



Editor: Swara Ravindranath (swara@iucaa.ernet.in)
 Editorial Assistant: Manjiri Mahabal (mam@iucaa.ernet.in)

No. 85 January 2011

Available online at <http://ojs.iucaa.ernet.in>

Contents...

Past events	1, 2, 4,5,6
Congratulations	1
Welcome and Farewell	2
Obituary	3
Seminars	5
IUCAA Preprints	6
Visitors	7
Know Thy Clouds	8



M. K. Bhan
 delivering the 22nd IUCAA Foundation Day Lecture

proteomics, stem cell biology, were also discussed. The speaker also presented India's achievements in the area of vaccines, and the new directions in biotechnology research in India, which includes major capacity building in genomics and designer breeding. Bhan also emphasized the future of nanobiotechnology, which is emerging with enormous potential by bringing together nanosciences and biotechnology.

The lecture was well attended and appreciated.

The Twenty-second IUCAA Foundation Day

The 22nd IUCAA foundation day lecture titled, "Biotechnology and Development: Potential Impact and Concerns" was delivered by M.K. Bhan, Secretary, Department of Biotechnology. In his talk, Bhan gave an overview of biotechnology research and its role in the betterment of human life through the influence of biotechnology on agriculture, human health, bioresource conservation and use, clean manufacturing, etc. He highlighted the recent developments in biotechnology that have led to new drug discovery, diagnosis, and predictive and personalized medicine. New innovations, and promotion of new sciences, such as, genomics, RNA biology,

Congratulations to...

Arvind Gupta, on being conferred with the TWAS Regional Prize for Public Understanding and Popularization of Science by the TWAS Regional Office for Central and South Asia (TWAS-ROCASA), Bangalore.

Introductory Workshop on Optical and Infrared Astronomy



Participants of the Introductory Workshop
on Optical and Infrared Astronomy

The Department of Physics, DDU Gorakhpur University organized an Introductory Workshop on Optical and Infrared Astronomy during October 26 – 29, 2010. The workshop was sponsored by IUCAA. It was attended by about 33 M.Sc. students including a few research scholars.

Most of them came from different universities in Uttar Pradesh and a few were from other states. The topics covered at the workshop included Large Telescopes, Radiative Processes, Star Formation and Evolution, Circumstellar Matter and Infrared Astronomy, Spectroscopy, Interstellar Medium, and Extra-galactic Astronomy. There was a demo session on Image Processing and Analysis. The inaugural lecture of the workshop was delivered by Ajit Kembhavi. Other IUCAA resource persons included Ranjan Gupta and R. Srianand. B. G. Anandarao, PRL, Ahmedabad; H.P. Singh, Delhi University; Hum Chand, ARIES, Nainital; D. C. Srivastava and Shantanu Rastogi of DDU Gorakhpur University also delivered conceptual lectures during the workshop. The documentary 'Cosmic Collisions' was also shown to the participants. The workshop was coordinated by Shantanu Rastogi, and D. C. Srivastava was the Convener. Vijay Mohan and Ranjan Gupta were the coordinators from IUCAA.

Welcome to...

Prakash Sarkar, who has joined as a Post-doctoral Fellow. His areas of research are Galaxy redshift analysis, Cosmic web, Galaxy distribution in SDSS, etc.

Workshop on Laboratory Astrophysics: Applications to Cosmic Dust



Participants of the Workshop on
Laboratory Astrophysics: Applications to Cosmic Dust

The workshop on Laboratory Astrophysics: Applications to Cosmic Dust was sponsored by IUCAA, and organised during November 12 - 13, 2010 at M. G. Science Institute, Ahmedabad. The topics covered at the workshop were light scattering experiments and theories, interstellar extinction and polarization, dust models, cometary dust, circumstellar dust, interplanetary dust, galactic chemical evolution, stardust, and microwave analog experiments.

About thirty five university and college students and teachers participated in the workshop. Scientists, Abhijit Sen (IPR, Ahmedabad); Ranjan Gupta, (IUCAA, Pune); U.C.Joshi, K. P. Subramanian, Kuljeet Marhas, Shashikiran (all from PRL, Ahmedabad) S.K.Sharma (S.N. Bose Inst., Kolkata), J. N. Desai (Ex-PRL), Sandeep Sahijpal (Punjab Univ.) and D.B.Vaidya (Ex-Gujarat College) have given talks at the workshop. A panel discussion on, 'Importance of laboratory astrophysics for cosmic dust studies', was held during the workshop. Ranjan Gupta (IUCAA) and C. V. Pandya (M. G. Science Institute) were the conveners for the workshop. Partial financial support for the workshop was also provided by Gujarat Council for Science and Technology (GUJCOST).

...Farewell to

Maulik Parikh, who has joined the Arizona State University, USA.

Mudit Kumar Srivastava, who has joined Astrophysikalisches Institut Potsdam (AIP), Germany, as a Post-doctoral Fellow.



Allan Sandage
(June 18, 1926 - November 13, 2010)

Allan Rex Sandage, an honorary Fellow of IUCAA passed away on November 13, 2010 after a prolonged illness. He was one of those rare observational astronomers, whose work sets new trends or provides solid bases for others to build upon.

Born on June 18, 1926 in Iowa City, USA, Sandage graduated from the University of Illinois in 1948 and later joined the California Institute of Technology as a graduate student of the experienced observational astronomer Walter Baade. He was also a graduate assistant to Edwin Hubble, the discoverer of the Expanding Universe. Sandage earned his Ph.D. degree at Caltech in 1953, the same year that Hubble died. Sandage continued Hubble's programme of measuring the redshifts and estimating distances of progressively fainter (and presumably farther) galaxies. He was associated with the Carnegie Observatories and Caltech during his active life.

A good observer, Sandage was able to remove several systematic observational errors in Hubble's observations, so that he could revise Hubble's value of the Hubble constant from 630 km per second per Megaparsec to approximately 100 km per second per Mpc. This resulted in raising the age of the universe to a high enough value, so that it could accommodate ages of most constituents like stars, star clusters and galaxies. However, his own measurements of the ages of globular clusters placed the typical age above 25 Gyr, above the age of a whole range of theoretical models. Today, however, the discrepancy has been resolved with the globular clusters not more than 12.7 Gyr old, whereas the universe is thought to be 13.7 Gyr old.

As seen from putting together various other observational constraints, the value of the Hubble constant quoted today is around 70 km per second per Mpc. To the end of his life, however, Sandage continued to argue in favour of a lower Hubble constant, namely, 50-55 km per second per Mpc. Here, however, he was increasingly found himself in minority.

Sandage continued Hubble's programme of testing Hubble's law to increasing distances by looking at fainter galaxies. He was interested in determining two parameters accurately: the Hubble constant H_0 and the deceleration parameter q_0 . Determining these parameters proved to be a lifetime quest. Earlier Sandage got a value for q_0 as large as 2, which came down in his later observations and in the late nineteen seventies, he was getting close to the value zero. By then it was becoming clear that the true value may still be hidden under a host of observational uncertainties. But the observational details found by Sandage and his coworkers proved to be invaluable. His 1961 paper, which clearly laid out what tests of cosmological models could be performed with large telescopes like the Palomar 200-inch, still continues to be a beacon for observational cosmologists.

With the discovery of quasars in 1963, the early thinking was that they were all radio sources, compact compared to the standard radio galaxy. By 1965, Sandage had found optical objects with no radio counterparts that he called 'quasi-stellar galaxies'. Later they were simply called quasi-stellar objects (QSOs) and it turned out that the radio property was found only in a small percentage of QSOs.

Sandage was also responsible for the discovery of a jet in the galaxy M 82, which in a sense started the study of active galactic nuclei. His two atlases of 1961 and 1981 give pictures of galaxies as per Hubble's classification scheme. Despite being an observer, Sandage was interested in theory. He once spent a couple of hours with me to clarify his doubts in general relativity, which he was trying to understand by reading my book.

An astronomer par excellence in the classical mode, Sandage increasingly found himself isolated in the "whiz-kid" observational cosmology today; but his classic work on the extragalactic distance scale, on galaxies and QSOs is of lasting value.

Jayant V. Narlikar

Workshop on Advanced Statistical Techniques for Astronomy

The workshop on Advanced Statistical Techniques for Astronomy was organized during October 4 - 8, 2010, at IUCAA, for illustrating the usefulness of advanced statistical techniques in Astronomy. Besides theoretical sessions, there were some hands on training sessions for the participants on Astronomical Data Analysis using VOSTAT and 'R' (a statistical package).

The first lecture was delivered by S.P. Mukherjee of Calcutta University. Mukherjee introduced the basic concepts of statistics and their applications in the different areas of Astronomy and Astrophysics. Ajit Kembhavi, in his two talks, discussed the different aspects of polynomial fitting to observed data on the basis of the Chi square statistic. Tarun Souradeep, during his talks, considered several problems related to the perturbed universe and cosmic microwave background radiation. On October 5, in the first two lectures, Atanu Biswas of Indian Statistical Institute, Kolkata, discussed the methods of resampling, and in particular, the bootstrap method.

The workshop was particularly focused on Bayesian and Multivariate Analysis. Dipankar Bhattacharya introduced the concepts of Monte Carlo simulation techniques for sample generations and some basic concepts of Markov Chain. On October 6, Kalyan Das of Calcutta University, discussed the usefulness of Bayesian methods, including Gibbs sampling. Somak Roychoudhuri of Birmingham University, UK, concentrated on Multivariate Clustering Techniques for the segmentation of data and other related problems in Astrophysics. On October 7, Tarun deep Saini of Indian Institute of Science, Bangalore, discussed the basic ideas of Statistical Inference Problems and also the Bayesian counterpart. On October 8, Rajaram Nityananda of NCRA, Pune, thoroughly discussed the Properties of Long Tailed Distributions and their applications related to Astronomical studies. Tanuka Chattopadhyay of Calcutta University, presented some case studies related to Clustering of Astronomical Objects. Peter Tino of Birmingham University, UK, illustrated some probabilistic modeling techniques for Astronomical Data in Machine Learning Applications.

Everyday in the afternoon, there were hands on training sessions supervised by Asis Kumar Chattopadhyay, Ranjeev Misra, Sabyasachi Bhattacharya (Indian Statistical Institute), Saptarshi Mondal (Calcutta University) and Abisa Sinha (Calcutta University).

The Workshop was attended by more than fifty participants from different parts of the country working on areas like Physics and Astrophysics, Mathematics, Computer Science, and Statistics. It was co-ordinator by Asis Kumar Chattopadhyay & Ajit Kembhavi.

Workshop on Compact Objects

The Workshop on Compact Objects under the India-South Africa bilateral project was held at IUCAA during December 15 - 17, 2010. A team of eight members from the University of KwaZulu-Natal (UKZN), Durban, South Africa, including faculty members and students, visited IUCAA to participate in the workshop. The participants from the Indian side were faculty members, students and postdocs of IUCAA, and a few other scientists from outside IUCAA. The primary motive of the workshop was to identify the current problems in the study of compact objects and to exchange ideas and initiate probable future collaborations. While the South African participants showed their expertise on the theoretical side, their Indian counterparts were more expressive on the current observational advancements in the study of the compact stars.

The meeting started with Sunil Maharaj of UKZN giving a review on some of the stellar models in general relativity. Megan Govender of UKZN showed his investigations on the role of heat flux during the gravitational collapse of a spherically symmetric star within the context of general relativity, considering the most general spherically symmetric line element matched to Vaidya's outgoing solution across a time-like hypersurface. Sudan Hansraj also from UKZN considered a charged version of the physically reasonable Finch-Skea neutral sphere and showed that it satisfied the elementary conditions for physical plausibility including the energy conditions. The thermal behaviour of Euclidean stars was presented by Gabriel Govender of UKZN. Pedro Mafa-Takisa of the UKZN talked on his new realistic solutions for charged matter with an equation of state and Anshyn John discussed the condition for pressure isotropy being reduced to a recurrence equation with variable, rational coefficients of order three and hence proved that this difference equation could be solved to find an exact solution to the field equations corresponding to a static spherically symmetric gravitational potential in terms of elementary functions.

Dipankar Bhattacharaya of IUCAA presented the current observational constraints of neutron star equation of state. Dipanjan Mitra of the NCRA gave a very exciting talk on the coherent radio emissions of radio pulsars. Bhaswati Bhattacharyya of IUCAA spoke on the current searching for radio pulsars in unidentified Fermi-LAT bright sources, while Harsha Raichur of IUCAA shared her thoughts on the X-ray flux variabilities in X-ray binaries. Ritam Mallik from IISc explained the effect of magnetic field on phase transition from neutron star to quark star. Amitai Bin-Nun, a visitor at IUCAA from the University of Pennsylvania, presented a comparatively new topic on whether gravitational lensing can constrain or detect a boson star in the galactic centre. Dipanjan Mukherjee and Sandeep Kumar, both from IUCAA showed their results on stability of accretion column on neutron star poles and modelling of Cyclotron Resonance Scattering Features (CRSF) in accreting neutron stars respectively.

The workshop was structured in a way that there was ample amount of time in between the talks and the participants could get enough time to hold some fruitful discussions among themselves. The conveners for the meeting were Ajit Kembhavi and Ranjeev Misra from IUCAA and Subharthi Ray from UKZN.

Introductory Workshop in Astronomy and Astrophysics (With one day on Star Formation)



Participants of the Introductory Workshop in Astronomy and Astrophysics (With one day on Star Formation)

An Introductory workshop in Astronomy and Astrophysics was organized by North East Centre for Research and Development (NECRD), IGNOU, Guwahati in collaboration with IUCAA, and sponsored by IGNOU and IUCAA. This workshop was intended for young researchers (final semester post-graduate students, research scholars, and college / university teachers) who are working in the area of Astronomy and Astrophysics. There were 25 participants from different parts of the country, mainly from north eastern India. The workshop was coordinated by Ranjan Gupta from IUCAA and Anil Ch. Borah from NECRD, IGNOU.

The workshop was inaugurated by K R. Srivathsan, Pro-Vice Chancellor of IGNOU. Resource persons who delivered lectures in the

workshop were H. L. Duorah, former Vice Chancellor of Gauhati University, H. P. Singh from Delhi University, Ranjan Gupta and Swara Ravindrath from IUCAA, Aruna Goswami from IIA, Kalpana Duorah, Archana Bora and Eesankur Saikia from Gauhati University. Topic of discussion in the workshop were Basic Theoretical Considerations of Star Formation, Stellar Properties, End State of Stars, Stellar Evolution, Interstellar Dust, Astronomical Spectroscopy, Galaxies, Star formation in Galaxies, Recent Trend in Cosmology, Coordinate System and Time, Use of Neural Network in Astronomy, and The Alchemy of the Universe. P. K. Goswami, Director of Technical Education, Govt. of Assam delivered the valedictory address and distributed the certificates to the participants.

Seminars

Listed below are the seminars given at IUCAA during October-December 2010.

19.10.2010 Aruna Goswami on *CEMP stars at high galactic latitude: Clues for early galactic chemical evolution*; 09.11.2010 Biswajit Paul on *Orbital evolution of X-ray binaries and QPOs in X-ray pulsars*; 10.11.2010 A. Arellano Ferro on *CCD photometry of globular clusters: The ongoing programme*; 18.11.2010 Deepto Chakrabarty on *X-ray timing of compact stars: Recent progress and future opportunities*; 23.11.2010 Sharvari Nadkarni-Ghosh on *Modelling non-linear large scale structure using Lagrangian perturbation theory*; 2.12.2010 James Binney on *Life in the blue cloud*; 3.12.2010 James Binney on *New methods in galaxy modelling*; 9.12.2010 P. Ajith on *Interfacing analytical and numerical relativity for gravitational wave astronomy*; 10.12.2010 Tuhin Ghosh on *Characterisation of CMB foregrounds*; 13.12.2010 Peter Eggleton on *Stellar mergers*.

A Night Sky Photometer Fabrication Workshop



Participants of 'A Night Sky Photometer Fabrication' Workshop

A Night Sky Photometer Fabrication Workshop was conducted at MVS, IUCAA, Pune, during December 6-10, 2010. Eight selected participants from various Universities/Colleges/Institutes took part in this workshop, which was organized at IUCAA after almost a decade. Mornings were devoted to introductory lectures on Basic Concepts of Photometry, Photometer Fabrication Theory, Time and Coordinate System, Data Analysis and Reduction procedures for the Fabricated Photometer, and Upcoming Large Optical Telescope Facilities. The rest of the day was spent in fabricating the various electronic cards, etc. for the photometer, and after completion, night observations

were carried out using standard stars to bring all the fabricated photometers to a single calibrated stage. The participants will continue observations with their photometers (and their telescopes) at their respective home locations and maintain a log of observations for future records.

The workshop was coordinated by Arvind Paranjpye and the resource persons were: Ranjan Gupta, Arvind Paranjpye, Vilas Mestry and Samir Dhurde .

IUCAA Preprints

Listed below are the IUCAA preprints released during October to December 2010. These can be obtained from the IUCAA library (library@iucaa.ernet.in). The preprints can also be freely downloaded from <http://www.iucaa.ernet.in/~library/preprints.html>

S. V. Dhurandhar and B. Krishnan, *A group theoretic approach to detecting gravitational waves from asymmetric rotating neutron stars*, IUCAA-22/2010; Marc Kamionkowski and Tarun Souradeep, *The odd-parity CMB Bispectrum*, IUCAA-23/2010; Gaurav Goswami and Tarun Souradeep, *Power spectrum nulls due to non-standard inflationary evolution*, IUCAA-24/2010; Minu Joy and Tarun Souradeep, *Perturbed power-law parameters from WMAP7*, IUCAA-25/2010; Sudhanshu Barway, Yogesh Wadadekar and Ajit K. Kembhavi, *Bar fraction in lenticular galaxies: dependence on luminosity and environment*, IUCAA-26/2010; S. Paul, L. Iapichino, F. Miniati, J. Bagchi and K. Mannheim, *Evolution of shocks and turbulence in major cluster mergers*, IUCAA-27/2010; and Nisha Katyal, Ranjan Gupta, and D. B. Vaidya, *Interstellar dust models towards some IUE stars*, IUCAA-28/2010.

Visitors (October - December 2010)

Devraj Pawar, Saptarshi Mandal, Pranjal Trivedi, Arun Kumar, Sheelu Abraham, S.G. Ghosh, Sanjay Ghosh, Shiraz Minwalla, Vasudha Bhatnagar, Bari Maqbool Bhat, Rizwan Shahid Khan, Anoop Kumar Srivastav, C.S. Stalin, Shailesh Kulkarni, Kiran Shanker, B.C. Paul, A. Janiuk, Aruna Goswami, Ranjan Sharma, Pratik Dabhade, Soma Mandal, Biplab Raychaudhari, Siddharth Malu, Y. Sobouti, Jishnu Dey, Mira Dey, George Disuz, Marykutty John, Asoke Sen, T. Aranjeni, Arellano Ferro, A. Zdziarski, H.S. Das, D. Paul, John Hutchings, B. Paul, K.P. Singh, G. Stewart, P.C. Agrawal, S. Seetha, K.S. Sarma, T. Parimalarangan, S. Megala, T.P. Srinivasan, Y. Ravi Kiron, K. Sriram, P. Shalima, Shruti Tripathi, Sharvari Nadkarni, Ryan Doering, Deepto Chakrabarty, Amritaksha Kar, Sunil Kumar, M. Srinivas, Gaurang Mahajan, V. Jithesh, K. Jeena, G. Date, Sonali Sachdeva, Amitai Bin-Nun, H. Tagoshi, N. Kanda, H. Takahashi, R. Botet, Sudhanshu Barway, James Binney, Ethan Vishniac, Arman Shafieloo, Romeel Dave, A. Toporensky, P. Ajith, P. Eggleton, Raj Bali, J. Clackson, Gour Bhattacharya, Pradip Mukherji, Rajendra Vadhwani, Sourav Kumar Sahoo, Kameshwar Wali, Sarbari Guha, Tanwi Bandyopadhyay, Ujjal Debnath, B.C. Chauhan, K.P. Harikrishnan, Sharanya Sur, Minu Joy, P.N. Pandita, Shuvendu Chakraborty, Tarun Deep Saini, G.C. Anupama, P. Vivekananda Rao, Shishir Deshpande, Atul Gurtu, and M.K. Bhan.

Also, there were about 50 participants attending the Workshop on Advanced Statistical Techniques in October. About 15 people, majority from South Africa attended the workshop on Compact Objects in December.

Long term visitors:

Ramesh Tikekar, Josep Maria Pons, Pushpa Khare.

Colloquia

Listed below are the IUCAA preprints released during October to December 2010

10.12.2010 Shiraz Minwalla on *Fluid dynamics from gravity*; 1.12.2010 Nobuyuki Kanda on *Starting the construction of new Japanese interferometric gravitational wave detector-LCGT*; 3.12.2010 Ethan Vishniac on *Magnetic reconnection in the universe*; 6.12.2010 Romeel Dave on *Galaxy formation in the cosmic ecosystem*; and 20.12.2010 Kameshwar Wali on *The legacy of S. Chandrasekhar (1910-1995)*.

Visitors Expected

January

R.G. Vishwakarma, Unidad Academica de Matematicas, Mexico; Surajit Chattopadhyay, Pailan College of Mgmt and Technology, Kolkata; Hum Chand, ARIES, Nainital; Abhay Ashtekar, Pennsylvania State University, USA; Sudhanshu Barway, SAAO, South Africa; Martin Roth, Astrophysics Institute, Potsdam, Germany; A.C. Fabian, Institute of Astronomy, Cambridge, UK; Craig Mackay, Institute of Astronomy, Cambridge, UK; Vasudha Bhatnagar, University of Delhi; T.R. Seshadri, University of Delhi; Pratyush Pranav, Kapteyn Astronomical Institute, The Netherlands; Pranjal Trivedi, Sri Venkateswara College, Delhi; Asis Chattopadhyay, Calcutta University; Rabin Chhetri, Sikkim Govt. College, Gangtok; Soumyadip Samui, ICTP, Italy; Anjan A. Sen, Jamia Millia Islamia, Delhi; David Buckley, SAAO, South Africa; Phil Charles, SAAO, South Africa; Suman Bhattacharya, Los Alamos, USA; Jibitesh Dutta, North Bengal Hill University, Darjeeling; Mehedi Kalam, Aliah University, Kolkata; Ashish Mahabal, California Institute of Technology, USA; Soma Mandal, Taki Govt. College, West Bengal; Isabelle Paris, Institut of Astrophysics, France; B.C. Paul, North Bengal University, Darjeeling; Pragati Pradhan, St. Joseph's College, Darjeeling; Farook Rahaman, Jadavpur University, W. Bengal; Saibal Ray, Govt. College of Engineering, Kolkata; Ahmad Fayaz, University of Kashmir, Srinagar; D. Ahluwalia, University of Canterbury, New Zealand; Anisul Usmani, Aligarh Muslim University; and Wei-Tou Ni, National Tsing Hua University, China.

About 100 people from various universities and institutes in India and abroad are expected to participate in the Wideband X-ray Astronomy: Frontiers in Timing and Spectroscopy Conference during January 13 - 16, 2011.

February

Pranjal Trivedi, Sri Venkateswara College, Delhi; Andrew DeBenedictis, Simon Fraser University, Canada; D.B. Vaidya, Gujarat College, Ahmedabad; K.P. Harikrishnan, The Cochin College, Kerala; Nidhi Joshi, Jamia Millia Islamia, Delhi; Ashim Roy, Indian Statistical Institute, Kolkata; and Anvar Shukurov, University of Newcastle, UK.

Cirrus: The thin wispy clouds

Instead of discussing sequentially the types of clouds, we will discuss the clouds seen most during this period of time, namely the Cirrus (in Latin for Curl), thin and delicate in appearance, like smoke from agarbatti (incense) stick. These wispy clouds are blown by high winds into long streamers. Presence of Cirrus clouds in the sky generally mean fair to pleasant weather.

These clouds can take various shapes. One of its famous forms is known as "mare's tails" because of the appearance. Technically these are cirrus fibratus.

Cirrus, are high altitude clouds. These are formed at an altitude of about 7000 to 8000 m above the surface of the ground level and

can reach 13000 m. These clouds are formed from almost any type of clouds by process called glaciation, in which water vapour freezes into ice crystals. Contrails of high flying aircrafts are formed by this process. These clouds cast no shadow on the ground and the sun/moon light shines through these clouds.

From the point of astronomical observations, apparently clear dark black night sky could be spectroscopic or photometric depending upon the presence or absence of this type of cloud. If the signal to noise ratio drops, blame it on Cirrus, if every thing else is fine.



Cirrus clouds
(picture also shows contrail at lower left)

Name	Cirrus
Symbol	Ci
Temperature	Sub zero
Height	8000 m – 12000 m
Symbol (Graphical Representation)	
Cirrus filament	
Cirrus dense particles	
Cirrus hook shape, thinking	

Khagol (the Celestial Sphere) is the quarterly bulletin of IUCAA

We welcome your responses at the following address :

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

Phone (020) 25691414; 25604100 Fax (020) 25604699

email : publ@iucaa.ernet.in

Web page : <http://www.iucaa.ernet.in/>