KHAGOL खगोल

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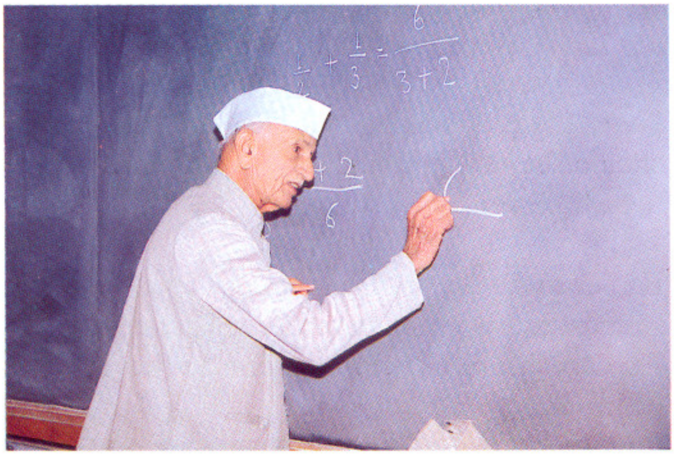
The Eleventh IUCAA Foundation Day Lecture

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 and Yash Pal delivering this lecture.

This year's Foundation Day lecture was given by Professor P.C. Vaidya on an innovative theme *"Chalk and Duster"*. Professor Vaidya is one of the foremost relativists of our country and the gravitational field of a radiating star, obtained by him originally in 1943, has found numerous applications in the study of relativity and astrophysics. He had an illustrious career in India in different capacities as Chancellor, Gandhi Vidyapeeth, Ahmedabad; Vice-Chancellor, Gujarat University, Ahmedabad; Chairman, Gujarat Public Service Commission; and Professor of Mathematics, Gujarat University, Ahmedabad. He is also a fellow of Indian Academy of Sciences and the founder member of International Society of General Relativity and Gravitation.

In his lecture, Professor Vaidya described - in his own inimitable style - his experiences as a teacher and researcher over the years in India and abroad. These experiences were both entertaining and



Professor P.C. Vaidya delivering the Eleventh Foundation Day Lecture

illuminating and Professor Vaidya could emphasize very unobtrusively the importance of continuing education for a teacher and the necessity of a passion for excellence and a willingness to learn from the students. He also pointed out how his approach towards teaching changed dramatically after his own first research experience and underscored the importance of not delinking research from teaching. He presented these features in the form of two laws characterising a good mathematics teacher, originally formulated by Professor S.N. Bose. Two aspects follow from these laws: First, the teacher should be an active research worker continuing to renew his

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The new faculty block (Brahmagupta) was inaugurated by Professor R. P. Bambah, Chairperson Governing Board of IUCAA on December 29, 1999

knowledge and adding to it. Second, the teacher should set ideals through his own life and actions to be followed by his students.

Earlier on the day, the Chairperson of the Governing Board, Professor R.P. Bambah, inaugurated the new Faculty block ***Brahmagupta*** at the IUCAA premises.

Live introduction to the Night Sky

All India Radio (AIR), Pune and IUCAA have jointly launched a monthly live programme ***"Akashdarshan — An Introduction to the Starry Heavens".*** These programmes, in Marathi, will be in the form of a live commentary anchored by Arvind Paranjpye. Listeners are invited to take their portable radio/transistor set to an open place and follow the instructions to learn about the starry skies live.

The first programme was aired on December 16, 1999 at 9:30 p.m. Ushaprabha Page, the Station Director of AIR, Pune opened the programme and Jayant Narlikar gave the over view and also answered a few questions put to him by two collegian amateur astronomers Amruta Modani and Yashodhan Gokhale. Nileema Thatte (who is a pediatrician by profession and an avid amateur astronomer) participated in showing the sky.

Sky maps are also being made available at IUCAA. The programme was well received in and around Pune.

Workshop on Interstellar Molecules

A workshop on Interstellar Molecules was held in Sri Krishnadevaraya University, Anantapur during October 29 - 31, 1999. The workshop was organized by R. Ramakrishna Reddy and T.V. Ramakrishna Rao of the Sri Krishnadevaraya University (SKU), Anantapur, on their campus. During the workshop, there were lectures on interstellar matter, molecular hydrogen emission lines, shock waves, dust in molecular clouds, spectroscopy of stars, stellar structure and evolution and atomic and molecular spectroscopy. The topics were covered in an introductory manner to benefit the students and teachers participating in the workshop. The lectures were delivered by J.N. Desai and B.G. Anandarao (PRL, Ahmedabad), H.C. Bhatt, Sunetra Giridhar and C. Sivaram (IIA, Bangalore), Ajit Kembhavi (IUCAA, Pune) and R. Ramakrishna Reddy (SKU, Anantapur). In addition to the lectures, activities like video screening of astronomical films and exhibition of books were organized.

1500th Year of Aryabhatiya

Eighteen scholars from all over India participated in the workshop organized at IUCAA to commemorate the 1500th year of the composition of the influential astro-mathematical text, ARYABHATIYA. The workshop was held at IUCAA during October 7-8, 1999.

Rajesh Kochhar, P. V. B. Subrahmanyam, S. Balachandra Rao, Vinod Mishra, and S. L. Singh gave lectures at the workshop.

Jayant Narlikar welcomed the participants and Rajesh Kochhar gave the concluding remarks. The workshop was coordinated by Arvind Paranjpye.

A detailed report on the activity of the Leonids in 1998 and its prediction for the 1999 was given as a supplement with the last issue of Khagol. Possible reasons for the failure of the Leonid storm and a surge of bright meteors about 16 hours ahead of the predicted peak were discussed in this supplement. This peak was very well documented by the team of meteor observers sent by IUCAA. After this successful run of Leonids last year, this year, the Pune group decided to take Leonid observations from three different stations. These stations were located about 200 kilometres from each other.

The first group went to a place called Sajjangadh on November 15, 1999. This place is about 130 kilometres south of Pune. From here the shower was monitored on four nights. At this station, 12 observers, took the meteor count. The second group of observers went to a place called Tahmani, which is about 60 kilometres due west of Pune on November 16, 1999 and the third group went to Sahyandri School about 80 kilometres north of Pune for one night on November 17, 1999. In all, 19 observers took part in the meteor counting. More than 55 hours of data was logged by all the three groups.

As the groups started observing on the night of November 15 they saw Taurids active and hardly any Leonids. On an average, 2 Leonids per hour were observed. On the next day, this rate went up to about 4 Leonids per hour. The peak was expected to be on November 18 at 0208 GMT (0738 IST). This meant that from India one would be monitoring the rise of the Leonids. On the night of November 17, up to three hours past midnight, that is 3 a.m. of November 18 (18th of Nov, 21:30 hrs. GMT) the Leonids activity was very poor. But after that the rapid rise in the activity was observed. A few bright ones were seen just before the sunrise at 6:42 a.m.

A team from Akashwani Pune (All India Radio, Pune) headed by Ushaprabha Page, the Station Director had reached Sujjangadh to record impressions of the observers as the Leonid activity progressed. Live patches of 5 minutes each were radioed to the station in Pune every hour starting form the midnight of November 17. These were then edited and the programme was broadcast the same morning. From Sajjangadh site Arvind Paranjpye, Neelima Thatte and Rhishikesh Kulkarni gave the commentary and from IUCAA, Yogesh Wadadekar summarized the Leonid activity based on what was available on the Internet till about 1:30 GMT. This programme was well received by the listeners as the element of excitement of live listening came through nicely.

On the night of November 18 four observers from Sajjangadh and four from Tahmani continued the observations. It was a different experience this time. The Moon was to set by about one and a half-hour past midnight. It was two days past the first quarter of the Moon and setting Moon was shinning reasonably. But one still could glimpse the active Leonids. The group started observing the Leonids after the moonset and saw sharply declining Leonids.

Observational reports have also been received from Mukesh Pathak from Rajkot and Srinivas Aundhkar.

By 23:30 GMT meteors were seen coming in twos or even threes

Large Scale Structure of the Universe

The appreciation of the complexity of the large scale structure of the universe began to come with bigger telescopes and better observing techniques.

One important development was the measurement of redshifts of galaxies on a large scale, which gives an idea of the distribution of matter in depth. From the 1980s, the surveys of specific directions have led to a picture of the extragalactic universe which is inhomogeneous on the scale of ~ 100 megaparsecs. Thus there are superclusters of this size interspersed with voids, also of comparable sizes. The voids seem to have very few galaxies in them. The supercluster would typically contain upwards of 10^{15} solar masses, distributed in the form of clustered galaxies, often spread out in a filamentary fashion.

The so-called Great Wall is one such structure that has dimensions 60 Mpc x 170 Mpc. The larger the scope of the survey, the more of this inhomogeneity is being revealed, and the question at present is, whether we have reached the end of the hierarchy of scale or there is more to come. The Hubble law itself identifies a scale of the order of 3000 Mpc. So as the scale-hierarchy grows the question arises as to whether the assumption of a homogeneous universe on a large enough scale, made by most theoretical cosmological models is still on a sound basis.

The data in the 1990s is also beginning to reveal relatively large scale motions of the order of 1000 km/s over and above that of the Hubble flow. While in a cluster, one may expect peculiar motions (due to gravitational interaction) of the order of 250 km/s, the above motions are on a larger scale. This has led to the hypothesis of the Great Attractor, which is a massive system (as yet unseen) responsible for generating such a motion in its direction.

These measurements acquire great theoretical importance within the framework of the standard big bang model, which assumes that in the early universe radiation and matter were closely coupled and so any inhomogeneities of matter would be coupled to those of radiation. The fact that the cosmic microwave background is so much more homogeneous than the matter distribution has led to the belief, that the inhomogeneities in matter became pronounced only after matter and radiation got decoupled. Indeed, the smoothness of the CMB had become something of an embarrassment to the theoreticians till 1992, when the COBE satellite revealed the first such inhomogeneities on the scale of about 10 degrees, and of magnitude of $\Delta T/T$ of a few parts in a million.

The present challenge before big bang theoreticians is to have a viable structure formation theory which meets the above observational constraints. The existence of non-baryonic dark matter is considered essential for such theories to work, but so far no acceptable theory has emerged.

Workshop on observational programmes with 2-m class optical telescopes

The workshop was organised jointly by Uttar Pradesh State Observatory (UPSO), Nainital and Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune from 25 - 29 October, 1999 at UPSO. There were thirty outstation participants representing different institutes, university and colleges and about 20 participants from UPSO.

In the near future 2 to 3 metre sized telescopes will be installed in the country. This workshop was organised to identify observational programmes to be taken up on such telescopes. The topics covered included gamma-ray bursts, open clusters, close binary systems, galaxies, AGNs, rapidly oscillating stars, microlensing, stellar spectroscopy and polarimetry. The speakers were Ram Sagar, S.N. Tandon, A.K. Kembhavi, S.K. Pandey, N.M. Ashok, Ranjan Gupta, U.S. Chaubey, B.B. Sanwal, Vijay Mohan and M.K. Das. Ph.D. students from UPSO also presented their research activity in the workshop.

A visit to Devasthal, proposed site for setting up the 3-metre telescope of UPSO and TIFR was organised on October 28.

Magnetic Fields of Neutron Stars

Introduction

There has always been a great interest in the ultimate fate of the stars after the nuclear fuel is exhausted. With the advent of Fermi-Dirac statistics Chandrasekhar proved that white dwarfs, with electron degeneracy pressure supporting the gravitation, could be one such end state. The logical extension of this argument is the *neutron stars* where the pressure comes from the degenerate neutrons and from the forces of nuclear interaction. Indeed, long before the discovery of pulsars, rapidly rotating strongly magnetized neutron stars, Baade & Zwicky suggested the possible birth of neutron stars in supernova explosions. The later discovery of a pulsar at the site of the Crab Nebula (the remnant of 1054 A. D. supernova) lent credence to this hypothesis. As a star of main-sequence mass $\gtrsim 8 M_{\odot}$ explodes in a supernova, most of its mass is thrown away and a compact neutron star ($M \sim 1.4 M_{\odot}$, $R \sim 10$ km) is left behind. [1,2]

Pulsar emission, pulsed and characterized by their precise periodicity, is essentially *magnetic dipolar* radiation derived from the kinetic energy of rotation. For a pulsar of period P and period derivative $\dot{P}$ the magnetic field is measured to be :

$$B \sim \left(\frac{3Ic^3 P\dot{P}}{8\pi^2 R^6}\right)^{1/2}, \qquad (1)$$

where, I is the moment of inertia and R is the radius of the star. This simple estimate only provides a measure of the dipole component. There have been a few direct measurements of the field, like that from the cyclotron line-strength of Her X-1, but the scope of such direct measurement is limited only to the case of X-ray binaries. The typical values of magnetic field lie in the range $\sim 10^8 - 10^{13.5}$ Gauss and perhaps with the recent conjecture of *magnetars* (thus named due to their extremely large magnetic fields) stretch up to $\sim 10^{15}$ Gauss. [2]

Unfortunately there is as yet no satisfactory theory for either the generation or the subsequent evolution of the magnetic field of neutron stars. In particular the evolution of the fields is of great importance because several other aspects of pulsar physics crucially depend on the nature of it. Though over the years a coherent picture has emerged, many of the key issues remain unresolved, like the generation of millisecond pulsars ($P \sim 10^{-3}$ s, $B \sim 10^8$ Gauss) and their evolutionary link to the population of normal pulsars through a processing in binaries. From observational facts and statistical analyses made on the pulsar population, the following conclusions can be drawn regarding the field evolution (see fig. [1] also) [3] :

a. Isolated pulsars with high magnetic fields ($\sim 10^{11}$ - 10^{13} G) do not undergo significant field decay over their lifetime.

b. Millisecond and globular cluster pulsars which almost always have a history of being a member of a binary, possess much lower field strengths suggesting that significant field decay occurs only as a result of the binary interaction.

c. Most of the millisecond pulsars are long-lived ($\sim 10^9$ years) and hence the field must be stable over long time-scales after the period of binary interaction is over.

d. High field pulsars processed in low-mass X-ray binaries (neutron star with a low-mass companion) end up as millisecond pulsars.

Origin of the Magnetic Field

There are two main theories for generating the magnetic field. The field can either be a fossil remnant from the progenitor star, or be generated after the formation of the neutron star. The nature and location of the currents in either case would be completely different owing to the peculiar internal structure of a neutron star [4]. Structurally, a neutron star has two different regions. The outer shell, the *crust*, is about a kilometer thick in which the density changes by eight orders of magnitude going from 10^6 g cm^{-3}to $10^{14.5}$ g cm^{-3}, and behaves like a crystalline solid of neutron rich nuclei. In the inner *core* has an average density of nuclear matter and is believed to have superfluid neutrons along with superconducting protons and ultra-relativistic, Fermi degenerate electrons [1].

Fossil Field - Originally suggested long before the discovery of pulsars, the idea of the fossil field is considered to be the most promising. The magnetic field existing in the core of the progenitor star gets enhanced when the core collapses in a supernova, conserving the magnetic flux. Flux conservation demands an increase in the field strength by a factor $(R_{\rm progenitor}/R_{\rm NS})^2$ which is of the order of

10^{10}. This can, depending on fields in the cores of the progenitor stars, produce fields as large as $10^{14} - 10^{16}$ Gauss. Calculations indicate that protons inside the core is a type II superconductor and therefore can support magnetic fields in quantised Abrikosov fluxoids each of which carry a flux quantum of $\phi = \frac{hc}{2e} = 2 \times 10^{-7}$ G-cm^2. [4a]
One major problem with the concept of a fossil field is that strong surface fields are not observed in massive stars except in some dynamically peculiar ones. It has been suggested that the fossil magnetic may not be a relic of the main sequence but can be generated in the core during the turbulent Carbon-burning phase. The strong field can therefore be hidden in the core, but given the short duration of the Carbon-burning phase, it is unclear whether this field can organize itself into large-scale poloidal components [4a,i]. Recent results hint that the core superconductor is likely to be of type I. This would imply completely different structure for the field and would require a redressal of some of the existing theories of field evolution [4a,ii].

Crustal Field - Almost all the existing field evolution models depend on ohmic dissipation of the currents in the crust where the electrical conductivity, though very large, is still finite (unlike the superconducting interior). Therefore, models that makes generation of crustal currents possible is a very attractive proposition. The interior of a neutron star quickly settles into a superconducting state after its birth as the temperature falls below T_c ($\sim 10^9$ K). Since the observed field values are much smaller than the critical field of this superconductor any field generated afterwards must be entirely crustal. It has been suggested that the magnetic field arises as a consequence of thermal effects occurring in the outer crust in the early phases of the thermal evolution of the neutron star. The field can grow either in the liquid phase and then be convected into the solid regions, or it could grow in the solid crust itself. In the solid, the heat flux is carried by the degenerate electrons giving rise to thermoelectric instabilities that in turn make the horizontal components of the magnetic field grow exponentially with time. Such instability can also develop if the liquid phase that lies above the solid contains a horizontal magnetic field. The coexistence of a heat flux and a seed magnetic field, in excess of 10^8 Gauss, in the liquid will cause the fluid to circulate which may lead to effective dynamo action. Either of these two instabilities will soon saturate to produce a field strength of $\sim 10^{12}$ Gauss, where the instabilities become non-linear. Further growth will be prevented when either the magnetic stress exceeds the lattice yield stress of the crust or the temperature perturbations become non-linear, both of which happen at a subsurface field of $\sim 10^{14}$ Gauss. The corresponding surface field is $\sim 10^{12}$ Gauss. The basic problem with post-formation field generation mechanism is that this mechanism is capable of generating only toroidal modes and the scale-size of the field is confined to the melting depth of the crust which is of the order of hundred meters. Therefore the origin of the observed large-scale dipolar fields still remains an open question. [4b]

Evolution of the Magnetic Field

In order to understand the observational facts attempts have been made to relate the field decay to the star's binary history. Two classes of models have mainly been explored - one that relates the field evolution to the spin evolution and the other attributing the field evolution to direct effects of mass accretion. All the models are basically built upon two themes, namely, a large scale macroscopic restructuring of the field lines in the interior (for example, the spin-down and expulsion of flux from the superfluid core of the star) and a microscopic mechanism (like the ohmic dissipation of the currents in the crust) actually dissipating the underlying currents. The different class of models usually assume different initial field configuration. Models depending on spin-down assume a core-flux supported by proton superconductor flux tubes. Whereas, models invoking ohmic dissipation usually assume an initial crustal configuration. It should be noted here that a whole host of models exist that discuss field evolution of isolated neutron stars but we shall confine our discussion to accretion-induced models here. [3]

The former class of models involves the inter-pinning of the Abrikosov fluxoids (of the superconducting protons) and the Onsager-Feynman vortices (of the superfluid neutrons) in the core. Neutron stars interacting with the companion's wind would experience a major spin-down, causing the superconducting core to expel the magnetic flux, which would then undergo ohmic decay in the crust. This coupled evolution of spin and magnetic field has been modeled both for the cases of wide low mass X-ray binaries and high mass X-ray binaries and shows that the final field values could be quite consistent with those observed for millisecond pulsars. Another scenario suggests a coupling between the spin and the magnetic evolution of the star via crustal plate tectonics - torques acting on the star cause crustal plates, and the magnetic poles anchored in them, to migrate, resulting in major changes of the effective dipole moment. [3a]

The other class of models attribute the field decay to direct effects of accretion. Initial work suggested that accreted matter might screen the pre-existing field. Later computations indicated that hydrodynamic flows may bury the pre-existing field reducing the strength at the surface. Recent estimates however indicate that strong Rayleigh-Taylor instabilities prevent such hydrodynamic flows to create horizontal components of the field at the expense of the dipolar component, and therefore such a screening mechanism may not provide for a viable scenario of field evolution in an accreting neutron star [3b,i].

The most important microscopic mechanism invoked for accretion-induced field decay is that of fast ohmic decay in an accretion-heated crust due to enhanced resistivity. There is also an additional effect that acts towards stabilizing the field. As the mass increases, a neutron star becomes more and more compact and the mass of the crust actually decreases by a small amount. So the newly accreted material forms the crust and the original crustal material gets continually assimilated into the superconducting core beneath. The original current carrying layers are thus pushed into deeper and more dense regions as accretion proceeds. The higher conductivity of the denser regions would progressively slow down the decay, till the current loops are completely inside the superconducting region where any further decay is prevented. This scheme also provides for a limiting minimum field strength—the so-called 'flooring' seen at $\sim 10^8$ G. The mechanism of ohmic decay, being unique to the crustal currents, is also used in models where spin-down is invoked for flux expulsion. [3b,ii]

It is evident that processes of both macroscopic and microscopic nature are active in the interior of an accreting neutron star. The change in angular momentum induces a large scale flux movement whereas a change in total mass gives rise to large scale material movement. Both these cause macroscopic restructuring of the current pattern. On the other hand, a change in temperature induces the microscopic process of ohmic dissipation, by which the energy stored in the large scale field is transferred to the random kinetic energy of the particles. It should be noted that most of the above models suffer from a number of uncertainties as listed below :

A. Thermal Behaviour -

i. Isolated Phase - The present data can be made to fit scenarios with both a *slow* or an *accelerated* cooling. Hence it is not clear which is the correct cooling behaviour of an isolated neutron star.

ii. Accreting Phase - the crustal temperature corresponding to a given rate of accretion has not been determined with any certainty. Also, the existing results are limited in their scope and there is no agreement between various authors.

iii. Post-Accretion Phase - No calculation exists for the thermal behaviour of this phase at all.

B. Transport Properties - The effects of the change in the chemical composition due to a) accretion and b) spin-down; and the dislocations, defects etc. of the crustal lattice are yet to be incorporated.

C. Equation of State - Apart from the uncertainties already existent for a cold equation of state for the nuclear matter the change in the chemical composition due to accretion introduces change in the equation of state and hence in a) the structure of the star and its b) transport properties. These effects are not taken care of in the field evolution models either.

Issues Unresolved

In summary, the issue of magnetic field in neutron star is, by no means, a closed chapter. We still need to understand :

• The theory of field generation and a possible method to distinguish between crustal and core field configurations.

• The nature of the evolution of higher multi-poles in presence of accretion, in particular the effect of Hall currents (existing models mainly concentrate on dipolar fields).

• The possible screening of the magnetic field by accreting material.
• The nature of field evolution in magnetars which are believed to have a rapid field decay without any binary companion. [5]
• The claim that some of the pulsars could be *Strange Stars* (stars made up of u, d and s quarks) instead of neutron stars regarding the evolution of their magnetic field. [6]

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5. **Magnetars** - Heyl J. S., Kulkarni S. R., 1998, ApJ, 506, L61

6. **Strange Stars** - Madsen J., 1998, PRL, 81, 3311

7. **Resource** - *Radio Pulsars*, 1994, ed. Weisberg J. M., American Association of Physics Teachers
Though somewhat dated a very good source book on pulsar research.

legend - ** - text book, * - review article

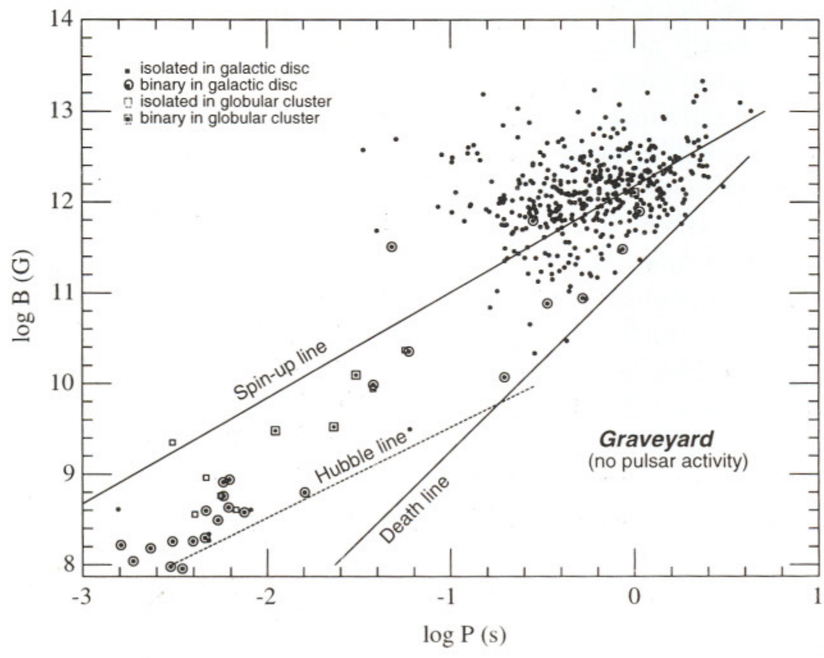

Figure 1: P vs. B of observed pulsars. The minimum spin-period achievable through binary recycling is along the Spin-up line. The Hubble line corresponds to the characteristic age of the pulsars equal to the age of the universe.

Introductory Summer School on Astronomy and Astrophysics

The School proposed to be held during May 22 - June 23, 2000 at Pune, is designed to introduce the students of physics, mathematics, electronics engineering and technology to the exciting fields of Astronomy and Astrophysics (A & A). No previous knowledge of A & A is necessary, although familiarity with the basic principles of mathematics and physics will be required.

The school will be funded by the Department of Science and Technology, New Delhi, and hosted by Inter-University Centre for Astronomy and Astrophysics (IUCAA) and National Centre for Radio Astrophysics (NCRA) of the Tata Institute of Fundamental Research, Pune.

We expect to have about 35 students participating in this programme. The programme of the school will consist of lectures, covering fundamentals of A & A as well as recent developments in the field. In addition, participants will take part in individual projects under suitable guidance. The lecturers for the school will be drawn from the leading A & A centres in the country, so that the participants will get an exposure to the work being done in these fields. There is a possibility for a few motivated students, to spend an additional week at IUCAA / NCRA after the school.

Eligibility: Students completing their 1st year M.Sc. (physics/applied mathematics/astronomy/ electronics) or 3rd year B.E./B.Tech. in 2000 can apply. Exceptionally bright and motivated students completing their B.Sc.(physics) in 2000 may also apply.

How to apply: In plain paper, in the following format : 1. Name, 2. Sex, 3. Date of birth, 4. Address for communication, 5. Qualifications (standard X onwards) with institution / year / subjects / class / grade / percentage of marks obtained, 6. Short write-up giving motivation for applying for the school, 7. Previous summer schools attended, if any, 8. Names and addresses of two referees (these referees should be teachers/project guides, etc.), and 9. Signature with date.

The applicants should request the above referees to send their confidential assessments/ recommendations under separate envelopes. Applications and referee reports should reach **The Coordinator, Core Programmes, IUCAA, Post Bag 4, Ganeshkhind, Pune 411 007**, by March 15, 2000. The selected candidates will be informed by April 15, 2000. They will be provided with travel, board and lodging for the duration of the school.

IUCAA Preprints

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

S. Bose, Naresh Dadhich and **Sayan Kar**, *New classes of black hole spacetimes in 2+1 gravity,* IUCAA-40/99; **Tarun Deep Saini**, **Somak Raychaudhury**, **Varun Sahni** and **A. A. Starobinsky**, *Reconstructing the cosmic equation of state from supernova distances*, IUCAA-41/99; **K. Srinivasan** and **T. Padmanabhan**, *A novel approach to particle production in an uniform electric field*, IUCAA-42/ 99; **T. Padmanabhan**, *Aspects of gravitational clustering*, IUCAA-43/99; **Habib G. Khosroshahi**, *Correlations among global photometric properties of disk galaxies*, IUCAA-44/99; **D. Mitra, S. Konar, D. Bhattacharya, A.V. Hoensbroech, J. H. Seiradakis** and **R. Wielebinski**, *Evolution of multipolar magnetic fields in isolated neutron stars and its effect on pulsar radio emission*, IUCAA-45/ 99; **Sushan Konar** and **Dipankar Bhattacharya** *Magnetic fields of neutron stars*, IUCAA-46/99; **Sanjeev V. Dhurandhar** and **Alberto Vecchio** *Search for continuous gravitational wave signals from sources in binary systems*, IUCAA-47/99; **Boudewijn F. Roukema** *COBE and global topology: An example of the application of the identified circles principle*, IUCAA-48/99; **B.F. Roukema** and **G.A. Mamon**, *Tangential large scale structure as a standard ruler: Curvature parameters from quasars*, IUCAA-49/99 *and* **Parampreet Singh and Naresh Dadhich**, Derivation of the Maxwell equations and the relation between electric and magnetic charge, IUCAA-50/99.

Call for Proposals

The Nuclear Science Centre (NSC), Delhi is setting up a radioactive ion beam (RIB) facility. The first beam extracted is of ^{7}Be and the first experiment to be done is to measure the angular distribution of the reaction $^{7}Be(d_1n)^{8}B$. This is being done jointly with scientists in BARC and SINP.

The NSC has invited IUCAA to suggest collaborative programmes in nuclear astrophysics using this facility. Further RIBs are being planned. IUCAA invites proposals from university faculty members in nuclear astrophysics which could use this facility at the NSC. Proposals may be sent to the Director, IUCAA.

Seminars

28.10.99 Daksh Lohiya *on* Going Beyond Standard Big Bang Cosmology and 15.11.99 H.S. Hans *on* My Nuclear Physics Experiments in Four Decades

IUCAA Observing Programmes

IUCAA has ongoing observing programmes for interested persons from universities and colleges. The programmes involve observing with small and large optical telescopes, through proposals submitted to various observatories in India and abroad, under their Guest Observing Programmes. Observations with the Ooty Radio Telescope and analysis of archived data obtained from various terrestrial and space based telescopes are also possible. Intending observers may work either individually or in collaboration with each other and/or with IUCAA faculty. Interested persons may write to the Head, Guest Observing Programmes, IUCAA (e-mail: rag@iucaa.ernet.in).

Proposals for holding Workshops/Schools Outside IUCAA

Proposals to conduct workshops/schools in Astronomy and Astrophysics or related areas are invited from university departments/affiliated colleges and the same may be sent to the Dean, Visitor Academic Programmes (VAP), IUCAA with a copy to the Chairman, Workshop Committee, IUCAA by March 1, 2000 (for events during March 2000 - October 2000) so as to be included in the academic calendar for the next academic year.

The following details should be given while sending the proposals: *the title (topic), duration of the workshop/school, topics to be covered and number of lectures in each topic, the level of audience and their number, the number of resource persons available locally and the number of resource persons expected from IUCAA, a description of the facilities available and the budget estimates (clearly stating the support offered by the host university / institute).*

It is generally expected that accommodation to the participants as well as the resource persons will be provided by the host institution. Other expenses will be borne by IUCAA. The proposers are encouraged to consult IUCAA faculty while framing the workshop/school proposal.

Once the workshop/school is approved, IUCAA will nominate a coordinator from its faculty, who will interact with the organiser in relation to academic programme, budget and identifying and approaching the resource persons.

Colloquia

11.10.99 Naresh Dadhich *on* Empty Space and its Dual in General Relativity; 23.12.99 Kailash C. Sahu *on* Gravitational Microlensing, Dark Matter, and Extrasolar Planets and 27.12.99 S. R. Sarma *on* Astronomical Instruments in Medieval India.

Visitors Expected

January 2000 : P.P. Hallan, Zakir Husain College, Delhi; K. Govinder,University of Natal, Durban; B.S. Sathyaprakash, College of Cardiff, University of Wales; Roy Maartens, Portsmouth University, UK; Lalan Prasad, Government P.G. College, Gopeshwar; Rajashree Thakur, Chowgule College, Goa; Tarun Ghosh, Kansas State University, J. Touma, University of Beirut, Lebanon; M. Burbidge, Centre for Astrophysics & Space Sciences, University of California, USA; Ch.V. Sastry, Institute of Astrophysics, Bangalore; A. Rawat, Regional Institute of Technology, Jamshedpur; J.C. Pecker, College de France, Paris; B.B. Walwadkar, Walchand College of Engineering; P.S. Naik, Gulbarga University;

Apart from the above, there will be participants attending the 3rd Level 1 workshop on Astronomical Photometry during January 17-21; the miniworskhop on Quasar Spectroscopy during January 21-23 and the International Conference for Science Communicators during January 28-30.

February : M.S. Khan, Kashmir University; N. Iqbal, Kashmir University; S. Chakravarti, Visva Bharati, Santiniketan; D. Malquori, Dipartment di Astronomia, Padova, Italy; M. Sargurumoorthy, Tamil Nadu Science & Technology Centre; Ram Sagar, UPSO; S.M. Chitre, TIFR, Mumbai; U.C. Joshi, Physical Research Laboratory, Ahmedabad; A. Moitra, INSA, Delhi; S. K. Pandey, Pt. Ravishankar Shukla University, Raipur; V. Polcaro, CNR-IAS, Italy

March : K. Jotania, Xavier's College, Ahmedabad; Tadashi Mukai, Kobe University, Japan; Akihide Kamei, Kobe University, Japan

Congratulations!

...to **H.P. Singh**, Senior Associate of IUCAA for being elected Fellow of the **Royal Astronomical Society.**

Visitors

(October - December, 1999)

S. Bhavsar, H. Khosroshahi, P.S. Wamane, A. Goyal, R. Ramakrishna Reddy, D. Lohiya, L.K. Jha, S.N. Hasan, S.N. Biswas, K.S. Sastry, Suresh Chandra, A.K. Sharma, S. Mukherjee, S.Chaudhuri, M.L. Kurtadikar, B. C. Paul, S. Banerji, S. Ray, B.Ramachandran, S.G. Ghosh, T.K. Dey, D.N. Guru, A. Banerjee, S.N. Paul, B.K. Ghosh, A. Abraham, K.C. Mathai, S. Johny, T.N. Manikanthan Nair, G.Chandrasekharan, S.T. George, V.O. Thomas, A. Beesham, U.V. Dodia, N.S.Singh, D.B. Vaidya, P.V. Kulkarni, K.K. Nandi, P.N. Pandita, G.P. sIngh, K. Shanker, H.S. Hans, R. Tikekar, M.K. Patil, P.S. Parihar, N.B. Humeshkar, P.K. Srivastava, D. Coward, A.C. Kumbharkhane, A. Bhattacharya, S.K. Sahay, M. Azimlu, Sajith Philip, Moncy John, A. Omont, P. Udayshankar, B.A. Bambah, N. Ibohal, K. Azad Singh, Mohd. Amir Khan, S. Chakrabarty, K. Sahu, M. Sami, G.P. Malik, Usha Malik, P. Gupta, F. Patadia, K. Indulekha, L. Banga, Vijayagovindan, K. Jotania, H.P. Singh, N. Kirbanand, P.S.Goraya, R. Bambah, A. Bhatnagar, R.P. Gangurde, E. Saikia, P.C. Vaidya, S.K. Banerjee, F. Naseri.

Apart from the above, about 20-25 people attended the workshop on 1500th year of Aryabhatiya during October 7-8, 1999.

Congratulations!

...to **T. Padmanabhan,** on being conferred with the ***Millennium Medal*** by Council of Scientific and Industrial Research (CSIR), India, *and*

...to **Tirthankar Roy Choudhury,** on being conferred with the ***Late Deblina Choudhari Award*** of Indian Physics Association, Pune Chapter, for best oral presentation by a research scholar.

GOA AND GRAVITATION

Many were the reasons for selecting Goa as the venue for a conference on gravitation. For instance, the natural beauty of the land with its emerald sea, the azure sky and the vast stretches of golden sand. The warm hospitality and the open friendliness of the people. A fascinating culture in which the East and the West have mingled together. In addition to all these, there was a historical reason as well. Legend has it that a sage belonging to this region discovered the universal law of gravitation some three hundred years before Issac Newton. It so happens that there are hardly any apple trees in Goa, but one can find coconut groves all around. Consequently the discovery of the law of gravitation by our sage was occasioned by the fall of a coconut, the world remained ignorant of his finding. This was indeed the first authentic case in unrecorded history of perishing without publishing.

[On the occasion of the ICGC-87 Conference at Goa; by courtesy of C.V. Vishveshwara.]

Vacation Students' Programme 2000

IUCAA invites applications for the tenth Vacation Students' Programme (VSP). Students selected under the VSP will spend seven weeks at IUCAA to work on specific research projects under the supervision of the IUCAA faculty. The programme will conclude with seminar presentations of the projects by the participants, a written test and interview. Those who perform well will be preselected to join IUCAA as research scholars to do Ph.D. after the completion of their degree.

Students who will enter the final year of the M.Sc. (physics/applied mathematics/astronomy/electronics)/B.Tech./B.E. courses in the academic year 2000- 2001 are eligible to apply. Applications, in plain paper, giving the academic record of the applicant as well as two letters of recommendations from teachers, mailed directly, should reach **The Coordinator, Core Programmes, IUCAA, Post Bag 4, Ganeshkhind, Pune 411 007**, by March 15, 2000. The selected candidates will be informed by April 15, 2000 for the programme to be held during May 22 - July 7, 2000.

***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) 565 1414

Fax (020) 565 0760

email: publ@iucaa.ernet.in

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