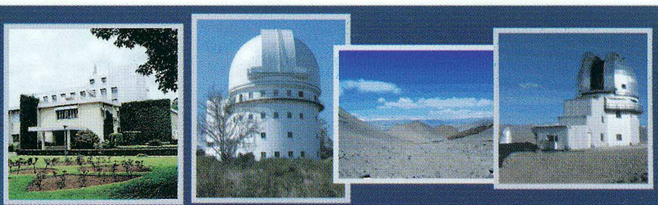


आईआईए न्यूज़लेटर

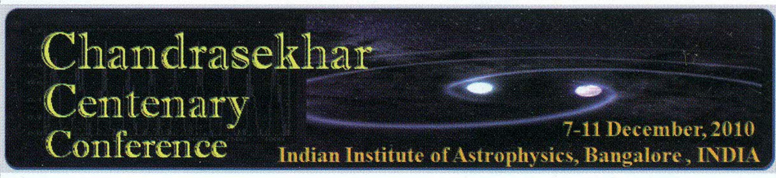
IIA Newsletter

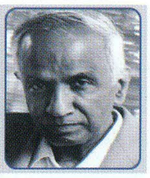
खण्ड 15 सं 4
Volume 15 No. 4

भारतीय ताराभौतिकी संस्थान
Indian Institute of Astrophysics

दिसंबर 2010
December 2010

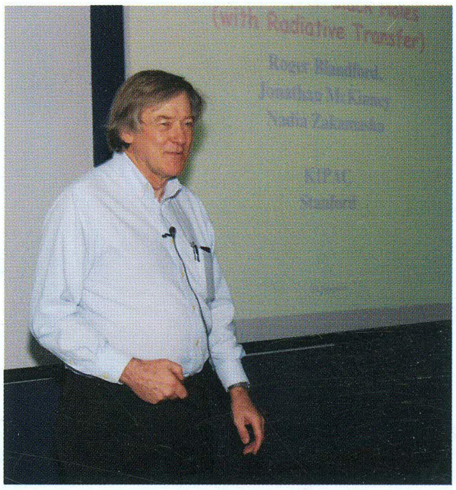
In this issue...





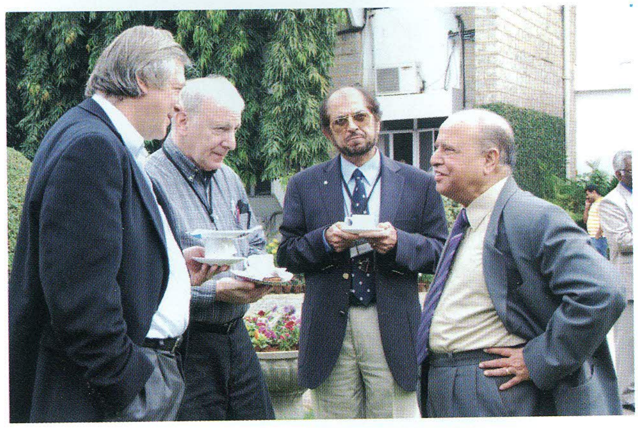
An international conference to commemorate the birth centenary of Professor S. Chandrasekhar was held during December 7-11, 2010 at the Indian Institute of Astrophysics, Bangalore. The main focus of the conference was on research areas in which Chandrasekhar made seminal contributions during his lifetime. The academic program consisted of several invited talks on topics ranging from stellar structure and evolution, astrophysical fluids and plasmas, stellar dynamics, magnetic hydrodynamic, compact objects, black hole physics, general relativity, stellar and planetary atmospheres. The rich legacy of Chandra's work and its vast impact on subsequent developments in the field of astronomy and astrophysics were highlighted in a series of stimulating and inspiring lectures delivered by eminent scientists both from India and abroad.

The conference was inaugurated by Dr Kasturirangan, who is currently a member of the Planning Commission, Government of India. Among the eminent scientists who spoke at the meeting were: Jeremy Goodman (Princeton University, USA), Peter Eggleton (University of Cambridge, UK), David Merritt (Rochester Institute of Technology, USA), Christopher Tout (University of Cambridge, UK), James Binney (University of Oxford, UK), Ravi Seth (University of Pennsylvania, USA), Axel Brandenburg (Alba Nova University Center, Nordita, Sweden), Roger Blandford (Stanford University, USA), Ethan Vishniac (Johns Hopkins University, USA) and Kameshwar Wali (Syracuse University, USA). Beside technical talks, a large number of people from various institutes, universities, and science organizations came to attend a couple of public lectures that were meant for general audience. The conference was co-sponsored by the Indian National Science Academy, the Indian Academy of Sciences, the National Academy of Sciences, the Inter-University Centre for Astronomy and Astrophysics (Pune), the Tata Institute of Fundamental Research (Mumbai), the Physical Research Laboratory (Ahmedabad), the Harish-Chandra Research Institute (Allahabad) and the Institute of Mathematical Sciences (Chennai).



Roger Blandford talking on hydrodynamic and hydromagnetic stability of black holes.

Kameshwar Wali, Syracuse University, USA speaking on "The Legacy of S. Chandrasekhar".

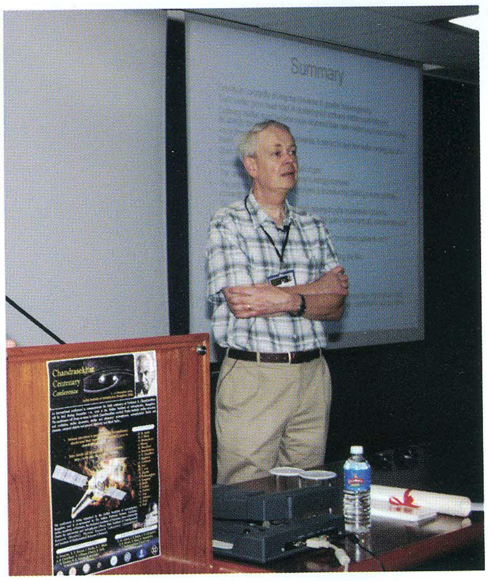


(From the left) : Roger Blandford (Stanford), Robert Wald (University of Chicago), S.S. Hasan (Director, IIA) and Kasturi Rangan conversing during a coffee break

The scientific programme of the conference was formulated and overseen by a scientific organizing committee chaired by T. Padmanabhan (IUCAA). The local organization was handled by a committee with members from IIA, RRI, IISc and ISRO, under the chairmanship of S.S. Hasan, Director of IIA.

R. Banyal and S. P. Rajaguru

Vainu Bappu Memorial Lecture



James Binney, FRS, is currently heading the Theoretical Astrophysics group at the Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, UK and is a Professorial Fellow of Merton College, Oxford. His research concerns the structure, dynamics and formation of galaxies. Professor Binney is well known for his fundamental contributions in the the above areas and, as every student of modern astrophysics would instantly recognise, his text book co-authored with S. Tremaine on 'Galactic Dynamics' has propelled several generations of students in this field. He has been a Fellow of the Royal Astronomical Society since 1973, obtained his doctorate from Oxford University in 1975, was a Lindemann Fellow at Princeton University during 1976, and became University Lecturer in 1981 and Ad Hominem Reader in Theoretical Physics in March 1990 at Oxford University. In July 1996 he became Professor of Physics at Oxford University. In 2000 he bacame a Fellow of the Royal Society of London and a Fellow of Institute of

The fourth Vainu Bappu Memorial Lecture was delivered by Professor James Binney, FRS, on the 9th of December, 2010. This event was organised as an evening public lecture during the Chandrasekhar Centenary Conference hosted by IIA. Professor Binney titled his lecture "What makes spiral galaxies tick?", in which he gave a masterly exposition of the birth, growth and death of spiral galaxies. Terming them as complex machines that are almost alive, Professor Binney traced the life cycle of a spiral galaxy and the insights gained through an interesting mix of the application of basic physics and the analysis of observational data. He described in a very detailed way both what we know and how we know it.

James Binney being felicitated with a bouquet of flowers at the end of his lecture.

Physics. He was awarded the 1986 Maxwell Prize and Medal, and the 2010 Dirac Medal by the Institute of Physics, London. He received the 2003 Brouwer Award of the American Astronomical Society.

Vainu Bappu Memorial Lectures were instituted in 2007, and the Lecture by James Binney was the fourth in the series. Previous awardees of these Lectures are Eugene N. Parker (2007), Douglas O. Gough (2008) and William D. Phillips (2009).

- S. P. Rajaguru

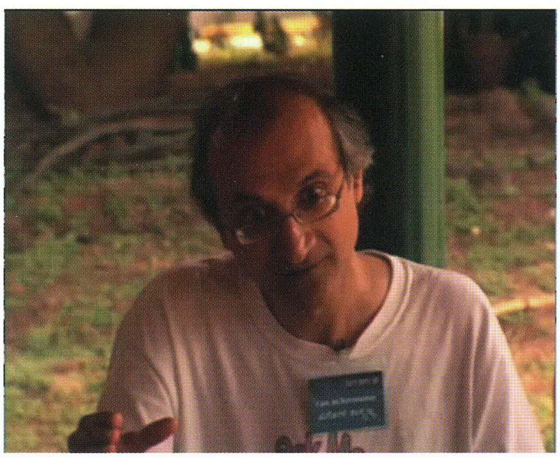
Kalpaneya Yatre

A consortium of institutes from Bangalore, viz., the Jawaharlal Nehru Planetarium, the Indian Institute of Astrophysics, ISRO Satellite Centre, the Srishti School of Art, Design and Technology, Vishveswaraya Industrial and Technological Museum and the Raman Research Institute organised a unique astronomy festival for the public on the grounds of the J.N.Planetarium during 25 November - 5 December, 2010, in which over 40,000 members of the public from Bangalore city, Bangalore rural district as well as more distant locations in the state participated.

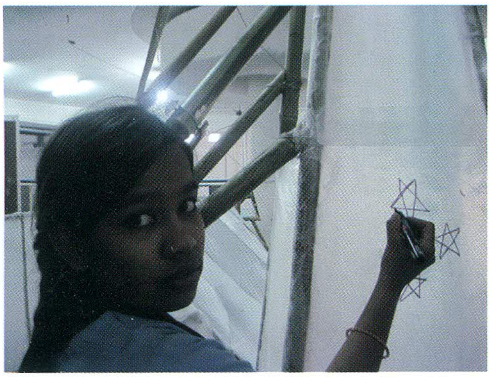
Christened 'Kalpaneya Yatre' or 'Journey of Imagination', this festival was unique in several ways. Firstly, it was the first time that multiple institutions came together to organise an astronomy event for the public in Bangalore. Secondly, it was an inter-disciplinary event with artist-designers from the Srishti school involved right from the beginning in the conception, design and implementation of the festival. Thirdly, the festival provided a space where the amateur astronomers and science popularisers of Bangalore joined hands with the astrophysicists and the artist-designers, to create a rich multi-dimensional experience for the public. The expanded partnership of the festival thus included the Bharat Gyan Vigyan Samithi, Bangalore Astronomical Society, Association of Bangalore Amateur Astronomers, Navnirmiti (Mumbai), Vigyan Prasar (Delhi), Experimental Film Society, Karnataka Rajya Vijnana Parishat, the JNP Club and Dynam Creativity Programmes.

The festival had a bilngual astronomy exhibition (in English and in Kannada) that covered the themes of history of astronomy ideas and people, the Sun and the Solar system, Stars, Galaxies and the Universe and Space Exploration. The exhibition had explanatory panels, 3-D working models as well as some interactive exhibits. A set of experiments and demos titled 'Science of Starlight' demonstrated the underlying principles of astrophysics. In addition, a wide range of activities were conducted, targeted at both youngsters and adults.

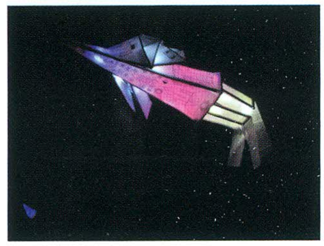
The festival was aimed at people aged 10 and above of all backgrounds. In order to encourage the widest possible participation, only a nominal fee was charged for adults and children had free entry. A highlight of the festival were the astronomy activity workshops that were conducted for students. These workshops were mostly designed by Navnirmiti (Mumbai), Vigyan Prasar and Bharat Gyan Vigyan Samithi, and about thirty children of middle- and high-school levels participated in each workshop learnt about astronomy, sun-viewing, making simple devices for astronomy observations, understanding Jantar Mantar, etc. A total of 950 students participated in these workshops that occurred every day during the festival. The workshops were mostly bilingual. Volunteers from different parts of the state who were trained as resource persons in a pre-festival workshop conducted by Navnirmiti (Mumbai) conducted and assisted these workshops. A resource base was thus created wherein these workshops can be replicated in the home regions of these volunteers. In addition, there was also a telescope-making workshop designed by Navnirmiti



Children at an Astronomy workshop



Children of the Government High School, Madivaala and the 'Understanding Satellites' project.



(Mumbai) for school teachers, in which a total of about 80 teachers made a low-cost telescope from a kit, which they could then take back for use in their schools.

The festival had several lectures by eminent astrophysicists, including three from IIA. Vishwanath Palahalli spoke in Kannada on *'Travellers of the Night'* (*Yaaminiya Yaatrikaru*), Firoza Sutaria spoke on '*Cauldrons of Creation: How stars live and die*', and Jayant Murthy spoke on '*Hrithik, 8-legged freaks from space, and us: The search for life in the cosmos*'. A very popular feature of the festival was the face-to-face interactions between the public and scientists. Over 25 astrophysicists from IIA participated in these '*Ask an Astronomer*' sessions that occurred once or twice each day. With the use of the internet and web-cameras, the public was brought into audio-visual contact with scientists working at the telescopes in different observatories of the country, including IIA's Vainu Bappu Observatory,Kavalur and the Indian Astronomical Observatory, Hanle. The public, and especially students had exciting conversations with the scientists at the telescopes in these sessions. Amateur astronomers of the Bangalore Astronomical Society, IIA's partners in outreach activities through the International Year of Astronomy, co-ordinated several sky-watching sessions in the evenings using their telescopes, including a 17" telescope. A multi-media interactive theatre presentation entitled 'Unscientific Storytelling' designed by Srishti, which explored the role of imagination and individual world views in science education and practice, was performed on three of the festival days, and several scientists from IIA participated as the interactive audience.

The students of Government High School, Madivaala, with whom IIA has had an extension programme since 2008, participated in a two-month long project on '*Understanding Satellites*', leading up to the festival. This project, designed by the Srishti School in collaboration with IIA and ISAC, had about 30 children participate in several pre-festival workshops including at IIA, and visit ISAC to see the satellite models. These activities were meant to trigger the imagination of the children to design satellite models, and culminated in a parade of satellite lanterns that the children made during the festival. In addition, about 200 children from the school were funded by IIA to spend a day at the festival to view the exhibition, participate in the student workshops, lectures and *Ask-an-Astronomer* sessions.

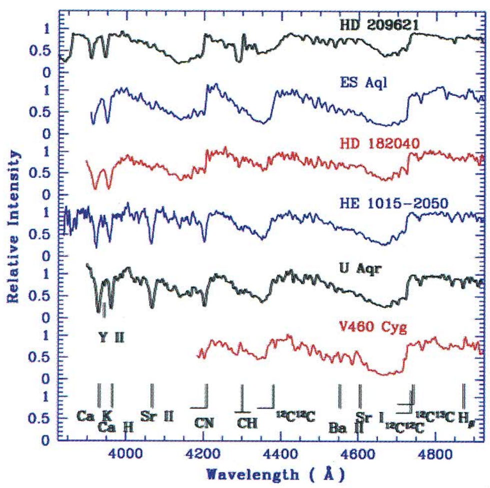
A major highlight of the festival was an inter-disciplinary all-day symposium on the final day. The symposium had speakers, respondents and participants from a wide variety of backgrounds, and included astrophysicists, social scientists, artist-designers, amateur astronomers, science popularisers, educators, facilitators, and members of the public, and there were very lively debates on the nature of the inspiration that astronomy is, astronomy as a vehicle for scientific literacy, rationality and the social responsibility of astrophysicists, and the disciplinary and cultural barriers to growth of the spirit of discovery. About ten astrophysicists from IIA participated in the symposium.

The Kalpaneya Yatre 2010 festival was funded by the Department of Science and Technology (Govt. of Karnataka), the Department of Science and Technology (Govt. of India), ISRO, IIA and Vigyan Prasar (Govt. of India) (http://kalpaneyayatre.org).

- Prajval Shastri, IIA co-ordinator for Kalpaneya Yatre

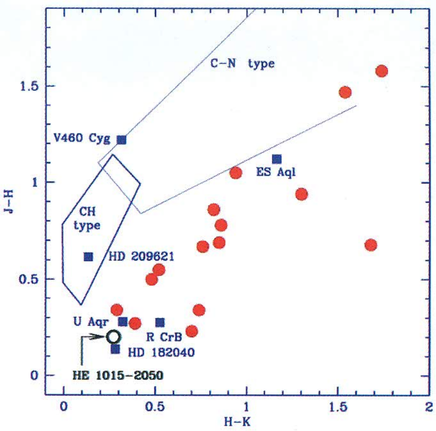
Discovery of a Hydrogen-deficient carbon star from HCT

Hydrogen deficient carbon (HdC) stars are a rare class of objects; only five Galactic HdC stars and about fifty one HdC stars of RCB type are known in our Galaxy. While HdC stars are spectroscopically similar to the RCB type stars, they are distinct from RCBs, as they do not show the deep minima and infrared excesses that are characterististics of RCB stars. The small size of the group of HdC stars is a major constrain for understanding their formation mechanism(s) and evolutionary properties. Using medium resolution spectroscopic data from Himalayan ChandraTelescope (HCT) we have identified HE 1015-2050 to be a hydrogen-deficient carbon star. The present discovery adds a new member to this rare group of objects.



A comparison between the spectrum of HE 1015-2050 with the spectra of V460 Cyg (a C-N star), U Aqr, ES Aql (cool HdC stars of RCB type),HD182040 (a non-variable HdC star), and HD 209621 (a CH star) in the wavelength region 3850-4950 Å. G-band of CH distinctly seen in the CH star's spectrum are barely detectable in the spectra of HE1015-2050 and other HdC stars spectra. When these stars' spectra are dominated by features due to carbon molecular bands the weakness of CH band is a clear indication of hydrogen deficiency. The large enhancement of Sr II at 4077 Å., in the spectrum of U Aqr is easily seen to appear with almost equal strength in the spectrum of HE 1015-2050. Y II line at 3950 Å., is detected in the spectra of both HE1015$-$2050 is the strength of the Sr II l 4215 line; this feature is inextricably blended with the nearby strong blue-degraded (0,1) CN 4216 band head in HD 182040. The spectrum of HE 1015-2050 compares closest to the spectrum of U Aqr.

The spectrum of HE 1015-2050 bears a remarkable similarity with the spectrum of U Aquirii (U Aqr), a cool HdC star of RCB type. The spectral characteristics and its location in the J-H vs H-K plane certainly places HE 1015-2050 in the same group to which U Aqr belongs; however, extended photometric observations of this object would be useful to learn the nature and extent of photometric variations. In particular, it would be interesting to see if there is any sudden decline in brightness, this being a characteristic property of HdC stars of RCB type. *This work has been published in 2010, ApJ, 723, L238.*



The location of HE~1015$-$2050 is shown in the J-H versus H-K colour magnitude diagram (open circle). The solid circles represent LMC RCB stars and the positions of the comparison stars and the prototype RCB star R CrB are marked with solid squares. The thick box on the lower left represents the location of CH stars and the thin box on the upper right represents the location of C-N stars (Totten et al. 2000). The location of HE~1015-2050 in the vicinity of U Aqr (and other HdC stars) in the J-H, H-K plane supports its identification with the group same as that of U Aqr.

- A. Goswami, D. Karinkuzhi, N. S. Shantikumar

Evidence of V-band polarimetric separation of CEMP stars at high Galactic latitude

Polarization is a characteristic property of stars evolving from red-giant stage to planetary nebula; it serves as an important indicator of stellar evolution. We have reported first-ever estimates of V-band polarimetry for a group of carbon-enhanced metal-poor (CEMP) stars from Hamburg/ESO survey. Although they have been well studied in terms of photometric as well as low- and high-resolution spectroscopy, not much is known about the polarimetric properties of the CEMP stars. V-band polarimetry was planned as the V-band is known toshow maximum polarization among BVRI polarimetry for any scattering of light due to dust. Stars with circumstellar material exhibit a certain amount of polarization that may be caused by scattering of starlight due to circumstellar dust distribution into non-spherically symmetric envelopes. The degree of polarization increases with asymmetries present in the geometry of the circumstellar dust distribution. Our results reflect upon these properties. While the sample size is relatively small, the polarimetric separation of the two groups (p % < 0.4 and p % > 1) is very distinct; this finding, therefore, opens up new avenue of exploration with regard to CEMP stars. *The results are published in 2010, ApJ, 722, L90.*

- A.Goswami, S. S. Kartha, A. K. Sen

Radiative Transfer in Multi-Dimensional Media

The solution of polarized radiative transfer (RT) equation is essential to understand the polarized (Stokes I, Q, U, V) spectra of the Sun. Most of the polarized RT studies are based on the assumption that the solar atmosphere is homogeneous at all the planes perpendicular to the atmospheric normal. Only the variation of the physical quantities along the atmospheric normal is considered. This is called a one-dimensional (1D) atmospheric model. However, the observations of the solar atmosphere have confirmed the presence of small-scale structures which represent the spatial inhomogeneity within the atmosphere. As these structures have different physical properties (e.g., magnetic field and temperature), it is clear that the lateral transport of radiation becomes important. The radiation field in an inhomogeneous solar atmosphere is not axi-symmetric. Therefore, the solution of the polarized line RT equation in multi-dimensional media becomes a basic necessity to model these observed solar atmospheric features. An idealization to simplify this problem is to

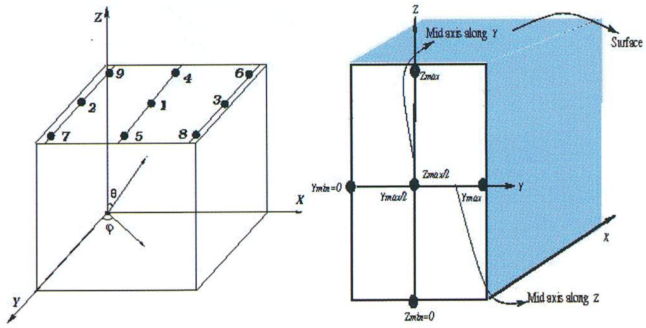


Figure 1. This figure shows the radiative transfer in 3D and 2D geometries

represent the inhomogeneities as computational boxes characterized by given physical parameters. Extensive studies on RT in two-dimensional (2D) and three-dimensional (3D) geometries have been made to understand the intensity profiles in spectroscopic observations. As the linear polarization (Stokes Q and U) of the radiation field is more sensitive to the non-axisymmetry than the intensity (Stokes I), the solution of the polarized RT equation in 2D and 3D geometries is needed to understand these spectropolarimetric observations.

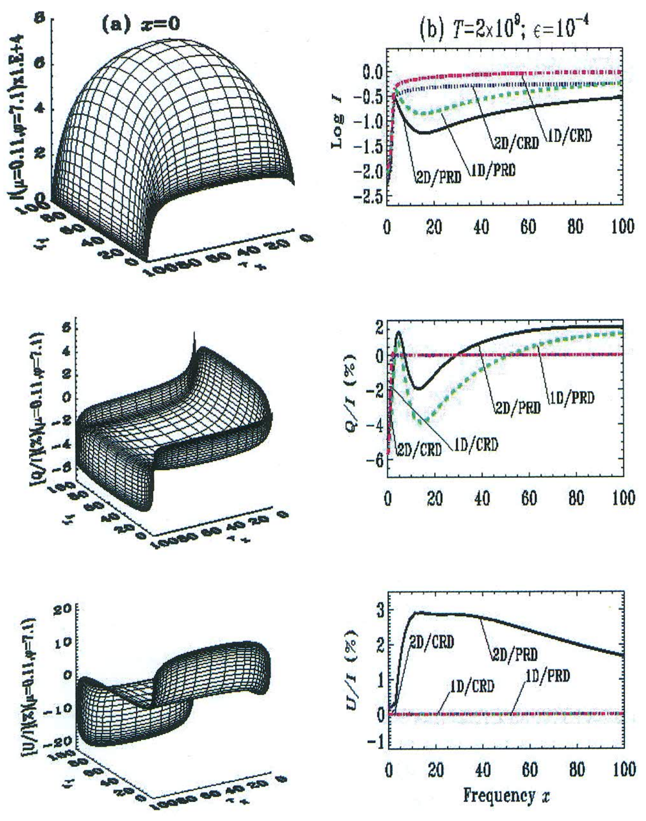


Figure 2 .Panel (a) shows the surface plots of the intensity I and the degree of linear polarization (Q/I, U/I) on the top surface of the computational cube. Panel (b) shows the important differences between CRD and PRD Stokes profiles in a semi-infinite 2D atmosphere. The 1D results are shown for comparison.

Polarized RT problems have been addressed in the past decade, but only for complete frequency redistribution (CRD). A first investigation with partial frequency redistribution (PRD), for 3D geometry,is developed in Anusha & Nagendra (2011, hereafter called Paper I). The solution of multi-dimensional polarized line transfer equation formulated in the Stokes vector basis is complicated. The reason for this is the explicit dependence of the physical quantities on 3 spatial co-ordinates, 2 angular variables defining the ray direction, and a frequency variable.Therefore, it is advantageous to write the transfer equation in a basis where it takes a simpler form.

In Paper I, we have formulated the polarized transfer equation in 3D geometry using the technique of the ‘irreducible spherical tensors’. In 3D geometries, the radiation field is non-axisymmetric (even in the absence of magnetic fields), because the finite optical depths in the X, Y, and Z directions break the azimuthal symmetry of the radiation field. In a 1D geometry, the radiation field is axisymmetric about the Z-axis. Due to these reasons, the shapes and magnitudes of the (Q/I, U/I) spectra differ significantly from the corresponding 1D cases. We have shown that the advantage of solving the transfer equation in the ‘irreducible spherical tensor basis’ is that the irreducible source vector becomes ‘completely independent of the angle variables' — making it easier to extend the existing 1D PALI methods to the 3D case. However, the irreducible intensity components remain dependent on the inclination and also on the azimuthal angle of the ray. In future, we will try to apply the solution method presented in Paper I to model the polarimetric observations of resolved structures like solar filaments and prominences.

Solving the polarized RT equation with PRD in multi-dimensional geometries is numerically expensive, both in terms of computing time and computer memory. To address this problem, in Anusha et al. (2011, hereafter called Paper II) we develop an efficient method to solve the polarized RT equation with PRD in a 2D slab. We assume that the medium is finite in two directions and infinite in the third direction. In Paper II, we apply the 'Stokes vector decomposition technique' developed in Paper I to 2D geometry. We show that due to symmetry of the Stokes I parameter with respect to the infinite axis, the Stokes Q becomes symmetric and the Stokes U becomes anti-symmetric about this axis. This decomposition technique is interesting for the development of iterative methods. Here we describe a numerical method called the Pre-BiCG-STAB (Preconditioned Bi-Conjugate Gradient) and we show that it is much faster than the Jacobi iteration method used in Paper I. In Paper II, we consider the case of semi-infinite atmospheres and compare the behaviors of the surface averaged emergent Stokes profiles in 2D geometry and the corresponding 1D solutions for CRD and PRD. We show that the deviation of the polarized radiation field in 2D geometry from that in 1D geometry exists both for CRD and PRD, but is more severe in the line wings of the PRD solutions. *These results are published in ApJ, 2011,726, 6 (Paper I) and 726, 96 (Paper II).*

-L. S. Anusha & K. N. Nagendra

Design and Development of Lyman Alpha Interference Filter for Astronomical Applications

On the basis of Lyman alpha profiles and its importance in the astronomical studies, we are developing Lyman alpha optical filter in which multilayer coating design is used. Filters with only one metal-dielectric pair resulted in poor filtering properties so filters with three metal dielectric pairs have been used.This provides much better transmittance hitherto achieved.These filters have been design as a part of institute interest in the solar research through space payload.

Lyman alpha line has certain important applications in the study of chromospheric and coronal regions of the sun. Lyman alpha line is also important in the study of cosmological objects as well. For example Lyman-alpha is used to determine red shifts and star-formation rates. Its profile and strength can also provide constraints on the age of star-forming galaxies, on their dust content and other ISM properties and on outflows. Furthermore Lyman-alpha luminosity functions (LFs), their red shift evolution and comparison with e.g. UV LFs provide invaluable information on galaxy populations and their evolution. Lyman-alpha is of great interest to identify very distant galaxies; it serves as a signpost for extremely metal-poor/Pop III galaxies, and is established as a crucial tool to measure cosmic reionization. Lyman-alpha galaxy surveys are also being used to map largescale structure, and to probe dark matter properties. [1]A typical profile of Lyman alpha line is as shown in Fig. 1.

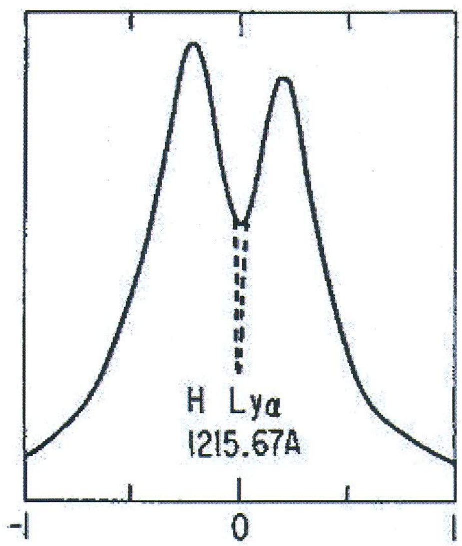


*Fig.1.Typical profile of Lyman alpha. The dotted portion of Lyman alpha is the telluric hydrogen absorption core. (**Source**: The Extreme Ultraviolet Spectrum of the Sun by Richard Tousey).*

As the small band gap allows electrons to absorb radiation with energies equal to or less than the energy of the band gap; causing the material to be significantly absorbing. So very large band gap energy has the chance of making a material transparent. There exist two materials with a band gap equal to or greater than 10.2 eV, the energy of the Lyman alpha line. Because of this characteristic, these two materials are suitable for the transmissive property at this wavelength. These two materials are LiF and MgF_2. [2]But we preferred to use magnesium fluoride in place of lithium fluoride as it is hygroscopic material which can result in poor quality filters unless great care is taken in a metal-dieelectric filter which

The optimized parameters of the filter are given in Table 1.

LAYERS	MATERIAL	THICKNESS (A°) @ CWL = 1215.42	THICKNESS (A°) @CWL = 1215.67	THICKNESS (A°) @CWL = 1215.921
1	Aluminum	200.8	200.8	200.8
2	MgF_2	153.6	153.7	153.8
3	Aluminum	431.5	431.7	431.8
4	MgF_2	159.1	159.2	159.3
5	Aluminum	179.4	179.5	179.6
6	MgF_2	197.8	197.9	198.1
	Total Thickness (A^0)	**Al** = 811.6 **MgF_2** = 510.6 **Total** = 1322.1	**Al** = 811.9 **MgF_2** = 510.8 **Total** = 1322.7	**Al** = 812.2 **MgF_2** = 511.2 **Total** = 1323.4

•***CWL*** : Central wavelength

consists of six alternating layers of aluminum as a metal and MgF_2 as a dielectric spacer layer: Al/MgF_2/Al/MgF_2/Al/MgF_2.[3] The advantage of metal- dielectric filter is that the out of band is partly reflected and partly absorbed while with all the dielectric transmittance filters, the out of band is mainly reflected. Also metal dielectric filters are selected because of the good rejection achieved in the near UV and the visible wavelength. The theoretical design has been done using thin film calculator software. The schematic of the optical design of Lyman alpha filter is shown in Fig. 2.

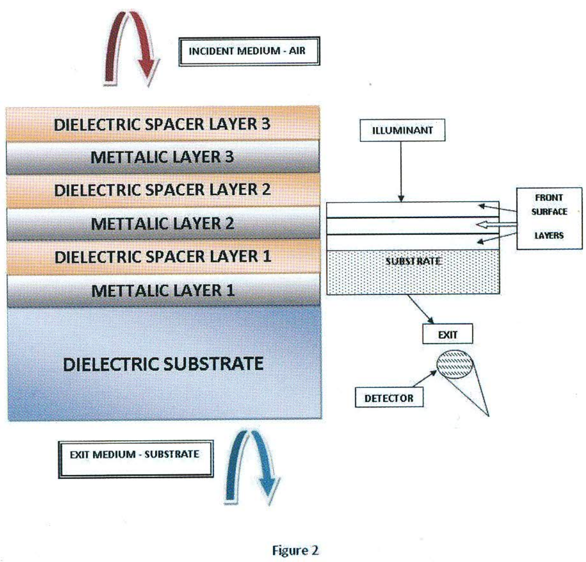


Fig. 2.

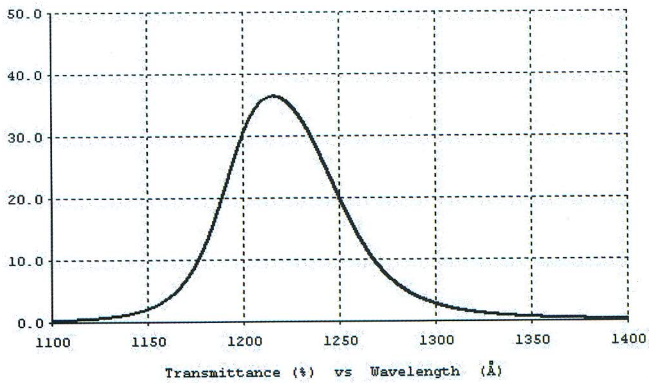


Fig. 3. Transmittance (%) vs wavelength (Å).

Transmission curve of the Lyman alpha filter as obtained from 3MDM design is shown in Fig. 3.

From the table, it can be noticed that 0.1 Å thickness controlling is necessary to achieve the 0.25 Å accuracy on the central line transmission.

Remarks: The present metal dielectric design for the Lyman alpha transmission filter with six alternating layers of Aluminum and Magnesium fluoride can provide the best transmittance value of 36.38 % for the Lyman Alpha line with a FWHM of 65.64 Å. The bigger challenge in the task is to control the thickness parameters practically as the thickness of each layers are less than 50 nm which is difficult to handle. Besides this, thickness controlling of 0.1Å is required to achieve the 0.25 Å accuracy on the central line transmission. The fabrication work of one such filter is in progress.

References :

1. The Extreme Ultraviolet Spectrum of the Sun : Richard Tousey.

2. Windows and Filters : Experimental Methods in the Physical Sciences , Vol 31

3. Filters for the WSO/UV by Fernendez-Perea-et al.

- A. K. Saxena & M D. Faisal Nawaz

Vibration Tests on the Engineering Model (EM) of the UVIT Payload on Astrosat

In the period from September 2010 to November 2010, the vibration tests on the EM of the UVIT was conducted at the Vibration Laboratory of the Environmental Test Facility (ETF) of the ISRO Satellite Centre (ISAC), Bangalore.

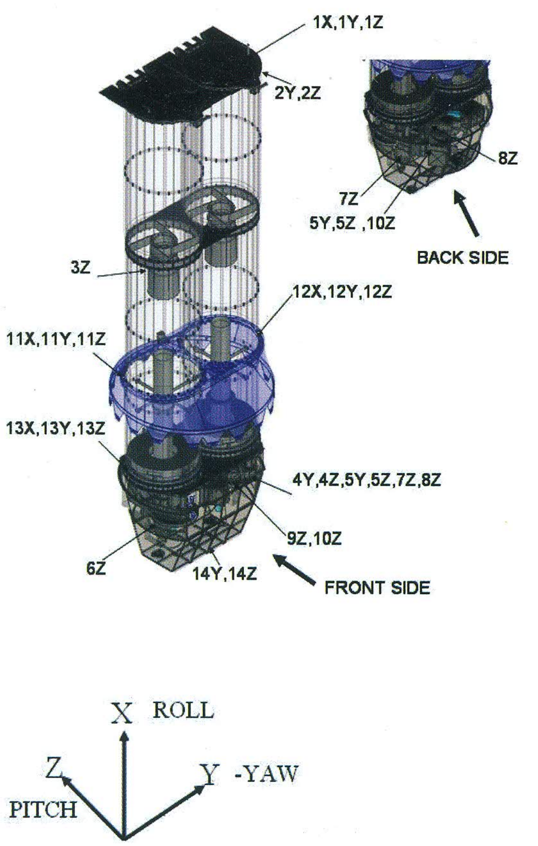


Fig.1. Control accelerometers (as required) 15x/15y/15z.

Accelerometers locations

The three axes of the payload viz. the pitch, yaw and roll are shown in the figure.The details of the tests conducted are given below.

The payload is subjected to two types of vibration depending on the profile of the input viz. sine vibration and random vibration. The sinusoidal test simulates the vibration pattern experienced by the payload due to the working of the rocket engines transmitted by the structure and the random vibration pattern is the one experienced by the payload because of wind buffeting and also the acoustic noise created by the working of the rocket engines.

The different categories of tests and the expected results are given below:

Low level sine: This is used to evaluate the "signatures" ie. to estimate the modal frequencies of the various sub-systems. This is also used as a check for the structural integrity of the payload after each test.

Acceptance level sine: This is the test wherein all sub-systems are subjected to the design load level.

Qualification level sine: This is the test wherein all sub-systems are subjected to a load level higher than the design load by a factor equal to the factor of safety.The factor of safety normally employed is 1.1.

Quasi Static or dwell test: If any sub-system has not experienced the design load level, a quasi static test is conducted where the sub-system is subject to the design load.

Low level random: This is used to evaluate the "signatures" ie. to estimate the modal frequencies of

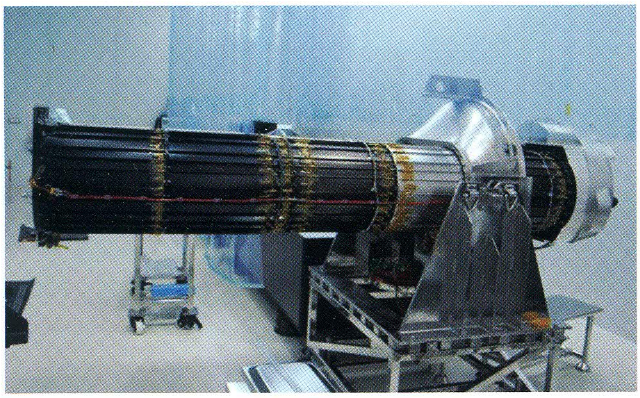


Fig. 2. EM of UVIT at the MGKM lab, CREST, IIA, Hosakote.View of main Baffles and telescope tubes of NUV channel.

the various sub-systems. This is also used as a check for the structural integrity of the payload after each test.

Acceptance level random: This is the test wherein all sub-systems are subjected to the design load level.

Qualification level random: This is the test wherein all sub-systems are subjected to a load level higher than the design load by a factor equal to the factor of safety. The factor of safety normally employed is 1.1.

A electrodynamic shaker was used to vibrate the payload and the power input is computed by the g level applied at the centre of gravity of the payload.

The input gets modified at the various sub-systems depending on the transfer function at the interfaces of the various subsystems.

During the design phase, a certain value is considered for the transfer function and this is verified by conducting the low level test.

The expected force levels at various sub-systems are computed for the acceptance level tests from the observed values of the transfer function termed as "beta".

If the expected level is higher than the design level for a sub-system, then a process known as notching is introduced where the input levels are reduced when thelevel of force cross the design limit at the subsystem. This is normally done by the automatic control system of the vibration test facility.

Accelerometers are used to sense the level of force that is experienced by a subsystem. These are piezoelectric devices that sense the vibration and convert them into a charge form. This charge output is converted into a voltage output by a conditioning amplifier.

36 accelerometers were used in the EM of the UVIT. In addition, 17 accelerometers were used on the vibration table as control accelerometers, the output of which is used as a feedback for controlling the input signal to the vibration table.

The UVIT has two channels viz. Far Ultra-Violet (FUV) and Near Ultra-Violet (NUV). In the EM, the FUV channel is replaced by a stainless steel model which simulates the FUV channel in terms of mass and moment of inertia.

The various subsystems of the UVIT like the camera proximity unit (CPU) which is the detector, the high voltage unit (HVU) for the detector, filter wheel motor and drive electronics and the door mechanism were found to perform optimally.

The hinges of the door mechanism however, failed during the qualification level sine test in Z axis. The same was replaced by a different material of higher thickness.The structural components were found to withstand the tests.

However, the fasteners holding the secondary baffle loosened during the qualification level random in Y axis. The system was put back in operation after making suitable modification.

The engineering model of UVIT (UltraViolet Imaging Telescope) has been successfully tested for vibration loads at ISAC, ISRO. Given the large size of this instrument, vibrations during the launch are expected to lead to quite large stresses on the structure and the optical/electrical parts. Thus, this was a very critical test and the instrument team was very eagerly and anxiously waiting for its successful completion. The tests involved very detailed monitoring of the acceleration levels; Fig. 1 shows locations of the accelerometers. In Fig. 2 is shown the assembled instrument mounted on a fixture for transport to ISAC. During the tests some deficiencies were noted, and these were rectified in short time. Successful completion of this test opens the way for assembly of the flight model without any major change of design in the structure.

The results of the tests were reviewed and approved by a committee consisting of expert members from ISAC and IIA.

- UVIT Team

IIA Research Publications

September - December 2010 §

(1) Hiremath, K. M. 2010, Sun and Geosphere 5, 17-22, *Physics of the Solar Cycle: New Views.*

(2) Banerjee, D., Gupta, G. R., *Teriaca, L., 2010, Space Science Review 120. *Propagating MHD Waves in Coronal Holes*

(3) *Moradi, H., ... Rajaguru, S. P.,... et al. (22 Authors), 2010. SoPh 267, 1-62, *Modeling the Subsurface Structure of Sunspots*

(4)* Acton, C. E., *Priestley, K., *Mitra, S., Gaur, V. K., 2010. Geophysical J., 441. *Crustal structure of the Darjeeling-Sikkim Himalaya and southern Tibet*

(6) Sujatha, N.V., Murthy, J., *Suresh, R., *Henry, R. C., *Bianchi, L., 2010, Ap J 723, 1549-1557.*GALEX Observations of Diffuse Ultraviolet Emission from Draco*

(7) *Bielby, R. M ., ... Stalin, C. S., et al. (15 Authors), 2010, A&A 523, A66. *The WIRCAM Deep Infrared Cluster Survey. I. Groups and clusters at z = 1.1.*

(8) *Sbordone, L., ... Sivarani, T., et al. (19 Authors), 2010, A&A ,522, A26. *The metal-poor end of the Spite plateau. I. Stellar parameters, metallicities, and lithium abundances*.

(9) *Balachandran, S. C., Mallik, S. V., *Lambert, D. L., 2010, MNRAS,1582. *Lithium abundances in the alpha Per cluster.*

(10) *Taricco, C., ... Sinha, N., et al., (9 Authors) 2010, Meteoritics and Planetary Science, 45, 1743-1750. *Cosmogenic radioisotopes in the Almahata Sitta ureilite.*

(11) *Chakrabarty, D., *Sekar, R., Sastri, J. H., *Pathan, B. M., *Reeves, G. D., *Yumoto, K., *Kikuchi, T., 2010, J. Geophys. Res., (Space Physics) 115, 10316. *Evidence for OI 630.0 nm dayglow variations over low latitudes during onset of a substorm.*

(12) Sengupta, S., *Marley, M. S., 2010, ApJL 722, L142-L146. *Observed Polarization of Brown Dwarfs Suggests Low Surface Gravity*

(14) Rajaguru, S. P., *Wachter, R., *Sankarasubramanian, K., *Couvidat, S., 2010, ApJL 721, L86-L91. *Local Helioseismic and Spectroscopic Analyses of Interactions Between Acoustic Waves and a Sunspot.*

(15) Muneer, S., Jayakumar, K., Rosario, M. J., Raveendran, A. V., Mekkaden, M. V., 2010, A&A, 521, A36. *Orbital period modulation and spot activity in the RS CVn binary V711 Tauri.*

(16) Aruna Goswami, Sreeja S. Kartha, *Asoke K. Sen, 2010, ApJ, 722, L90, *Evidence of V-band polarimetric separation of carbon stars at high Galactic latitude*

(17) Aruna Goswami, Drisya Karinkuzhi, N.S. Shantikumar, 2010, ApJ, 723, L238, *HE 1015-2050: Discovery of a hydrogen deficient carbon star at high Galactic latitude*

(18) Sampoorna, M., *Trujillo Bueno, J., *Land Degl'Innocenti, E., 2010, ApJ, 722, 1269-1289, *On the Sensitivity of Partial Redistribution Scattering Polarization Profiles to Various Atmospheric Parameters*

(19) Anusha, L. S., Nagendra, K. N., 2011, ApJ, 726, 6, *Polarized line formation in multi-dimensional media. I. Decomposition of Stokes Parameters in arbitrary geometries*

(20) Anusha, L. S., Nagendra, K. N., *Paletou, F., 2011, ApJ, 726, 96, *Polarized line formation in multi-dimensional media. II. A fast method to solve problems with partial frequency redistribution*

§ ***From IIA Repository***

* ***Collaborators***

Symposium on Indian Science

The 21st annual meeting of the Third World Academy of Sciences took place in Hyderabad, India, this year during 19-22 October. The conference was inaugurated by the Prime Minister, Dr Manmohan Singh, who in his inaugural address described how science is a key driver that guides global discourse. Over 300 delegates from the developing world gathered to deliberate on a variety of topics including current science research, education, scientific priorities for development and means to achieve excellence.The first symposium of the conference was on Science in India, which covered a broad range of topics of Indian research, where Prajval Shastri from IIA gave a talk on *Munching Black Holes and Growing Galaxies*.

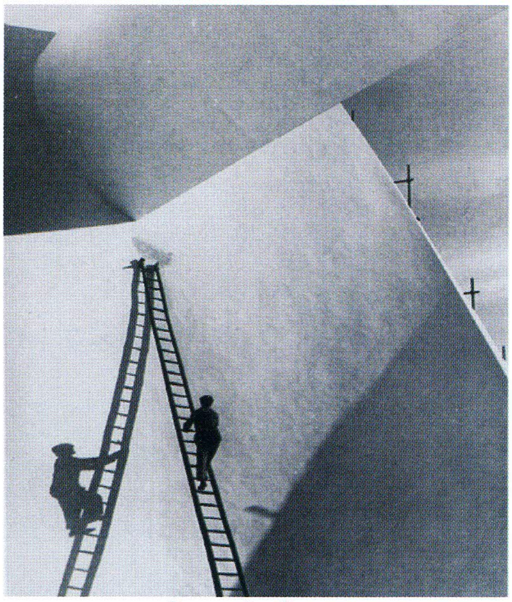
- Prajval Shastri

Scientific Legacy of S. Chandrasekhar

Summary of Chandrasekhar's research

Chandra is well known for his discovery in 1930, during his voyage from India to England, of a limit on the mass of a star that can become, in its terminal stage, a white dwarf. The limit, known as the Chandrasekhar limit (1.4 $M_{\odot}$), is hailed as one of the most important discoveries of the twentieth century, since it paved the way to the discovery of the other two presently known terminal stages of a star: neutron stars and black holes. Subsequently, Chandra's distinctive pattern of research encompassed diverse areas, each of which occupied a period of five to ten years, resulting in a sequence of a large number of papers and ending with a monograph. Six such monographs known for their thoroughness, lucidity, and scholarship have had dramatic and lasting effects on diverse fields of astronomy and astrophysics by providing not only numerical results for comparison with observations, but also mathematical models and mathematical techniques for solving them.

In brief, Chandra's major contributions to twentieth century astrophysics were in studies of the structure and stability problems during stellar evolution, stellar dynamics dealing with distributions of matter and motion in the aggregation of stars in galaxies and star clusters, the principles of radiation transfer and radiation equilibrium in stellar atmospheres, particularly the theory of the illumination and polarization of the sunlit sky, and the theory of the negative ion of hydrogen which resolved a long standing controversy of the thirties pertaining to the solar spectrum and the abundance of hydrogen in the sun. During 1952-61, he worked on several problems in magnetic fields culminating in book on Hydrodynamic and Hydromagnetic stability. Beginning in 1960, Chandra's main interests turned to Einstein's general theory of relativity and to bringing it into its "natural home," astronomy. He developed the post-Newtonian scheme to systematically take into account the general relativistic effects. Chandra's contributions to the mathematical theory of black holes and his studies of the exact solutions of Einstein's equations provided new and important physical and mathematical insights into the richness and beauty of Einstein's theory. In the last years of his life, Chandra devoted his main efforts to a study of Newton's Principia, reworking Newton's proofs in more modern scientific language. His monograph on this work was published just prior to his death in 1995.



Ascent of man

Chandra is often thought of as a scholar in the classical tradition of Lord Rayleigh (John William Strutt) and Jules-Henri Poincare. Some two-thirds of his research papers are collected together in seven volumes. A book titled "Truth and Beauty" by Chandra is a collection of seven lectures that express his thoughts on aesthetics and motivations in science. His outlook to science is captured in the picture, (inlay) 'Ascent of man' that adorned his office.

Selected results of Chandrasekhar and its impact

Fluids and Plasmas (1949-1957): Chandrasekhar made fundamental contributions to Magnetohydrodynamics (MHD) with particular attention to generation, static equilibrium and dynamical stability of magnetic fields in various settings with conceptualized applications to astronomical problems. Inspired by Heisenberg he worked on a formulation of an equation for the energy spectrum of statistically isotropic homogeneous hydrodynamic turbulence and generalized the Von Karman-Howarth equation to MHD.

The structure of the Galactic magnetic field is central to acceleration and propagation of cosmic rays. Along with Enrico Fermi, he worked on the structure and dynamics of the magnetic fields in the spiral arms and made the first estimates which are in rough agreement (within a factor of 2) of modern observations.

Chandrasekhar derived and exploited the magnetic virial theorem to explain magnetic stars and obtained stability criteria for magnetized equilibria in many general situations. He obtained with Prendergast the field equations for the general case of magnetostatic equilibrium with axisymmetry. He worked out the analytic solution to the axisymmetric force-free Lorentz equation which has important applications for the solar plasma. With Kendall, he extended this solutions to non-axisymmetry and resistive decays.

With Kaufman and Watson he developed a perturbation solution to the collisionless Boltzmann equation in the strong field limit applying to the stability of the magnetic pinch. With Bachus he provided the formal proof of the anti-dynamo theorem for the ideal axisymmetric case that proscribes the maintenance of the magnetic fields in this setting.

He studied several effects of the magnetic fields on the dynamical instability of the Couette flows, the Rayliegh-Taylor and Kelvin-Helmholtz instability. Many of the situations studied by him continue to be rediscovered in modern computer simulations and find applications in stars and astrophysical disks. One such differential rotation instability is believed to play a key role in angular momentum transport in disks, a subject that is very relevant in the modern context.

Theory of Radiative Transfer (1943-1950): Chandrasekhar's most important contributions in this area are the discrete ordinatemethod, the invariance principles and polarization. An integro-differential equation of transfer with two-point boundary conditions presents a difficult mathematical problem. Chandrasekhar reduced this finite set of ODE by introduction of quadrature scheme into the integral term, whose solutions at large order were shown to be exact.

Chandrasekhar developed and formalized the ideas first introduced by Ambartsumian in the late 1940s. The invariance principles greatly simplifies the transfer problem by showing the forms of the scattering and transmission functions. The four elegant invariance principles given Chandrasekhar's text on the subject represent the foundations of radiative transfer theory.

One noteworthy numerical calculation for the problem of Thompson scattering using discrete ordinates was the maximum of 11 % in the degree of polarization for grazing emergence, a result that is widely quoted. In order to extend the Rayleigh's theory which was base on a single scattering approximation, Chandrasekhar formulated the full scattering problem with polarization using Stokes's parameters. Chandrasekhar went on to find the solution for diffuse reflection of a semi-infinite Rayleigh scattering atmosphere. Along with Elbert he produced complete polarization sky maps based on this theory which showed precisely the character of the observations, in particular the neutral points on the Sun's meridian and also the complete neutral lines.

Stellar structure and Evolution (1929-1939): As a young student Chandrasekhar built on Fowler's invocation of Fermi-Dirac statistics in the structure of stars. Realizing that relativistic forms are required, he derived the celebrated mass-radius relation for White Dwarfs. Chandrasekhar included the correct form for a degenerate relativistic gas and solved the equations of hydrostatic equilibrium. He predicted a upper imit to the mass of White Dwarf of 1.4 $M_{\odot}$ famously known as theChandrasekhar limit. He went on to develop and build the theory of stellar structure using integral theorems, homologous transformations and the method of stellar envelopes. These analytic results are fundamental in the field and formed the basis for constructing sophisticated numerical stellar models of the modern era. With Schonberg he found a critical mass limit of an isothermal core which is about 10 % of the mass of the star which has profound implications for the evolution of the star with a helium core and a radiative envelope. It is this critical fraction that predicts the Hertzsprung gap in the HR diagram, a region between the main sequence and the red giants where there is a paucity of stars.

His early results led inescapably to the conclusion that sufficiently massive stars will ultimately collapse to black holes, though he returned to the subject in 1964 to make a detailed study of relativistic instabilities and study of black hole properties for the next thirty years.

Statistical and Dynamical Problems in Astronomy (1939-1943; 1961-1968): The important results obtained by Chandrasekhar in stellar dynamics include those on ellipsoidal hypothesis and stellar relaxation time with application to dynamical friction.

He produced both steady state and time dependent models for the distribution functions that are constant on ellipsoids in velocity space. He found a larger space of solutions to the steady state problem than previously thought possible (beyond the Stackel potentials) and gave the integrability conditions. He investigate various time dependent models to discover instability in the steady state models and investigated spiral structure. He also studied axially symmetric systems and found a correct prescription for the potential. He used the formalism to find useful results for spheroidal systems.

Chandrasekhar, in a very intricate calculation, estimated the relaxation time including deflection of stars and time average of the energy fluctuations which was previously incorrectly evaluated by Eddington, Schwarzchild and Rosseland.

Chandrasekhar applied powerful statistical methods to attempt a better theory of stellar fluctuations. The main goal was to find the relaxation time as a function of the random variable of the fluctuating force field. In two rigorous papers with the famous Von Neumann he worked out these ideas which involves the principal task of evaluating the joint probability distribution of force field in terms of the rate of the fluctuation. After a very difficult calculation, Chandrasekhar and Von Neumann show the existence of dynamical frictional force that is proportional to the velocity.

Chandra devoted much of the period from 1960 to 1968 to the virial method and analysis of the figures of classical ellipsoids and their stability. The importance of this lies in the fact that the tensor virial theorem can be exploited to find approximate information about figures seriously distorted from the spherical by rotation or magnetic fields. He found with Lebovitz that in the context of incompressible figures of the Maclaurin spheroids, the virial equations yielded exact frequencies. It presented an attractive alternative to arduous expansions in ellipsoidal harmonics which was used in analyzing Jacobi ellipsoids by Poincare, Darwin, Lyapunov and Jeans. He with Lebovitz applied the machinery to study Maclaurin and Jacobi sequences and extended it to the more general family of Reimann ellipsoids previously discovered by Dirichlet, Dedekind and Riemann. He invented new results and cleaned up many classical results in this area.

General Relativity and Mathematical Theory of Black holes (1962-1983): Once Chandrasekhar started on relativity, he never left it. The first problem he worked on was the study of pulsation of a spherical star in GR. It immediately had an impact in astronomy in showing that quasars were likely to be single supermassive stars. He went to attack a very formidable problem of gravitational radiation reaction, namely how does the emission of gravitational radiation affect the emitting system, in particular when the system is self-gravitating. He produced the answer upto the 2.5 post Newtonian Order. Several approaches are based on this valuable work.

Chandrasekhar presented a unified picture of black hole perturbations which was mired in different approaches and explained several mysteries. He also worked on Dirac equation in Kerr space time which he was able to separate correctly. He also worked on the solution of the Einstein-Maxwell equations known as the Kerr-Newman metric. He studied Kerr-Newman holes and their perturbations.He worked on colliding plane waves in general relativity with Xanthapolous which is considered fundamental to the understanding of singularities. All this has profound implications for calculation of templates for detection of gravitational waves.

Newton's Principia (1995): Armed with the knowledge of Latin, Chandrasekhar analyzed the results obtained by Newton by trying to re-discover his proofs. He was amazed by simplicity of the geometric methods used by Newton in the face of powerful modern algebraic methods. Chandrasekhar's last book was written for the scientific community to recover the remarkable insight of the intellectual giant of past era that was lost down the centuries.

To conclude, it is fair to say that S. Chandrasekhar was an extraordinary mathematician, a greater physicist and the greatest astronomer of the twentieth century whose results continue to have lasting impact and have permeated nearly all the fields of Astronomy.

- *Arun Mangalam*

हिन्दी पखवाड़ा व हिन्दी दिवस समारोह -2010

14 सितम्बर 2010 को भारीतीय ताराभौतिकी संस्थान में आयोजित हिन्दी दिवस के दौरान पुरस्कार विजेताओं के साथ अन्य स्टॉफ सदस्य। (बाएं से दाएं) एम.पुरुषोत्तम, मीना, एन.सत्य भामा, मालिनी राजन, डॉ. पी.कुमरेसन, प्रो. आर.सी.कपूर, एन.के. प्रमीला, एल.जोसफीन, बी.प्राणेश राव

01 सितम्बर 2010 से 14 सितम्बर 2010 के दौरान हिन्दी पखवाड़ा का आयोजन किया गया। इस आयोजन को सफल एवं रोचक बनाने के लिए संस्थान में हिन्दी वाद - विवाद , हिन्दी गान, हिन्दी अंत्याक्षरी , हिन्दी निबंध तथा हिन्दी अनुवाद प्रतियोगिताओं का आयोजन किया गया ।

14 सितम्बर 2010 को भारीतीय ताराभौतिकी संस्थान में हिन्दी दिवस भव्य रूप से मनाया गया। इस समारोह की अध्यक्षता डॉ. पी. कुमरेसन, प्रशासनिक अधिकारी ने की। उन्होंने अपने संबोधन में सरकारी कामकाज में हिन्दी का प्रयोग सभी सरकारी अधिकारी एवं कर्मचारियों का नैतिक दायित्व है और कहा कि सरकारी कामकाज सरल, सहज तथा आम बोल चाल की भाषा में निपटाया जाना चाहिए। प्रोफेसर आर.सी. कपूर, सलाहकार ने गृह मंत्रालय द्वारा प्रेषित गृह मंत्री का संदेश प्रस्तुत किया। तदोपरांत विभिन्न प्रतियोगिताओं के 18 विजेताओं को पुरस्कार वितरित किए गए। श्री ए. नरसिंह राजू, कार्मिक अधिकारी ने आभार प्रदर्शित करते हुए हिन्दी दिवस का समारोह सुखद समापन किया।

दिनांक 16 सितम्बर 2010 को वेणु बापू वेधशाला, कावलूर में हिन्दी दिवस का आयोजन किया गया । हिन्दी गान तथा हिन्दी अंत्याक्षरी प्रतियोगिता का आयोजन किया गया । तदोपरांत प्रतियोगिताओं के 08 विजेताओं को पुरस्कार वितरित किए गए।

एम.पुरुषोत्तम
कन्सल्टेंट (हिन्दी)

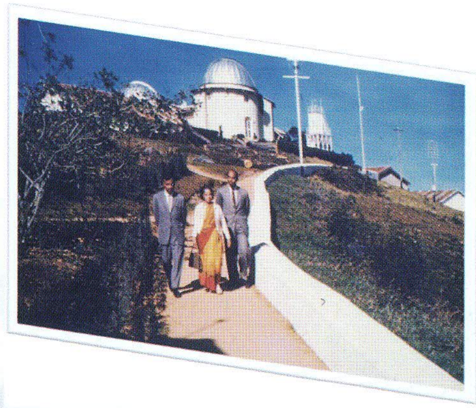
From IIA Archives

Recapturing Chandra @ iia

Recapturing Chandra @ iia

On the occasion of the Chandrasekhar Centenary Conference organized at IIA between 7th to 11th December 2010, there was a photographic exhibition set up by the Library. These photographs were taken during the visits of Prof. S. Chandrasekhar to IIA, starting from 1961 to 1993.

Prof. S. Chandrasekhar with students & staff of Kodaikanal Observatory in the Year 1961.

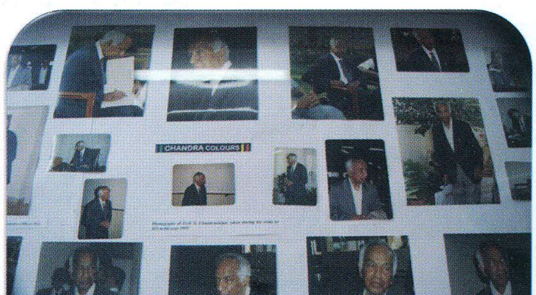


S. Chandrasekhar and Mrs. Lalitha Chandrasekhar walking down the lane with Prof. M. K. V. Bappu from the North-South Domes of the Kodaikanal Observatory in 1961.

Prof. S. Chandrasekhar and Mrs. Lalitha Chandrasekhar with Prof. M. K. V. Bappu and other staff at IIA during his visit to Optics Laboratory in the year 1981.

Prof. S. Chandrasekhar giving a colloquium on "Nonradial oscillations of stars as a problem in the scattering of gravitational waves" during his visit to IIA on January 11, 1993.

Prof. S. Chandrasekhar with students at IIA in the Year 1993.



The panel on "Chandra Colors" depicts Chandra in different poses making a rich addition to the collection.

- Christina Birdie

New Appointments

IIA welcomes ...

... **Mousumi Das** joined IIA on December 6, 2010 and will be working with the "Stellar and galactic astrophysics group on observational astronomy". Her PhD was on Formation, Stability and Starburst in Molecular Clouds under the JAP program of IISc, Bangalore. She works broadly in the area of extragalactic astronomy and her present interests lie in understanding the evolution of dark matter dominated late type galaxies.She has worked as a postdoctoral fellow at Raman research institute and Kerr Fellow at the University of Maryland where she worked with the millimetre astronomy. She wasAssistant Professor, Department of Physics, BITS, Hyderabad before joining IIA.

... **Pravabati Chingangban** joined IIA on December 29, 2010. She worked at the Astrophysics Research Centre for the Structure and Evolution of Cosmos (ARSEC) Sejong University, Korea, as a Research Professor till mid December 2010. She will be working at the Institute on research topics of interest to her, in close association with the core group on theoretical astrophysics. Her thesis was on "Connection and Curvature in the Fibre Bundle Formulation of Quantum Theory" and she obtained her degree in 2003 from Jamia Millia Islamia, New Delhi.

Farewell

IIA wishes all the best to ...

... **V. Chinnappan** joined IIA on September 5 1974 and was elevated to various positions. He acquired his Ph.D on ***A new approach to Stellar Image Correction for Atmospherically Degraded Images*** during the service in the year 2009 from BangaloreUniversity. Chinnappan retired in October 2010.

... **K.S. Subramanian** joined IIA as a support staff on 7.8.1975 at VBO, Kavalur and retired in October 2010.

... **V. Murugesan** worked as a support staff at VBO, Kavalur and retired in December 2010.

Chandrasekhar Post-Doctoral Fellowship

The Director, IIA invites applications from exceptionally bright candidates with outstanding academic credentials for the award of 'Chandrasekhar Post-Doctoral Fellowships' in all areas of astrophysics. Applications are accepted at any time of year. The fellowship is for an initial period of two years, extendable to three, with a minimum monthly stipend of Rs.25,000/-, an annual contingency grant of Rs.1,00,000/-, housing and medical benefits, and support for travel to Bangalore. More details are at http://www.iiap.res.in/postdoc.htm.

Editors: S. P. Rajaguru, T. Sivarani and S. Rajiva
Editorial Assistance : K. Suchitra, P. Masuna
Photo Credits: T. K. Murali Das

Indian Institute of Astrophysics
II Block, Koramangala, Bangalore 560 034, INDIA
Tel : 91 (80) 2553 0672 Fax : 91 (80) 2553 4043
Voicemail : 91 (80) 2553 9250 E-Mail : newslet@iiap.res.in