectrum than any terrestrial counterpart). The COBE was also the first to detect tiny fluctuations in the background which, according to many cosmologists, are signatures of galaxy formation.

Late in catching up with other space based telescopes was gamma-ray astronomy which achieved notable success with the launch of the Compton Gamma Ray Obsevatory in 1990. Its discovery of gamma-ray burst sources of enormous energy are posing challenges to theoreticians. It has several instruments on board for imaging and spectroscopy.

This account does not include the many spacecrafts which have extensively toured the solar system and brought considerable information about it, which would otherwise not be available from the Earth. We shall look at these in the next parsecstone.

Clusters and Superclusters of Galaxies

Clusters and Superclusters of galaxies are the largest structures in the Universe bound by self-gravity. Of the mass of a typical rich cluster, about (1–2)% would be in optically luminous galaxies, and up to 10% in hot gas radiating predominantly in the x-ray region of the electromagnetic spectrum[1]. It is evident that most of the gravitational force that binds galaxies into clusters comes from dark matter. In the 1930s, in the context of the Coma cluster, it was this that led Fritz Zwicky to postulate the predominance of unseen matter in the Universe[2].

The distribution of galaxy clusters

Rich clusters of galaxies are rare, their density in the nearby Universe being about 10^{-6} Mpc^{-3}, compared to that of bright galaxies like ours (10^{-2} Mpc^{-3}). About 5% of all galaxies are in clusters. About 75% of the galaxies in a typical rich cluster would be early-type (E & S0) galaxies, as opposed to 25% in the field.

The average density of galaxies within rich clusters is about 100 times that in the field. Typically, the distribution of galaxies within a cluster is represented by a modified isothermal sphere (King model) of the form $n = n_0(1 + r^2/r_c^2)^{-\alpha}$, where $\alpha = -1.5$ in the central regions, and $\alpha = -2.5$ in the outskirts. Typical values for cluster properties, including core radius r_c and central number density n_0, are listed in Table 1.

Following Zwicky's early compilation, the first systematic catalogue of clusters in the Northern hemisphere was compiled by Abell in the mid-50s. His criteria for selecting rich clusters from photographic plates have been widely used– those having $\geq$30 galaxies within $2h_{75}^{-1}$ Mpc of a fiducial centre between the magnitude m_3 of the third brightest galaxy and $m_3 + 2$. His collaborators extended this survey to the whole sky (excluding the Galactic plane) in the 1980s [3]. The distribution of all Abell clusters is shown in Figure 1. However, the Abell cluster catalogue suffers from superposition effects, and is complete to only a redshift of $z \lesssim 0.2$.

A more objective way to compile clusters would be to detect them from their x-ray emission. The Einstein EMSS survey did produce a small but useful catalogue of bright clusters; for instance, it is the source of the CNOC survey out to $z \simeq 0.5$. However, only parts of the deeper ROSAT all-sky cluster survey are published even after a decade of its completion– for instance, the REFLEX survey covers 475 clusters (90% with redshifts) brighter than 3×10^{-12} erg s^{-1} cm^{-2} (0.1–2.4 keV) from it (also see BCS and XBACS [3]).

The cluster-cluster correlation function has the same slope (about –1.8) as that of the galaxy-galaxy correlation function, which is often cited as an argument in favour of self-similar hierarchical structure formation scenarios. Their correlation length is about $30\pm5\,h_{75}^{-1}$ Mpc.

It is not clear on what scales clusters of clusters (Superclusters) are bound, but there is evidence of merging clusters in the cores of the richest ones (e.g., Shapley, Carina-Pictor). Catalogues of Superclusters [4], constructed using percolation techniques on optically selected rich clusters, reveal filamentary web-like structures extending over hundreds of Mpc. Claims of periodicity of about 150 h_{75}^{-1}Mpc in the distribution of rich clusters are yet to be disproved. Coherent structures on such large scales could be in conflict with most of the models of cosmogony.

Table 1: Properties of typical Rich Clusters

Number of members[a]	30–300 galaxies
Central density (n_0)	$500\,h_{75}^3$ Mpc^{-3}
Mass[b]	10^{14}–$10^{15}\,h_{75}^{-1}\,M_\odot$
Radius[c]	$(1-1.5)\,h_{75}^{-1}$ Mpc
Core radius (r_c)	$(0.1-0.3)\,h_{75}^{-1}$ Mpc
Velocity dispersion (σ_r)	(500–1200) km s^{-1}
(median)	800 km s^{-1}
Blue luminosity[b]	$(5-50)\times10^{11}\,h^{-2}\,L_{B,\odot}$
$\langle M/L_{\rm B}\rangle$	$\sim 250\,h_{75}\,M_\odot/L_{B,\odot}$
X-ray temperature	(2–15) keV
X-ray luminosity	$(10^{43}-10^{45})\,h_{75}^{-2}$ erg s^{-1}

[a] Number of galaxies with magnitudes between m_3 and $m_3 + 2$ within $2h_{75}^{-1}$ Mpc of the centre of the cluster.

[b] Mass and luminosity estimates within $2h_{75}^{-1}$ Mpc .

[c] The radius is defined where the galaxy surface density drops to $\sim$ 1% of the central core density.

[1] Here the Hubble constant $H_0 = 75h_{75}$ km s^{-1} Mpc^{-1}.

[2] More extensive coverage of the subject can be found elsewhere [1,2]

What are clusters made of?

Since the baryon fraction of the Universe, predicted by cosmic nucleosynthesis in the Standard Big Bang model, is about $0.025\,h_{75}^{-2}$, it is very unlikely that a large fraction of this dark matter is baryonic. The stars and gas can make up almost all the expected baryon fraction in clusters. Most of the matter in clusters and superclusters is therefore presumably in non-baryonic form.

The total mass of a cluster can be determined using three independent methods: (i) the temperature of the hot intracluster gas, (ii) the velocity dispersion of galaxies within a given radius, and (iii) distortions of background galaxies due to gravitational lensing. The first two require the assumption that the galaxies and gas in the cluster are in hydrostatic equilibrium, while the third is a more direct means of measuring the matter distribution.

The baryonic component: stars and gas

Within $2h_{75}^{-1}$ Mpc of a rich cluster, the baryon fraction is

$$\Omega_b/\Omega_m \geq 0.09\,h_{75}^{-1.5} + 0.02,$$

where the first term comes from the gas and the second from galaxies. This value observed from the gas and stars represents a lower limit to the baryon fraction; of course, additional baryonic matter may exist in the clusters.

This suggests that the baryon fraction observed in rich clusters exceeds that of an $\Omega_M = 1$ universe by a factor of about 4. Since detailed hydrodynamic simulations show that baryons do not segregate into rich clusters, the above results imply that either the mean density of the universe is $\Omega_m \lesssim 0.3$, or that the baryon density is much larger than predicted by nucleosynthesis [5].

The hydrostatic equation for a spherical system can be used to derive an expression for the total gravitating mass $M(<r)$ interior to radius r,

$$M(<r) = \frac{-k_B T(r) r}{G\mu m_p}\left(\frac{d\ln\rho}{d\ln r} + \frac{d\ln T}{d\ln r}\right)$$

where $\rho(r)$ is the density and $T(r)$ the temperature of the gaseous component. This expression can be applied to clusters or subclusters having reasonable symmetry, even for systems with considerable ellipticity (prolate or oblate). In principle, for simple geometries, the gravitating mass can be determined as a function of radius using x-ray parameters alone [6].

The applicability of the hydrostatic assumption for the gas requires that the sound crossing time of the system be short over the scale D of interest. The sound crossing time in a cluster is given by $\tau_{\rm sound} = 7 \times 10^8 D_{\rm Mpc} T_8^{-1/2}$ yr where T_8 is the gas temperature in 10^8 K. For rich clusters ($T_8 \sim$0.5–1), the sound crossing time being comparable to the dynamical timescale. The hydrostatic condition is generally applicable only over the central few Mpc in a cluster.

Also important is the relatively short mean free path of protons in the cluster $\lambda_H \simeq 25\,T_8^2 n_H^{-1}$ kpc, where n_H is the gas density in 10^{-3} cm^{-3}. This ensures that the velocity distribution of the gas particles is isotropic and that the uncertainty regarding tangential velocity components is not important. Imaging x-ray spectroscopy (ASCA, Chandra) also provides a means to distinguish between projected clusters and superposed substructure since one can measure both the morphology of the system and the energy of the x-ray photons.

The relation between the bolometric x-ray luminosity L_X of a cluster and the temperature T_X of its x-ray emitting gas has received much attention in recent years [7]. If the relation is assumed to be a power-law $L_X \propto T^n$, then models in which the cluster gas and dark matter evolve together predict $n = 2$. The current best measured values from ROSAT luminosities and ASCA temperatures from about 50 clusters give $n = 2.64 \pm 0.27$, which indicates heating of the intracluster gas by sources other than gravitation, presumably by the same supernovae that enriched the gas with heavier metals.

Dynamical mass estimates

For a spherical galaxy cluster of number density $n(r)$, the equation of hydrostatic equilibrium gives the mass within a radius r,

$$\frac{-GM(<r)}{r^2} = \frac{1}{n}\frac{d}{dr}(n\sigma_r^2) + 2\frac{\sigma_r^2 - \sigma_t^2}{r^2},$$

where $\sigma_r(r)$ and $\sigma_t(r)$ are the radial and tangential velocity dispersions of the galaxies at each radius. We can estimate the projected density distribution and the line-of-sight velocity dispersion from observations. Estimating the dynamical mass

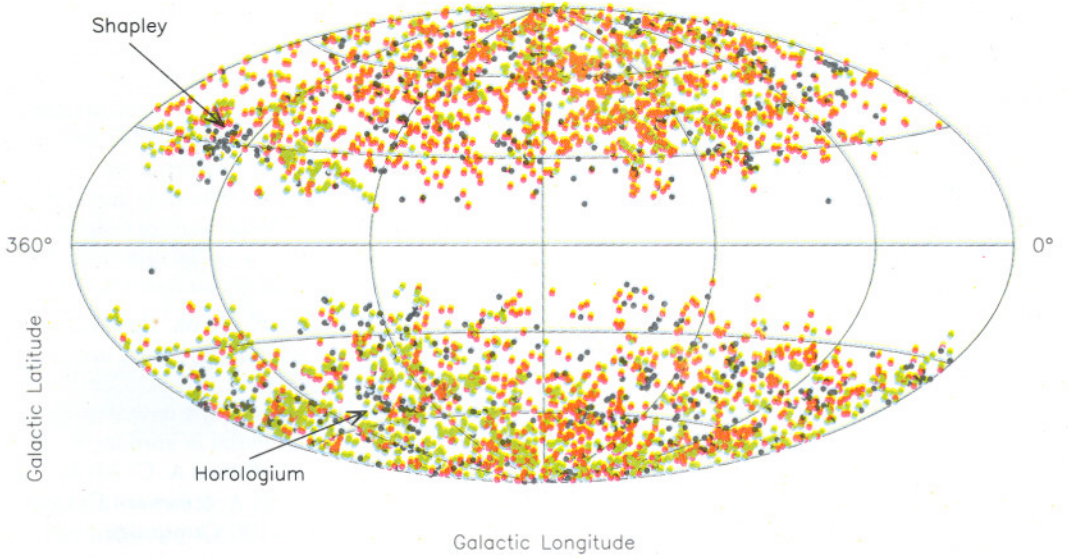

Figure 1: The distribution of 4076 optically selected Abell clusters plotted in an equal-area projection in Galactic coordinates. Clusters lying within redshift $z \leq 0.1$ are plotted in black, between $0.1 < z \leq 0.2$ in red and $z > 0.2$ in green. The underpopulated area is the portion of the sky obscured by our own Galaxy. The two richest Superclusters in the $z \leq 0.1$ Universe are indicated.

$M(r)$ has therefore to depend on simplifying assumptions, like mass following light ($\rho \propto n_{\rm gal}$), and an isotropic velocity distribution ($\sigma_r = \sigma_t$ for all r). More complicated models show that the observed mass profiles are given by near-isotropic velocity distributions rather than predominantly radial distributions [8]. The typical dynamical mass of rich clusters within an Abell radius (determined from the virial theorem for an isothermal distribution) is $M_{\rm cl} \simeq 1.0 \times 10^{15}\, h_{75}^{-1} M_\odot$.

Mass estimates: gravitational lensing

When the central surface density of a cluster exceeds the so-called critical density,

$$\Sigma_c = \frac{c^2 D_S}{4\pi D_L D_{LS}} \sim 1\,{\rm g\ cm}^{-2},$$

where D_L, D_S and D_{LS} are the distances to the cluster, the source and between the cluster and source respectively. Bright sources (like quasars) behind clusters will generally form multiple sources. Extended sources like galaxies can be seen as arcs and arclets ("strong lensing"), which help in the modelling of the mass distribution in the core of the cluster acting as a gravitational lens [9]. A puzzling discrepancy between the x-ray and lensing estimates of rich cluster masses has recently inspired a closer look at the basic assumptions underlying the two methods [10].

This method is very promising in determining the mass distribution in the outer parts (1–5 Mpc) of clusters, using the systematic distortion of the shape of background galaxies ("weak lensing"). Recently the mass and mass-to-light ratio of a supercluster of galaxies was estimated using observations of weak lensing on a scale of about 6 Mpc, yielding $M/L_B = (210 \pm 30)\, h_{75}$, comparable to that of rich clusters [11].

Evolution of Cluster Abundance

The observed present-day abundance of rich clusters of galaxies places a strong constraint on the present value of the cosmological density parameter $\Omega_M \simeq 0.25\, \sigma_8^{-2}$, where σ_8 is the r.m.s. mass fluctuation on $8\, h^{-1}$ Mpc scales (a $\sigma_8 = 1$ Universe is unbiased). Furthermore, the evolution of the abundance of rich clusters with redshift can potentially help to determine Ω_M and σ_8 independently.

The growth of long-wavelength perturbations (still in the linear regime) is significantly milder in low-Ω_M, high-σ_8 models, and in models with non-zero Λ, compared to their growth in $\Omega_M = 1$, low-σ_8 (biased) Gaussian models. The fluctuations in the latter start growing more recently thereby producing strong evolution in recent times. As a result, in an $\Omega_M = 1$ Universe, rich clusters are much rarer at high redshifts ($z > 0.5$) than in low-density Universes, where density fluctuations evolve and freeze out at early times. Bahcall and collaborators [12] have used this argument to show that finding even a few Coma-like clusters (from the CNOC sample) at $z > 0.5$ over about 10^3 deg^2 of sky contradicts an $\Omega_M = 1$ model, where only about 10^{-2} such clusters would be expected (when normalized to the present-day cluster abundance).

A few unsolved problems

1. What is the distribution of matter in the haloes of rich clusters, i.e., between their fiducial radius of ~1 Mpc and their tidal radius of ~6–8 Mpc? Weak gravitational lensing studies may provide some answers.

2. What is the mass-to-light ratio and Ω_M on the scales of the largest bound structures? Does mass follow light on large ($\gtrsim$50 Mpc) scales (*i.e.* what is the value of the bias factor?) If not, is the bias factor a function of scale?

3. What is the cause of the discrepancy between masses derived from lensing and those from x-ray data? The presence of cooling flows seem to account for some of the anomaly.

4. Is the gas in clusters isothermal? What is the origin of this gas and its metal abundance?

5. How are rich clusters formed? How do they evolve? Are there any fundamental plane relations between their various properties (similar to those in galaxies) that can be related to their formation history? Do these apply to poorer clusters?

6. How important are magnetic fields in the physics of clusters?

7. What is the number density of clusters at high redshift ($z \gtrsim 1$)? Are their properties similar to low-redshift clusters? Can their abundance be used to constrain models of cosmogony?

8. What are the largest coherent bound structures? What is the typical morphology of these structures? What is the baryon fraction and mass-to-light ratio of superclusters?

9. On what scales do coherent peculiar velocities exist?

10. How rich are the richest clusters? How empty are the emptiest voids?

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New Trends in Near Infrared Infrared Astronomy

Participants of the workshop on New Trends in Near Infrared Astronomy

Physical Research Laboratory (PRL), Ahmedabad and Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, jointly organized the workshop on New Trends in Near Infrared Astronomy, during August 17-20, 1999 at PRL. The workshop was inaugurated by G.S. Agarwal, Director, PRL. There were thirty outstation participants representing different institutes IIA (5), IUCAA (2), UPSO (3), NCRA (1), TIFR (3), SAC (3) and universities (12), apart from a similar number from PRL.

The recent developments in the Infrared (IR) technology have generated great excitement in observational astronomy. With the availability of the IR array detectors such as NICMOS-3, one can get a panoramic view of the infrared sky unravel the mysteries of star-forming regions and galaxies. Mt. Abu Infrared Observatory, operated by PRL, is equipped with such a camera in addition to other IR backend instruments. As the technology of IR array detectors is new and doing astronomy with it is not very straightforward, the sharing of the experiences between the users is very important. This workshop was organized keeping this idea in mind and with a goal to provide the Indian Astronomers interested in IR astronomy, a platform to interact with other astronomers and the experts in the field. The workshop proved to be successful in achieving these goals.

The workshop covered a wide range of topics in IR astronomy, both from instrumentation and theory/ observation viewpoints. Ian S. Glass (South African Astronomical Observatory) was the main resource person and gave a series of talks covering basics of near IR photometry, study of the Milky Way through the imaging of the inner bulge and variability of AGNs in near IR. He cautioned on the use of IR standards and underlined the need to prepare a set of standard stars for the observatories. There were also talks by experts from various institutes within the country on various topics - ISOGAL, DENIS and 2MASS surveys, IR detectors, their characterization, imaging Fabry-Perot Spectrometer in near IR, lunar occultation approach in near IR to measure angular sizes of late type stars, inner Milky Way and the extinction map in the central region of the galaxy, morphology of star burst galaxies in near IR, elliptical galaxies and fundamental plane, young galactic star clusters, Mira variables, novae, Be Stars, etc. The main speakers were I. Glass, A. Kembhavi, Ram Sagar, T.N. Rengarajan, U.C. Joshi, D. Ojha, R. Bisht, G.C. Kilambi, K.S. Baliyan, B.G. Anandrao, T. Chandrasekhar, N.M. Ashok, S. Rao, A.K. Sen, Shashikiran, U.S. Kamath, A. Chitre, M.S. Nandakumar, P.V. Watson and A. Tej.

In addition to these talks, there were presentations on future plans and new facilities coming up in IR astronomy by various institutes, such as IIA (T.P. Prabhu, G.C. Anupama), IUCAA (R. Gupta) and UPSO (Ram Sagar). One of the main attractions of the workshop was presentation of the new results obtained using NICMOS-3 and other IR instruments relating to galactic and extra-galactic studies.

A panel discussion was organised as a part of the workshop on the future direction of IR astronomy and issues related to astronomy at large. The discussion which was very lively and stimulating, also took into consideration the remarks made by the PRL Director in his inaugural speech on the lack of interest in astronomy among the young students. Ian S. Glass chaired the panel discussion. One common opinion was that the IR community in the country is small and there is need to have more interaction and collaboration among the astronomers and also to exchange expertise in IR technique. It was also felt that such workshops should be organised every year, reviewing the progress made and the direction to be taken in future.

International Conference for Science Communicators

The National Centre for Science Communicators, Mumbai is organising an International Conference for Science Communicators (ICSC 2000) during January 28-29, 2000 at IUCAA. Among the participants, there will be about 200 writers, publishers, editors, broadcasters and policy-makers in the field of popular science and about 10 per cent of them coming from abroad.

The invited talks and subsequent discussion, to be held at IUCAA's Chandrasekhar Auditorium, are grouped into six sessions:

1. Social Implications of Science and Technology
2. Perspectives of Science Communication
3. Resources for Science Communicators
4. Science Education and the Media
5. National and International Networking of Science Communicators
6. Financial Viability of Science Communication.

Besides these, there will be three popular science lectures, open to the general public to be held at the Bal Gandharva Auditorium in Pune.

A limited number of poster papers will be accepted from participants. Those wishing to participate are requested to contact as soon as possible, the National Centre for Science Communicators, Vidnyan Bhavan, V.N. Purav Marg, Sion-Chunabhatti, Mumbai 400022 (Phone: (022) 522 4714, 522 6268; Fax: (022)5226268; E-mail: vidnyan@bom7.vsnl.net.in). The conference fees for each accepted Indian participant is Rs. 400/- except for Life members of NCSC .

Workshop on Nuclear Astrophysics

A workshop on Nuclear Astrophysics is being held at IUCAA, Pune during December 20-22, 1999. Those who are interested to participate in this workshop, may kindly contact Somenath Chakrabarty, Dept. of Physics, University of Kalyani, Kalyani 741 235, West Bengal. E-mail: somenath@klyuniv.ernet.in.

Third Level - 1 Workshop on Astronomical Photometry

The third Level - 1 Workshop on Astronomical Photometry will be held at IUCAA during January 17 - 21, 2000. 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 will be 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, IUCAA, before November 10, 1999, with a brief 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.

IUCAA Preprints

Listed below are the IUCAA preprints released during July - September 1999. These can be obtained from the Librarian, IUCAA (library@iucaa.ernet.in).

R.S. Kaushal and D. Parashar, *Power law inflationary scenario with a scalar field exponential potential model*, IUCAA-29/99; **A.K. Sen**, **Ranjan Gupta**, **A.N. Ramprakash** and **S. N. Tandon**, *Imaging polarimetry of some selected Dark Clouds*, IUCAA-30/99; **R. Srianand**, *High resolution study of associated C IV absorption systems in NGC 5548*, IUCAA-31/99; **R. Misra**, *A two zone model for the broad iron line emission in MCG-6-30-15*, IUCAA-32/99; **V. Sahni**, *Generating Λ from the vacuum*, IUCAA-33/99; **N. K. Dadhich**, **L.K. Patel** and **R. Tikekar**, *Global monopole as dual-vacuum solution in Kaluza-Klein Spacetime*, IUCAA-34/99; **N. K. Dadhich** and **L.K. Patel**, *Gravoelectric-dual of the Kerr solution*, IUCAA-35/99; **N. K. Dadhich**, *Electromagnetic duality in general relativity*, IUCAA-36/99; **L.K. Patel** and **N. K. Dadhich**, *Exact solutions for null fluid collapse in higher dimensions*, IUCAA-37/99; **L.K. Patel**, **R. Tikekar** and **N. K. Dadhich**, *Higher dimensional analogue of McVittie solution*, IUCAA-38/99; **L.K. Patel**, **N. K. Dadhich** and **R. Tikekar**, *Domain walls in Kaluza-Klein spacetime*, IUCAA-39/99.

Do It Yourself
Astronomical CCD Camera

The IUCAA Instrumentation Laboratory has developed the design and facilities to build a low cost CCD camera. This camera can be used with any telescope with aperture of 8 inch or larger diameter.

We invite applications from the university / college faculty to make a CCD camera for their own use. It will take about two months to make this camera and applicants may make this in more than one installment. Applicants, however, should note that they should be prepared to stay at IUCAA for at least a month at a time. IUCAA will provide local hospitality for the visit.

Applications, in plain paper, should be forwarded through the Head of the Department / Institution. Applicants should write a note, not exceeding 500 words, on their proposed application of the CCD camera, astronomical or otherwise (including the details of the instrument with which the CCD will be used). Those who want to use this camera for astronomical applications would be given priority.

Applications should be sent to S. N. Tandon, Head, Instrumentation Laboratory at IUCAA, or by email to sntandon@iucaa.ernet.in.

Balloon Astrobiology Experiment

A multi-institutional proposal initiated by J.V. Narlikar at IUCAA and N.C. Wickramasinghe at Cardiff University, UK, to measure the density of micro-organisms at different heights in the atmosphere, has been funded by ISRO. The experiment involves a balloon based cryogenic sampler, which will collect air samples at heights upto 35 kms. and bring them down in sealed bottles for analysis. Apart from ISRO and IUCAA, several other scientists including some from TIFR (Mumbai), CCMB (Hyderabad) and Cardiff University (UK), will participate in this experiment.

The experiment will test the hypothesis, first proposed in the 1970s by Fred Hoyle and Wickramasinghe, that micro-organisms are being continuously brought in by cometary debris, meteor showers, etc. and descend on Earth from above the atmosphere. A series of balloon flights will be needed to see whether there is any significant link between cometary passages and rise of the density of micro-organisms in the atmosphere. The first flight is scheduled in December 1999.

Recently, there has been a considerable re-thinking on the issue of how life originated on the Earth. The concept of implantation of life, through bacteria and viruses of extraterrestrial origin is not considered as outlandish today, as it was two decades ago. Hence, positive findings by the proposed balloon experiment will mark a great step forward in our perception of this important issue.

Vacation Students' Programme (VSP) 1999

During the period May 24 - July 9, 1999, IUCAA conducted the Vacation Students' Programme for young students from universities and engineering colleges. Twelve students, hailing from all parts of India, participated in this year's VSP. They participated in a fairly comprehensive lecture programme of about 20 days' duration, in which faculty members from IUCAA and NCRA, gave a series of lectures that covered various aspects of observational and theoretical astrophysics. Under the VSP programme, these students, depending upon their aptitude and interest, also took up their own research projects, which they conducted with great deal of enthusiasm and interest. During this period, they freely interacted and discussed their ideas with faculty members, post doctoral fellows and research scholars. They also made excellent use of IUCAA resources, such as the computer centre, the library, and audio-visual aids. During the final phase of VSP, the students presented their project results and took a written test. Based on the performance two meritorious candidates were preselected to join IUCAA as regular research scholars in August, 2000.

Visitors

during July- September 1999

S. Kar, S. Bharadwaj, B. Basu, K.P. Madhusoodanan Nair, J.C. Bhattacharyya, N. Banerjee, S. Malu, S. Singh, L.M. Saha, M.K. Das, D. Thatte, P.S. Wamane, N.C. Wickramasinghe, R. Ramakrishna Reddy, G.P. Malik, P. Rajaratnam, S. Ramani, S. Shivaji, S. Ramadurai, P.M. Bhargava, Moncy John, C. Sivakumar, S. Datta, S. Bhavsar, S.R. Valluri, R. Cowsik, G. Menon, Leony Mary, Felbin Kennedy, A. Mahabal, S.R. Kulkarni, F. Harrison, D. Frail, S. Sinha, D. Bhattacharya, Ram Sagar, S.K. Pandey, A. Ambastha, G.M. Ballabh, R. Cowsik, U.P. Singh, K.S.V.S. Narasimhan, B. Mukhopadhyay, A. Mody, Y. Hatwalne, S. Hasan, R. Simon, P. Vasu, D. Ghoshal, V. Sheorey, A. Pimpale, P.K. Srivastava, P. Upadhyay, A. Zdziarski

Apart from this about 20-25 people visited IUCAA to attend the workshop on Gamma Ray Bursts during August 26-28, 1999.

Visitors Expected

October : N. Srivastava, APSU, Rewa; D. Lohiya, Delhi University; L.K. Jha, L.N.T. College, Muzaffarpur; S. Biswas, Kalyani University; S. Mukherjee, North Bengal University; A. Goyal, Hans Raj College; R. Ramakrishna Reddy, Srikrishna Devaraya University, Anantpur; B. Ishwar, BRA Bihar University, Muzaffarpur; K.S. Sastry, Osmania University, Hyderabad; M.L. Kurtadikar, JES College, Jalna; S. Chaudhuri, Gushkara Mahavidyalaya, Burdwan; B.C. Paul, North Bengal University; S. Banerji, Burdwan University; T.K. Dey, Gurcharan College, Silchar; M. Khan, Jadavpur University; S. Chandra, SRTMU, Nanded; Arvind K. Sharma, SRTMU, Nanded.

November : Ch.V. Sastry, Indian Institute of Astrophysics, Bangalore; Chun-Chuan Pei, Purple Mountain Observatory, China; P.V. Kulkarni, Sangli; P.N. Pandita, NEHU, Shillong; J.S. Bagla, MRI, Allahabad; D. Coward, University of Western Australia;

December : A. Bhattacharya, Jadavpur; N. Ibohal, University of Manipur; U. Narain, Meerut College.

Chand Jog's name was inadvertently missed out in the visitors' list in the previous Khagol.

A Historic Patents Trial

During December 18-20, 1854, a famous patents trial took place in London's Guildhall. William Henry Fox Talbot was suing a professional photographer Martin Larouche for openly flaunting the Talbot patent of photographic printing on paper.

Fox Talbot, a scientist of repute had discovered the process and patented it. Although a Frenchman named Daguerre also had a photographic recording process to his credit, it was on metal, not on paper as the Fox Talbot's process could manage. The plaintiff had an impressive lawyer, one of the best in Europe, in Sir William Grove, a scientist and an FRS, besides a list of knowledgeable witnesses including three professors of Chemistry. On the other side, public opinion and the lobby of photography magazines that used Larouche's services, backed the defendant. The lay user of photography did not wish to pay a license fee for the process.

Neither the judge, nor the jury could get to first base with the technicality of the process, and the judge's summing up reflected this fact. The result was that Fox Talbot lost the case. He later wrote: "Nothing could be more illusory than such a trial. Neither the judge, nor the jury understood *anything* of photography... it was as if I or any other landsman were called upon to hear evidence and pronounce judgement, on the conduct of a naval captain in a gale of wind..."

A Scottish academic at the time declared that Talbot would have received a fair trial in Scotland where the judges were well versed in photography. Incidentally, his rival Daguerre also lost a similar case in France.

[Source: *A Brief History of Light* by R. J. Weiss, World Scientific.]

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

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