KHAGOL खगोल

IUCAA

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Science Day at IUCAA

The N.C. Rana Memorial Trophy for the best all-round performance in the inter-school science festival went to the students of the Jnana Prabodhini Prashala.

Members of the IUCAA academic staff presented exciting new results in astronomy, physics and mathematics to members of the public during the Open House.

The annual Science Day was celebrated at the Inter-University Centre for Astronomy and Astrophysics (IUCAA) on February 26, 1998, with a Science Festival for high school students in the morning and an Open House for the general public in the afternoon and evening. The festival featured a number of inter-school competitions. During the afternoon events, visitors could view special displays on the research facilities and activities at IUCAA, and meet many of the academic staff and students.

The Inter-school Science Festival

As in previous years, IUCAA organized inter-school science competitions for students up to Class X in the morning. About 550 students from over 90 (English, Marathi and Hindi medium) schools in the Greater Pune area participated in four competitions: a Science Quiz contest, two Essay (English and Marathi) competitions and a Drawing competition on scientific themes.

Inside...

The final round of the Science Quiz between the six top schools lasted over two hours.

The audience included students, their teachers and parents.

Each school was represented by up to six students and a teacher. From each school, one student competed for the Drawing competition, where they were asked either to *Design a spaceship*, or to imagine a sample of *Deep sea life*, or what would happen if *The Pathfinder finds life on Mars*. First and second prizes were awarded to Gaurav S. Sawant (St Patrick's High School, for his imaginative drawing of the discovery of life on Mars) and Kranti Girme (Jnana Prabodhini Prashala, for her spaceship design) respectively.

Another student from each school participated in either of the two Essay competitions, where they were asked to write, in English or in Marathi, on any one of diverse topics like *If I were an alien left on Earth by a spaceship*, *If I became a science teacher* or *What would I like to clone*. The first and second Marathi Essay prizes were awarded to Kalyani Kokate (HHCP High School for her essay on *Cloning*) and to Dambar Thapa (Samata Vidyalaya for his essay on *Dreams of being a science teacher*) respectively. Ratnakar Ranade (DES English High School) won the first prize in the English category for his fantasy about *Being a Martian abandoned on Earth*, while Darshan Vaidya (Don Bosco High School) won the corresponding second prize for his essay *If I were a Science teacher*.

Each school was represented by a team of four students in the first round of the Science Quiz, where they had to answer 25 multiple-choice questions in physics, astronomy, mathematics, chemistry and biology in 45 minutes. Of these, six schools were chosen to compete for the Quiz Trophy in the final round, which was conducted in the presence of a full Chandrasekhar Auditorium. The six teams faced five rounds of questions, many involving slides and pictures. The team from Kendriya Vidyalaya (Southern Command) were the clear winners of the Quiz trophy. The tie for the second place went into a protracted tie-breaker round, culminating in the second place for Jnana Prabodhini Prashala, and the third place for Loyola High School.

The trophy for the best overall performance (the N.C. Rana Memorial Trophy) was won by the Jnana Prabodhini Prashala. Individual prizes (book tokens) were given to each winner. J.V. Narlikar gave away the prizes.

A major attraction of the morning's events was the lecture demonstration by Kiran Purandare and members of his group **Nisargavedh** on *Bird life in Maharashtra,* where the audience was made familiar with the appearance and calls of many of the exceptional birds of the region.

The Open House

The Open House in the afternoon and evening was held jointly with our neighbouring institution, the National Centre for Radio

Visitors to the Instrumentation Laboratory were shown how an automated telescope works.

After dark, hundreds of visitors queued up to view the sky with one of a dozen telescopes set up in the Aditi complex.

Demonstrations of astronomical image processing and astronomical resources on world-wide web attracted many of the younger visitors.

The permanent exhibits, like the Foucault pendulum at IUCAA, attracted many visitors.

Astrophysics (NCRA). Both the institutions were open to the general public, and had set up exhibits especially prepared for this purpose.

Most of the academic members (including students and visitors) of IUCAA were present in the Bhaskara lobby to discuss their research with the visitors; many of them had put up posters providing glimpses of their work. In the Instrumentation Laboratory, one could witness the current status of their automated telescope and low-cost photometer projects, plus various demonstrations involving lasers and CCD cameras. The staff of the Computer Centre and a few students provided demonstrations of the working of the internet, of samples of the Astronomical Data Centre at IUCAA, and of the image processing research that is carried out at IUCAA.

Two parallel series of half-hour public lectures (in English, Hindi and Marathi) given by IUCAA and NCRA scientists were arranged to capacity audiences all through the afternoon. The lecturers were found themselves surrounded by members of the audience with questions for long times outside the lecture halls. Video films on astronomy and space programmes were also shown at yet another location. The library's display included an account of C.V. Raman's work, which is commemorated by the National Science Day each year.

From 7 p.m. till midnight on February 26 and 27, hundreds of visitors viewed the night sky through telescopes set up by IUCAA members with the help of members of the amateur astronomers' organisation, Jyotirvidya Parisanstha, Pune. The same telescopes had been used during the Open House on the 26th to view the Sunspots and Venus during daytime.

IUCAA recorded over 4000 visitors during this period, in addition to the students who had taken part in the morning's events.

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 be sent to the Dean, Visitor Academic Programmes (VAP), IUCAA with a copy to the Chairman,Workshop Committee, IUCAA by June 15, 1998 (for events during February 1999 - July 1999) / January 15, 1999 (for events during August 1999 - January 2000) so as to be included in the academic calendar for the next academic year. The proposal should include the title (topic), tentative dates 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.

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.

The Origin of Elements

There were two attacks on the problem of understanding the origin of chemical elements in the universe, both in the 1940s. George Gamow and his younger colleagues Ralph Alpher and Robert Herman explored the avenue provided by big bang cosmology. According to this model, during the period of around 1 - 200 seconds, the universe passed through a density - temperature phase when conditions were suitable for thermonuclear fusion. Gamow believed that this process would generate most atomic nuclei found in the universe.

A paper written by Alpher, Hans Bethe and Gamow in the Physical Review in 1948 described this approach and because of the names of the authors, the theory became known as the α-β-γ theory.

In the end, it turned out that the process worked only for light nuclei, upto essentially helium, with every small quantities of Li, Be and B. The gap between atomic mass range 5 - 8, caused by the lack of stable nuclei made the nucleosynthesis process impossible beyond this range.

In 1946, in a paper in the Monthly Notices of the Royal Astronomical Society, Fred Hoyle proposed the alternative route of stellar nucleosynthesis. As main sequence stellar models had demonstrated, stars like the Sun are making helium in a slow but steady way by synthesizing hydrogen nuclei. Why not pursue this process further in future evolutionary stages?

Again, the gap in the mass range 5-8 became an obstacle. Although Ed Salpeter had proposed 'jumping' across this gap to make carbon from three helium nuclei, a three-body collision being rare, would not work. In 1954, Hoyle came up with the ingeneous solution that the reaction to carbon is a *resonant* reaction. His calculations suggested that this reaction should produce an excited state of carbon which would subsequently decay to normal state. The question was, did such an excited state of carbon exist?

The question was soon settled when Ward Whaling and Willy Fowler at Caltech found it by experiment! And so, not only was the crucial gap bridged, but a way was found to understand the evolution of stars beyond the main sequence. The next important landmark in stellar nucleosynthesis was the comprehensive work of Geoffrey and Margaret Burbidge, Willy Fowler and Fred Hoyle in 1957. Popularly known as the B^2FH theory, it explained how most nuclei are formed in stars.

Did this supplant the primordial nucleosynthesis theory of Gamow, et al? Not quite! That theory was to make a comeback, as we shall see in the next Parsecstone.

Welcome to...

Rainer Wichmann, who has joined as a post-doctoral fellow and his research interests are low-mass pre-main sequence stars, star formation and history of solar neighbourhood.

... Farewell to

L. Sriramkumar, who has joined the Racah Institute of Physics, Hebrew University, Jerusalem, Israel, as a post-doctoral fellow and

Ashish Mahabal, who has joined the Physical Research Laboratory, Ahmedabad, as a post-doctoral fellow.

Talks during visits abroad

S.V. Dhurandhar : *Data analysis of inspiralling compact coalescing binaries*, Department of Physics, Australian National University, Canberra, Australia, February 20 and Department of Physics, University of Western Australia, Perth, Australia, February 24.

R. Srianand : *Do central engines of quasars evolve by accretion*, February 12, Institut d'Astrophysics, Paris, and *H_2 molecule in $z = 2.8112$ damped system toward q0528-250*, March 4, Institute of Astronomy, Cambridge, UK.

J.V. Narlikar : *Quasi-steady State Cosmology : An alternative to Big Bang*, Institut d'Astrophysics, Paris, March 27 and 31.

Inhomogeneous Cosmological Models

It is remarkable that a simple solution of the Einstein field equation for gravitation describes the large scale behaviour of the real Universe we live in so very well. The solution is the well-known Friedman-Robertson-Walker (FRW) model. It predicts that the Universe is homogeneous, isotropic and expanding, and has had an explosive Big-Bang singular beginning in the finite past, about 10^{10} years ago. This is the standard model of the Universe. The observations that support the model are the large-scale Hubble expansion, the cosmic microwave background radiation (CMBR) and abundance of Helium and light elements. Based on these, we build up an intricate story of the evolution of the Universe right from its singular birth.

Around the same time when the CMBR was discovered in mid sixties, there also occurred a very important parallel development on formal theoretical front in which Penrose and Hawking [1] established certain very powerful general theorems proving inevitability of occurrence of singularity in GR for reasonable spacetime and matter properties. This led to the general belief that the big-bang singular beginning of the Universe is not a model dependent, but rather a general prediction of GR. Here was a situation in which the observation matching exactly the theoretical prediction, and the prediction is quite general independent of specific matter distribution or symmetry of spacetime. We are thus led to a totally closed situation.

Howsoever successful and compelling the standard model may be, it does create uneasiness in a discerning mind for, it invokes special properties of homogeneity and isotropy. By no means can these properties be considered generic. Furthermore, there exist large scale structures in terms of voids, superclusters and galaxies which for their evolution and description would require inhomogeneity. There is a long list of arguements in favour of consideration of inhomogeneous models, for their novelity and strength: I shall mention the two of them (there is an excellent review of physics in inhomogeneous models in the recent monograph by Krasinski [2], which also contains a comprehensive bibliography): (i) Tavakol and Ellis [3-4] considered the stability of solutions of differential equations and showed with examples that behaviour of solutions change drastically from periodic to chaotic for changing values of free parameters. This indicates that set of cosmological models is probably structurally unstable [5]. They have argued strongly in favour of studying models without symmetry. (ii) A simple argument shows that in principle, existence of gravitational lens is inconsistent with conformal flatness of the FRW model [2]. In the Minkowski spacetime, we know that any two events lying on the half light cone (future/past) can never be joined by a timelike curve. In conformally flat spacetime, the light cone structure is the same as in the Minkowski and hence so should be the case for the FRW metric. In gravitational lens, the light bends due to lens and hence, an off the symmetry axis observer will receive signals, that though emanated at same time, at different times. This means, the future light cone of the emission event is crossed by the timelike observer at two different points. That must not be so for a conformally flat spacetime, because it is prohibited for flat spacetime. That is, the observationally established fact of existence of gravitational lens thus challenges conformal flatness of the standard FRW model.

The monograph [2] contains a comprehensive discussion of all the inhomogeneous cosmological solutions so far obtained. It may surprise one that despite non-linearity of the differential equations, there is quite an abundance of solutions, with several solutions being rediscovered time and again by many authors. To make the equations tractable, one has to make simplifying assumptions which often throw out whatever is physically meaningful and relevant. Thus, despite the abundance of formal solutions there is acute paucity of physically relevant models. This book is an eye-opener for solution-finders, and it is a valuable reference. For the detailed discussion of the various solutions and models I could not possibly do any better than referring the reader to this book.

I would now discuss one of the remarkable and interesting features of inhomogeneous spacetimes, which had not been discussed in [2] for the reason that models do not tend to the FRW model in the limit. (We shall restrict our discussion to 4-dimensions.) This came to light in 1990 with Senovilla's discovery [6] of singularity-free exact solution satisfying all the reasonable conditions. Contrary to the general belief and folklore based on the Penrose-Hawking singularity theorems [1], here was an exact perfect fluid ($\rho = 3p$) solution of the Einstein equation that satisfied all the energy and causality condition and yet had no singularity for the entire range of the coordinates. This did cause a bit of flutter amongst specialists and non-specialists alike. By all counts, it was a remarkable discovery and was so commented upon by Maddox in Nature [7]. This gave rise to public excitement and Senovilla was nominated that year amongst the ten most important persons in Spain. The key question was: how did the theorems permit it? On closer analysis, it turns out that the solution satisfied all but one of the assumptions of the theorems. The assumption in question was the existence of compact trapped surfaces. It had all along been known that this was the weakest point of the singularity theorems which were otherwise so general and powerful. This assumption was motivated by the considerations of gravitational collapse. Its manifestation in cosmology would be that matter-energy distribution should be sufficient to make the geodesic congruence to converge to a big-bang singularity in the past. This is certainly an additional assumption on the energy density in the Universe, which may or may not be true. The important point to recognise is that this solution served the key purpose of dispelling the unfounded general belief that the singularity theorems prohibit occurrence of singularity-free cosmological models without reference to matter distribution. This novel example has probably only succeeded in correcting the specialists' view, with non-experts still hooked on to the folklore.

Subsequently, it has been shown that the solution in question was not isolated but there exists a large family of non-singular solutions [8-9]. The singularity-free family is cylindrically symmetric and admit the equations of state for radiation and stiff fluid [9]. The family could be considered as arising out of inhomogenization and anisotropization of the FRW model [10] and could be set in a general framework of cosmological models [11]. There was also an attempt, which is partially successful, to prove the uniqueness of the singularity-free metric for an orthogonal spacetime, separable in space and time variables [12] (I believe, this result is true but some more tedious analysis has to be carried out to prove it). There is an excellent forthcoming review by Senovilla [13] on singularity theorems and their consequences, wherein, an in-depth study of various aspects has been done. For a serious reader, this would be of invaluable education.

While, it is interesting that non-singular cosmological models exist in GR, the key question is: could they be applied to the real Universe? Their cylindrical symmetry was the most repelling feature for their practical application in cosomology and astrophysics. Some of us have recently addressed the question of what it takes to make a spherical model singularity-free [14-15]. If we let the fluid to be imperfect and also allow for energy flux (heat/null radiation), then it is easy to see, one need solve no equations for a spherical model. This is the lazy man's way of doing relativity. The non-trivial question is then to give a non-singular prescription for the metric and the physical parameters. We achieve this by letting Tolman's static non-singular solution to expand, by making the free parameter in the solution, a function of time. The simple choice of the effective scalar factor $a^2 + b^2 t^2$ is sufficient to give a singularity-free model with proper fall off behaviour for density, pressure, pressure anisotropy and heat-flux. All the energy conditions are satisfied and there occurs no singularity of any kind as could be seen from the geodesic completeness of the spacetime. The model is both inhomogeneous and anisotropic. It typically begins with low density at $t \to -\infty$ and contracts/expands anisotropically to high density at $t = 0$, and then again goes to low density as $t \to \infty$. It is possible to consider the model as perfect fluid with radial null radiation flux [15].

The driving force for construction of these models was to demonstrate that it is possible to have spherical non-singular models. The primary obstacle has thus been overcome. It would still take quite a bit of doing to get to practical applications of these models. One thing that seems to emerge from these investigations is that shear plays very important role. Even though shear contributes favourably to collapse in the Raychaudhuri equation, its presence in certain cases seems to be essential for acceleration [16], which in absence of rotation is the lone player resisting the collapse. The dynamical action of shear to make collapse incoherent seems to be more relevant in avoidance of singularity than its positive contribution in the focussing of geodesics. I would, therefore, conjecture that presence of shear along with acceleration is necessary for avoidance of singularity in cosmological models.

It has been argued by Ellis and coworkers [17-18] that energy density required to thermalise the CMBR is sufficient to converge the past geodesic congruence leading to a big-bang singularity in finite time. Of course, the model used to deduce this result is FRW but the result holds good even for perturbed FRW. This may very well be the case, yet it should be recognised that the strength of the result rests on the FRW model. Notwithstanding strong arguments in favour of the big-bang, I consider it pertinent to consider in greater detail inhomogeneous singularity-free models at the least to mark the boundary of singular cosmology, and at best to provide a possibility that the Universe in the present form could have evolved as an asymptotic limit of a singularity-free model. In all fairness, we could say that this is an open question.

Finally, I would like to recall some notable contributions to inhomogeneous models by Indian workers. Sen [19] was the first to state that voids will develop in inhomogeneous cosmological models, and Narlikar [20] was the first to argue for inhomogeneous generalization of the FRW metric. These works date back to mid thirties, which make them the pioneer considerations of inhomogeneous cosmological models. There is a healthy share of Indian work in the bibliography of [2]. Let us hope that this tradition would be kept up and improved upon.

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WHEPP5 at IUCAA

The 5th Workshop on High Energy Physics Phenomenology was held at IUCAA during January 11-25, 1998. There were 80 participants, including 19 from abroad and 19 from Indian universities. The rest were from various Indian institutes, such as IISc, IMSc, IUCAA, PRL, MRI, NPL, SINP and TIFR.

There were 25 invited talks on various topics and 4 working groups on i) Astroparticle Physics, ii) Collider Physics and B-Factories, iii) Quantum Chromodynamics and iv) Physics Beyond Standard Model. There were seminars in these working groups as well as discussion meetings. The topics covered in plenary talks included: Higgs and SUSY Searches at LHC (D. P. Roy), The Inflationary Universe (V. Sahni), Gravitational Lensing as a Cosmological Probe (A. Stebbins), Quark Gluon Plasma (S. Gupta), Neutrino Masses and Mixing (E. Ma, W. Grimus), Gauge Mediated SUSY Breaking Models (G. Bhattacharyya, B. Mukhopadhyay), Recent Results from Tevatron (N.K. Mondal), LEP-II (S. Banerjee) and HERA (J. Gayler), Particle Dark Matter (M. Drees), Astrophysical Constraints on New Particles (J.A. Grifols, S.Mohanty), R-parity Non-conserving SUSY (H. Dreiner, D. Choudhuri), Quarkonium Production (M. Kraemer), Direct Photon Production (M. Fontannaz) CP-violation (R. Aleksan), Particle Mass Limits in SUSY (P.N. Pandita), Topological Defects and Cosmology (R. Brandenberger), Low-x Physics (R. Basu), Resolved Photons (R.M. Godbole), Photon Colliders (F. Boudjema) and Quantum Loop Effects in SUSY (J. Sola). A special feature of this workshop was its emphasis on the exciting growing area of Astroparticle Physics.

Workshop on Stellar Structure and Evolution

A research level workshop on Stellar Structure and Evolution was held at IUCAA during February 9-13, 1998. About 40 participants attended the workshop. The academic programme consisted of short lecture courses as well as seminars, which covered different aspects of stellar processes. The main lecturers were H. Antia (TIFR), B. Datta (IIA), G. Meynet (Geneva Obs.), H. Singh (Venkateswara College, Delhi) and C. Tout (IOA). The topics covered included helioseismology and asteroseismology, equations of state, compact binaries, physical processes, stellar populations, nucleosynthesis, equation of state, rapid binary evolution, etc. C. Tout also conducted a series of tutorials on Eggleton's stellar evolution code.

Workshop on The Physics of Stars

A workshop on the Physics of Stars was held at the Department of Mathematical Sciences, University of Tezpur, during January 16-20, 1998. This was a follow-up of an introductory workshop on astronomy & astrophysics held in the same department in early 1997. About 40 participants from Assam and some from other North-Eastern states participated in the workshop. Lectures on various aspects of stellar structure, evolution, compact objects including white dwarfs and neutron stars, etc. were given by B. Datta (IIA), R. Gupta (IUCAA), A. Kembhavi (IUCAA) and H. Singh (Venkateswara College, Delhi). Tutorial sessions were conducted by Yogesh Wadadekar (IUCAA). The workshop was coordinated by A. Borkakati of Tezpur University and his colleagues. There was excellent response to the lectures and there were lively discussions between participants as well as participants and lecturers. A trip to the Kaziranga Sanctuary was arranged during the workshop.

Introductory School on Astronomy and Astrophysics

An Introductory School on Astronomy and Astrophysics for college teachers was held during March 2-6, 1998, at the Department of Physics, Bangalore University. It was inaugurated by the Vice-Chancellor, N.R. Shetty. Forty college teachers participated in the school.

The resource persons and the topics were: K.S.V.S. Narasimhan (Positional Astronomy, Systems of time, etc.); M.N. Anandaram (Basic stellar properties); Ranjan Gupta (Telescopes, Stellar spectra and Observational aspects); C. Sivaram (White dwarfs, Neutron stars and Black holes); S.P. Bagare (Solar physics) and Biman Nath (Stellar structure and evolution). Tutorial sessions were held in the afternoons to clarify doubts and solve problems.

Several interesting video shows and night sky watching sessions were also conducted. At the end of the school, the participants expressed their satisfaction on the content of the lectures and the other arrangements. Some of them felt that they would like to make telescopes with the help of IUCAA and attend more detailed workshop on Astronomy and Astrophysics.

Ranjan Gupta was the coordinator from IUCAA and B.A. Kagali was the coordinator from Bangalore University.

Seminars

5.1.98 J. Mikolajewska *on* Symbiotic systems: Interacting binaries with the longest orbital periods; 6.1.98 A. Chakraborty *on* What's new at the heart of the lagoon nebula?; 12.1.98 B. Jain *on* Gravitational lensing and cosmology; 27.1.98 R. Di Stefano *on* Discovering planets and other topics in gravitational microlensing; 28.1.98 A.N. Petrov *on* On the energy distribution in general relativity; 11.3.98 J. Bagchi *on* The detection of Compton scattering of cosmic microwave background photons (CMBR) from the relativistic gas in a galaxy cluster; 16.3.98 J. Vijapurkar *on* Post-asymptotic giant branch stars; and 24.3.98 Fu-Xing Hu *on* The orientation of spin vector of bright disk galaxies in the local super cluster and its implication and Introduction to Chinese astronomy.

Colloquia

19.1.98 T.V. Ramakrishnan *on* Why are high temperature superconductors interesting ?; 12.2.98 G. Meynet *on* Wolf-Rayet stars: A link between gamma ray lines, meteorites and cosmic rays?; 2.3.98 B.P. Das *on* Atomic probes of the unification of fundamental forces; 9.3.98 N.D. Hari Dass *on* Duality in its many avatars; 17.3.98 J.K. Bhattacharjee *on* What is turbulence and why should we be mindful of it?; and 30.3.98 S. Chakravarti *on* Life in anharmonic wells.

IUCAA *Preprints*

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

T. Padmanabhan, *Quantum structure of spacetime and blackhole entropy*, IUCAA-1/98; **Varun Sahni**, B.S. Sathyaprakash and Sergei F. Shandarin, *Shapefinders:a new shape diagnostic for large scale structure*, IUCAA-2/98; **Valerio Faraoni** and Edgard Gunzig, *Lensing by gravitational waves in scalar-tensor gravity: Einstein frame analysis*, IUCAA-3/98; **T. Padmanabhan**, *Event horizon: Magnifying glass for Planck length physics*, IUCAA-4/98; **Naresh Dadhich**, L.K. Patel and Ramesh Tikekar, *A duality relation for fluid spacetime*, IUCAA-5/98; **S.V. Dhurandhar**, *Hierarchial search strategy for inspiraling compact binaries*, IUCAA-6/98; **H.K. Das**, S.M. Menon, **A. Paranjpye** and **S.N. Tandon**, *Site characterisation for the IUCAA telescope*, IUCAA-7/98; **Sayan Kar**, *Naked singularities in low energy, effective string theory*, IUCAA-8/98; F.I. Cooperstock, **V. Faraoni** and D.N. Vollick, *Influence of the cosmological expansion on local systems*, IUCAA-9/98; **S. Sridhar** and J. Touma, *Stellar dynamics around black holes in galactic nuclei*, IUCAA-10/98; and **R. Srianand** and Gopal-Krishna, *Do the central engines of quasars evolve by accretion?*, IUCAA-11/98.

GR 15 Proceedings

Pre-publication price date has been extended to May 31, 1998.
Printed book is expected by May 31, 1998.

Price

INDIA : Library: Rs.750/-, Individual : Rs. 500/-, IAGRG members : Rs.300/-
INTERNATIONAL : US $ 50 (Including Postage)

For details about the payments contact **Naresh Dadhich** (e-mail: nkd@iucaa.ernet.in) at IUCAA.

Erratum

P.C. Vaidya's name as a speaker in the inaugural session of GR15 was inadvertently missed in the report that appeared in the previous issue of Khagol. The error is regretted.

- Editor

See the Sunspots

After an extended absence, the sunspots have started reappearing on the photosphere of the Sun. Sunspots, which are cooler regions on the Sun, follow a cycle of about 11.5 years.

It was Galileo who first made the scientific observations of sunspots and discovered that the Sun rotates on its axis once in about four weeks. The Sun is, however, not a rigid body. A spot near the equatorial region of the Sun takes about 25 days to go once round the Sun. This duration increases to about 33 days for a spot near 75 degrees north or south of the solar equator. This phenomenon, known as differential rotation, was discovered by Richard Carrington, a British astronomer, in 1859.

As the science progressed, astronomers discovered many more interesting properties of the sunspots, but we shall not go into those here. In this astroproject, we will see how to observe the sunspots.

The best way to observe sunspots is to project the image of the Sun on a sheet of paper kept behind the eye piece of a telescope. Any telescope or a binocular can be used for this purpose. Make sure that the body of the eye piece is not made of plastic, else it might melt by the image of the Sun formed by primary mirror of lens.

The projection screen described here is designed particularly for the 3" CSIO telescope. However, this should give an idea if you have a different telescope. It should not take more than an hour to make such a screen.

Please refer to the drawing of your telescope given in the telescope manual. The sleeve connecting the 45 degree prism and eye piece assembly to the telescope tube has 45 mm diameter. On this line, projection screen assembly is to be fixed. The clamps for the projection screen is made out of standard 12 mm thick wooden plank. You will require 80 mm long bolts of 3 mm diameter to sandwich the sleeve between the clamps and hold it firmly.

Extension arm is for keeping the projection screen at a fixed distance. Its length is 42 cm, which will give you the diameter of the solar image of about 10 cm. This arm can be made of bidding strips and the two clamp pieces can be obtained from frame makers or from any carpentry shop for a little or no cost.

The projection screen is made of a thick and stiff card board sheet, such as covers of note books. You can use thick folder covers too. Cut two pieces from the cover of size 17 x 17 cm and stick a clean graph paper of white background on one of the sheets. Stick the two cut pieces to each other. Normally 2.5 to 3 mm of thickness will be stiff enough. To protect it from the weather and other hazards, get this screen laminated. If you find it difficult to get it laminated then you may put it in a transparent plastic jacket and seal it from all the sides. The plastic covering will not only protect it from the moisture, etc. but you can stick a paper with scotch tape for drawing the Sun's spots. Now, complete the assembly as shown in the drawing. To get a good grip betweent the clamps and the sleeve, you may line the clamps with strips of rubber sheets. You can cut the sheets from cycle tube.

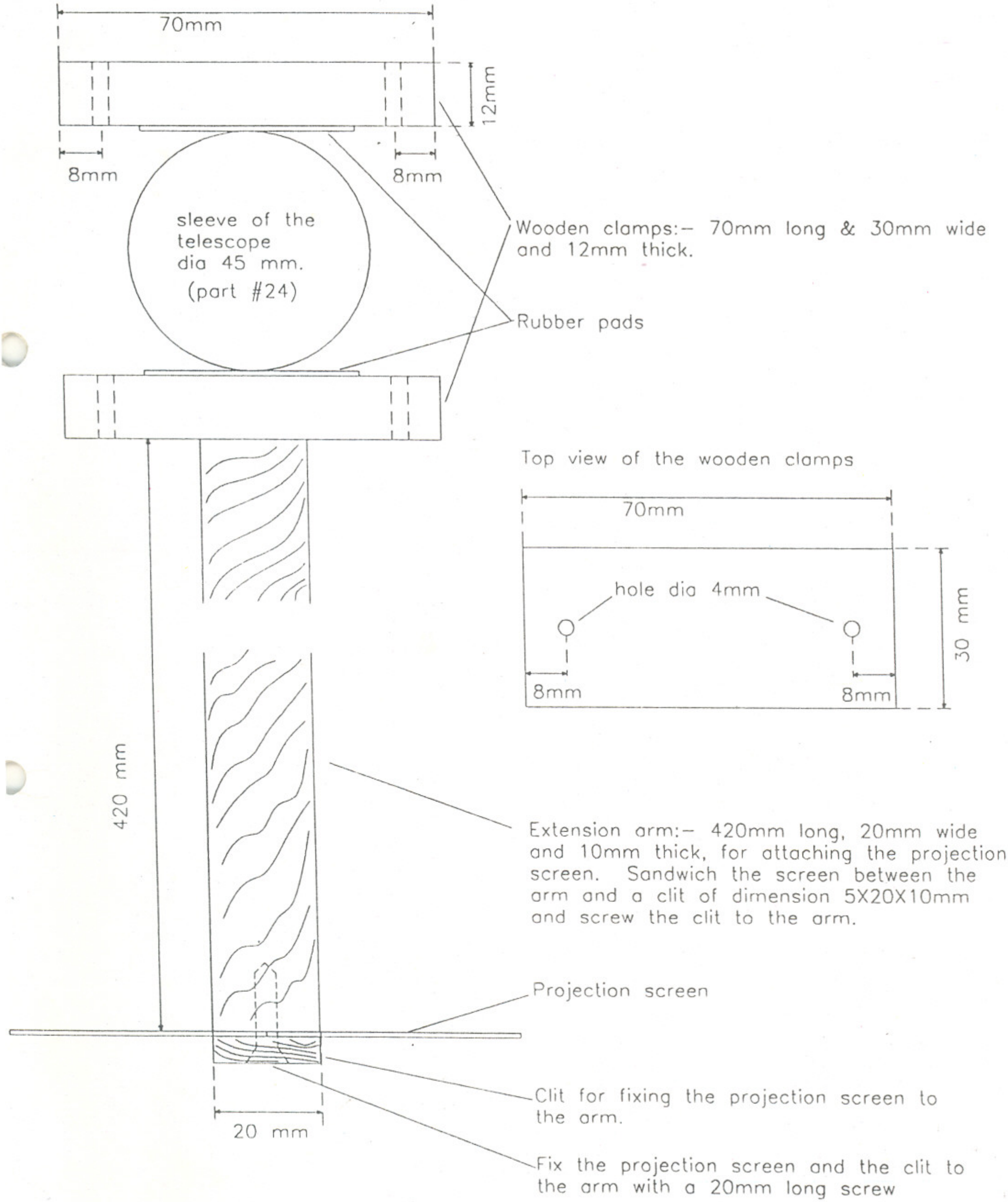
You can use the laboratory telescope on the spectroscope. Reflect sunlight on the telescope as described in Astroproject 17 (October 1997). If you are using a binocular, cover one of the objective lens. For observing, set up the equipment near a corridor so that you can stand in the shadow.

Try to make drawings and estimate the sizes of sunspots. Remember, the Sun is about 109 times bigger than the Earth.

You can sometimes see a spot growing or dying in a few hours time. That is, you can see something as big as Earth being created or destroyed on line. With careful observations you too can derive the rotation period of the Sun. Write to us if you cannot figure it out for yourself. We will tell you how!

This photograph shows the projection screen mounted on a 3 inch CSIO telescope.

Projection screen for the 3inch telescope



Visitors during January-March 1998

A.N. Petrov, R. Di Stefano, A. Borde, A. Chitre, A. Chakraborty, Sanjiv Kumar, T. Subba Rao, I. Chakraborty, R.V. Gavai, P. Mathews, G. Ogale, Asadollah Ghamari, Nimai Singh, M.K.Parida, S.D. Rindani, Mukesh Desai, H. Diener, M. Kraemer, S. Chakraborty, P. Banerjee, S.K. Pandey, P. Poulose, A. Datta, S. Chakrabarti, A. Datta, H. Widyan, A. Goyal, N. Panchapakesan, S. Datta, D.K. Choudhury, F. Boudjema, A. Ghosal, A. Kundu, S. Roy, B. Mukhopadhyaya, R. Adhikari, K.R.S. Balaji,, R. Basu, G. Bhattacharya, S. Dugad, V. Soni, N.K. Mondal, S. Raychaudhuri, D. Ghosh, S. Gupta, R. Sridhar, P. Roy, S. Banerjee, M. Drees, D.P. Roy, S. Vempati, E. Ma, A. Datta, S. Sahu, G. Bhattacharyya, G. Dutta, D. Choudhury, A. Dighe, U. Mahanta, Indumathi, P. Agrawal, S. Rakshit, A. Stebbins, J. Gayler, J.A. Grifols, I. Waga, W. Grimus, F. Vissani, K. Agashe, B. Jain, N.G. Deshpande, P.N. Pandita, Amit Kundu, J. Sola, F. Sutaria, R. Brandenberger, B. Ananthanarayan, U.A. Yajnik, M.K. Patil, B. Chatterjee, T.V. Ramakrishnan, S. Mahajan, A. Mukherjee, Sanjay Kumar Sahay, S.P. Khare, S. Gupta, D.V. Joshi, C. Sivakumar, V.R. Mathrubhuteswaran, Jitendra Singh, Abhijnan Rej, C. Tout, H.P. Singh, G.P. Pimpale, P.S. Wamane, P.J. Lavakare, G. Meynet, Alom Gupta, S. Aundhkar, S.G. Tagare, S. Ray, H.H. Antia, P.S. Parihar, Nilkashi, M.K. Da, L.M. Saha, A.K. Chaudhury, E. Saikia, B.G. Anandarao, A. Tej, T. Chandrasekhar, U.S. Kamath, C. Muthumariappan, Watson Varicatt, N.M. Ashok, G. Dewangan, M.L. Kurtadikar, M.K. Patil, P.K. Srivastava, Bhaskar Datta, N. Rajasekhar Rao, N. Surchanra Singh, J.P. Chaturvedi, R. Pandey, Kiran Shankar, Shishir Deshmukh, D.A. Choudhary, A. Avalaskar, Bhanu Pratap Das, F. Hu, J. Down, M.K. Bode, J.M. Daly, D. Carter, Vivek Mittal, A.K. Sharma, Kanti Jotania, T.R. Seshadri, A.K. Gupta, J. Vijapurkar, N.D. Hari Dass, J.K. Bhattacharjee, S.S. De, D. Munshi, Suresh Chandra, A.D. Choudhury, S.K. Ray, V.S. Kale, Soumya Chakravarti, S. Ramani, A.A. Rangwala, and D.P.Roy.

Visitors Expected

April : Avinash Khare (IOP, Bhubaneswar), S.N. Karbelkar (College of Engineering and Technology, Akola), Moncy John (St. Thomas College, Kozhencherry), Ramakrishna Reddy (Sri Krishnadevaraya University, Anantapur), Nazeer Ahmed (Sri Krishnadevaraya University, Anantapur), R. Tikekar (Sardar Patel University, Vallabh Vidyanagar), R. Saraykar (Nagpur University), L.K. Patel (Gujarat University, Ahmedabad), and T. Subba Rao (S.K. University P.G. Centre, Kurnool)

May : R. Nityananda (RRI, Bangalore), Debojyoti Dutta (IIT, Kharagpur) P.S. Naik (Gulbarga University), Raj Bali (University of Rajasthan, Jaipur), Asoke Sen (Assam University, Silchar), Manoranjan Khan (Jadavpur University), Udit Narain (Meerut College), S.P. Bhatnagar (Bhavnagar University), V.H. Kulkarni (Bombay University), Renuka Datta (Bethune College, Calcutta), H.P. Singh (Sri Venkateswara College, Delhi), L.M. Saha (Zakir Hussain College, Delhi), K.N. Joshipura (Sardar Patel University, Vallabh Vidyanagar), P.K.Bhuyan (Dibrugarh University), V.C. Kuriakose (CUSAT, Cochin), and M.K. Das (Sri Venketaswara College, Delhi).

June : Somenath Chakraborty (University of Kalyani), Ashok Goyal (Hans Raj College, Delhi), P.C. Vinodkumar (Sardar Patel University, Valabh Vidyanagar), P. Khare (Utkal University, Bhubaneswar), D. Raichaudhury (Jadavpur University), V. Venugopal (IIT, Madras), B. Ishwar (B.R.A. Bihar University, Muzaffarpur), and N. Banerjee (Jadavpur University).

Absolutely Certain but Absolutely Wrong!

"The question whether nebulae are external galaxies hardly any longer needs discussion. It has been answered by the progress of research. No competent thinker, with the whole of the available evidence before him, can now, it is safe to say, maintain any single nebula to be a star system of co-ordinate rank with the Milky Way"... **Agnes Clerke** (1945) echoing the prevailing general sentiment in her book, *The System of the Stars*. Within two decades, the existence of external galaxies was established.

"Chandrasekhar...shows that a star of mass greater than a certain limit M...has to go on radiating and radiating and contracting and contracting until, I suppose, it gets to a few km. radius, when gravity becomes strong enough to hold in the radiation, and the star can at last find peace...I think, there should be a law of nature to prevent a star from behaving in this absurd way.." **A.S. Eddington** while commenting on the work of S. Chandrasekhar on the maximum mass of a white dwarf (Royal Astronomical Society Meeting on January 11, 1935). Nature apparently has not obliged and what Eddington considered absurd, are today commonly known as black holes.

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

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