# KHAGOL खगोल

IUCAA

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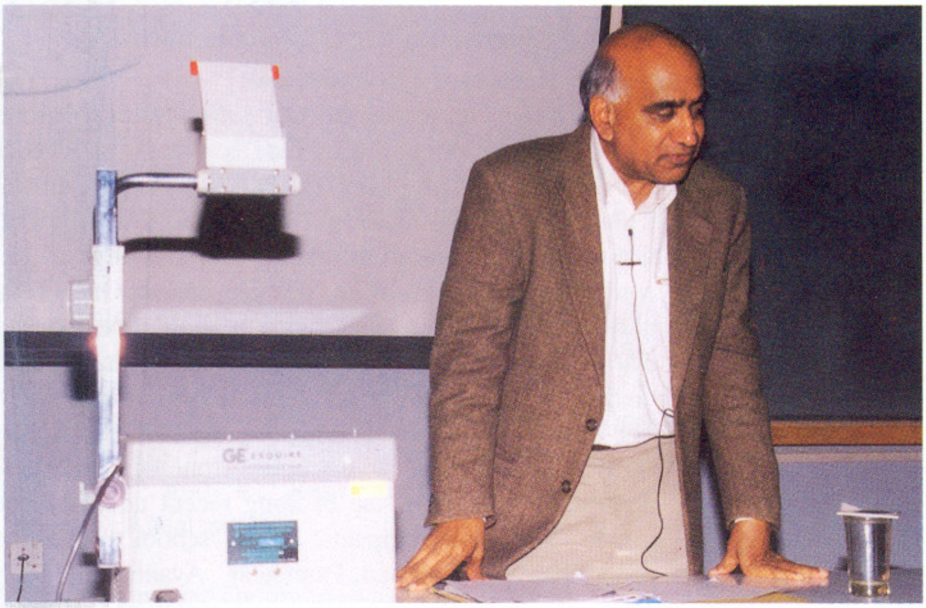
## Thirteenth Foundation Day Lecture at IUCAA



T. V. Ramakrishnan delivering the 13th Foundation Day Lecture

The thirteenth Foundation Day lecture of IUCAA was delivered by T.V. Ramakrishnan of Indian Institute of Science, Bangalore. He chose a topic which is close to the hearts of several academics in the country: "The Present Crisis in Higher Education and Some Possible Ways out". He gave a very thoughtful discussion of the issues involved in this complex problem and compared the situation in our country with that in a few other countries. After such a survey he presented some concrete suggestions which - in his opinion - will be of value in alleviating this problem. In particular, he felt that reformulating undergraduate courses as four-year courses along the lines of professional courses will go a long way in attracting good students to science. He also pointed out that in our country there was an unhealthy segregation of research and teaching which is causing considerable harm. An integrated approach in which the same institution and faculty members are involved in graduate, postgraduate and research training of students will go a long way in improving the current situation.

**Congratulations to ...**

**S. V. Dhurandhar** for being elected **Fellow of the Indian Academy of Sciences.**

**T. Padmanabhan** for being selected as a **Sackler Distinguished Astronomer** to visit the Institute of Astronomy, University of Cambridge for short durations

and also for being elected the winner of the **15th Khwarizmi International Award.**

*Contents...*

## Introductory School on Astronomy and Astrophysics

The Introductory School on Astronomy and Astrophysics was held at Rajarshi Shahu College, Latur during October 15-19, 2001 and began with a key note address delivered by J.V. Narlikar, Director, IUCAA. P.R. Deshmukh, Director, Shiv Chhatrapati Shikshan Sanstha to which Rajarshi Shahu College belongs, was in chair and Principal R.L. Kavle was also present on this occasion. In addition to J.V. Narlikar, J. Bagchi and A.N. Ramaprakash (the Coordinators from IUCAA), T.K. Das, Arvind Paranjpye, M.K. Patil and A.C. Kumbharkhane have also contributed to the programme. Most of the topics covered were meant for undergraduate level students and some for M.Sc. students. Teachers who attended the school benefitted significantly.

In conjunction with the school, two lectures of J.V. Narlikar and one of Arvind Paranjpye were arranged under the science popularisation programme. These lectures and an interview were well received by the students and citizens of Latur. For the interview with J.V. Narlikar, the questions were collected from the local schools and colleges, and there was an overwhelming response from the students and teachers. Arvind Paranjpye conducted a programme of sky watching. There were 85 participants, including local residents.

**Participants of the Introductory School on Astronomy and Astrophysics held at R.S. College, Latur during October 15-19, 2001**

## Commission on History of Ancient and Medieval Astronomy

The 21st International Congress of History of Science (ICHS) was held in Mexico, during July 9 - 14, 2001. The Congress was sponsored by the International Union of History and Philosophy of Science (IUHPS), which in turn is adhered to the International Scientific Union (ICSU). ICHS is held every fourth year. The next Congress will be held in China in 2005.

This congress has approved a proposal from S.M.R. Ansari, former Professor of Physics, Aligarh Muslim University, for the creation of a new Commission for the History of Ancient and Medieval Astronomy. Ansari was elected President of this Commission for the period 2001-2005. Those interested in becoming members of this commission could get in touch with Ansari at Raxa.Ansari@vsnl.com.

## Mini School on Astronomy and Astrophysics at H.N.B. Garhwal University, Srinagar-Garhwal

**Participants of the Mini School on Astronomy and Astrophysics at H.N.B. Garhwal University**

A Mini School on Astronomy and Astrophysics sponsored by IUCAA was organized by the Department of Physics, H.N.B. Garhwal University (HNBGU), Srinagar-Garhwal, Uttaranchal during October 18-22, 2001. The university had recently introduced astronomy and astrophysics as a compulsory part of its M.Sc. physics course. One of the aims of the school was to provide a short term refresher course to the teachers of the universities/colleges, to enable them to tackle the new course they are beginning to teach. The school also provided an opportunity to M.Sc. Physics students as well as research scholars from the region to be introduced to some of the exciting recent developments in the subject. Participants at the school were drawn from Garhwal, Kumaon, Pantnagar, Avadh and Delhi universities. There was a large representation of students and faculty from the host department.

The topics covered at the school included Stellar Structure and Evolution, Neutron Stars and Pulsars, Binary Stars, Solar and Planetary Physics, General Relativity and Physical Cosmology. At least three lectures were delivered by each resource person and summaries of important ideas and recent developments were provided. There was a significant amount of discussion following each lecture and there was close interaction between participants and the lecturers over the period of the school. The speakers/lecturers included Naresh Dadhich (IUCAA), M.K. Das (Sri Venkateswara College, Delhi University), D.C. Joshi (HNBGU), Ajit Kembhavi (IUCAA), Sushan Konar (IUCAA), S.Mukherjee (North Bengal University), Purohit (HNBGU) and L.M. Saha (Zakir Husain College, Delhi University). Popular level talks on "The New Planets" by Ajit Kembhavi and on "Murmuring Mountains" by A.N. Purohit, Vice Chancellor of HNBGU were also delivered during the school. Dr. K.D. Purohit was the coordinator from the host university.

## *Workshop on Fundamentals of Astronomy and Astrophysics*


**Participants of the workshop on Fundamentals of Astronomy and Astrophysics**

A workshop on Fundamentals of Astronomy and Astrophysics was held at V.R. College, Nellore during September 8 - 10, 2001 with the financial support from IUCAA.

The lectures were delivered by Ranjan Gupta (IUCAA), K.S.V.S. Narasimhan (Chennai), H.P. Singh (Delhi University), B.A. Kagali (Bangalore Unviersity), N. Udaya Shankar (Raman Research Institute, Bangalore), S. P. Bagare (Indian Institute of Astrophysics, Bangalore) and R. Ramakrishna Reddy (S.K. University, Anantapur).

A local organizing committee was formed with D. Gopal Krishna Murthy (Principal, V.R. College) as the Chairman. There were a total of about 60 participants, out of which 26 were from outside and the rest were local participants.

The workshop was inaugurated by K. Narayana (Director, SHAR Centre, Department of Space, Sriharikota) on September 8, 2001. He delivered the inaugural address on Astronomy. There were totally fourteen lectures and it was worth noting that besides the selected participants, about 40 others also attended the lectures on all the three days.

All the participants have appreciated the lectures and the way the workshop was conducted. The participants have unanimously suggested to have some demonstration classes during such workshops.

## *Regional Workshop on General Relativity and Gravitation*

A Regional Workshop on General Relativity and Gravitation was held in the Department of Physics, University of Kalyani during November 21-22, 2001. There were 35 participants at the workshop out of which 10 were from universities and colleges from outside the Kalyani region. There were 12 invited speakers. The workshop was inaugurated by the Vice-Chancellor, Kalyani University and the academic session was started with a key note address by A.K. Raychaudhuri.

In the classical gravitation and cosmology section of the workshop, various lecturers spoke about accretion of matter onto black holes, black holes no hair theorem, Noether symmetry approach to cosmology, possiblity of inflation with arbitrary initial conditions, formation of voids, and inhomogeneous cosmological models with energy flux. In the quantum gravity and quantum theory of curved space-time section, the speakers talked on instanton solutions in higher dimension in connection with Hawking-Turok instanton, quantization of fourth order gravity theory, preheating and reheating mechanism in early universe through the method of CWKB, unification of the string theory calculations in low energy limit through Sagnac effect.

There was also a lecture on future experimental and observational work with the 14" telescope of Assam University, Silchar. All those who attended the workshop, including young research students from the universities actively participated in the discussions following the lectures. Somenath Chakrabarty from the Physics Department of Kalyani University, who is a visiting associate of IUCAA, was the Coordinator of the workshop.

**Participants of the Workshop on Interface of Gravitational and Quantum Realms**

A cosy and intimate meeting was organized at IUCAA during December 17-21, 2001 to discuss the current problems in the emerging interface between gravitational and quantum realms. It was a collection of about 30 active workers, drawn from both home and abroad, and the speakers included D.V. Ahluwalia, J. Anandan, N. Dadhich, G. Date, N. Firsova, T.R. Govindarajan, N.D. Haridas, V. Husain, P. Joshi, S. Kar, U. Mohrhoff, S. Mukherjee, T. Padmanabhan, S. Sarkar, L. Sriramkumar, D. Sudarsky, C.S. Unnikrishnan, L. Urrutia, M. Visser and U. Yajnik. The topics covered a wide spectrum, including concerns and effects centred on black holes, cosmology and interplay between gravitational and quantum realms and its astrophysical and experimental consequences; and also the questions of non-locality and particle propagation. The proceedings of the workshop will be published as a special issue of Modern Physics Letters A.

The meeting was conceived by D.V. Ahluwalia and Naresh Dadhich . The format of the meeting was quite informal, where the speaker was asked to chair his own talk and it worked wonderfully. It was also discussion promoting, not only by extensive use of the black board but also with a generous provision of 90 minutes for most talks. The IUCAA kund provided an excellent venue for informal discussions. Participants were very happy and felt quite charged to continue this series with a frequency of about 2 years.

**Welcome to ...**

**Kandaswamy Subramanian**, who has joined as a Core Faculty Member. His research interests are Gravitational Lensing, Origin of Cosmic Magnetic Field, Cosmology and Structure Formation, and Early Universe.

**Ranjeev Misra**, who has joined as a Core Faculty Member. His research interests are Black Hole and Neutron Star Binaries, Active Galactic Nuclei and Quasars, High Energy Radiative Processes and X-ray Data Analysis.

**Harvinder Kaul Jassal**, who has joined as a Post-doctoral Fellow. Her research interests are String Propagation in Curved Spacetime, Physics from Higher Dimensions and Field Theory in Curved Spacetime.

**... Farewell**

**Tarun Deep Saini**, who has joined the Institute of Astronomy, Unversity of Cambridge, U.K. as a Post-doctoral Fellow.

H.M. Antia

Tata Institute of Fundamental Research, Mumbai.

# Helioseismology

Helioseismology, or the study of solar interior using the frequencies of oscillations, started with the work of Deubner in 1975 which demonstrated that these oscillations are the normal modes of oscillations of entire Sun. Just like the seismic study of Earth's interior, the study of solar oscillations allows us to probe the structure and dynamics of solar interior. The frequency of these oscillation modes depends on solar structure and dynamics. Hence, with the accurate measurement of frequencies of about half million modes of solar oscillations it is possible to learn a lot about the solar interior. With the availability of almost continuous observations in the last 6 years it has become possible to study not only the solar structure but also the rotation rate in solar interior. While these results support the so called standard solar model, there have been many surprises too.

## 1 Observation of solar oscillations

The solar oscillations were first discovered by Leighton and his colleagues in 1963 when they measured the velocity of fluid element at some point on the surface of the Sun. This velocity was measured through the resulting shift in a spectral line. Because of the well-known Doppler effect, the line will be blue shifted when the fluid element is moving towards us while it will be red-shifted if the fluid is moving away from us. The observed shift in spectral line was found to vary quasi-periodically with a period of about five minutes and these oscillations were referred to as five-minute oscillations. The nature of these oscillations was not clear and many theories were put forward to explain them. With more detailed observations of Deubner which — for the first time — provided information about both temporal and spatial scales it was established that these oscillations are standing acoustic waves in the solar interior. Once the nature of these oscillations was established it was immediately recognised that these can provide a useful diagnostic for the solar interior.

Until recently most of our knowledge of solar interior was based on theoretical studies involving solution of usual equations of stellar structure and evolution. There was no detailed test to confirm that the basic assumptions involved in deriving the equations of stellar evolution are indeed correct. The study of solar oscillations has filled this gap and it is now possible to test theoretical solar models by comparing the theoretically calculated frequencies with observed frequencies.

Early study of solar oscillation were based on data taken over a few hours. It was soon realised that to get more accurate frequencies and to resolve closely spaced peaks in power spectrum one needs a long time series. Also in order to study modes with various length scales it is necessary to image the Sun at moderately high resolution and to study the velocity at each point on solar surface. Since we can observe the Sun for at most 15 hours from most sites on the surface of Earth, it is necessary to adopt a different strategy to get longer time series. Three alternatives have been tried: (i) To place the instrument at the geographic south pole, where — in principle — the Sun is visible for about six months, but due to weather condition, it is difficult to get continuous observations for more than 15 days. Nevertheless, some of the first long duration observations were obtained from south pole. (ii) To observe the Sun from a network of identical instruments located around the Earth, thus giving an almost continuous coverage of Sun. Typically, about six sites separated in longitude are selected for network and the data from all these sites is combined to get a continuous series. Because of weather conditions and instrument down time there would still be small gaps in data, but these can be handled. The most successful of the ground based network is the Global Oscillation Network Group (GONG) which operates six stations at Learmonth Solar Observatory (Australia), Udaipur Solar Observatory (India), Observatorio del Teide (Spain), Cerro Tololo Interamerican Observatory (Chile), Big Bear Solar Observatory (U. S. A.) and High Altitude Observatory, Mauna Loa (U. S. A.). This network has been operating since October 1995. (iii) To observe from a suitably located satellite. The near Earth orbiting satellites are not suitable as the Earth will eclipse the Sun. The most exhaustive observations have been carried out by the three instruments on board the SOlar and Heliospheric Observatory (SOHO) satellite located at the Lagrangian point between the Earth and Sun. Thus it gets a continuous view of the Sun. Further, being above the Earth's atmosphere it is not affected by weather and atmosphere. The main helioseismology instrument on this satellite is the Michelson Doppler Imager (MDI) which together with the GONG project is the main source of all helioseismic data. This satellite was launched on December 1995 and apart from some interruptions during 1998-99 it has been observing the Sun almost continuously. The availability of accurate seismic data from GONG and MDI during the last 6 years has led to rapid advances in helioseismology.

The data from these instruments consists of line of sight velocity obtained through Doppler effect at a grid of points on the solar surface. Such images are known as Dopplergrams. Each image is decomposed in terms of spherical harmonics,

$$v(\theta, \phi, t) = \sum_{\ell m} A_{\ell m}(t) Y_{\ell m}(\theta, \phi)$$

to obtain a time series for each spherical harmonic component. Here, $v$ is the observed velocity at solar surface and $Y_{\ell m}$ are the spherical harmonics. The index $\ell$ is referred to as the degree of mode, while $m$ is the azimuthal order. This time series is then Fourier transformed to calculate the frequencies.

## 2 Basic Theory

Just like any musical instrument the Sun also has well-defined modes of oscillations in which it can oscillate. The amplitude of these oscillations on the solar surface is found to be very small, being of the order of 10 cm/s or less in radial velocity or typically 30 m in peak to peak radial displacement. This should be compared with the solar radius of $7 \times 10^8$ m. Because of such small amplitudes these oscillations were not discovered until recently. Again because of small amplitudes these oscillations can be considered as small perturbations to the equilibrium state, which simplifies the theoretical treatment considerably. Since the Sun is a three dimensional object, these modes are characterised by three quantum numbers, $n, \ell, m$, where $n$ is the radial quantum number which gives the number of nodes in radial direction, while $\ell, m$ define the shape of eigenfunction in horizontal direction.

¿From theoretical solar models it has been known that the energy is generated through nuclear reactions taking place in the core where the temperature is high enough. This energy is then radiatively transported outwards until a radial distance of about 2/3 of solar radius. As the temperature decreases the opacity of solar material increases and around this point the opacity becomes too large to allow radiative transfer with permissible temperature gradient. Thus in the outer 1/3 of solar radius the energy is transmitted by convection and this region is known as the convection zone. The depth of this convection zone has now been accurately measured from seismic data. For more detailed review of the subject the readers can refer to sources mentioned in the bibliography [1].

The modes of solar oscillations can be roughly classified into two types, the acoustic or p-modes where pressure gradient provides the dominant restoring force; or the gravity or g-modes where the buoyancy provides the main restoring force. (The gravity modes should not be confused with the gravitational waves in general relativity.) The observations of solar oscillations have failed to detect any g-modes so far. The p-modes are essentially sound waves travelling in the solar interior. As the sound waves travel towards the centre of the Sun they get refracted due to increasing sound speed (because of increasing temperature). At some depth these waves suffer total internal reflection and come back to the surface, where they are again reflected. Thus sound waves are trapped in some region of solar interior. The lower turning point of these waves is determined by the angle of inclination with respect to the radial direction. Thus waves with smaller inclination travel deeper into the solar interior. These are the modes with large horizontal scale or low $\ell$. On the other hand, modes with high $\ell$ get reflected close to the surface. While the radial mode corresponding to $\ell = 0$, that is spherically symmetric perturbations, correspond to sound waves propagating radially. These waves can travel all the way to the centre of the Sun. Thus each of these oscillation modes is trapped in different regions of solar interior and its frequency depends on the properties of solar interior inside the region where the mode is trapped. This is an important property of solar oscillations which enhances its diagnostic value. If all the modes were trapped in same region it would be difficult to extract much information about solar interior from their study.

## 3 Helioseismic Inferences

It is straightforward to compute frequencies of oscillations for a solar model. These frequencies can then be compared with observed frequencies to test the model. By varying the input physics or any other parameter in solar model we can construct more models and compare their frequencies with observations. In principle, with such comparison we can find out which model is in better agreement with observations. This is referred to as the direct approach and has not been very successful because, so far it has not been possible to construct any solar model that has frequencies which agree with observed values within the errors. Although the frequencies of a good solar model agree to within a fraction of percent with observations, the errors in observed frequencies are much less — being of the order of 0.001% for a large number of modes. Further, it has been shown that most of these uncertainties arise from layers just below the solar surface. Since this frequency difference is much more than what is expected from other sources it is difficult to obtain much information about solar interior from direct comparison of frequencies.

Since the frequencies of solar oscillations depend on the solar model, if the frequencies of all modes are known, it is in principle possible to infer some properties of solar interior and such techniques are referred to as inverse methods. In the inverse methods an attempt is made to infer the solar model from the frequencies instead of comparing the frequencies of models with observations. In practice, since only a finite number of frequencies are known the scope of inversion is limited. Since most of the observed modes are the acoustic modes, their frequencies are mainly determined by the sound speed in the region where the corresponding mode is trapped. Thus by using frequencies of different modes it has been possible to obtain the sound speed in most of the solar interior. Only a few of the low $\ell$ modes propagate to the inner solar core where bulk of the energy is produced. Hence, the errors in inferred sound speed are larger in this region. If the frequencies of g-modes which are trapped in inner radiative region of the Sun were known the inference about solar core would be more reliable. Similarly, since frequencies of modes have been accurately determined only for $\ell < 250$, all these modes are propagating in the outer about 1 percent of solar radius and once again it is difficult to determine the structure of these layers from current helioseismic data. If the frequencies of higher degree modes can be obtained accurately the inferences about surface layers will improve. Apart from sound speed the frequencies of solar oscillations also depend on the density and hence it is also possible to determine the density in solar interior. With currently available data sets it is possible to determine the sound speed in bulk of the solar interior to an accuracy of better than 0.1%, while the density is determined to a somewhat lower accuracy. The inverted profiles of sound speed and density in solar interior provide strong constraints on solar models. The current solar models compare rather well with inverted profiles, with the maximum difference in sound speed being about 0.3% and that in density about 2%. This excellent agreement has been possible by constant interplay between theory and observations. With the availability of accurate seismic data it is possible to test input physics, like the opacity or equation of state of solar material, that is required to construct solar models. As a result, there has been significant improvements in these physical inputs during the last decade resulting in better agreement with observations. Another important improvement in the solar models was the recognition that helium and heavy element diffuse into the interior. Although the time-scale of diffusion is larger than solar life-time, during the solar evolution a few percent of helium would diffuse into the interior thus reducing the helium abundance in the outer layers of the Sun. Thus the hydrogen abundance in the core is reduced. Since hydrogen is the basic fuel for sustaining a star during its main sequence life-time the life-time of star would be reduced if the available fuel for producing energy is reduced. This has some implication for the so called age problem in cosmology. It is found that the age of some of the globular clusters is larger than the age of the universe in some models of the standard big bang cosmology. If diffusion of helium is included in stellar evolution calculations the estimated ages of globular clusters will reduce thus bringing it closer to the age of the universe.

Historically, first attempt to study solar interior was through the observations of solar neutrinos which are expected to be emitted during the nuclear reactions. Since the neutrinos are weakly interacting they pass through the Sun and should be observable at the Earth. The first observations by Davis showed that the observed flux is about 1/3 of what is expected from a solar model. This deficit has been named as the solar neutrino problem. At that time it was thought that the discrepancy is due to errors in solar models and lot of effort was put in to improve these models. However, these efforts were not very successful and with more neutrino experiments showing deficit by varying amounts it became difficult to accommodate these in a solar model. With the independent confirmation of solar model by helioseismic data it is now clear that the solution of solar neutrino problem has to be sought in terms of nonstandard particle physics involving oscillations between different flavours of neutrinos. Recent results from the Sudbury Neutrino Observatory (SNO) support this solution although the exact mechanism of neutrino oscillations has not yet been uniquely identified. With these developments the Sun is effectively being used as a calibrated source of neutrinos to study particle physics.

Apart from internal structure it is also possible to determine the rotation rate in the solar interior using helioseismic data. Surface observations have demonstrated that the Sun is rotating with the rotation period varying from about 25.5 days at the equator to 36 days at the poles. This rotation would lead to splitting of mode frequencies which depends on rotation rate in the region where the corresponding mode is trapped. Thus, once again, we can use inversion techniques to infer the rotation rate in the solar interior as a function of both radius and latitude. From these inversions it has been demonstrated that contrary to the theoretical expectations, the differential rotation observed at the surface continues throughout the convection zone below which there is a sudden transition to almost rigid rotation in the radiative interior. The transition region has been named as the tachocline and we still do not understand how this shear layer is formed during the course of stellar evolution. Further the rotation rate in solar core is found to be smaller than the equatorial rotation rate at the solar surface. It is generally believed that when the stars are formed, because of conservation of angular momentum in the collapsing cloud the stars pick up a fast rotation rate as is actually seen in young stars. Some angular momentum is gradually lost through the stellar wind and it was generally believed that the solar core may be rotating much faster than the surface. The fast rotating solar core has implication for the well-known test of general relativity using the precession of orbit of the planet mercury. It is well-known that a discrepancy of $43''$ per century in the precession rate is precisely accounted for by general relativity. But if the solar core is rotating much faster than the surface then the resulting distortion in the Sun can also cause some perihelion shift due to purely Newtonian effects thus spoiling the excellent agreement with general relativity. With helioseismic data we now know that the solar core is not rotating faster and the resulting distortion in the Sun is too small to cause any significant precession of perihelion of mercury.

Apart from all these inferences the accumulated helioseismic data can also be used to study temporal variations in the solar interior. It is well-known that the number of sunspots vary quasi-periodically with a period of roughly 11 years. The mechanism of this activity has not been understood so far and it would be interesting to check what variations in solar interior are implied by the seismic data. This will hopefully help us in understanding the operation of elusive dynamo.

## References

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Gough, D. O., 1993, Course 7. Linear adiabatic stellar pulsation, in Astrophysical fluid dynamics, Les Houches Session XLVII, eds., Zahn, J.-P., Zinn-Justin, J., p399
Gough, D. O., Toomre, J., 1991, Ann. Rev. Astron. Astrophys., 29, 627
Cox, A. N., Livingston, W. C., Matthews, M. (eds.) Solar Interior and Atmosphere, Space Science Series, University of Arizona Press

## IUCAA Preprints

Listed below the IUCAA preprints released during October - December 2001. These can be obtained from the Librarian, IUCAA (library@iucaa.ernet.in)

Anand S. Sengupta, Sanjeev V. Dhurandhar, Albert Lazzarini and Tom Prince, Extended hierarchical search (EHS) algorithm for detection of gravitational waves from inspiraling compact binaries, IUCAA-42/01; Archana Pai, Sukanta Bose and Sanjeev Dhurandhar, Computational cost for detecting inspiraling binaries using a network of laser interferometric detectors, IUCAA-43/01; T. Padmanabhan, Combining general relativity and quantum theory:points of conflict and contact, IUCAA-44/01; T. Roy Choudhury and T. Padmanabhan, A Simple analytical model for the abundance of damped Ly alpha absorbers, IUCAA-45/01; Varun Sahni, M. Sami and Tarun Souradeep, Relic gravity waves from Braneworld inflation, IUCAA-46/01;Sushan Konar, Photon propagation in a magnetized medium, IUCAA-47/01; Naresh Dadhich, Sayan Kar, Sailajananda Mukherjee and Matt Visser, R=O spacetimes and self-dual Lorentzian wormholes, IUCAA-48/01; M.Sami, Inflation with oscillations, IUCAA-49/01; M. Sami, An exact inflationary solution on the brane, IUCAA-50/01; Arvind K. Sharma and Suresh Chandra, Detection of rotational lines of NaSH molecule, IUCAA-51/01; D.C.Srivastava and S.K.Sahay, Data analysis of continuous gravitational wave : Fourier transform - I, IUCAA-52/01; D.C.Srivastava and S.K.Sahay, Data analysis of continuous gravitational wave : Fourier transform - II, IUCAA-53/01; D.C.Srivastava and S.K.Sahay, Data analysis of continuous gravitational wave : All sky search and study of templates, IUCAA-54/01; Axel Brandenburg, Wolfgang Dobler and Kandaswamy Subramanian, Magnetic helicity in stellar dynamos : new numerical experiments, IUCAA-55/01; Silviu Podariu, Tarun Souradeep, J. Richard Gott, Bharat Ratra and Michael S. Vogeley, Binned cosmic III microwave background anisotropy power spectra:peak location, IUCAA-56/01; Tapas K. Das, Generalized shock solutions for hydrodynamics black hole accretion, IUCAA- 57/01; S.V.Dhurandhar, K. Rajesh Nayak and J-Y Vinet, Algebraic approach to time-delay data analysis for LISA, IUCAA-58/01; T. Padmanabhan, Cosmic inventory of energy densities:issues and concerns, IUCAA-59/01; A. Banerjee, Heat flow in general relativity, IUCAA-60/01

## Vacation Students' Programme 2002

IUCAA invites applications for the twelfth 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, and an interview. Those who perform well will be preselected to join IUCAA as research scholars to do Ph.D. after the completion of their degree and other requirements.

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 2002- 2003 are eligible to apply. Applications, in plain paper, giving the academic record of the applicant as well as two letters of recommendations (not character certificates) from teachers, mailed directly, should reach **The Coordinator, Core Programmes, IUCAA, Post Bag 4, Ganeshkhind, Pune 411 007**, by March 15, 2002. The selected candidates will be informed by April 15, 2002 for the programme to be held during May 20 - July 5, 2002.

## Second Level, 2nd Workshop on Astronomical Photometry

The second level, second workshop on Astronomical Photometry was conducted at IUCAA during November 21 - 23, 2001. One of the aims of the workshop was to get the feedback from those who participated in the first level workshop in which they made their photometer at IUCAA. Eight participants were invited to attend this workshop and were requested to bring the photometers made by them. Vilas Mestry checked the photometers.

S. N. Tandon, Ranjan Gupta, B. D. Vaidya and Arvind Paranjpye gave talks on the issues related to astronomical photometry. Every participant was also invited to present the work carried out by him or her using the photometer. Umesh Dhodia from Bhavnagar University, used the photometer for variable star observations and for estimating the brightness of the night sky. P. Nagaraju from Vijaya College, Bangalore talked about the use of the photometer in the laboratory experiments. Many others have familiarised themselves with different aspects of photometry.

An overnight trip was organized to Wai, a place about 100 k.m. south of Pune for actual observations. On November 23rd, Ranjan Gupta moderated a discussion on "coordinated observing programme". It was agreed by the participants that they would initiate a regular night sky monitoring programme. The workshop was conducted by Ranjan Gupta and Arvind Paranjpye.

# Workshop on Telescope Making

A Workshop on Telescope Making was conducted at IUCAA during October 29 - November 15, 2001. Eighteen teams of two members each participated in this workshop from different parts of India. All the teams made reflecting telescope of 150 mm diameter primary mirror. The optical configuration of the telescopes was Newtonian and the telescopes were mounted on an altazimuth mount. The participants have taken the completed telescopes to their respective organizations.

On October 29th, the workshop started with Jayant Narlikar's brief welcome address. Ajit Kembhavi gave an overview of the workshop and also encouraged the participants to interact with IUCAA faculty and to make best use of the facilities here. In his talk, Ajit Kembhavi told the participants that the telescope that they would be making would become a powerful instrument in taking science to public, which is the need of the day.

Vinaya Kulkarni guided the participants and supervised every stage of making the telescopes. A target was set for every day and it was mandatory for every pair to achieve that goal before calling it 'a day'. Participants followed the instructions and achieved the goal enthusiastically. Tushar Purohit, a local amateur astronomer who also made his telescope in IUCAA, helped Vinaya.

The aim of the workshop was not limited to participants making their own telescope; they were expected to go back and conduct similar activity in their own home town. An evening session was conducted by Arvind Paranjpye every day to discuss the progress of the day's work and to clarify any doubts in the minds of the participants. During this session, matters related to common errors and their remedies, different approaches to various stages of making the telescopes, etc. were discussed. Arvind Paranjpye also discussed various observing programmes which could be taken up with the telescopes.

After the grinding and polishing was completed, the mirrors were tested (the process called figuring) by observing the Ronchi patterns. Using a modified web camera, the pattern was displayed on a computer screen. The interpretation of the pattern and corrective measures that were to be taken, if required was explained to all the participants.

During polishing and figuring stages of mirror making, the participants had relatively less workload. They were invited to attend special evening lectures by IUCAA faculty and the speakers were requested to join them for dinner. Talks by T. Padmanabhan, Jayant Narlikar, S. N. Tandon and Ajit Kembhavi were an intellectual treat for the participants. H. K. Das took interactive session for the participants on computer aided optical designing. The participants also visited the Giant Metrewave Radio Telescope site at Khodad.

A few components of the telescope, such as Newtonian secondary and spider, eyepiece and an altazimuth mount were purchased off the shelf from Tejraj and Co., Mumbai. The participants made their own mirror cells, cut the tubes and mounted all the components to complete the telescope.

All the telescopes were ready on November 13th and all IUCAA members were invited for an evening high tea, where the participants proudly 'showed off' their prized creation.

On November 14th Ajit Kembhavi gave away the participation certificates in a very informal ceremony. On the occasion he told the participants that now they have made their first telescope; they should think of bigger projects such as putting these telescope on equatorial mounts and adding sidereal drive to it. He also told them that IUCAA would be very happy to help them in every possible manner. Rabin Chetry from Sikkim University expressed gratitude on behalf of the participants and appreciated IUCAA's efforts.

**Participants busy in different activities at the workshop on Telescope Making**

# Introductory Summer School on Astronomy and Astrophysics

The School proposed to be held during May 20 - June 21, 2002 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 2002 can apply. Exceptionally bright and motivated students completing their B.Sc.(physics) in 2002 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 (not character certificates) under separate envelopes. Applications and referee reports should reach **The Coordinator, Core Programmes, IUCAA, Post Bag 4, Ganeshkhind, Pune 411 007**, by March 15, 2002. The selected candidates will be informed by April 15, 2002. The selected candidates will be provided with travel, board and lodging for the duration of the school.

### Seminars

04.10.2001 Parthasarthy Ganguly on *Applying the Bohr Model for Hydrogen Atoms to Interacting Atoms*; 11.10.2001 Pawan Kumar on *The Enigmatic Cosmic Gamma-Ray Bursts*; 18.10.2001 A.A. Ubachukwu on *Relativistic Beaming and Orientation Effects in High Luminosity AGNs and their Implications for Unification Theories and Cosmology*; 25.10.2001 Paul Baki on A *Geometric Representation of the Electromagnetic Field in Finslerian Geometry*; 22.11.2001 Jihad Touma on *Nonlinear Core-Mantle Coupling I: Historical Background*; 27.11.2001 Jihad Touma on *Nonlinear Core-Mantle Coupling II: Consequences of Passage Through Resonance on Earth and Venus*; 29.11.2001 and Dave Green on *A Power Spectrum Analysis of Neutral Hydrogen in the Galaxy.*

### Colloquia

9.10.2001 Wasaburo Unno on *Causality and Indra's Net (ENN in Japanese)*; 12.11.2001 Sanjay Jain on *Studying Complex Networks in Biology and the Social Sciences: Some Recent Approaches and New Insights*; 12.12.2001 Kavan U. Ratnatunga on *Gravitational Lensing in the HST Medium Deep Survey*; 19.12.2001 A.V. Patki on *Rocket and Launch Vehicle Development at ISRO.*

## Visitors to IUCAA October-December 2001

Z. Turakulov, R.S. Kaushal, S. Barway, R. Ramakrishna Reddy, P. Abdul Azeem, S. Chakravarty, J.S. Bagla, P.K. Srivastava, A. Banerjee, Y. Shtanov, S.N. Paul, S. Bhattacharya, K.K. Mondal, J. Touma, B.C. Paul, S. Banerji, S. Chaudhuri, S. Mukherjee, S.G. Ghosh, C.S. Mali, L.K. Jha, S.K. Banerjee, J. Dey, M. Dey, M.J. Hedau, R.S. Tikekar, M.K. Patil, D.A. Green, M. Sinha, S. Bhowmick, A. Nigavekar, R.P. Bambah, O.P. Nigam, L. Chaturvedi, P. Vinu, D.B. Vaidya, S. Jain, M. Sami, S.C. Kaushik, S.K. Poplaghat, M.L. Kurtadikar, S. Sahijpal, K. Sahu, V. Gopisankararao, P. Petit-Jean, K. Ratnatunga, T. Erben, A.C. Kumbharkhane, M. Visser, A.V. Patki, S.R. Choudhury, Ram Sagar, B. Bhattacharya, N. Mukunda, T.P. Prabhu, L. Sriramkumar, Z. Ahsan, A. Joseph, B. Phookun, A. Bhatnagar, Yash Pal, T.V. Ramakrishnan, S.P. Dasthakur, V.R. Dabral, V.N.R. Pillai and S. Sengupta,

About 150 visitors attended the various workshops held at IUCAA during this period.

## Visitors expected

**January 2002:**

N. Bishop, University of South Africa; G. Ferland, University of Kentucky; J. Bishop, University of Pretoria, South Africa; James Rose, University of North Carolina, USA; M. John, St. Thomas College, Kozencherry; Sajith Philip, St. Thomas College, Kozencherry; A. Ahmed, Kashmir University; S.K. Pandey, Pt. Ravishankar Shukla University, Raipur; M. Sami, Jamia Millia Islamia, New Delhi; M. Dey, Presidency College, Calcutta; E. van den Heuvel, University of Amsterdam; B. Schutz, Max-Planck Institute for Gravitational Physics, Germany; A. Omont, Institut d'Astrophysique, Paris; N. Mukunda, IISc.,Bangalore; T.P. Prabhu, IIA, Bangalore; S.R. Choudhary, University of Delhi; R. Ramsagar, State Observatory, Nainital; P. Khare, Utkal University, Bhubaneswar; G. Burbidge, CASS, USA and L.K. Patel, Gujarat University.

**February 2002:**

G.S. Khadekar, Nagpur University; S. Ray, Darjeeling Govt. College; Saibal Ray, Darjeeling Govt. College.

About 200 participants are expected to attend the 21st meeting of the Astronomical Society of India to be held at IUCAA during February 5-8, 2002.

## The Untidy Discoverer of Neptune

In his article "Old Tripos Days at Cambridge" the statistitian Karl Pearson relates the following incident about John Couch Adams, the Cambridge astronomer, who was one of the co-discoverers of the planet Neptune:

"One vacation time, I was playing tennis in the grounds of an hotel at St Ives, Cornwall, when up the drive came an old-fashioned pair followed by a porter carrying one large skin-covered trunk on his back - it was all a little out of date even fifty-eight years ago. But I was thrilled; here *was* a chance! I returned to my game, but I had hardly served when I saw the back of the porter, the hairy trunk and the old-fashioned pair, obviously tired, retreating down the drive! I threw down my racquet, for I knew there were vacant rooms in the hotel, and I rushed to the manageress. 'What have you done?' I cried; "you have turned away the discoverer of Neptune.' 'Neptune or no', she replied, 'I am not going to have dowdies like those in this hotel!' Such is the fate of genius if it does not put on its best clothes when it enters a big hotel."

[From article dated September 20, 1935 in the *Mathematical Gazette*, vol xx, p. 27, 1936]

**Please note the change in Telephone and Fax numbers !!!**

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

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