KHAGOL खगोल

IUCAA

Editor
T. Padmanabhan
(e-mail : paddy@iucaa.ernet.in)

Design, Artwork and Layout
Santosh Khadilkar
(e-mail : snk@iucaa.ernet.in)

No. 37

A Bulletin of the
Inter-University Centre for Astronomy and Astrophysics
(An Autonomous Institution of the University Grants Commission)

January 1999

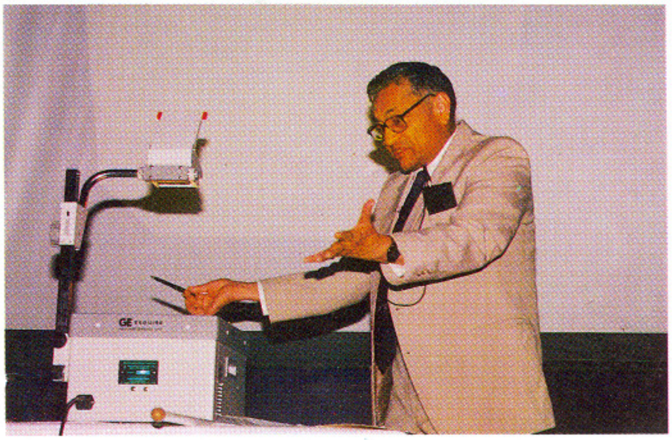
The Tenth IUCAA Foundation Day Lecture

One of the major annual activities of IUCAA is the Foundation Day lecture delivered by an eminent personality on December 29 every year. In the previous years, we were fortunate in having people like Michael Berry, Suma Chitnis, R.A. Mashelkar delivering this lecture.

This year's Foundation Day lecture was given by the eminent astrophysicist Professor Devendra Lal on "Influences of the Interstellar Matter on the Solar System". Professor Lal had an illustrious career in India in different capacities including that of Director, Physical Research Laboratory, Ahmedabad. After his retirement, he is currently working at Scripps Institution of Oceanography, Geosciences Research Division, La Jolla, USA.

In his lecture, he described the interplay between the solar system and the inter-stellar medium and how the local influences exerted by the inter-stellar environment can be studied by using different probes. We learn about the local ISM (inter-stellar matter) influences in two ways: from astronomical/astrophysical observations of the local ISM, and from archival proxy records of radiation in the terrestrial and extra-terrestrial samples. This field is now a viable new area of astrophysical inquiry, springing into life with recent advances in our knowledge of physical processes based on extensive temporal observations of solar wind, solar activity, and charged particle radiation and dust in the heliosphere.

He discussed in detail the methods used to discover archival proxy records of Solar System charged particle history and in particular how the observational data, theories and search for the proxy records are evolving. Professor Lal emphasised that this story can be considered as a text book example of how theories and observations grow hand in hand, feeding each other, as was done earlier for understanding the evolutionary history of the Solar System.



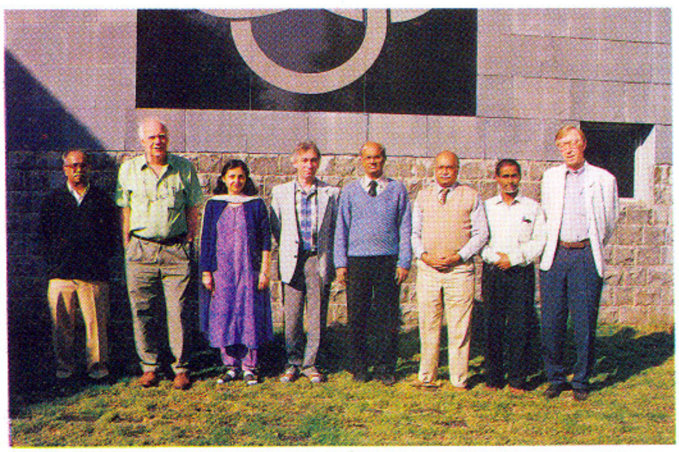
Professor Devendra Lal delivering the Tenth IUCAA Foundation Day Lecture

Inside...

The Seventh Meeting of the SAC-IUCAA

The seventh meeting of the Scientific Advisory Committee (SAC) of IUCAA was held from January 4 to 7, 1999. Richard Ellis, Ed van den Heuvel, K. Babu Joseph, Vinod Krishan, Jnanadeva Maharana, Franco Pacini, Ram Sagar and R. Rajaraman visited IUCAA and carried out an extensive exercise which included visits to the scientific facilities, presentations by the IUCAA associates, faculty, post-docs and students, informal discussions with the academic, scientific and administrative staff as well as a visit to the site of the proposed IUCAA Telescope. The feedbacks given by the SAC-IUCAA will be carefully followed up for suitable action.

While the SAC members may very well have been exhausted at the end of their meeting, they are assured that their visit, as on previous occasions, has been found by all of us at IUCAA to be very stimulating. This year the Decennial Year Meeting followed the SAC meeting and it had the benefit of participation by the SAC members.



SAC at IUCAA

Decennial Year Meeting

To mark 10 years of IUCAA's existence, a scientific meeting was organised during January 7-10, 1999. The meeting was not focused on a particular theme but rather covered the entire spectrum of gravitation, cosmology, astrophysics and astronomy. It was attended by about 125 persons. It included IUCAA's associates and other friends, philosophers and guides, and about 2 dozens colleagues from abroad of which, half of them came from South Africa.

As organisers, we were a bit anxious about how would it kick off, but it did very well highlighting the moot point that it was sufficient to have good speakers, never mind whether there was a thematic focus or not. Just to sample the topics covered, quantum mechanics, gravity and topology, supernovae and neutron stars, gamma ray bursters, deceleration parameter and distant supernovae, isotopes in different cosmologies, singularity problem, solar interior, galactic magnetism and dust, interstellar turbulence, probing QSO's, large scale structure, our own motion in the universe and so on.

On the afternoon of January 7, there was a special session of felicitation to Jayant Narlikar on his completing 60 years. It was marked by warmth, affection and informality which brought forth the high esteem in which his colleagues and friends hold him.

Brain-Storming on the IUC-Mode

At the initiative taken by Armaity Desai, the Chairperson, UGC, IUCAA hosted a one-day brain-storming session on December 30, 1998, to review the role of Inter-University Centres in the university sector, and how the IUCs-network can be widened to include other fields of study. About forty distinguished academics participated in the meeting, and the discussion covered many different aspects. There was a general appreciation of the performance of the six IUCs created so far and an expectation that other subjects, especially inter-disciplinary ones, including from the areas of social sciences and humanities would be covered by more IUCs in the future.

The Chairperson, UGC felt that the brain-storming exercise was very useful in suggesting to the UGC, a future course of action. The meeting had been organized under the auspices of the Forum of Inter-University Centres set up by the UGC.

Inauguration of the IUCAA *Science Park*

The IUCAA Science Park was inaugurated by the UGC Chairperson, Armaity Desai on IUCAA's tenth Foundation Day. This outdoor ensemble of exhibits illustrate basic principles of astronomy, physics and mathematics that are of interest to the lay person. Most of these exhibits require the interactive involvement of the visitor in their operation.

The UGC Chairperson, Armaity Desai inaugurating the IUCAA Science Park

The Chandrasekhar Auditorium at IUCAA has been used for the last few years for public events for science awareness aimed at members of the public of all age groups, in particular high school students. This Science Park will help the people who visit these science programmes in getting some hands-on experience of scientific principles.

Sympathetic Swings

Trapped in the Maze!

The Park occupies a plot of 5000 sq. m. surrounding the Chandrasekhar Auditorium in the Aditi complex of IUCAA. Only the first stage of the park, consisting of 12 exhibits, is in place at the moment. The Park will have about 30 exhibits in all, to be added in the course of the next two years.

The exhibits include a system of coupled swings on which the visitors can discover sympathetic oscillations for themselves, and a pair of parabolic reflectors showing how sound can be focussed such that whispers can be heard 80 metres away. The visitor can discover how the speed of planets vary in their orbit according to Kepler's second law by running along the Planetrek, a scaled-down version of the Hampton Court Maze which has already become popular with visitors, as has the mechanical demonstration of why one sees only one face of the moon.

All the exhibits in the park have been fabricated and installed by the National Council of Science Museums (NCSM), Calcutta.

Whisper from a distance

Cultural Programmes

A cultural festival was organised over a two week period as part of the decennial year activity at IUCAA. Pune is known for its cultural fervour and there are many festivals organised in the city during the winter every year. The festival in IUCAA was in this tradition and it enabled the many visitors who come to IUCAA to get a taste of what the city has to offer. The festival consisted of plays, vocal and instrumental recitals, and a Kathak dance. The only item presented by a troupe from outside town was by the well-known playwright and director Satyadev Dubey and his group, who presented the interesting play Insha Allah. Veena Sahasrabudhe, who is one of the famous classical vocalists resident in Pune, presented a vocal recital while the Kathak dance was performed by Maneesha Sathe and her troupe. Two short, one act plays, See-Saw (in Marathi) by students from S.P. College, Pune, and Sudama Ke Chawal (in Hindi) by the group known as Samanvay, were also staged. The music was rounded off with a vocal recital by Ranjani Ramachandran and a santoor recital by Dhananjay Daithankar. The performances were all arranged in the Chandrasekhar Auditorium and were very well attended by IUCAA members and their families, visitors as well as invitees from the city.

Kathak dance being performed by Maneesha Sathe and Shambhavi Vaze

Top to bottom:

- Inhouse Cultural Programme : Inaugural dance
- Vocal recital by Veena Sahasrabudhe;
- Sudama Ke Chawal - A one act play

IUCAA-NCRA *Graduate School*

The IUCAA-NCRA Graduate School (conducted jointly with the National Centre for Radio Astrophysics (NCRA), Pune is divided into two semesters (four terms) spread over one year. Each term is of roughly seven weeks duration. During Graduate School, the Ph.D. students (Research Scholars) are taught relevant advanced courses in Physics and are also introduced to courses in Astronomy and Astrophysics. The Graduate School structure is given below. The number of teaching hours is shown in brackets after each course, the dates may vary slightly.

Semester I, Term I, From Aug. 16 to Oct. 08, 1999.

01. Methods of Mathematical Physics I (21)
02. Introduction to Astronomy and Astrophysics I (14)
03. Electrodynamics and Radiative Processes I (14)
04. Quantum and Statistical Mechanics I (14)

Semester I, Term II, From October 25 to December 17, 1999.

05. Methods of Mathematical Physics (General Relativity) II (14)
06. Introduction to Astronomy and Astrophysics II (14)
07. Electrodynamics and Radiative Processes II (14)
08. Quantum and Statistical Mechanics II (14)

Semester II, Term I, From January 03 to February 25, 2000.

09. Astronomical Techniques I (14)
10. Galaxies : Structure, Dynamics and Evolution (21)
11. Cosmology (21)

Semester II, Term II, From March 06 to April 28, 2000.

12. Astronomical Techniques II (14)
13. Inter-stellar Medium (14)
14. Extragalactic Astronomy (14)
15. Topical Course (<21)

16. Project Work (This will be done during May - June, 1999).

The course work is supplemented by a regular stream of seminars and colloquia by members of IUCAA and Visitors.

Do It Yourself *Astronomical CCD Camera*

With pleasure, we announce that 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 diameter or larger.

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 all the necessary material and local hospitality.

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 (please enclose 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 e-mail to sntandon@iucaa.ernet.in.

Telescope Making for Amateurs at IUCAA

IUCAA guides and provides facilities to amateur astronomers for making small reflecting telescopes. This activity is going on for the last couple of years, but during last one year and a half, this activity is accelerated. Interested persons can make 6" and 8" Newtonian telescopes. Facilities for grinding, making pitch-tools, polishing, testing and figuring are provided in the Science Popularization Laboratory at IUCAA. Users grind and polish their mirrors themselves, either in the laboratory or at home. Testing and figuring of the mirrors is done in the laboratory. It takes nearly 50 hours for making one 6" mirror. The mirror is silvered in the laboratory or aluminizing is done outside IUCAA. Amateurs make Dobsonian or equatorial mounts. The entire cost of the telescope (nearly Rs. 2000–3000, depending on the make) is borne by the amateurs. During the last year, 42 telescopes of 6" diameter and 4 telescopes of 8" diameter have been made. Colleges and astronomy clubs are invited to use the facility.

Pulsars : The Cosmic Time-Pieces

Date: August 6, 1967. Location: Cambridge, England

Jocelyn Bell, a graduate student in the Mullard Radio Astronomy Observatory in the Cavendish Labs of Cambridge University was monitoring interplanetary scintillation as part of her Ph.D. thesis on scintillating radio sources. Going through her data transcripts, she came across very rapid and regular pulsations, the likes of which were never detected before. When she brought the result to the attention of her supervisor, Antony Hewish, he realized that the results needed checking into in detail. Were they of terrestrial origin? Could they come from an extra-terrestrial civilization? Or, between these two mundane or esoteric options lay a third, namely a new type of astronomical source?

Careful follow up led to the third option. With a very steady pulsation period of

1.3373011512 seconds,

the source was indeed a new addition to the astronomer's scrapbook of sources. It was named 'pulsar' and the first one detected from Bell's data-charts was called CP 1919 (Cambridge Pulsar with sidereal time 19h 19m). Later new terminology catalogues pulsars by three letters PSR (Pulsating Source of Radio) followed by their right ascension and declination. More than 500 pulsars are now known in the Galaxy.

Pulsars are known for the steadiness of their pulse rate and over a long term, they compare favourably with atomic clocks in time-keeping accuracy. Over very long term, however, the pulsar period increases.

The astrophysical understanding of a pulsar owes basically to a model proposed by Tommy Gold in 1968. The Gold model considers a spinning neutron star whose magnetic axis is not aligned with the spin axis. The electrical charges in the pulsars 'atmosphere' are whirled round rapidly across the magnetic field lines, due to which they radiate in narrow beams. The typical beam sweeps across space much like a lighthouse beacon and the observers falling in the path of the beam see the pulse effect.

Thus, we can say that because of energy loss, the spin rate of a pulsar slows down with time, the characteristic time of change may be of the order of billion years. Typically the rapidly spinning neutron star is a remnant of a supernova explosion, although in an asymmetric explosion, the core containing the star may be ejected away from the original location of explosion. One of the rare cases where the pulsar is found close to the site of explosion is of Crab nebula. The Crab supernova was seen to explode from the Earth in the year 1054 AD.

Another breed of pulsars arises from evolution of a star as member of a binary system; in this case the resulting pulsar may acquire a large spin from exchange of matter from the companion stars. Thus, pulsars with period measurable in milliseconds have been found.

The pulsar PSR 1913+16 has been a gift to general relativists. Being a member of a binary system, it has been used to test the predictions of general relativity, such as time delay, and periastron precession. Most importantly, its accurate time-keeping has helped to demonstrate that the binary system emits gravitational waves as predicted by relativity.

Pulsars have netted three Nobel Prizes, to Antony Hewish for their discovery, and to Russell Hulse and Joe Taylor for their use in testing general relativity.

QSO Absorption Lines and Galaxy Formation

Introduction

One of the main aims of a cosmologist is to understand the formation and evolution of the galaxies in the universe. Some of the main physical parameters one needs to know in order to get a complete picture are:

- amount of baryons available from which galaxies can form,
- power-spectrum of density fluctuations,
- nature of ultra-violet (UV) background radiation field (heating),
- abundances of molecules and heavier elements in the early universe (cooling),
- time evolution of the above parameters.

Detailed studies of the spectra of distant Quasi-Stellar Objects (QSOs) suggest that, one can, in principle, get all the necessary information through the absorption lines produced by the gas clouds which happen to intersect our line of sight. In this resource summary, I will briefly discuss the basic ideas used in the study and provide detailed references for the interested readers to pursue further.

Identification

The first step in the absorption line study is to identify all the absorption lines in the spectrum. Due to the cosmological expansion, a line transition occurring in UV (say 1000-2000 Å) in the rest frame of a cloud will be shifted to the optical (> 3600 Å) wavelengths in the observer's frame. First, one generates a list of rest wavelengths and the oscillator strengths of the strong ground state electronic transitions in H, C, N, O, Mg, Fe and Si (see [1] for extreme UV lines; [2] for lines with $\lambda \geq 912$ Å). A series of templates are generated for different redshifts by suitably shifting the lines in the list. Next step is to perform cross-correlation analysis between these templates and the observed spectrum. The redshifts at which the cross-correlation has maxima (i.e., set of absorption lines are present at the expected position) gives the probable redshifts of the absorbing clouds. Reality of these absorption redshifts (usually called absorption systems) is checked by the careful analysis of the profiles and line ratios of transitions from same ground state (doublets or multiplets) of an atom/ion.

Classification

The absorption systems which are identified could be produced by the gas (a) in our galaxy, (b) associated with the QSO and (c) cosmologically distributed between us and the QSO. Though, all three are important in their own right, we concentrate only on the case (c), and will refer to these systems as 'intervening systems'. Based on the number N of neutral hydrogen (H I) atoms present in the cloud along our line of sight (called column density), the systems are classified as (i) Lyman α systems ($N < 10^{17}$ cm^{-2}), (ii) Lyman limit systems ($N > 10^{17}$ cm^{-2}) and (iii) damped Lyman α ($N > 10^{20}$ cm^{-2}) systems. Almost all these systems show absorption due to heavier elements like C and Si. This suggests that the gas has undergone at least one cycle of star formation. Deep imaging studies around known absorption systems in the low redshifts show that most of these systems are somehow or other related to luminous galaxies (see [3]-[12]). Thus, they are useful in understanding the formation and evolution of disks and gaseous halos in normal galaxies. More details can be found in the articles in the conference proceedings listed separately in the end.

Baryon content of the universe

It is important to know the baryonic content of the universe before building realistic galaxy formation models. In the standard cosmological models light elements (H, He, Li, etc.) are formed during very early epoch and light element ratios are uniquely determined by the value of the density parameter, Ω, as the nuclear reaction rates and the neutrino lifetime are well determined. Deuterium provides the most sensitive measurement of Ω [13]. As *D* is easily destroyed during the star formation, in order to measure its primordial abundance one needs to use the gas which has undergone very little star formation. Metal poor absorption line systems are useful for such studies. The velocity separation between the Ly α and Deuterium α line is about ~ 84 km/s. Thus, one needs metal poor absorption system with very little velocity structure so that D lines can be detected easily. There are a few cases where absorption due to *D* (see [14]—[19]) is detected. However, these observations do not converge to a single value of Ω due to the technical problems in the data analysis like deblending of components, effect of line saturation, continuum and background subtraction, etc.

Analysis of D absorption in significant number of systems with uniform data analysis techniques will constrain Ω.

From the statistical properties of different absorption systems, one can find the fraction of the baryon that is locked in absorption systems and how this fraction changes with time (see [20]-[22]). In the case of damped Lyman α absorbers, the evolution of Ω in the redshift range z = (0.0-3.5) can be parameterised as,

$$\Omega_D(z) = (0.23 \pm 0.08) \times 10^{-3} \exp[(0.07 \pm 0.15)z].$$

Estimating such a relation for other kind of systems is difficult as most of the mass in these systems (as the gas is ionized) is in protons, and we detect only neutral Hydrogen in absorption. Thus, the estimated Ω will heavily depend on our choice of model parameters.

It was realised that even if very small amount of material is present in the diffuse intergalactic medium (IGM), due to large distances between the QSO and the observer, there are enough atoms available to produce a complete absorption in the short wavelength side of H I Ly α emission line of the QSOs (called Gunn-Peterson effect, [23]). The tests using H I Lyman α and He I λ 584 Å absorption has not shown such absorption so far suggesting the conclusion that the IGM is either highly ionized or contains much lower fraction of baryons in the universe than originally expected. If the ionization is the cause then one would expect to see Gunn-Peterson effect in the case of He II λ 303.8 Å. There are a few claims of detection of Gunn-Peterson effect in He II and in principle it is possible to estimate the fraction of baryons in the diffuse IGM ([24]-[26]). Extreme UV observations using proposed space telescope FUSE will provide this fraction over a range of redshifts. These observations together with the Ω due to luminous objects as a function of time (obtained using deep imaging techniques) will provide tight constraints on any exchange of matter (infall or outflow) between galaxies or proto-galaxies and IGM.

Power-spectrum of density fluctuations

According to most current models, galaxy formation occurred through gravitational collapse of primordial density fluctuations, with subsequent cooling and condensation of gas within dark matter halos ([27]). Observed clustering and its evolution of the absorption systems suggest that their formation and evolution is dominated by gravity. Thus, the statistical properties of absorption lines like number density distribution, column density distribution , clustering, etc. can be used to constrain the nature of the initial power-spectrum of density fluctuations ([28]-[31]). These studies suggest that standard cold dark matter (CDM), hot dark matter (HDM) and mixed dark models (MDM) models with COsmic Background Explorer (COBE) normalization under predict the number density of damped systems. Models with cosmological constant are viable.

Background radiation

The absorption lines detected in the QSO spectra are produced due to ions of different ionization states suggesting the gas is not completely neutral. In order to keep the ionization conditions intact for a long period of time one needs some sort of equilibrium. It is usually believed that the absorbing gas is in ionization equilibrium with the UV background radiation. One can imagine the clouds are immersed in a UV radiation both, most probably contributed by the light from QSOs and young galaxies. If the absorbing clouds are farther away from individual sources of UV radiation, they will see a mean radiation field contributed by all the distant sources. However, when the clouds are present close to the UV source (say QSO) they will see the excess radiation. For a cloud of given mass there will be more neutral hydrogen available if it is further away from the UV source. Thus, each QSO will have a sphere of excess radiation with a radius equal to the distance at which the radiation from the QSO equals the mean background. If hydrogen clouds are uniformly distributed in space then the clouds within the sphere of influence of QSOs will have statistically lower hydrogen column densities. Since the signal-to-noise in the spectrum puts condition on the lower limit of the detectable column density, there will be a reduction in the number of clouds detected within the sphere of influence. That is, one is expected to find a statistical deficit of absorption lines close to the redshift of the quasars. This is known as inverse effect or proximity effect. Thus, by statistically estimating the radius of influence, we can estimate the background radiation ([32]-[36]), as we know the flux of the QSO. Such studies suggest that intensity of the background radiation is constant in the redshift range z = 2.0-4.0 and decreases steeply at low as well as high redshifts. Amount of UV background radiation and its evolution is important as it contributes to the heating of the gas — thereby acting against gravitational collapse and galaxy formation.

Another background radiation which cosmologists are interested in is Cosmic Microwave Background radiation (CMB). In the standard cosmology, this radiation is a relic of the big-bang and the temperature of this radiation evolves as, $T(z) = 2.73\ K\ (1 + z)$. Thus, measuring the temperature of CMB at different redshifts is useful in testing the standard model. If one assumes that the absorbing gas is in equilibrium with the CMB then population ratios between the ground state and the excited state of neutral and singly ionized carbon can be used to estimate the CMB temperature in the redshift range 2 to 3. There are few cases in which such estimates are possible and the results are consistent with the predictions of standard model ([37]-[40]).

Molecules and heavier elements

In order for the matter to undergo gravitational collapse, one needs to reduce the kinetic energy by cooling the gas in a time-scale shorter than the dynamical time-scale. Line transitions, through different energy levels in the molecules and heavier elements, are very efficient means of cooling the gas. Thus, the presence of heavy elements and molecules are the key for efficient formation of galaxies. Since we detect absorption due to few ionization states of an atom (due to the constraint on the observable wavelength) one does not know the ionization state of the gas accurately. The accuracy of the derived heavy element abundance will be decided by how accurately we model the ionizing conditions in the absorbing clouds. However, one can make a good estimate in the case of damped Lyman α systems as the ionization corrections are very low. Thus, using the ionization states of different elements which trace the neutral hydrogen gas (like Ni II, Cr II, S II, etc.), one can get reliable estimate of heavy element enrichment ([41]-[44]). The data available till today suggests that there is a clear increase in the heavy element abundance with decreasing redshift. Obtaining such an evolution in the metal enrichment using the derived average star-formation rate as a function of redshift [45] from the direct imaging of galaxies is an open problem today.

It is well known that in our galaxy, the sites of recent star-formation are always associated with molecular clouds. If the absorption systems are sights of ongoing star formation activity in the early universe then one would expect to find molecules in these systems. Despite intensive searches H_2 and Co molecules are detected only in handful of cases ([46]-[52]). At present, it is not clear whether the early universe is devoid of efficient molecular formation or our sample of absorbers is somehow biased against clouds with large molecular content. Radio survey of absorption systems, which is not biased due to dust extinction, will clarify this issue. The existing data, however, seems to be consistent with low star formation rates at early epochs.

Summary

In this Resource Summary, I have briefly mentioned the status of estimating different physical parameters which are important for the galaxy formation models using absorption lines. With ongoing and future observational programmes, one is hoping to get a much clearer picture within a few years. The estimated parameters, together with the star formation rate and its evolution one derives from observing the distant galaxies, will be useful in building a more realistic model of galaxy formation and evolutions.

Useful conference proceedings

- QSO absorption lines: Probing the universe, 1987, Ed. C. J. Blades, D. A. Turnshek, C. A. Norman, Cambridge University Press.

- QSO absorption lines, 1994, Ed. G. Meylan, Springer.

- Structure and evolution of the intergalactic medium from QSO absorption systems, 1997, Ed. P. Petitjean, S. Charlot, Edition Frontieres.

References

1. Vernor et al. 1994, A&A, 108, 287.

2. Morton, D. 1991, ApJS, 77,119

3. Bergeron,J., & Boisse, P. 1991, A&A, 243,344.

4. Steidel, C. C., et al. 1994, ApJ,437, 75.

5. Lanzetta, K., et al. 1995, ApJ, 440, 435.

6. Lanzetta, K., et al. 1996, ApJ, 456, 17.

7. Bowen, D., et al. 1996, ApJ, 464,141.

8. Churchill, C. W. et al. 1996, ApJ, 471, 164.

9. Djorgovski, S. G. et al. 1996, Nature, 382, 234.

10. Guillemin, P & Bergeron, J. 1997, A&A, 328, 499.

11. Chen, H. et al. 1998, ApJ, 498,77.

12. Boisse, P., et al. 1998, A&A 333, 841.

13. Schramm, D., 1991, Physica Scripta, 736, 22.

14. Songaila, A. et al. 1994, Nature, 364, 599.

15. Tytler, D., et al. 1996, Nature, 381,207.

16. Songaila, A., et al. 1997, Nature, 385, 137.

17. Rugers, M. & Cohen, C. J. 1996, AJ, 111, 2135.

18. Webb, J.K. et al. 1997, Nature, 388, 250.

19. Brules,S. & Tytler, D. 1998, ApJ, 507,732.

20. Lanzetta, K. et al. 1995, ApJ, 440, 435.

21. Wolfe, A. et al., 1995, ApJ, 454, 698.

22. Storrie-lombardi, et al. 1996, MNRAS, 283,79.

23. Gunn, F. E., Peterson, B. A. 1965, ApJ, 142, 1633.

24. Jakobsen, P. et al., 1994, Nature, 270,35.

25. Davidson, A.F. et al., 1996, Nature, 380,47.

26. Reimers et al. 1997, A&A, 327,890.

27. White, S.D., & Rees, M. 1978, MNRAS, 183, 341.

28. Mo, Mirandla-Escude, 1994, ApJ, 430, l25.

29. Subramaniam, K., Padmanabhan, T. 1994 (IUCAA preprint)

30. Pando & Fang,/astro-ph/9509032.

31. Hui, L./astro-ph/9807190

32. Carswell, et al. 1982, MNRAS, 198,91.

33. Bajtlik, et al. 1988, ApJ, 327, 570.

34. Bechtold, J. 1994, ApJS, 91,1

35. Srianand, R. & Khare, P. 1996, MNRAS, 280, 767.

36. Cooke, et al. 1997, MNRAS, 284, 552.

37. Songaila, A. et al. 1994, Nature, 371, 43.

38. Lu et al. 1996, ApJS, 107, 475.

39. Ge, J., Bechtold, J., & Black, J. H. 1997, ApJ, 474, 67.

40. Ge. J., Bechtold, J. 1998, Preprint of Steward Observatory no. 1427.

41. Pettini et al. 1994, ApJ,426,79.

42. Pettini et al. 1997a, ApJ, 478, 536.

43. Pettini et al. 1997b, ApJ, 486, 665.

44. Ledoux, C., et al. 1998, A&A, 337.51.

45. Madau, et al. 1998, ApJ, 498, 106.

46. Black et al. 1987, ApJ, 317, 442.

47. Chaffee et al. 1988, ApJ, 335, 584.

48. Foltz et al. 1988, ApJ, 324, 267.

49. Levshakov et al. 1992, A&A, 262, 385.

50. Wiklind. T., Combes, F. 1994, A&A, 288, 41.

51. Ge, J., Bechtold, J. 1997, ApJ,477,l43.

52. Srianand, R., Petitjean, P. 1998, A&A, 335, 33.

Joydeep Bagchi
Arvind Paranjpye

Receiving and understanding the radio noise from Jupiter and its curious moon Io

Like many great discoveries, the story of discovery of radio emission from Jupiter and it's moon Io is full of surprises. This first detection of radio emission from any planetary body was made by B.F. Burke and his graduate student K.L. Franklin in 1955. They had been operating a newly built radio antenna known as the 'Mill's Cross' to conduct a sky survey. The aerial was tuned to 22.2 MHz and it received radio waves within a beam only 2.5 degrees wide. They set the telescope to the declination of Crab nebula in constellation Taurus and allowed the sky to drift through the beam as the earth rotated. After Crab, and another radio source IC 433 had transited, a strong and curious bit of radio noise appeared on their recorder graph. They first attributed this noise to the farming activity going on around the observatory. However, they were surprised to note that the noise occurred almost at the same sidereal time each day and it also slowly drifted westwards from its sidereal position day by day. As any good astronomer would know, this could only mean that not only the radio source is located far away amongst the stars, but it is shifting relative to the fixed stars!

Another colleague H. Tatel, who had tried unsuccessfully to detect hydrogen gas on Jupiter a few days back, somewhat facetiously suggested that perhaps this curious radio noise could be coming from Jupiter. At this suggestion, they all went out and had a good laugh when they saw the brilliant Jupiter high up in the sky. The very notion of such intense radio waves coming from a planet was simply preposterous! But nature thought otherwise. Out of curiosity, when Franklin looked up the position of Jupiter in an almanac, he was startled to find it located about right! This set all their alarm bells ringing and soon with more systematic observations it became clear that Jupiter indeed was the culprit! The radio noise was recorded only when Jupiter was within the narrow confines of their radio beam and the noise source exhibited the same change of direction as Jupiter did during its retrograde loop of 1955. This discovery took the entire scientific world by surprise and soon all the major radio telescopes were trained on to Jupiter to listen and understand it's mysterious radio noise. Thus, nature revealed one of its secrets in most unexpected manner and the truth proved contrary to all conventional wisdom.

What causes the radio noise on Jupiter?

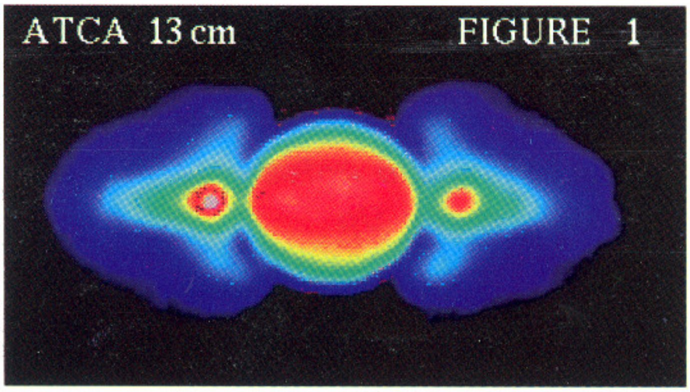
Since that momentous day in 1955, when the radio noise of Jupiter was first recorded by Burke and Franklin, many ground and space telescopes (such as Hubble) and several interplanetary spacecrafts, such as VOYAGER, ULYSSIS and GALILEO have studied the phenomenon from close range. Although there are more unsolved questions than answers, the broad facts, if put simply, are as follows:

(1) The most intense part of radio emission is received at DECAMETRIC wavelengths, with waves longer than 10 metres or frequencies shorter than 30 MHz. Mainly in the frequency range of 18-22 MHz, intense and sporadic 'radio bursts' and 'noise storms' can be heard. These last from minutes to hours and are quite unpredictable. The central role of Jovian moon Io was discovered by Bigg in 1964 when he noticed that the radio noise was very intense whenever the Earth, Jupiter and Io were in a special configuration. This happens only when Jupiter's meridional sector 200-270 degrees faces earth and the phase angle of Io is in range 205-260 degrees. The rotation period of radio source was found to be 9h 55m 29s, about 5 minutes longer than Jovian equatorial rotational period of 9h 50m 30s. This puts the noise source close to the polar regions of Jupiter (It does not rotate like a solid ball but spins faster at the equator than the poles).

(2) The location of radio emission is in the intense magnetosphere (a vast region filled with charges, radiation and magnetic field) of Jupiter. The Jovian magnetosphere is about 20,000 times more energetic than earth's and any astronaut foolish enough to venture here would die instantly of radiation poisoning. The charged particles are confined to a doughnut shaped cloud in the equatorial plane where the Galilean moon Io orbits (about 422,000 km from Jupiter). The strong magnetic field of Jupiter, shaped somewhat like a bar magnet, soon guides these particles to it's polar regions, where they gyrate about the field lines and produce the radio noise. Figure 1 shows a radio image of Jupiter (central oval), the radiation belt along the Io's orbit (red and blue zones to each side) and the particles being guided to polar regions (blue crescents).

(3) The Hubble Space Telescope pictures taken in ultraviolet light have recently shown the spectacular images of intense auroral activity. These aurorae are produced when some of these particles plunge into Jupiter's upper atmosphere. Figure 2 shows the images of these auroral ovals over the north and south Jovian poles. The power dissipated in these aurorae is about 100 million mega watts, compared to 'mere' 10,000 mega watts for earth's aurorae.

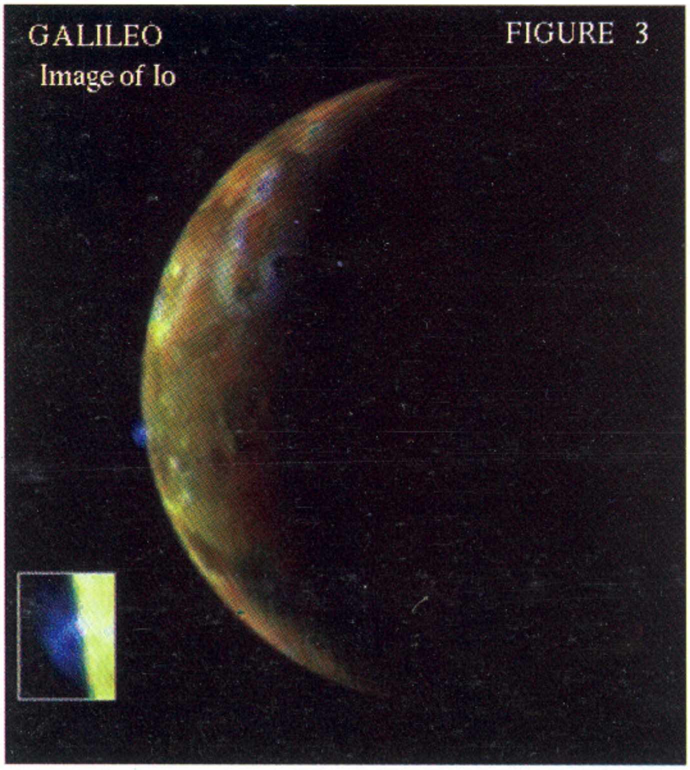
(4) Unlike the earth's radiation belts and magnetosphere, where most particles are captured from the sun, the Jovian aurora and it's radio emission is powered by charged particles ejected by its curious moon Io in the form of several volcanos that erupt often and spew material hundreds of kilometers into space. A GALILEO spacecraft picture of one such volcanic eruption is shown in Figure 3 (blue plume). Most

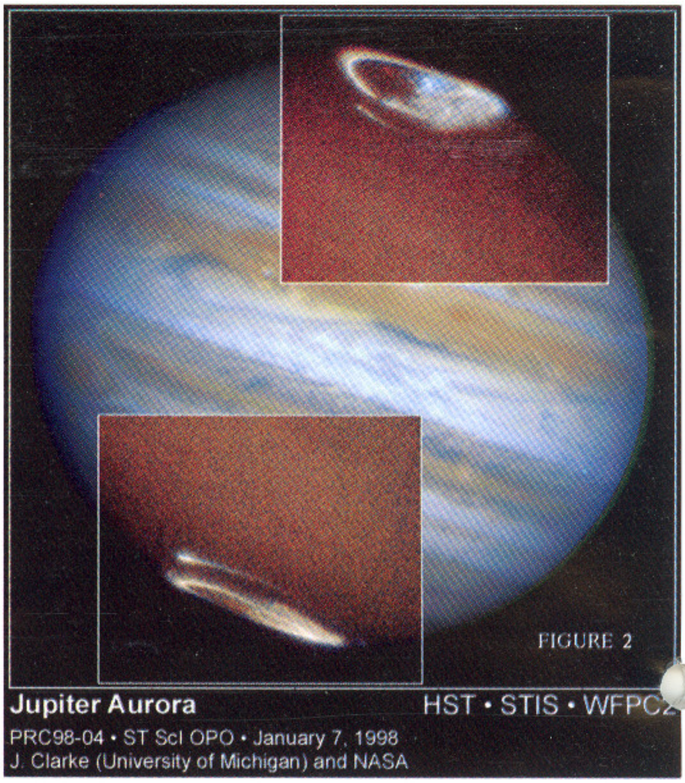


ejected material falls back and covers entire surface by yellow, brown sulphur compounds. However, the volcanic gases make the atmosphere of Io a good electrical conductor. Io acts as an electrical generator as it moves through the Jupiter's magnetic field, developing about 400,000 Volts and generating a current of about 3 million Amperes that flows between Io and the polar regions of Jupiter. This current is the main source of the decametric radio noise and the aurorae.

A simple antenna system to receive the radio waves from Jupiter and Io

A simple radio antenna setup is described here that you can build in your backyard or rooftop. With this antenna you can receive the radio noise described above and conduct some scientific experiments to better understand the fascinating radio phenomenon of Jupiter and Io. The simplest antenna that you can build is a dipole cut to the frequency of interest. Choose a good open space far from busy traffic, tall buildings, transformers and overhead power lines in order to minimise the unwanted radio noise. Now choose your frequency of reception between 18 and 23 MHz. Say, this frequency is





f MHz. The required length of the half-wave dipole would be L (metres) = 142.5/f (Mhz). As an example, say we choose 21 MHz for frequency. Therefore we are going to need a dipole of length L = (142.5/21) = 6.79 metres. Add about 40 cm length to this and from #12 gauge stranded copper wire cut the required length. The extra length is necessary to tie the wire to the insulators, but finished length should be L as calculated above. It does not matter if the wire is insulated or not and almost any copper wire would work just as well. Although, the antenna dimensions are optimized for frequency f, it would work well for range of frequencies near this value.

Now we require some pieces of insulators to support and stretch the wire horizontally. You can buy these from local electronics shop or else take a plastic ruler and saw off few 2.5 inch long sections and drill holes on their both ends to construct your own insulators. Cut the wire exactly into two half sections and tie them to the insulators as shown in Figures 4 and 5. Tie some nylon twine to the end insulators and using them fix the wire horizontally between two vertical poles or walls, as shown in the figure. To start with, an approximate north-south orientation of the dipole axis should be tried.

It is necessary that the height of the antenna above the ground be kept at H = 75/f metres. Remember again that f is frequency in MHz and, therefore, for 21 MHz operation, the height must be 75/21 = 3.57 metres above ground. At this height, the reception pattern of the dipole would be quite broad with maximum reception in vertical direction (perpendicular to dipole), zero reception along the axis of dipole, and intermediate for other directions. Now, buy sufficient long length of RG-59/U (75 Ohms, 0.24 inch outer Dia.) type co-axial cable to connect antenna to the radio receiver. This type of cable is commonly used in cable

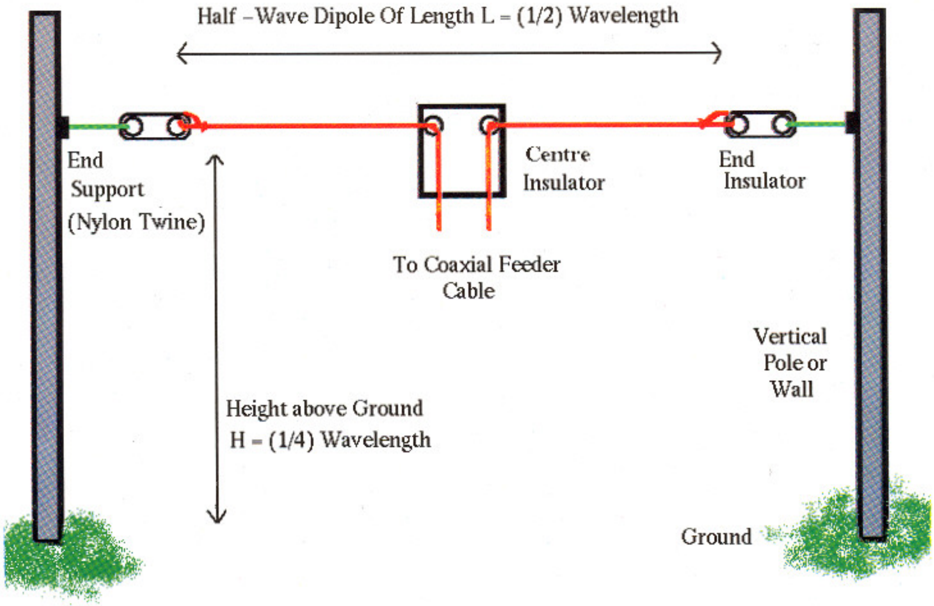


FIGURE 4

television networks and it is freely available. Do not use more than 50 feet length to avoid signal losses. You can also try using 300 Ohms twin parallel-wire type TV antenna cable but it would be more lossy. Connect coaxial cable to dipole following the figure 5 and clamp it on the central insulator as shown. Once antenna end is ready, connect the other end of the co-axial cable to a short-wave radio receiver. Many good receivers have external antenna socket and the cable can be easily connected to it using a suitable jack. If no antenna socket exists, connect the cable's copper shield to the chassis ground and the inner conductor to the antenna end of the tuning gang capacitor. Tune the receiver at a spot close to 18-23 MHz frequency and by slowly tuning within this range try to pick up the strong radio noise of Jupiter with occasional modulation or intense rapid bursts of radio noise. Of course, you must ensure that Jupiter is out there, sufficiently high up to be received by the dipole! Also, make sure that the radio waves are indeed from Jupiter by noting if the noise appears/disappears as Jupiter rises/sets at your horizon. In case, if you happen to receive weak or no signal, keep trying for several days till, as we mentioned before, Earth, Jupiter and Io come in their most favourable configuration to generate a strong noise (This may happen about once in two days; more exact daily predictions can be obtained from the authors). The non-Io dependent part of the radio emission should be heard more often. Once you have familiarised yourself with the character of the noise, try replacing the loudspeaker by a multimeter set to the most sensitive range of AC voltage reading. This way one can take a quantitative measure of radio wave intensity for scientific experiments.

What scientific experiments you want to conduct with this antenna depends on your ingenuity and interest. We can suggest a few here:

(1) Localization of radio source on Jupiter from rotational period.
(2) Probability curve of wave intensity as function of Earth, Jupiter and Io position.
(3) Do other moons of Jupiter have any effect on the radio noise?
(4) Does the activity on Sun (sunspots, flares, etc.) affect the radio noise from Jupiter's magnetosphere?
(5) How the radio noise intensity varies with time and the frequency of reception?

Some more sensitive antenna systems with capability to detect the polarization of Jupiter's radio waves would be presented in the forthcoming issues of 'Khagol'.

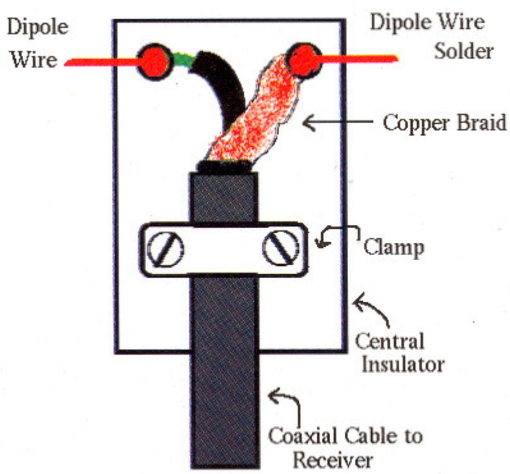


FIGURE 5

Introductory School on Astronomy and Astrophysics (at Delhi)

An Introductory School on Astronomy and Astrophysics was organised by the Department of Physics, Sri Venkateswara College, University of Delhi during October 5-9, 1998. The school was sponsored by IUCAA with additional support from CSIR, UGC and DST. It was primarily aimed at B.Sc. (Hons.) Physics students of the university who would be interested in pursuing the subject for their higher studies. Around 45 students from Delhi and neighbouring towns participated in it.

J.V. Narlikar (IUCAA) started the proceedings by giving an introduction and overview of the subject. He also delivered a public lecture on 'Anomalous Phenomena in Astronomy' in which UGC Chairperson Armaity Desai, Director of University of Delhi South Campus Abhai Mansingh and staff of Sri Venkateswara College were present. Ranjan Gupta (IUCAA) introduced the students to various definitions in Astronomy and Astrophysics Instrumentation by way of four lectures. A.K. Kembhavi (IUCAA) gave four lectures on Stellar Structure and Evolution and Compact Objects. Varun Sahni (IUCAA) delivered three lectures on Introductory Cosmology and Large Scale Structures in the universe. L.M. Saha (Zakir Hussain College, Delhi University), M.K. Das and H.P. Singh (both Sri Venkateswara College, Delhi University) gave talks on Coordinate System, The Solar System, the Sun and Helioseismology respectively. In addition, tutorials and video shows were arranged. An observing trip was organised at the historic Suraj Kund in the neighbouring Haryana where the participants observed through a 5 inch reflector. A slide-show on comet Shoemaker-Levy Jupiter collision was presented by Ranjan Gupta. The participants were asked to fill up response sheets for their views and a bound copy of the feedback forms is being kept in the IUCAA library.

Workshop on Total Solar Eclipse 1999

A one-day workshop on Total Solar Eclipse was held on October 24, 1998, for activities to be planned for the Total Solar Eclipse of August 11, 1999. There were about 100 participants from all over India. In the morning, there were three plenary talks, "Where amateur astronomers can help professionals?" by J.N. Desai of the Physical Research Laboratory, Ahmedabad, "Instrumentation for eclipse observations" by A. Ambastha of the Udaipur Solar Observatory, and "Recording eclipse: Visually, chemically and electronically" by Arvind Paranjpye, IUCAA.

In the afternoon, there was a session of contributed talks by several participants, about their previous experiences and plans for the next eclipse. This was followed by a panel discussion on "Solar eclipse as a tool to popularize science", The workshop was organized on behalf of IUCAA's Science Popularization Committee by Ranjan Gupta and Arvind Paranjpye.

Workshop on Databases, Data Visualization and Image Processing

A workshop on Databases, Data Visualization and Image Processing was held at IUCAA during November 15-24, 1998. This workshop was supported by a generous grant by the International Centre for Theoretical Physics, Trieste under the UNU programme. Persons who lectured at the workshop were Francois Ochsenbein of CDS, Strasbourg; Jean-Luc Starck of CEA-Saclay; Steve Odewahn of Caltech; Anand Deshpande of Persistent Systems, Pune; S. Chaudhuri and Uday Desai of IIT, Mumbai; and Ashish Mahabal of PRL, Ahmedabad, as well as several persons from IUCAA. There were also seminars given by various experts. There were about 80 participants at the workshop from different parts of India and three participants from Iran. The topics covered ranged over different areas of image processing, restoration, data mining and data analysis. There were several demonstrations and practical sessions for the participants of the workshop. A number of possible collaborations have been planned during the workshop.

TIFR-IUCAA Winter School

The 3rd school in TIFR-IUCAA winter school series was on the subject of "High Energy Gamma Ray Astrophysics". It was held at the High Energy Gamma Ray Observatory, Pachmarhi of the Tata Institute of Fundamental Research during October 27 to November 4, 1998. In all, 17 participants, representing all the 5 regions (Northern, Southern, Eastern, Western and Central) of the country attended the meeting. Most of the participants were young research scholars. A few M.Sc. students and teaching faculty of universities also participated in the school.

The faculty for the school was drawn from TIFR, IUCAA, PRL, NRL/BARC and Cosmic Ray Laboratory, Ootacamund. The subject matter of Gamma Ray Astrophysics was covered in detail along with the related fields like X-ray Astronomy and Cosmic Ray Physics. Some introductory lectures were also arranged on General Astronomy, Radio and Optical Astronomy to impress upon the relevance of multi-wavelength observations. Introductory lectures on particle detection techniques, Front-end-Electronics, Data Acquisition Systems, Statistical Treatment of Data, Monte Carlo Simulation Techniques, etc. were offered to train the participants in experimental techniques. Hands-on experience with some of the modern detectors were provided by arranging 5 experimental sessions. Participants were grouped in smaller numbers of 3-4 while doing these experiments. The experiments included concepts on the detection of charged particles using plastic scintillators, detection of Cherenkov radiation, orientation and tracking of telescope systems and measurement of background night sky light. The response from the participants to the lectures and experiments was very good. The school provided an informal atmosphere and an environment to interact with the faculty of the school and technical/scientific personnel of High Energy Gamma Ray Observatory.

School on Gravitation and Cosmology

A School on Gravitation and Cosmology was held at the Department of Physics, Cochin University of Science and Technology (CUST), Kochi, during October 26-31, 1998, under the joint auspices of IUCAA and the Department of Physics, CUST. The coordinators of the school were V.C. Kuriakose (CUST) and T. Padmanabhan (IUCAA). About 30 participants from different universities/colleges participated in the school and a few of the participants presented their work as seminars. The main lecturers giving the courses in the school were, K. Babu Joseph, S.Bose, J.V. Narlikar, T. Padmanabhan and K.Srinivasan.

Introductory School on Astronomy and Astrophysics (at Patna)

An Introductory School on Astronomy and Astrophysics was organised by the Indira Gandhi Science Complex-Planetarium, Patna, during November 9-13, 1998. The school was sponsored by IUCAA. It was primarily aimed at exposing students at the B.Sc. and M.Sc. levels to the various facets of the subject. In addition to the students, lecturers from various colleges also participated in the school. The participants were drawn from Patna, Magadh and Bihar universities.

The following resource persons were invited to deliver technical lectures: Ranjan Gupta (IUCAA), K.S.V.S. Narasimhan (Visitor, IUCAA), S. Biswas (Kalyani University) and Bhola Ishwar (Bihar University). The topics covered were Observational astronomy, Astronomical instruments, Time and co-ordinate systems in astronomy, Large scale structure in cosmology, and Two/Three body problem in celestial mechanics. Besides the above, popular lectures on some aspects of Astronomy with the help of slides were also given by: Ranjan Gupta, IUCAA (*on* Shoemaker Levy - Jupiter collision), S. Banerjee, IIT, Kharagpur (*on* The dramatic life of stars and the origin of the solar system), Subasis Basu, SINP, Calcutta (*on* Solar system), Rupayan Bhattacharyya, Break Through Science Society, Calcutta (*on* Journey through the world of galaxies), and Champa Das, Break Through Science Society, Calcutta (*on* Solar eclipse).In addition to these lectures, a few video shows were also organised on some interesting aspects of astronomy. The local coordinators of this school were B.K. Sinha, Indira Gandhi Science Complex-Planetarium, and S.P. Varma, Physics Department, Patna University. Ranjan Gupta co-ordinated the school from the IUCAA side.

2nd Sino-Indian Workshop on Astrophysics

The second Sino-Indian Workshop on Astrophysics was held at IUCAA during December 3-6, 1998. This was the second in a series of workshops which have been planned to provide a forum for scientists from China and India to interact together and to set up long term collaborations. The first workshop in the series was held at Nanjing, China in 1995. Six Chinese astronomers, Qiao Guojun, Huang Keliang, Peng Qiuhe, Li Xiaoqing , He Xiangtao and Qiu Yuhai, attended the workshop while the Indian community was represented by about 15 people from different institutes and universities in India. The workshop had 2 main themes, pulsars and quasars. A number of lectures were given by the Indian and Chinese astronomers and there were also informal discussions and person to person contacts, which will hopefully lead to research projects. It is expected that the next workshop in the series will be organised in China in due course.

Users' Committee

A meeting of the IUCAA Users' Committee was held on December 28, 1998. The meeting was attended by committee members, special invitees from amongst the regular users of IUCAA facilities, as well as senior members of the IUCAA administrative and scientific staff. There were useful discussions about the facilities offered at IUCAA , the pattern of the usage so far and the improvements required to make them more effective. It was agreed at the meeting that some journals which are not at the moment subscribed to by the IUCAA library, but are important to a section of the visitors, should be obtained after surveying the needs of the community. It was decided that in the peak season, a visitors' forum would be set up with a coordinator from amongst the visitors . The forum will help in organising seminars, setting up interactions amongst visitors and between visitors and IUCAA faculty. This forum will help in providing further structure and organisation to activities already taking place. It was also decided that heads of colleges and universities from which associates come to IUCAA would be appraised from time to time about activities taking place at IUCAA and they would also be encouraged to visit IUCAA.

IUCAA Preprints

Listed below are the IUCAA preprints released during October-December 1998. These can be obtained from the Librarian, IUCAA (library@iucaa.ernet.in).

R.S. Kaushal, *On the equation for stability of a star against radial oscillations*, IUCAA-36/98; B.S. Sathyaprakash, **Varun Sahni**, Sergei Shandarin and Karl B. Fisher, *Filaments and pancakes in the IRAS 1.2 Jy redshift catalogue*, IUCAA-37/98; S. Biswas, A. Shaw and B. Modak, *Time in quantum gravity*, IUCAA-38/98; B.S. Sathyaprakash, **Varun Sahni** and Sergei Shandarin, *Morphology of clusters and superclusters in N-body simulations of cosmological gravitational clustering*, IUCAA-39/98; **Sushan Konar** and Dipankar Bhattacharya, *Magnetic field evolution of accreting Neutron stars-III*, IUCAA-40/98; **T. Padmanabhan**, *Conceptual issues in combining general relativity and quantum theory*, IUCAA-41/98; **Yogesh Wadadekar**, Braxton Robbason and **Ajit Kembhavi**, *Two dimensional galaxy image decomposition*, IUCAA-42/98; Dipanjan Mitra, **Sushan Konar** and Dipankar Bhattacharya, *Evolution of multipolar magnetic field in isolated neutron stars*, IUCAA-43/98; **K. Srinivasan** and **T. Padmanabhan**, *Particle production and complex path analysis*, IUCAA-44/98; **A. Mangalam**, R. Nityananda and **S. Sridhar**, *Constrained violent relaxation to a spherical halo*, IUCAA-45/98; R.G. Vishwakarma, *Comments on "Remarks on a decrumpling model of the Universe"*, IUCAA-46/98; R.G. Vishwakarma, Abdus Sattar and A. Beesham, *LRS bianchi-type I models with a time dependent cosmological "Constant"*, IUCAA-47/98; **K. Srinivasan** and **T. Padmanabhan**, *Doing it with mirrors: classical analogues for black hole radiation*, IUCAA-48/98; **Sunu Engineer**, Nissim Kanekar and **T. Padmanabhan**, *Nonlinear density evolution from an improved spherical collapse model*, IUCAA-49/98; **M. Nouri-Zonoz** and **T. Padmanabhan**, *The classical essence of black hole radiation*, IUCAA-50/98.

Visitors

during October-December 1998

S. Chakraborti, S.N. Karbelkar, J. Mathew, D.B. Vaidya, K.K. Nandi, B.G. Anandarao, T.P. Prabhu, J.M. Espinosa, P. Alvarez, K.P. Singh, George Joseph, V.R. Mathrubhutheswaran, J.N. Desai, A. Zdziarski, J. Mikalojewska, A.C. Tikekar, R.S. Tikekar, Suresh Chandra, K. Sridhar, Z. Ahsan, S. Odewahn, I. Bardoloi, F. Ochsenbein, J.L. Starck, P.N. Pandita, H.P. Singh, G. Menon, N.M. Ashok, L.K. Patel, H.Khoshroshahi, A.K. Sapre, J. Sclater, E. Saikia, P. Shastri, He Xiangtao, Guojun Qiao, P. Dasgupta, Qiu Yuhai, Li Xiaoqing, A. Ray, D. Bhattacharya, Peng Qiuhe, Huang Keliang, K. Shanker, M.K. Patil, Yuan Qirong, D.P. Negi, V.R. Dabral, S.P. Sachdeva, P. Mahajani, C. Vanderriest, G. Herpes, J. Drilling, S.M. Chitre, A. Ashtekar, G. Burbidge, S. Dutta, Chanda Jog, M. John, K. Yugindro Singh, V.B. Johri, Parampreet Singh, H. Kastrup, S. Chakrabarty, U. Narain, R.K. Sharma, P. Agarwal, S. Chakravarti, H. Bohidar, S.D.Maharaj, J.D. Krige, G. Ambika, R.P. Bambah, D. Lal, N. Kumar, R.N. Basu, A.K. Sen, A. Bhanumathi, Yash Pal, M.M. Chaudhri, S. Mukherjee, M. Muniyamma, G.D. Sharma, V. Ramakistayya, A. Gnanam, A. Desai, Pramod Kumar, A. Krasinski.

Apart from this, about 150 - 200 people who visited IUCAA for attending various workshops, the UGC brainstorming meeting and the IUCAA decennial year meeting.

Visitors Expected

January: J.C. Pecker, College de France; J. Sellwood, Rutgers University, USA; D.B. Vaidya, Gujarat College; J. Lewins, Cambridge Society; K. Shivanandan, Naval Research Laboratory, USA.

February: J. Batt, Ludwig Maximilian University; G. Pelletier, Laboratoire d'Astrophysique de l'Observatoire de Grenoble, France; D. Malin, Anglo–Australian Observatory.

Seminars

7.10.98 Michael Tobar *on* Advanced gravitational wave detection project in Japan and Australia; 20.10.98 Sukanta Bose *on* How to cast your net and catch the wave; 29.10.98 Andrzej Zdziarski *on* X-ray slopes, compton reflection, and accretion disks in blackhole binaries and seyferts; 12.11.98 N.D. Ramesh Bhat *on* Pulsars and the local ISM; 2.12.98 P.N. Pandita *on* Neutrino mass and grand unification; 11.12.98 Qirong Yuan *on* Orientation of field galaxies in the local supercluster and luminosity correlation of the X-ray selected radio-loud AGNs; 16.12.98 John Drilling *on* Spectral classification of hot subdwarfs; 24.12.98 Chanda J. Jog *on* Local stability criterion for stars and gas in a galactic disk; and 26.12.98 Hans Kastrup *on* Quantum mechanics and quantum statistics of Schwarzschild black holes.

Spirit of Science vs Intellecutal Property Right

The following incident has been narrated by Eve Curie in her book on 'Madame Curie' :

One day Pierre received a request from certain American technicians asking for information about the process of separating radium from the ores and its purification. "We can describe the results of our research without reserve, including the process of purification..." to which Marie assented, "Yes, naturally!" "Or we can consider ourselves to be the proprietors or inventors of radium," added Pierre. They could patent the process and fully benefit by its monetary gains which they certainly and fully deserved. But Marie was quick to declare: It is impossible. It will be contrary to the scientific spirit." Pierre replied, "I think so too. But I do not want this decision to be taken lightly. Our life is hard and it threatens to be hard for ever. For our children and for us this patent would represent a great deal of money, a fortune. It could eliminate our drudgery and assure us comfort. And most important, we could have a fine laboratory of our own!"

After a good deal of reflection, Marie Spoke: "Physicists always publish their research completely. If our discovery has a commercial future, that is an accident by which we must not profit. And radium is going to be of use in treating disease... It seems to me impossible to take advantage of that." ...Silence... Then Pierre echoed her previous sentence, "No. It would be contrary to the scientific spirit."

from "Profiles in Greatness"
by Swami Sastrananda

Colloquia

13.11.98Anil Kakodkar *on* New R&D thrusts in BARC; and 4.12.98 John Sclater *on* The Andrew Bain fracture zone (southwest Indian ocean): An example of distributed extension within a large offset oceanic transform fault.

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) 351414

e-mail
publ@iucaa.ernet.in

Fax
(020) 350760

Telex
0145 7658 GMRT IN

Web page : **http://www.iucaa.ernet.in/**